MITIGATION COSTS IN SECOND-BEST ECONOMIES: TIME PROFILE OF EMISSIONS REDUCTIONS AND SEQUENCING OF ACCOMPANYING MEASURES

Meriem Hamdi-Cherif, CIRED, 45bis avenue de la Belle Gabrielle, 94736 Nogent-sur-Marne, France
Phone: +33(0)143947374, e-mail: hcmeriem@centre-cired.fr
Henri Waisman, CIRED, 45bis avenue de la Belle Gabrielle, 94736 Nogent-sur-Marne, France
Phone : +33(0)143947378, e-mail: waisman@centre-cired.fr
Céline Guivarch, CIRED, 45bis avenue de la Belle Gabrielle, 94736 Nogent-sur-Marne, France
Phone : +33(0)143947362, e-mail: guivarch@centre-cired.fr
Jean-Charles Hourcade, CIRED, 45bis avenue de la Belle Gabrielle, 94736 Nogent-sur-Marne, France
Phone : +33(0)143947380, e-mail: hourcade@centre-cired.fr

Overview

This article revisits the role of the time profile of carbon emissions reductions for climate policies design. Using the CGE energy-economy Imaclim-R model, we demonstrate that the emission profile does not significantly change the time profile and the magnitude of mitigation costs. Recycling carbon tax revenues towards lower labour taxes and early action on long-lived infrastructures significantly reduce mitigation costs. These complementary measures are as important as the time profile of emissions for mitigation costs. The sequencing of these options is closely related to the intertemporal tradeoff on emissions reductions.

Methods

For the sake of clarity, we limit our analysis to a unique stabilization objective expressed as the total radiative forcing in 2100, as for the Representative Concentration Pathways developed for the fifth IPCC Assessment Report (van Vuuren et al., 2011). The target chosen is 3.4W/m2 in 2100, with a possibility of overshoot of the target during the 21st century.
We build four carbon emission trajectories (T-1, T-2, T-3 and T-4) over the period 2010-2100, which differ in terms of date (and level) of the emissions peak and of long-term stabilization level but which all lead to the same radiative forcing in 2100. T-1 is the trajectory where the most important mitigation efforts have to be done at the beginning of the period (early action). T-4 is the one where the mitigation efforts are concentrated at the end of the period (delayed action). T-2 and T-3 are two intermediate trajectories between T-1 and T-4. These trajectories are elaborated by using a three-reservoir carbon-cycle model (atmosphere, biosphere + surface ocean, deep ocean) calibrated on the IMAGE model (Ambrosi at al., 2003).

The analysis of economic interactions is conducted using IMACLIM-R (Waisman et al, 2012), a hybrid multi-region, multi-sector general equilibrium model which embarks sectoral expertise into a macroeconomic framework to assess CO_2 emissions scenarios and policies. One specificity of Imaclim-R is to adopt a hybrid matrix ensuring consistency between money flows and physical quantities; it is built by modifying input-output tables from the GTAP-6 dataset to make them fully compatible with 2001 IEA energy balances and data on passengers' mobility from (Schäfer and Victor, 2000). From its calibration date 2001, IMACLIM-R describes dynamic trajectories in one year steps through the recursive succession of static equilibria representing the second-best nature of economic interactions (including market imperfections and underuse of production factors) and dynamic modules representing the evolution of technical and structural constraints. This structure adopts adaptive anticipations so that agents take investment decisions according to the extrapolation of past and current trends; the gap between these expectations and real market outcomes conditions growth trajectory and their position with respect to their natural rate given by demographic and productivity trends.

The analyses carried out in this paper rely on sixteen policy scenarios, which differ according to the four options for carbon emission trajectory and four groups of macroeconomic and sectoral measures adopted in the context of climate policies to go with carbon pricing. We consider more precisely two types of carbon revenue recycling (fully redistributed to households (*Hsld*), or used to reduce labour taxes (*Labour*)) and two transportation infrastructure policy (depending whether a voluntarist action towards a reduction of mobility needs through infrastructure development is undertaken or not). These two groups of measures are chosen because they have a complementary effect, revenue recycling affecting economic adjustments in the short- and medium-term, whereas the impacts of transport infrastructure policies are more significant in the long-term.

Results

We start by investigating the dependence of aggregated mitigation costs over the time profile of emission reductions under the assumption of full redistribution of carbon revenues to households and no specific infrastructure policy. This is done by comparing the discounted costs for different values of the discount rate (7%, 3%, 1%) representing respectively a short-term, medium-term and long-term vision.

At a global level, there is a high dependence of the GDP losses on the chosen discount rate. Indeed, these discounted costs are rather insensitive to the emission profile under the 3% discount rate case, whereas they are widely dispersed according to the emission trajectory for both short-term and long-term visions. Obviously, in a short-term perspective the earlier the most important efforts will be made, the more costly it will be: in such a vision, the higher mitigation costs are obtained under the stabilization scenario T-1, with discounted losses that amount to 3.2%. Conversely, the higher aggregated GDP losses with respect to the BAU scenario, when a long term perspective is adopted, are observed under the stabilization trajectory T-4, i.e. the case where the most important efforts have to be done at the end of the period. In that case, the global discounted losses reach 11.1%.

The second step of the analysis investigates the interplay between the time profile of carbon abatements and the complementary measures that act at different time horizons. To do so, we extend the previous analysis to alternative measures:

(i) Reforming the fiscal system as a way to reduce the short and middle term effects of the mitigation policies

We find that whatever the time horizon and whatever the timing of emission reductions, the recycling on labour taxes proves to reduce the mitigation costs. This is because this measure helps to decrease the energy-to-labour costs ratio in the production process by fostering more intense use of workers. The magnitude of this effect is particularly important in the short-term (7% discount rate) where GDP losses obtained with a fiscal reform are reduced in average by 42% with respect to the *Hsld* scenario, while they are reduced in average by 28% with a medium term vision (3% discount rate) and only by 22% under a long term perspective (1% discount rate). This makes sense, because these measures to moderate production costs are particularly important during the first phase of the climate policy, in which energy costs rise and technical change is limited by strong inertias.

(ii) Early action on transport infrastructures as a way to reduce long term costs

We find that the reduction of mobility needs and the shift towards low-carbon modes allows meeting the same climate objectives with far more moderate GDP losses whatever the temporal perspective adopted and whatever the timing of emission reductions.
When we adopt a short term vision, it appears that the more delayed action is the less costly one with GDP losses amounting less than 1%. In this case, these losses obtained with a fiscal reform and an infrastructure policy deployment are reduced by 69% with respect to the 'carbon price only' policy. When medium and long term perspectives are adopted, we find also that a delayed action can be efficient. Indeed, without waiting the last moment to act (T-4), our results show that a postponed mitigation action (T-2 or T-3) is possible and provides less higher GDP losses than in the case of an early action on emissions. Under these two last temporal perspectives too, the gains obtained via the fiscal reform and the infrastructure policy are significant: the costs are reduced by 56 to 60% with respect to the 'carbon price only' scenario.

Conclusions

We demonstrate that the emission profile does not significantly change the time profile and the magnitude of mitigation costs, but rather operates a time shift in their occurrence according to the period where most efforts are conducted.
Two principal sources of high costs are identified. On the one hand, the increase of the energy-to-labour costs ratio consecutive to the introduction of the carbon price in the short-term; on the other hand, transport-related emissions which force a rise of carbon prices in the long-term in all scenarios.
We then investigate the effect on these profiles of two complementary policies: an alternative recycling method for carbon revenues towards lower labour taxes and an infrastructure policy aimed at decoupling economic activity from mobility. Both measures taken separately prove to reduce notably mitigation costs by offsetting the short-term energy price increase and limiting the long-term rise of carbon prices, respectively. Taken together, they even prove to combine their effects to offer very important reductions of mitigation costs.
This quantitative assessment leads to the conclusion that the measures accompanying carbon pricing are as an important determinant of mitigation costs as the time profile of emission, and that the sequencing of these options is closely related to the intertemporal tradeoff on emission reduction.

References

Ambrosi, P., J.-C. Hourcade, S. Hallegatte, F. Lecocq, P. Dumas and M. Ha-Duong. Optimal control models and elicitation of attitudes towards climate damages. *Environmental Modeling and Assessment* Volume 8, Number 3, 135–147, 2003.
Schäfer, A, Victor, D.G. The future mobility of the world population. *Transportation Research Part A: Policy and Practice* Volume 34, Number 3, 171-205, 2000
Detlef P. van Vuuren, Jae Edmonds, Mikiko Kainuma, Keywan Riahi, Allison Thomson, Kathy Hibbard, George C. Hurtt, Tom Kram, Volker Krey and Jean-Francois Lamarque, et al. The representative concentration pathways: an overview. *Climatic Change* Volume 109, Numbers 1-2, 5-31, 2011.
Waisman, H., Guivarch, C., Grazi, F., Hourcade, J.-C. The IMACLIM-R Model: Infrastructures, Technical Inertia and the Costs of Low Carbon Futures under Imperfect Foresight. *Climatic Change*, in press, 2012.