Seminar 4: Adaptation and mitigation as responses to climate change

Consider a country or region that faces potential or actual damages due to climate change that takes place over time. In this problem we will only look at damages that result at a given point of time (or during a given period of time) in the future.

These damages can be reduced or modified by two types of activity that the country or region can carry out:

1. Short-run adaptation to the occurring climate change. This activity takes place after the climate has changed, and in direct response to the climate problem that arises ex post.
2. Long-run adaptation, carried out at an initial point of time, but having effect during the future period of time after the climate has changed.

Consider the following function describing the relationship between future climate damages, and long-run and short-run adaptation:

(1) $$ND(t) = B\left[ED(t) - A_L(0) - A_S(t) + \alpha A_L(0)A_S(t)\right]^2 \equiv B\left[Q(0,t)\right]^2.$$

Here ND(t) denotes (net) climate damages at time t, ED(t) is an indicator variable for (expected) gross (unabated) negative impact of climate change in the economy ("gross climate damages"), $A_L(0)$ is long-run (anticipatory) adaptation to climate change taking place at point 0, and $A_S(t)$ is short-run adaptation activity taking place at time t, in response to climate damages occurring at that time. In (1), α denotes an "interaction effect" between long-run and short-run adaptation. B is a positive constant.

1. Discuss whether the function (1) can be considered as a reasonable description of net damages resulting from climate change.

2. What is the relationship between long-run and short-run adaptation as described by (1)? Could it be correct to claim that more long-run adaptation "reduces the need for" short-run adaptation? Discuss in this connection the parameter α, which can be either positive, negative or zero. What do you think is the most reasonable case?

3. Consider that ED(t) is an uncertain variable. Discuss whether the specification of (1), in terms of short-run adaptation activity, is relevant and reasonable. Could you think of another way to specify this variable in (1)?

Consider now the determination of long-run and short-run adaptation. Long-run adaptation is determined at time 0, while short-run adaptation is determined at time t, when the climate damages actually occur.

First, consider short-run adaptation. This is determined by maximizing the following function:

(2) $$V_S(A_S(t)) = -ND(t) - c_S A_S(t).$$

Here, c_S is the unit cost of adaptation expenditures at time t.

4. Derive the first-order condition for this country, with respect to short-run adaptation activity in period t.

5. Study some relevant properties of the optimal solution for A_S. In particular, study how short-run adaptation can depend on long-run adaptation.

Consider next long-run adaptation. This is determined at time 0, before the climate impact occurs. The function to be maximized is in this case:

(3)
$$V_L(A_L(0)) = -\delta_L ND(t) - c_L A_L(0).$$

Here δ_L is a discount factor for discounting of the period from the time 0 (at which time expenditures for long-run adaptation are incurred) to time t (when climate damages occur), while c_L is the unit cost of long-run adaptive expenditures.

6. Assume first that $A_S(t)$ is taken as exogenously given by the region when determining A_L. Derive the first-order condition for optimal long-run adaptation in such a case.
7. Consider next a case where the optimal response of short-run adaptation, in response to the initial long-run adaptation, is taken into consideration in determining the initial long-run adaptation. Show how this effect is likely to affect long-run adaptation.

Note that in (1), we are simply considering an expectation effect, ED(t), in such a way that short-run adaptation is also a function of ED(t), where D(t) is an uncertain variable. An alternative would be to assume that ED(t) is decisive for determining A_L, while A_S is instead determined by D(t), so that there is no more uncertainty at the time when A_S is determined.

8. How would the analysis for A_L and A_S be affected by such a change in assumptions?