Abstract

The interaction of society, economy and the climate system has been studied for the integrated assessment (IA) of climate change using a cost-benefit analysis (CBA). Structural dynamic models have been developed and applied to highlight two topics rarely addressed in current CBA/IA models: the different objectives that drive the actions of economic and societal actors, and the representation of economic growth. The models include an explicit description of the basic dynamic processes of the system, in contrast to the general equilibrium approach of standard economics.

The general Structural Dynamic Integrated Assessment Model (SDIAM) described in this thesis is developed from two basic models: the Structural Dynamic Economic Model (SDEM) and the impulse-response function climate model NICCS [Hooss *et al.* 2001]. SDEM focuses on the interaction of entrepreneurs and workers and describes growth as the consequence of profit-driven productivity increase. Entrepreneurs invest to enhance productivity, this generates profits that decay subsequently due to factor cost increases. Persistently positive profits require persistently growing productivity. Economic growth is achieved when part of the profits is also invested to enlarge the capital stock.

In SDIAM, society is introduced as an additional actor. Further extensions to SDEM are modules for energy costs, climate change (NICCS), and climate damage costs. Intangible climate damages enter directly in the societal welfare function, while tangible damages affect the entrepreneurial welfare function. To enhance its welfare, society influences economic decision-making by imposing levies on CO_2 emissions. Entrepreneurs optimize within the levy framework, which they take as given.

Numerical experiments with these models yield the following results. Without societal action, the transition from a fossil fuel based to a non-fossil driven energy system depends on the cost dynamics of fossil fuels and climate damage costs; it starts in the middle of the 21st century. Climate change damages are maximal around 2050 at 2.7% of GDP. When society imposes levies, these payments are included in the determination of the timing of the energy system transition. Levies lead to a reduction of emissions and climate damages, the magnitude depending on the way in which levy revenues are spent. However, if the same discount factors are applied uniformly to all costs, the net effect on societal welfare is negative, because the reduction of climate damages is overcompensated by losses in consumption. These losses result from entrepreneurial adaptations to higher costs related to energy use.

The contradiction of this result with recent societal efforts to curb greenhouse gas emissions (e.g. under the Kyoto protocol) is resolved if it is assumed that the valuation of climate damages in the societal welfare function increases with time relative to the value of consumption. This result confirms recent calls for differential discounting of climate change [Hasselmann *et al.* 1997, Hasselmann 1999].

Other features, like learning curves in the energy cost dynamics or unemployment in the societal welfare function, have been estimated but not yet been explicitly included in the present study.