distant time horizons. The biggest challenge of all for EDE is the persistence of high poverty and inequality in the distribution of inclusive wealth and human wellbeing in spite of the fast rates of economic growth and per capita consumption.

Environment and development: achievements and challenges in climate economics

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The economic analysis of the natural environment and of economic development encompasses most complex topics and issues. Accordingly, many contributions in the field are either cross-disciplinary or very detailed and broad in perspective. The core methodology of economics is different, however. Economic models are generally used to drastically reduce complexity and to look at a low number of analytical relationships. This allows for analysis of the basic mechanics of the problems in a concise manner and for the derivation of closed-form model solutions. There are of course seminal contributions using the procedure, e.g., Hotelling (1931) and Dasgupta and Heal (1974). But for the crucial issue of climate change the profession appears to be somewhat reluctant to push strongly for constructing a stringent analytical framework; the field is still dominated by relatively complex integrated assessment models. These yield many important insights but, in certain cases, provide contradicting results and sometimes lack intuition. Hence, climate economic models providing closed-form solutions on future growth and optimum climate policy appear to be warranted.

Climate change is a major topic in current environmental science but, at the same time, in development economics, because it will have a strong impact on the growth of less developed countries. In fact, the costs of global warming are severely biased against the less developed economies. The main reasons are significant differences in climate vulnerability and the internationally unequal availability of capital and knowledge for climate adaptation. Capital is a crucial factor for both growth and climate impacts. As an example, the 2010 floods in Pakistan damaged some of the most fertile agricultural grounds, causing losses of land, crops and cattle and destroying railway networks, roads, barrages, canals, villages, infrastructure and other essential facilities. The recent Typhoon Haiyan in

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the Philippines was one of the strongest recorded storms ever to make landfall. The surge swept away entire cities; several million people have been affected, some killed, many displaced or left homeless. If developing countries have to use an ever-growing share of their scarce capital for the protection of their economies against rising temperatures, their development prospects become severely limited.

According to the different impacts of warming, efforts in climate change mitigation are indicated both for environmental and development reasons. Following the reasoning above, they help to improve growth prospects in less developed economies. It is of course rational to ask whether development targets could also be met by different means. The plan to give more direct aid as a substitute for active climate mitigation had a clear impact on some countries' positions at recent international climate negotiations. But recent research suggests that it is preferable to pursue active climate policies because they positively affect economic dynamics (see Bretschger and Suphaphiphat, 2014).

It remains as a major challenge for climate economics to further intensify theoretical research on the central economic mechanisms at work. Specific issues are, first and naturally, the dynamic nature of the problem. Resource extraction and stock pollution are inherently non-static in nature, just as is economic development. To get the dynamics right in the economic and the environmental system is a major part of the task. A second cornerstone is the treatment of capital, which is known to be crucial for growth. Natural disasters such as tropical hurricanes, massive floods, severe droughts or major landslides harm existing capital, much more than (or at least in addition to) having an impact on utility or current production, as is often assumed. The economic consequences of warming thus consist of destruction of infrastructure and the loss of physical and human capital, causing a lasting setback to economic growth. A third and most important issue is the appropriate modelling of uncertainty. It is known that economic activities cause carbon and other greenhouse gas emissions, thus increasing the stock of greenhouse gases in the atmosphere. Moreover, it is at least highly probable that global temperature increase and associated climate change raise the severity of natural disasters. But the economic damages stemming from these undesirable events are still not easily predictable; that is, they remain uncertain. The integration of increasing natural resource scarcities and very limited decay rates of greenhouse gases are further issues to be considered appropriately in theoretical climate models.

Another most demanding issue is to actively engage in policy advice and to develop politically feasible pathways towards achieving a global climate treaty. Economists can best contribute to the process by providing clear and robust results on the different possible scenarios and solutions. For example, it has to be stressed by economists that predicted costs of climate policies are lower when including appropriate dynamics and induced innovation effects. However, we also have to acknowledge that the economic impacts of an international agreement are likely to be major and certain to be asymmetric between the different countries; hence, the self-centered interests of the countries are naturally very different. Specifically,

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the question of how to include historic responsibilities is critical for certain industrial countries. Whether the final mechanism will be a quantity or a price regulation is less critical, provided that the emission targets are compatible with the agreed temperature targets and the deal is considered to be fair to all the negotiating parties. These are indeed tough requirements, stretching the degree of complexity in political decision making to a mountain-high maximum.

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Mother polar bear and cub walking on ice floe in the Arctic Ocean, north of Svalbard, Norway
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