

Global economic response to flood damages under climate change

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Climate change affects societies across the globe in various ways. In addition to gradual changes in temperature and other climatic variables, global warming is likely to increase intensity and frequency of extreme weather events. Beyond biophysical impacts, these also directly affect societal and economic activity. Additionally, indirect effects can occur; spatially, economic losses can spread along global supply-chains; temporally, climate impacts can change the economic development trajectory of countries.

This thesis first examines how climate change alters river flood risk and its local socio-economic implications. Then, it studies the global economic response to river floods in particular, and to climate change in general.

Changes in high-end river flood risk are calculated for the next three decades on a global scale with high spatial resolution. In order to account for uncertainties, this assessment makes use of an ensemble of climate and hydrological models as well as a river routing model, that is found to perform well regarding peak river discharge. The results show an increase in high-end flood risk in many parts of the world, which require profound adaptation efforts. This pressure to adapt is measured as the enhancement in protection level necessary to stay at historical high-end risk. In developing countries as well as in industrialized regions, a high pressure to adapt is observed - the former to increase low protection levels, the latter to maintain the low risk levels perceived in the past.

Further in this thesis, the global agent-based dynamic supply-chain model *acclimate* is developed. It models the cascading of indirect losses in the global supply network. As an anomaly model its agents - firms and consumers - maximize their profit locally to respond optimally to local perturbations. Incorporating quantities as well as prices on a daily basis, it is suitable to dynamically resolve the impacts of unanticipated climate extremes. The model is further complemented by a static measure, which captures the inter-dependencies between sectors across regions that are only connected indirectly. These higher-order dependencies are shown to be important for a comprehensive assessment of loss-propagation and overall costs of local disasters.

In order to study the economic response to river floods, the *acclimate* model is driven by flood simulations. Within the next two decades, the increase in direct losses can only partially be compensated by market adjustments, and total losses are projected to increase by 17% without further adaptation efforts. The US and the EU are both shown to receive indirect losses from China, which is strongly affected directly. However, recent trends in the trade relations leave the EU in a better position to compensate for these losses.

Finally, this thesis takes a broader perspective when determining the investment response to the climate change damages employing the integrated assessment model DICE. On an optimal economic development path, the increase in damages is anticipated as emissions and consequently temperatures

increase. This leads to a significant devaluation of investment returns and the income losses from climate damages almost double.

Overall, the results highlight the need to adapt to extreme weather events - local physical adaptation measures have to be combined with regional and global policy measures to prepare the global supply-chain network to climate change.