Climate Change Impacts in an Increasingly Connected World

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Climate change has strong impacts on natural and socio-economic systems around the globe. Economic performance can be affected by changing climatic conditions and extreme weather events through numerous channels such as agricultural and industrial output, energy demand and labour productivity. In addition to these direct links, economic outcomes can be influenced by climatic events in more complex manners due to highly interconnected production processes and global trade networks. A better understanding of the overall economic implications of climate change is important to avoid social problems and to comprehensively estimate the costs of future warming.

In my thesis, I aim to contribute to this understanding by investigating climate change impacts in the context of an increasingly connected global economy. To this end, I use numerical, analytical and econometric tools. In particular, I develop a model to study global economic cascade effects. It builds on multi-regional input-output data that provide information on trade relations between various regional sectors thereby describing the static structure of a global network of economic flows.

In the first article of my thesis, I propose an algorithm to increase the level of sectoral and regional detail of these data (*Wenz et al., 2015*). The algorithm's strength lies in the flexible combination of multiple proxy data sources in different iteration steps along which the accuracy of the refined data improves.

In order to analyse the dynamic response of the network to local weather extremes, I co-developed the model *acclimate* that I present in the second and third articles. It describes the propagation of climate-induced production losses from one regional sector to the next via supply shortages (*Bierkandt, Wenz et al., 2014*) and demand reductions (*Wenz et al., 2014*). The propagation of losses can be buffered by transport times, the availability of stored input goods, the possibility of production extension and the directing of demand to less affected suppliers.

In the fourth article, I apply the model to study the propagation of heat stress-induced production losses (*Wenz & Levermann, 2016*). I find that the susceptibility of the global economic network to the propagation of such losses has increased over the first decade of this century and that this increase is mainly due to enhanced economic connectivity. The influence of this structural change dominates over the effect of the comparably weak warming during this period. The results suggest that the intensification of international trade has the potential to amplify climate-related production losses if no adaptation measures are taken.

In the last two articles of my thesis, I study specific aspects of the climate-economy relationship with a focus on the agriculture and electricity sectors. The fifth article concentrates on the transmission of supply shocks from exporting to importing countries in the food sector (*Bren d'Amour, Wenz et al., 2016*). The vulnerability of countries to such shocks is analysed by simultaneously accounting for critical caloric import dependencies and teleconnections in the global food system. The results point to similar vulnerability patterns of geographically clustered countries: the Middle East, Western Africa and Central America are most vulnerable to supply shocks in wheat, rice and maize, respectively. Sub-Saharan Africa is most at risk if the exposure of the poor is factored in.

In the sixth article, I investigate the impact of temperature on electricity consumption and peak load in Europe (*Wenz et al., 2016*). I find a non-linear and statistically significant relation across all examined countries based on which I project future national electricity demand under different climatic futures. The projections show that electricity demand and peak load can be expected to increase in Southern and Western European countries and to decrease in the North. This North-South polarization, which is most pronounced under a scenario of unabated climate change, would have major ramifications for the location of costly peak-generating capacity and transmission infrastructure.

Articles

[1] **L. Wenz**, S. Willner, A. Radebach, R. Bierkandt, J. Steckel, A. Levermann
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[2] R. Bierkandt, **L. Wenz**, S. Willner, A. Levermann
Acclimate - a model for economic damage propagation. Part I: basic formulation of damage transfer within a global supply network and damage conserving dynamics
Environment Systems and Decision 34 (2014)

[3] **L. Wenz**, S. Willner, R. Bierkandt, A. Leverman
Acclimate - a model for economic damage propagation. Part II: a dynamic formulation of the backward effects of disaster-induced production failures in the global supply network
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[4] **L. Wenz** & A. Levermann
Enhanced economic connectivity to foster heat stress-related losses
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[5] C. Bren d'Amour, **L. Wenz**, M. Kalkuhl, J. Steckel, F. Creutzig
Teleconnected food supply shocks
Environmental Research Letters 11 (2016)

[6] **L. Wenz**, A. Levermann, M. Auffhammer
North-South polarization of European electricity consumption under future warming
Nature Energy (under review)

[Appendix] C. Otto, S. Willner, **L. Wenz**, K. Frieler, A. Levermann
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[Appendix] N. Glanemann, S. Willner, **L. Wenz**, R. Bierkandt, A. Levermann
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