

Climate Shocks and Economic Growth: Bridging the Micro-Macro Gap*

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Abstract

How do environmental shocks affect macroeconomic outcomes? A growing and influential body of empirical work has sought to quantify the impacts of climate shocks on economic growth. However, this literature currently faces three fundamental gaps: First, empirical studies have found a wide range of seemingly contradictory results, ranging from positive effects of climatic disasters (e.g., Skidmore and Taya, 2002) to large negative effects of tropical storms (e.g., Hsiang and Jina, 2015) and temperature shocks (e.g., Dell, Jones, and Olken, 2011). These results have yet to be reconciled. Second, the empirical literature has remained largely disconnected from macroeconomic growth models (e.g., Ikefuji and Hoori, 2012), making it difficult to compare results across approaches. Third, empirical studies' findings on climate shocks and growth have generally not been incorporated into climate-economy models. Attempts to do so have shown the potential for significant policy implications, but have again highlighted the challenge of mapping reduced form growth estimates into the structure of climate-economy models (Moore and Diaz, 2015). This disconnect is of concern not only for policy makers (Obama, 2017), but echoes a broader micro-macro gap afflicting the climate change economics literature.

This paper thus brings a novel macroeconomic model-based perspective to the data in order to advance the literature in these three dimensions. First, building on incomplete markets approaches (Krebs, 2003), we present a stochastic endogenous growth model where households face both aggregate and idiosyncratic (partly uninsurable) risks from climatic shocks. In particular, disasters may affect both the depreciation and productivity of different types of capital (analogous

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to business cycle risks in Krebs, 2003). We then revisit the empirical literature through the lens of this model. In particular, we analytically map the impact estimates identified by competing empirical estimation approaches into their structural counterparts in the model. The first main results is that the diverging results of key prior empirical studies can be reconciled as measuring different components of the overall impact of disasters on growth. For example, cross-sectional regressions identify the impact of disaster *risk* on long-run growth, which can be positive or negative depending on whether precautionary savings effects outweigh rate-of-return effects, in line with empirical studies (e.g., Skidmore and Taya, 2002). In contrast, panel fixed effects regressions of wind speed realizations estimate the effect of disaster *strikes*, which the model predicts to be negative and persistent, again in line with the empirical evidence (e.g., Hsiang and Jina, 2015). Importantly, the model also demonstrates the limitations of reduced form output-growth estimates for gauging welfare effects of climate change: An increase in climate risk can affect growth and welfare in opposite ways.

Second, we propose an alternative approach to estimating disaster impacts that can be directly incorporated into structural climate-economy models and therefore inform estimates of the welfare costs of climate change. This approach specifically focuses on quantifying climate shock impacts on the *structural determinants of growth* - such as total factor productivity and capital depreciation - rather than on the endogenous equilibrium outcome of output growth itself.

Third, we empirically showcase how to implement this approach by producing novel estimates of the impacts of tropical cyclones and climate change on economic outcomes and welfare in Vietnam. Our approach (i) matches the empirical literature’s standard of causal identification by using plausibly exogenous variation in extreme weather events to identify their impacts on productivity and income risks, (ii) accounts for adaptation to climate change by explicitly modeling how households respond to changes in the weather risk distribution, and (iii) thus produces welfare estimates in a fully specified decisions-under-uncertainty endogenous growth climate-economy model. On the economic side, the estimation combines standard data on aggregate factors with detailed, nationally representative survey data from the Vietnam Household Living Standards Survey (2004-2014) to quantify the impacts of climate shocks on household income risks. On the climate side, we combine detailed historical cyclone data with synthetic cyclone track projections under future climate change (Emanuel, 2008) to estimate the change in the probability distribution of climate shocks facing households.

The benchmark results suggest that changes in cyclone risks by 2100 will depress long-run growth in Vietnam by an economically significant 0.07 – 0.14 percentage points - on the same order of magnitude as recent estimates of the effect of U.S. business cycles on U.S. growth (Krebs, 2003, Barlevy, 2004). The associated welfare costs are estimated to range from -0.9% to -1.7% of initial consumption.

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