The Impact of Climate Change on Developed Economies

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Introduction

A consensus from the research based on **national** data is that climate change **does not negatively** affect developed economies.

*Burke et al. (2015) find: "Europe could **benefit** from increased average temperatures" (p. 3).*

However, recent research based on **sub-national** data challenges this consensus.

*Deryugina and Hsiang (2014) find that increases in **daily** temperature above 15 °C significantly reduce personal income at the county level in **the United States**.*

In this paper, we revisit the relationship between temperature and growth.

1. To understand if adaptation over long run makes developed countries not negatively affected by climate change, we focus on **five-year** average temperatures, not daily or annual temperatures.
2. To understand if it is the United State or developed economies in general that are not negatively affected by climate change, we study **the United States** as well as **the European Union**.

Objective

In this paper, we use **sub-national** data to examine the **long-run** relationship between temperature and growth within **the United States and the European Union**.

Data

There are two potential issues with using national data.

1. As Nordhaus (2006) points out, "for many countries, averages of most geographic variables (such as temperature or distance from seacoast) cover such a huge area that they are virtually **meaningless**" (p. 3511).
2. If there is a nonlinear relationship between temperature and growth within a country, the impact at the average national temperature will be a biased estimate of the average impact across the country, due to **Jensen's inequality**.

We therefore follow Nordhaus (2006) and use the G-Econ data. **G-Econ** estimates real gross output at a **1-degree longitude by 1-degree latitude** resolution at a global scale.

Empirical Methodology

Our base **linear spline** model is derived from a Cobb-Douglas type production function:

$$y_{it} = \mu_i + \theta_t + \sum_m \tau^m T_{it}^m + \sum_m \rho^m P_{it}^m + \gamma l_{it} + \eta_{it}$$

where y_{it} is the five-year growth rate in GCP in cell i, μ and θ are cell and time fixed effects, T_{it}^m 's are the linear spline of the five-year average temperature, P_{it}^m 's are the linear spline of the five-year average precipitation, and l_{it} is the five-year growth rate in population.

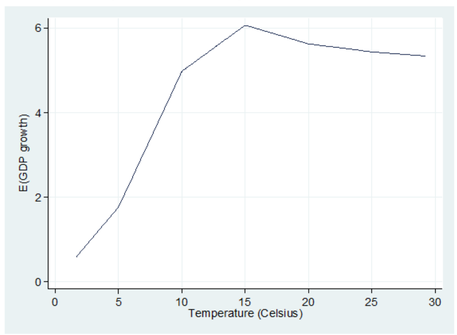
We use **3 °C-wide** temperature bins. For the US sample, m is set to 12, and the knots are -9, -6, -3, 0, 3, 6, 9, 12, 15, 18, and 21 (i.e., the first temperature bin is T < -9 °C, the second one is -9 ≤ T < -6, and so on). For the EU sample, m is set to 7, and the knots are 0, 3, 6, 9, 12, and 15 (because few cells have average temperatures below -3).

The mean impact of temperature on economic growth is $f(T_{it}) = \sum_m \tau^m T_{it}^m$.

With the parameter estimates based on our linear spline regression models, we compare the economic growth under two scenarios. One is the "**no warming**" scenario in which temperatures are assumed to stay at their 1995 levels ("counterfactual"), and the other is the "**warming**" scenario in which temperatures increase.

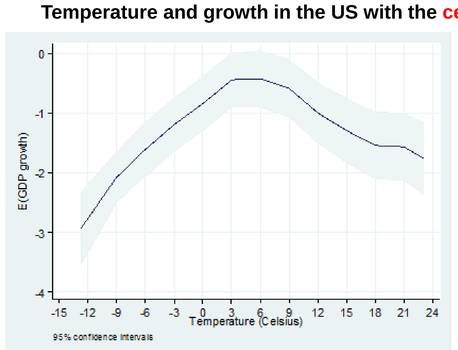
Empirical Results

Temperature and growth with the country-level data



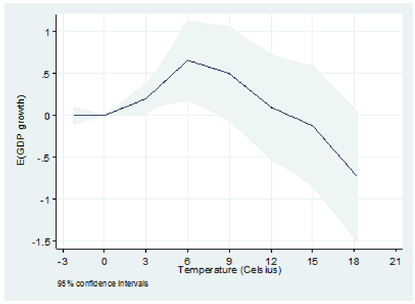
Growth peaks at an annual average temperature of about **15 °C** in the G-Econ sample, if we use the national data.

Temperature and growth in the US with the cell-level data



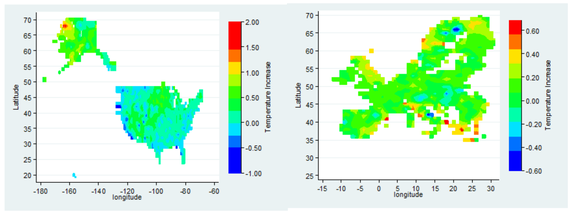
Growth increases with temperature, but only until **6 °C**, well **below** the optimal temperature based on national data.

Temperature and growth in the EU with the cell-level data



Growth increases with temperature, but only until **6 °C**, well **below** the optimal temperature based on national data.

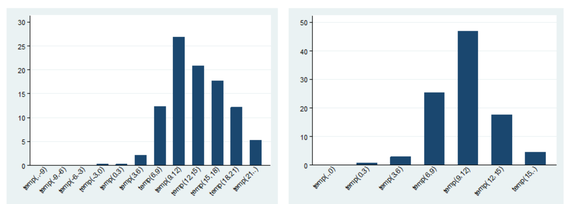
Heterogeneous temperature increases across cells in the US and the EU



Warming is not homogenous. Thus, we would mis-estimate the impact of climate change on economic growth if we used national-level temperature projections.

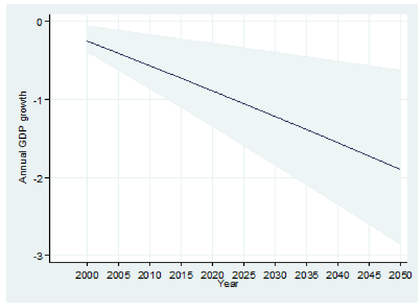
This motivates us to use the **grid-level temperature projections** downscaled from CMIP5 (IPCC, 2014) by Hijmans et al. (2005). More specifically, we focus on the climate projections for **2050**, which consist of a total of **63** projections and are derived from **19** Global Climate Models (GCM) combined with **four** Representative Concentration Pathways (RCP).

Heterogeneous distribution of production in the US and the EU



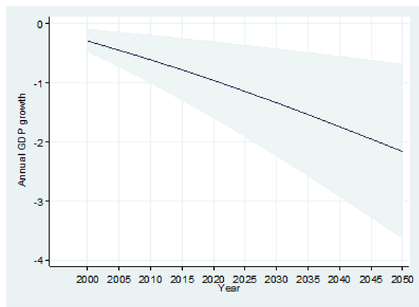
Production occurs mainly in cells with temperatures **above the optimal temperature**, suggesting that temperature increases projected by IPCC (2014) could have **significantly negative impact** on economic growth.

Impact of climate change on US economic growth



By 2050, with IPCC projected warming, the annual economic growth in the US would be **1.90%** lower relative to the counterfactual case in which temperatures stay at their 1995 levels.

Impact of climate change on EU economic growth



By 2050, with IPCC projected warming, the annual economic growth in the EU would be **2.17%** lower relative to the counterfactual case in which temperatures stay at their 1995 levels.

Conclusions

In this paper, we extend Deryugina and Hsiang (2014) and Colacito et al. (2016), and find that long-run temperature increases significantly negatively affect the US and the European Union.

Our results suggest that mitigation over long run does not make developed economies not negatively affected by climate change.

Therefore, our results suggest more proactive climate policy.

Acknowledgments

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