NORTHERN ARIZONA UNIVERSITY
FOUNDED 1899

The Economic Impact of Climate Change on Asian Developing Economies

Xiaobing Zhao

Northern Arizona University, Flagstaff, AZ, USA

Introduction

There is a growing literature that employs subnational data to estimate the economic impact of temperature shocks (e.g., Colacito et al., 2016; Du and Zhao, 2017)

However, research with subnational data on emerging economies is still limited. The extant studies typically focus on the short-horizon (annual) relationship between temperatures and economic outcomes in China (e.g., Chen and Yang, 2017; Li, Cong, and Gu, 2017)

This paper extends the literature along two dimensions:

1. To account for adaptation, we focus on the relationship between temperatures and economic outcomes over the long horizon (e.g., five years), not the annual horizon in previous studies.
2. To understand if it is China or emerging economies in general that are negatively affected by climate change, we study not only China but also India.

Objective

This paper uses **sub-national** data to examine the economic impact of temperature shocks on China and India. Our underlying assumption is that as two emerging economies at the similar level of development and in the same region, the impact of temperature changes on economic growth is similar across two countries.

Data

Developed by Nordhaus (2006), Gecon is a geophysically-scaled economic data set. It divides the terrestrial Earth into a grid with 25,572 cells measuring 1-degree latitude by 1-degree longitude and provides estimates for each cell's economic production, temperature, precipitation, population, and other important demographic and geophysical variables. These data are available for 1990, 1995, 2000, and 2005.

Empirical Methodology

The 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 follow previous studies and use 3˚ C-wide temperature bins. The marginal impact of temperature on economic growth is then:

$$f(T_{it}) = \sum_m \tau^m T_{it}^m$$

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.

The GDP of the economy of China and India is the sum of underlying cells' GCP:

$$Y_t = \sum_i Y_{it}$$

The cumulative GDP growth from period 1 to period t in the economy can be written as:

$$g_t = \sum_i w_i g_{it}, \text{ where } w_i = \frac{Y_{i0}}{Y_0}$$

The cumulative GDP growth of the economy is:

$$g_t \approx \sum_i w_i \sum_t y_{it} = \sum_t \sum_i w_i y_{it}$$

$$g_t = \sum_t \sum_i w_i (f(T_{it}) + X_{it})$$

where $X_{it} = \mu_i + \theta_t + \sum_m \rho^m P_{it}^m + \gamma l_{it} + \eta_{it}$

Similarly, the GDP growth under the counterfactual is

$$\bar{g}_t = \sum_t \sum_i w_i (f(T_{i1}) + X_{it})$$

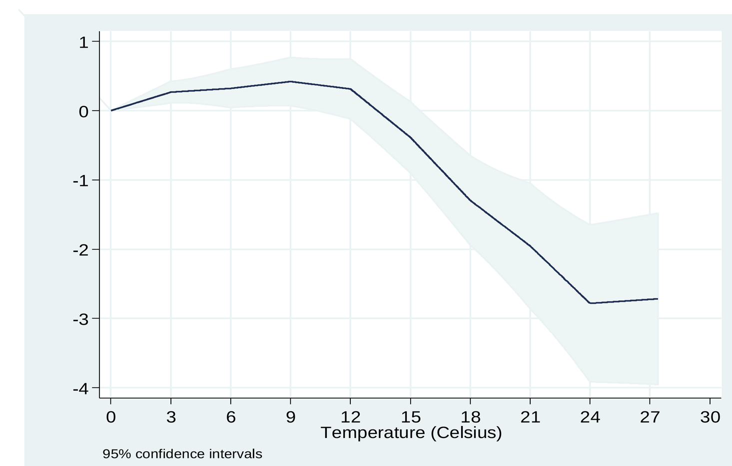
Thus, the impact of climate change on the cumulative GDP growth is

$$g_t - \bar{g}_t = \sum_t \sum_i w_i (f(T_{it}) - f(T_{i1}))$$

Empirical Results

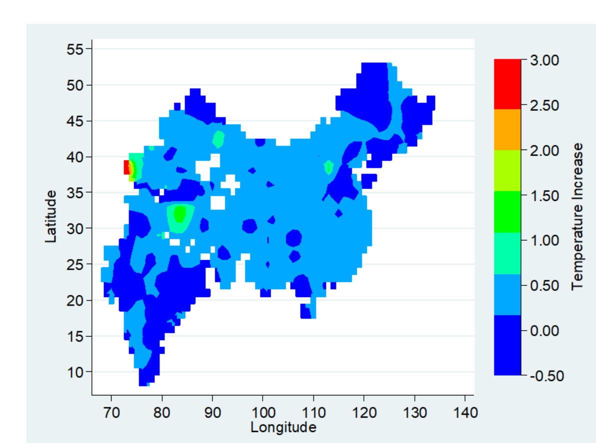
Nonlinear Temperature-Growth Relationship

We estimate different versions of the linear spline model for the merged China and India sample and conclude that, consistent with the results based on national data (e.g., Burke, Hsiang and Miguel, 2015), there is also a significant nonlinear concave relationship between temperature and economic growth at the cell level, with the optimal temperature of about 9-12 °C.



The above figure presents the marginal impact of temperature on economic growth—the economic growth of China and India increases slightly with temperature, but only until about 9-12 °C.

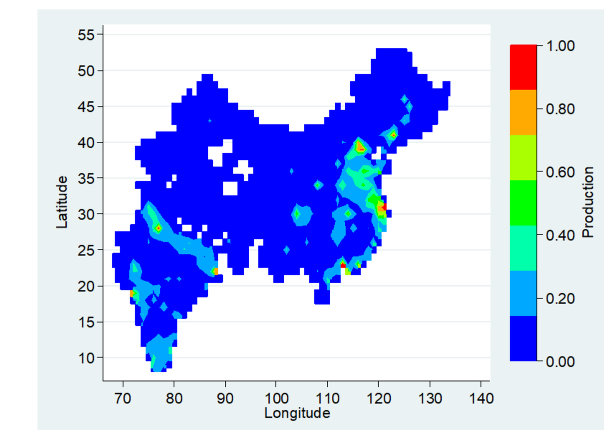
Heterogeneous Temperature Increases



Warming is not homogenous across cells, as shown above for China and India from 1995 to 2005. Thus, we would mis-estimate the impact of climate change on economic growth if we used national-level temperature projections.

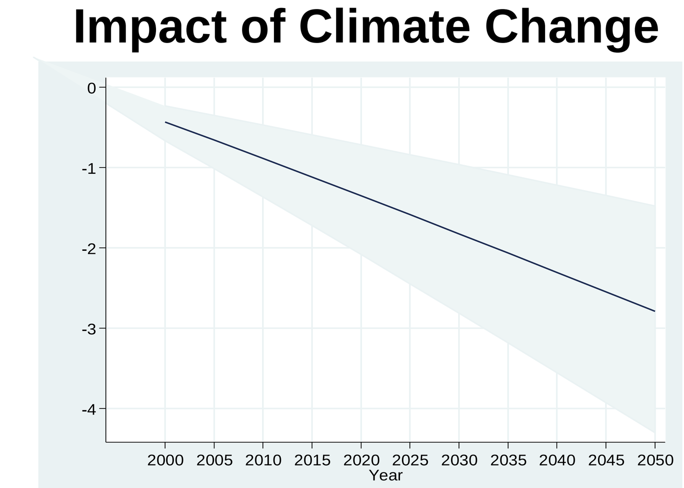
This motivates us to use the **grid-level temperature projections** downscaled from CMIP5 (IPCC, 2014) by Hijmans et al. (2005). We focus on the climate projections for **2050**, which consist of a total of **63** projections and are derived from **19** Global Climate Models (GCM) combined with **four**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

Heterogeneous Distribution of Production



The impact of climate change on economic growth also depends on the distribution of production. In China and India, much of production occurs in hot regions where temperatures are **above the optimal temperature**, as shown above, suggesting that temperature increases projected by IPCC (2014) could have significantly negative impact on their economic growth.

Impact of Climate Change



By 2050, with IPCC projected warming, the annual economic growth in China and India would be 2.79% lower relative to the counterfactual case in which temperatures stay at their 1995 levels.

Conclusions

With subnational GEcon data, this paper extends the literature by examining the economic impact of temperature shocks on China and India due to their economic significance. There is a significantly nonlinear relationship between temperature and growth, with the optimal temperature of about 12 °C . Because much of production takes place in hot regions, IPCC projected temperature increases have significantly negative impact on the economic growth of China and India. The results suggest more proactive climate policy.

Climate Change: Impacts & Responses