THE EFFECT OF CLIMATE CHANGE ON ECONOMIC GROWTH: A STRUCTURAL GLOBAL VECTOR AUTOREGRESSIVE APPROACH

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Overview

Earth's climate is rapidly changing and its impact on the economic environment is indisputable. However, quantifying the losses - or benefits – triggered by climate shocks in terms of real economic activity is not a simple endeavor. We perform a macroeconomic analysis of the effects of climate shocks – namely temperature and precipitations shocks – on economic growth across different countries. Seminal works in climate econometrics show that higher temperatures are associated with a reduction in economic growth, especially in low income and warm countries (Dell et al., 2012; Burke et al., 2015). However, there is no consensus on the response of economic growth to weather events. Many empirical works find that some countries - classified as cold and rich - are positively affected by climate change (Acevedo et al., 2020). Instead, a strand of literature provides evidence of a overall negative effect on economic activity for all countries (Kahn et al., 2021). We contribute to the literature in several respects. First, we explicitly allow for climate endogeneity with respect to the global economy. Following Pretis (2020), economic and environmental systems are determined with feedbacks in both directions, as opposite to what is assumed by most of the literature which takes climate as given. Second, we account for the role of trade and international spillovers among countries. Third, we set up a new methodology to deal with the structural estimation of a Global VAR model. The structural analysis is per se a novelty in climate econometrics literature, that usually relies on reduced-form specifications.

Methods

We propose a revised version of the GVAR model originally proposed by Pesaran et al. (2004), which encompasses the Bayesian structure identification proposed by Baumeister and Hamilton (2015). Our model consists in two-step estimation procedure. In the first stage, country specific SVARX^* models are estimated, where the endogenous variables are temperature (t_t), precipitations (p_t) and real GDP growth (y_t), and foreign exogenous variables capture the role of the global economy y_t^*.[1] This allows us to identify the net effect of climate shocks on country-specific GDP growth rates. In the second step, we estimate a global SVAR model in which the identification of the global shocks is achieved by exploiting trade and climate interdependencies. The value added from the second step estimation is the identification of the global stuctural shocks, defined as shocks hitting the variable of interest in all countries.

In the first-step estimation, country-specific models are expressed as follows:

$$A_0 x_t = k_0 + \sum_{l=1}^{2} B_l x_{t-l} + c x_{t-1}^* + u_t \qquad (1)$$

where A_0 is a $k\ x\ k$ matrix of contemporaneous structural parameters (being k the number of variables), B_l are $k\ x\ k$ matrices of lagged structural coefficients and x_{t-1}^* is a vector of exogenous foreign variables. Country-specific structural shocks are collected in the $k\ x\ 1$ vector, and the associated structural variance-covariance matrix is given by $E[u_t u_t'] = D$.

We identify three structural shocks, namely temperature ($u_{t,t}$), precipitations ($u_{p,t}$), and economic activity shocks ($u_{y,t}$). A positive temperature shock is defined as an unexpected increase in the temperature in deviation from its norm; similarly, a positive precipitations shock is an unexpected increase in the precipitations in deviation from the norm, and finally a positive economic activity shock is defined as an unexpected increase in economic growth.

In the second stage, the estimated country-specific models are stacked to form one large single global model, which is given by:

[1] Foreign exogenous variables are defined in the GVAR framework as weighted averages of all the other countries' variables, with the weights equal to trade shares. For this reason, we only include foreign real GDP growth as exogenous variable.

$$G_0X_t = K_0 + G_1X_{t-1} + G_2X_{t-2} + \tilde{u}_t. \quad (2)$$

The G_0, G_1 and G_2 matrices contain the stacked estimated global model coefficients. The model is then estimated at the global level and the identification of the global structural shocks accounts for the climate and economic spillovers among countries. At this point, we can compare the results coming from single countries models with those where trade is allowed to mitigate or amplify climate effects on economic growth.

This study relies on annual macroeconomic data for 33 countries. Specifically, we use in the analysis the original economies included in the standard GVAR sample, as illustrated in Mohaddes and Raissi (2020), which account for more than 90% of world GDP and cover all the geographical regions. We collect data, provided by the World Bank, from 1960 to 2016 about real GDP growth rates and climate variables. Temperature and precipitations are expressed as deviations from their norm, with the norm defined as the moving average with respect of the past 30 years.

Results

Our first-step estimation results, referring to single countries, show that the response of economic growth to climate shocks is different geographically. According to our findings, the majority of countries, both advanced and developing, are negatively exposed to temperature shocks, in contrast with some previous studies according to which cold and richer countries should suffer a lower cost with respect to hot and poor ones. Moreover, by analysing the Forecast Error Variance Decomposition we see that, while only climate explains the variability of real GDP growth on impact, there exists a feedback effect from economic activity to climate variables through time, suggesting that endogeneity of temperatures and precipitations does play a role. We expect our second-step estimation results to be consistent with the fact that almost all economies should be negatively affected by a global temperature shock. Furthermore, our findings will be more grounded on economic theory with respect to local projection estimates which are derived from reduced-form panel data models. Moreover, our results are obtained from a structural identified global model that takes into account the interrelations of the economies. Finally, trade is expected to mitigate the negative effects of climate change with respect to the country-specific results.

Conclusions

We study the effects of climate shocks on the real economic activity, both at country level and within a global set up. Three main conclusions emerge from this analysis. First, there is evidence that climate and economic growth are mutually influenced, suggesting the importance to account for the fully endogeneity of the system. With this respect, a relevant portion of the changes in temperature and precipitations are explained by economic activity shocks in the long run. Second, climate change plays a role both in local and global perspectives. Whereas the local aspects are usually highlighted by the literature, the focus on a global system, where climatic and economic interconnections are explicitly modeled, is a novelty. Finally, we find that the majority of countries are negatively affected in terms of economic growth when exposed to climatic shocks, especially in the long run.

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