LETTER

Temperature impact on GDP growth is overestimated

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I am writing about the PNAS article entitled "Global warming has increased global economic inequality" by Diffenbaugh and Burke (1). I believe that all of the numerical results cited in this article are wrong, because the methodology is not valid.

The abstract says this research yields "a ratio between the top and bottom deciles that is 25% larger than in a world without global warming," determined over the period 1961 to 2010. Any experienced peer reviewers should say to themselves, "This is far too big a difference to be correct—what is wrong?," since average global warming over this period is less than 1.0 °C.

Page 5 of this article states that "we repeat the primary regression calculation described in Burke et al. (14)," which relies on equation 15 from ref. 2. Importantly, this regression equation for changes in economic growth is a function only of temperature, precipitation, and time. Thus, this regression equation has no economically based independent variables that would explain most of the time dependence of economic growth over 49 y. That is the key theoretical flaw in the research, because for any regression equation relevant to explaining the changes to gross domestic product (GDP) growth over time all theoretically important economic variables that explain economic growth need to be included. This is because most of the year-to-year changes in GDP growth will be due to changes in key economic parameters such as interest rates, deficit spending, labor participation rates, private investment, technical innovation, and so on. Only the residual year-to-year changes in GDP growth might be due to changes in annual temperatures. This implies that the regression equation used for this PNAS article is useless, because it assumes that most changes in economic growth rates can be described by a quadratic function of time in addition to some dummy variables, which is clearly not true over 49 y.

The first fatal flaw in estimating equation 15 is that economic growth for all countries is assumed to be impacted by the same function of temperature, as the authors of ref. 2 acknowledge. Clearly, a small agricultural country is going to be affected by temperature changes differently than a large industrial country. Also, the authors do not realize that the temperature terms will primarily pick up the impact of single-year changes in temperature on GDP, whereas the time function will pick up the longer-term climate change impacts, as well as many other unspecified trends.

The second fatal flaw is that the value of GDP per capita for all countries was given the same weight in the panel estimation methodology, which greatly distorts the estimated coefficient of any noncountry-specific term, such as the temperature terms. Namely, small countries are weighted the same as the United States.

Of course, both of these fatal flaws in the use of the regression equation are not most relevant to the reasonableness of the research results given that the theoretical basis for the regression equation is completely wrong.

1 N. S. Diffenbaugh, M. Burke, Global warming has increased global economic inequality. *Proc. Natl. Acad. Sci. U.S.A.* **116**, 9808–9813 (2019).
2 M. Burke, S. M. Hsiang, E. Miguel, Global non-linear effect of temperature on economic production. *Nature* **527**, 235–239 (2015).

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