The Adverse Impact of Temperature on Income

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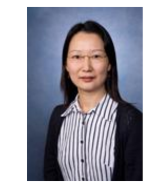

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Introduction

Most studies (e.g. Dell et al. 2008, 2009) find a negative relationship between temperature and income (GDP per capita), implying that global warming has an adverse impact on economic activities.

However, Nordhaus (2006) finds a positive relationship between temperature and income (GDP per area), suggesting that the impact of global warming may be positive.

Objective

This study was conducted to investigate whether the simple relationship between temperature and income by Nordhaus (2006) is spurious and suffers from an omitted-variables problem (Dell et al. 2008).

Methods

Model: Two possible linkages between temperature and income in literature are

1. Indirect historical effects of temperature on income through institutions (e.g. Acemoglu et al. 2002); and
2. Direct contemporaneous effects of temperature on income (e.g. Sachs 2003),

We thus consider a Cobb-Douglas type production function where the 2nd term captures effect 1, and the 3rd term captures effect 2.

$$Y_i = e^{\varepsilon_i} e^{\delta T_i} A_i(T_i) K_i^{\alpha} L_i^{\beta}$$

Y–total income (output)
ε–disturbance term
T–temperature
A–productivity which is a function of T
K–capital
L–labor
α–output elasticity of capital
β–output elasticity of labor
α, β < 1

Let $K_i = v_i L_i$ where v_i is capital-labor ratio, $L_i = o_i P_i$ where o_i represents employment-population ratio:

$$Y_i = v_i^{\alpha} o_i^{\alpha+\beta} e^{\varepsilon_i} e^{\delta T_i} A_i(T_i) P_i^{\alpha+\beta}$$

We measure income by output per person, or output per area (P is population and S is area):

$$\frac{Y_i}{P_i} = v_i^{\alpha} o_i^{\alpha+\beta} e^{\varepsilon_i} e^{\delta T_i} A_i(T_i) P_i^{\alpha+\beta-1}$$

$$\frac{Y_i}{S_i} = v_i^{\alpha} o_i^{\alpha+\beta} e^{\varepsilon_i} e^{\delta T_i} A_i(T_i) P_i^{\alpha+\beta} S_i^{-1}$$

Take log on both sides of each equation, and use country dummy variables d_i as proxies for $\log(v_i^{\alpha} o_i^{\alpha+\beta} A_i(T_i))$:

$$\log(\frac{Y_i}{P_i}) = \phi d_i + (\alpha+\beta-1)\log(P_i) + \delta T_i + \varepsilon_i$$

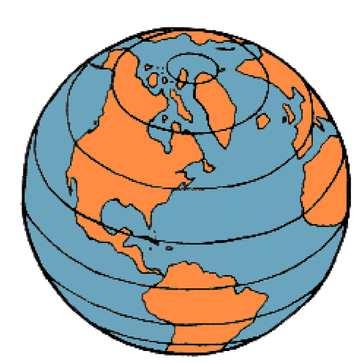
$$\log(\frac{Y_i}{S_i}) = \phi d_i + (\alpha+\beta)\log(P_i) - \log(S_i) + \delta T_i + \varepsilon_i$$

To model potential **nonlinear** effects of temperature on income empirically, we adopt a cubic polynomial in temperature (e.g. Nordhaus 2006):

$$\log(\frac{Y_i}{P_i}) = \varphi d_i + a_1 T_i + a_2 T_i^2 + a_3 T_i^3 + b\log(P_i) + e_i$$

$$\log(\frac{Y_i}{S_i}) = \tilde{\varphi} d_i + \tilde{a}_1 T_i + \tilde{a}_2 T_i^2 + \tilde{a}_3 T_i^3 + \tilde{b}\log(P_i) + \tilde{c}\log(S_i) + e_i$$

Data: a geophysically-scaled economic data set (**G-Econ**) developed by Nordhaus (2006), which estimate gross output at a 1-degree longitude by 1-degree latitude resolution at a global scale and allow a cell-level analysis.



Results

Table 1. Temperature-income relation when population (P) and area (S) are omitted

Panel A: $\log(\frac{Y_i}{P_i}) = \varphi d_i + a_1 T_i + a_2 T_i^2 + a_3 T_i^3 + e_i$

	T	T^2	T^3	R^2
Coefficient	**-0.02846**	-0.00035	0.00003	0.9031
t-statistics	-29.27	-9.47	16.79	
p-value	0.0000	0.0000	0.0000	

Panel B: $\log(\frac{Y_i}{S_i}) = \tilde{\varphi} d_i + \tilde{a}_1 T_i + \tilde{a}_2 T_i^2 + \tilde{a}_3 T_i^3 + e_i$

	T	T^2	T^3	R^2
Coefficient	**0.34514**	-0.00244	-0.00030	0.7365
t-statistics	91.31	-16.66	-35.84	
p-value	0.0000	0.0000	0.0000	

If income is measured by $\frac{Y_i}{P_i}$, a_1 is negative—global warming has an **adverse** impact on economic activities.

If income is measured by $\frac{Y_i}{S_i}$, $\tilde{a}_1$ is positive—global warming has a **positive** impact on economic activities.

Table 2. Temperature-income relation when population (P) and area (S) are included

Panel A: $\log(\frac{Y_i}{P_i}) = \varphi d_i + a_1 T_i + a_2 T_i^2 + a_3 T_i^3 + b\log(P_i) + e_i$

	T	T^2	T^3	*Log(P)*	*Log(S)*	R^2
Coefficient	**-0.02652**	-0.00037	0.00004	-0.00049		0.9031
t-statistics	-21.62	-9.77	15.50	-2.59		
p-value	0.0000	0.0000	0.0000	0.0096		

Panel B: $\log(\frac{Y_i}{S_i}) = \tilde{\varphi} d_i + \tilde{a}_1 T_i + \tilde{a}_2 T_i^2 + \tilde{a}_3 T_i^3 + \tilde{b}\log(P_i) + \tilde{c}\log(S_i) + e_i$

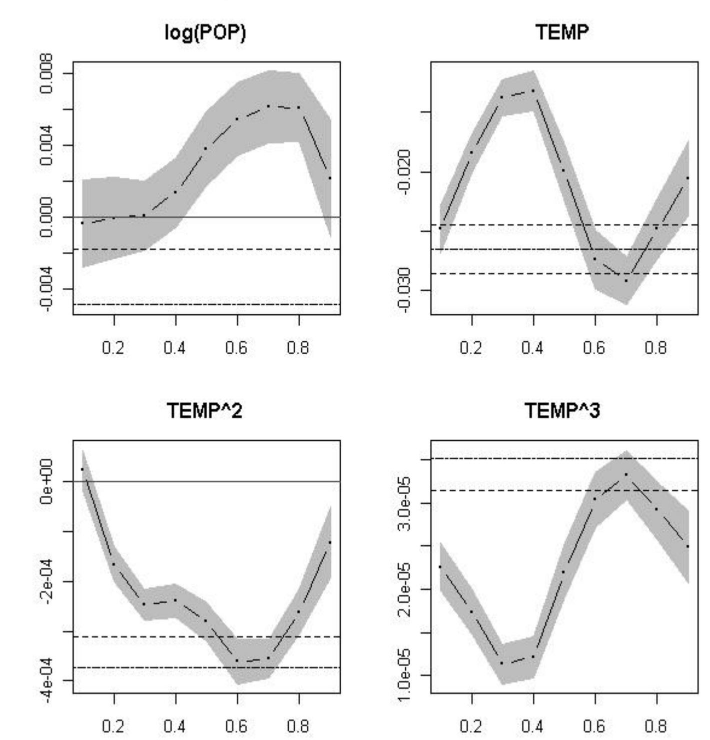
	T	T^2	T^3	*Log(P)*	*Log(S)*	R^2
Coefficient	**-0.02737**	-0.00038	0.00004	0.99787	-1.00992	0.9826
t-statistics	-21.40	-9.89	15.65	450.40	-237.86	
p-value	0.0000	0.0000	0.0000	0.0000		

If income is measured by $\frac{Y_i}{P_i}$, a_1 is **positive**.

If income is measured by $\frac{Y_i}{S_i}$, $\tilde{a}_1$ is **positive**.

Figure 1: Regression quantile coefficients of the temperature-income relation

$$\log(\frac{Y_i}{P_i}) = \varphi d_i + a_1 T_i + a_2 T_i^2 + a_3 T_i^3 + b\log(P_i) + e_i$$



a_1 is -0.03 for τ = 0.7, so the estimated impact of **a 1.0° C Celsius increase in temperature** is **3% decrease in GCP per capita** for the grid areas that are at the upper 0.3 quantile of the income distribution.

Conclusions

We show in this study that the results of Nordhaus (2006) is due to an omitted-variables problem.

The adverse impact of a 1.0° C increase in temperature (due to global warming) can be as much as a 3% decrease in income for developed nations.

Literature cited

Acemoglu, D., Johnson, S., Robinson, J., 2001. The colonial origins of comparative development: an empirical investigation. American Economic Review. 91, 1369-1401.

Dell, M., Jones, B., Olken, B., 2008. Climate change and economic growth over the last half century. NBER Working Paper No. 14132.

Nordhaus, W., 2006. Geography and macroeconomics: new data and findings. Proceedings of the National Academy of Science. 103, 3510-3517.

For further information

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