The Adverse Impact of Temperature on Income

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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:

\[ Y = \alpha \prod_{i=1}^{C} A_i(T) \prod_{i=1}^{C} K_i \prod_{i=1}^{L} L_i \]

where \( Y \) is capital-labor ratio, \( L = \alpha P \) where \( \alpha \) represents employment-population ratio:

\[ Y = \alpha \prod_{i=1}^{C} A_i(T) \prod_{i=1}^{C} K_i \prod_{i=1}^{L} L_i \]

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

\[ \frac{Y}{S} = \alpha \prod_{i=1}^{C} A_i(T) \prod_{i=1}^{C} K_i \prod_{i=1}^{L} L_i \]

Take log on both sides of each equation, and use country dummy variables \( d_i \) as proxies for log income:

\[ \log \frac{Y}{S} = \log(\alpha) + \log(\prod_{i=1}^{C} A_i(T)) + \log(\prod_{i=1}^{C} K_i) + \log(\prod_{i=1}^{L} L_i) + d_i + \epsilon_i \]

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

\[ \log \frac{Y}{S} = \alpha \prod_{i=1}^{C} A_i(T) \prod_{i=1}^{C} K_i \prod_{i=1}^{L} L_i + \log(\prod_{i=1}^{C} A_i(T)) + \log(\prod_{i=1}^{C} K_i) + \log(\prod_{i=1}^{L} L_i) + d_i + \beta T + \gamma T^2 + \delta T^3 + \epsilon_i \]

Data: a geophysically-scaled economic data set (G-Econ) developed by Nordhaus (2006), which estimate gross output at a 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

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Panel A</th>
<th>Panel B</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta )</td>
<td>-0.00050</td>
<td>-0.00045</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>0.99950</td>
<td>0.99945</td>
</tr>
<tr>
<td>( \delta )</td>
<td>-0.00005</td>
<td>-0.000045</td>
</tr>
<tr>
<td>( \epsilon )</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
</tbody>
</table>

Panel A: \( \log \frac{Y}{S} = \alpha \prod_{i=1}^{C} A_i(T) \prod_{i=1}^{C} K_i \prod_{i=1}^{L} L_i + \log(\prod_{i=1}^{C} A_i(T)) + \log(\prod_{i=1}^{C} K_i) + \log(\prod_{i=1}^{L} L_i) + d_i + \beta T + \epsilon_i \)

If income is measured by \( \beta \), \( \gamma \), \( \delta \), \( \epsilon \) are omitted.

Panel B: \( \log \frac{Y}{S} = \alpha \prod_{i=1}^{C} A_i(T) \prod_{i=1}^{C} K_i \prod_{i=1}^{L} L_i + \log(\prod_{i=1}^{C} A_i(T)) + \log(\prod_{i=1}^{C} K_i) + \log(\prod_{i=1}^{L} L_i) + d_i + \beta T + \gamma T^2 + \delta T^3 + \epsilon_i \)

If income is measured by \( \beta \), \( \gamma \), \( \delta \), \( \epsilon \) are omitted.

Conclusions
We show in this study that the results of Nordhaus (2006) is spurious and suffers from an omitted-variables problem. The adverse impact of a 1°C increase in temperature (due to global warming) can be as much as a 3% decrease in income for developed nations.

Literature cited

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