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Research Brief

The Global Economic Impacts of Climate Change

Background

Time is ticking away for the world to reduce greenhouse gas emissions and avoid a global average temperature increase above 2 degrees Celsius. Mitigation and adaptation are two pillars of global efforts to alter the current course and address the effects of climate change, and they will be front and center when the international community meets in Paris in December 2015 to negotiate an international climate treaty. A large gap in mitigation efforts remains to meet the 2 degree target, so the idea of adaptation to build resilience into our social and economic systems has gained traction.

At a micro- or local-level, climate impacts and the economic costs associated with them are already evident. Rising sea levels, increased risk of sudden and severe flooding, drought and threats to the electric grid are among these impacts. Severe weather events have increased in frequency and intensity with climate change, with associated costs tripling to nearly \$50 billion annually in recent years. Losses associated with declining food and agricultural production, property and

About the Researcher

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facilities destruction, and infrastructure damage are well documented. Many programs and efforts exist to adapt to these challenges including through the United Nations Framework Convention on Climate Change (UNFCCC's) National Adaptation Plans (NAPs) which includes assistance with financing, technology and capacity-building – particularly for the poorest countries.

While micro-level impacts such as declining crop yields are well documented, the effects of temperature



Photo Credit: Adobe Stock

on complex human societies and overall economic productivity remain poorly understood. The research on which this brief is based provides the first evidence that the entire global economy is linked to global climate change at a macro scale. It examines how deviations from economic growth trends are related to temperature trends at a country-specific level and provide insights into the comparative impact of growth trends between wealthy and poor countries. The brief further provides important data on the recent history of climate adaptation, showing that – contrary to common perception – wealth has not facilitated countries' abilities to adapt.

Key Research Findings – Temperature and Economic Productivity

Beyond a certain optimal temperature of 13 degrees Celsius (approximately 55 degrees Fahrenheit), country-level economic production responds negatively to increasing temperature. However, the response is non-linear – the magnitude of change in economic output is not equal for each degree of temperature rise. For example, economic losses resulting from a temperature change from 15 to 16 degrees are less severe than the response from 25 to 26 degrees.

Colder countries, mainly northern European countries,

increase their productivity as annual temperature increases, until a turning point beyond which productivity declines gradually with further warming and becomes more rapid at higher temperatures, as noted above. Unmitigated climate change and higher temperatures are expected to have further negative impacts on countries at all income levels, including:

- Seventy-seven percent of countries will be poorer in per capita terms by 2100 than they would be without climate change;
- Significant negative effects in all cases for poor countries and significant or marginally significant effects for rich countries.

Key Research Findings – Adaptation: Wealthy versus Poorer Countries

While much of global economic production currently occurs in parts of the world where temperatures are optimal, both rich and poor countries exhibit similar responses to temperature. Poor tropical countries exhibit larger responses mainly because they are hotter on average, and thus closer to the temperature threshold, not because they are poorer. Evidence from previous studies suggests that rich countries might be

Change in GDP per capita by country by 2100 compared to a world without climate change.

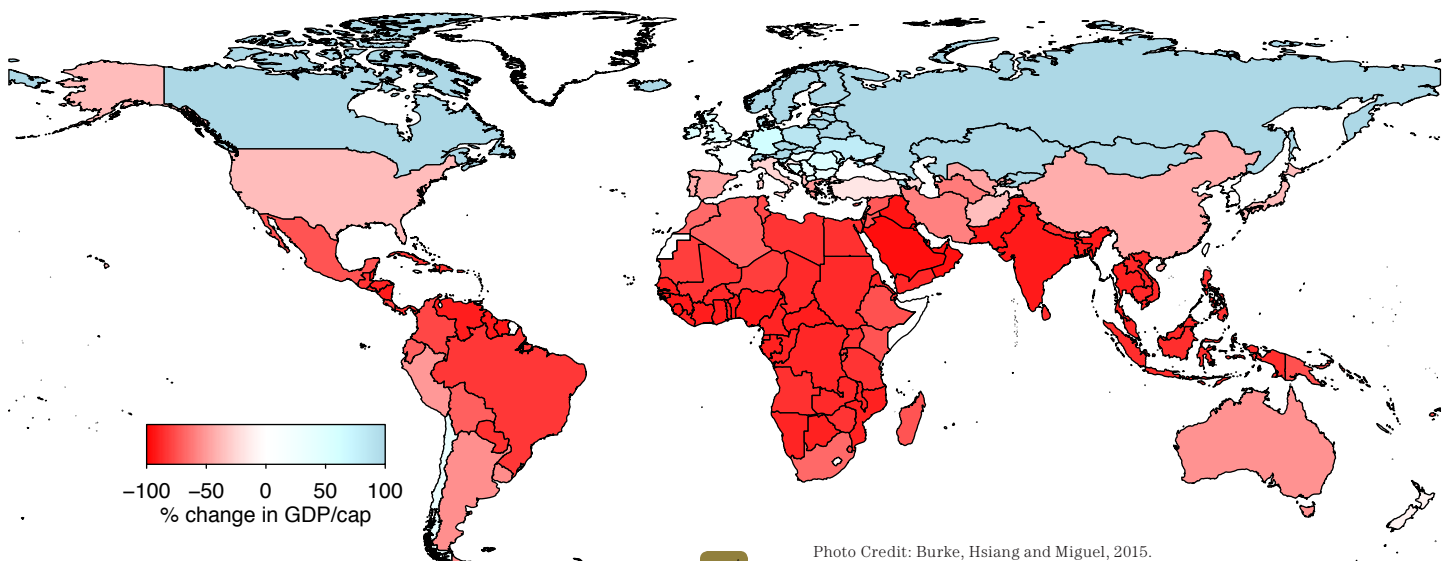


Photo Credit: Burke, Hsiang and Miguel, 2015.

somewhat less affected by temperature, but our research shows that their response to temperature increase is indistinguishable from that of poor countries, and we estimate 80 percent likelihood that warming will negatively affect these countries.

Most concerning is the lack of evidence that wealth has helped countries adapt to climate change. Our research shows that:

- Technological advances or the accumulation of wealth and experience since 1960 has not fundamentally changed the relationship between productivity and temperature;
- Substantial observed warming over the period 1960-2010 does not appear to induce notable adaptation efforts.

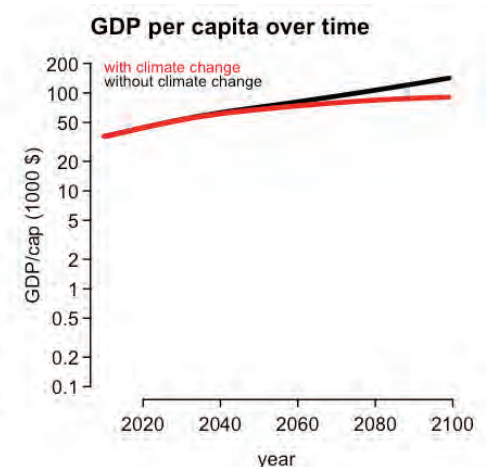
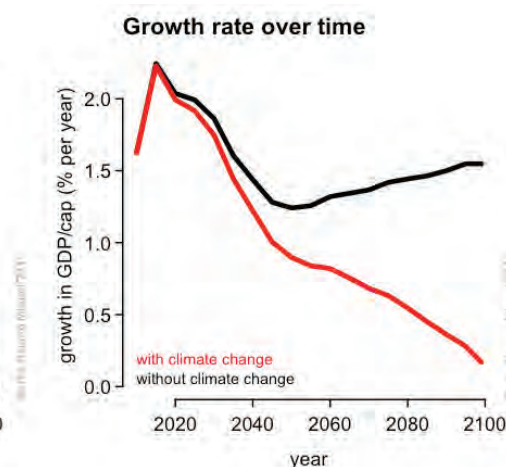
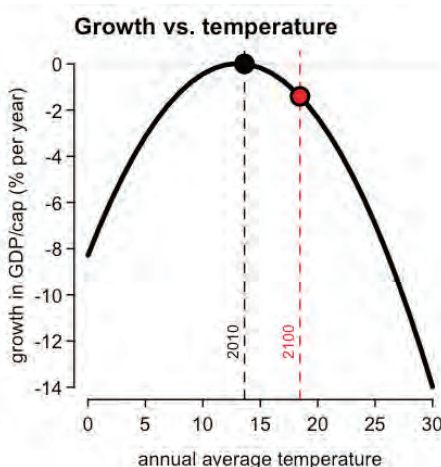
Key Points for Policy-makers

Only weak evidence exists to support the notion that richer populations are less vulnerable to warming. Of far greater concern, no evidence exists to show that experience with high temperatures nor with technological advances over the last half century altered the global impact of temperature. This suggests that adaptation to

climatic change may be more difficult and costly than previously believed and that the accumulation of wealth, technology, and experience might not substantially mitigate global economic losses over a reasonable time horizon.

In contrast to prior estimates, global losses are expected to correspond negatively with global average temperature increases, specifically:

- If future adaptation mimics that of the past, unmitigated warming will reshape the global economy by reducing average global incomes roughly 25 percent by 2100 and widening global income inequality compared to a future world without climate change;
- Climate change reduces projected global economic output by 23 percent in 2100 relative to a world without climate change;
- The poorest 40 percent of countries are expected to have average incomes more than 75 percent lower by 2100 relative to a world without climate change, while the richest 20 percent of countries experience slight gains, since they are generally cooler. This trend is expected to increase global economic inequality.



Expected global temperature increase and change in annual United States GDP growth rate by 2100.

Photo Credit: Burke, Hsiang and Miguel, 2015

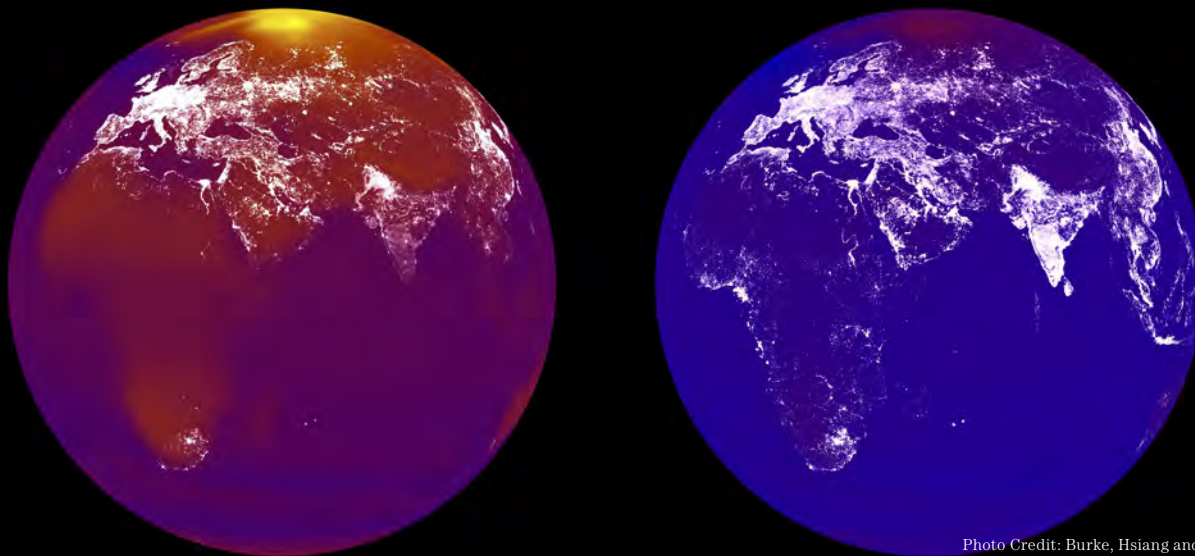


Photo Credit: Burke, Hsiang and Miguel, 2015

Two possible futures. Colors are 2100 temperatures under “business as usual” climate change (left) and aggressive climate policy (right). This image shows a simulation of future nightlights, as seen from space, since richer economies tend to glow brighter. A hotter world is a more unequal world, with the north benefitting and tropical economies declining. A cooler world leads to more equitable global growth, offering regions like Africa the chance to “catch up”

Conclusions

Accounting for the global effect of temperature is crucial to constructing income projections under climate change because countries are expected to become both warmer and richer in the future. In contrast to prior work in this area, our research assumes that productivity declines more rapidly at higher temperatures – not at a one-to-one correlation – and we find that rich and poor countries behave similarly at similar temperatures, offering little evidence of adaptation. This implies that we cannot expect rich countries to be unaffected by future warming, nor can we expect the impacts of future warming to decrease over time as countries become wealthier. Rather, the impact of additional warming is expected to worsen over time as each country becomes warmer on average.

If societies continue to function as they have in the recent past, climate change will likely reshape the global economy by substantially reducing global economic output and possibly amplifying existing global economic inequalities, relative to a world without climate change. Although it is possible that adaptation through unprecedented innovation and deployment of new technologies, defensive investments, and risk sharing mechanisms could minimize the human consequences

of these effects, adaptation through unanticipated migration, social conflict, and reduced opportunities for international trade – either through political restrictions or correlated loss of productivity around the world – could potentially exacerbate them.

This research brief is based on a paper from the journal *Nature*, published on-line on October 21, 2015, entitled “Global non-linear effect of temperature on economic production.” The paper, led by Stanford University’s Marshall Burke, provides the first evidence that economic activity in all regions is coupled to the global climate and establishes a new empirical foundation for modelling economic loss in response to climate change.

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