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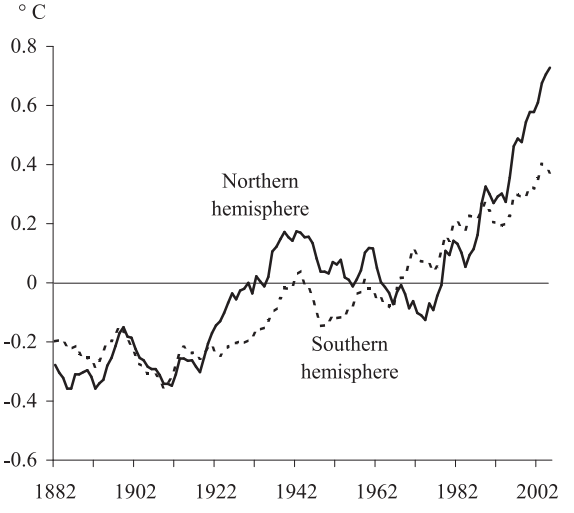
Regional Variation in the Potential Economic Effects of Climate Change

Extensive scientific evidence suggests that the worldwide climate has been warming in recent decades and is likely to continue doing so (IPCC 2007). The possible contribution of human activity has produced considerable debate about appropriate responses by governments, businesses, and individuals to "mitigate" (limit) the extent of global warming by reducing greenhouse gas emissions, a primary source of which is fossil fuels. A key element in this debate is the magnitude of the net economic costs associated with potential climate change.

One area of considerable uncertainty in regard to the economic effects of climate change is the likely differential impact of global warming across geographic regions. In this *Economic Letter,* we provide a partial overview of recent research that examines such geographic variation in the economic impact of climate warming in North America. Not surprisingly, this research suggests that the adverse effects will be greatest in locations where the existing climate is warm, although some regions and sectors may benefit from a warmer climate.

Figure 1
Temperature deviations, 1882–2005
(relative to 1951–1980 mean; 5-year average values)



Source: NASA/Goddard Institute for Space Studies, http://data.giss.nasa.gov/gistemp/graphs/

Climate change

The scientific evidence regarding climate change that is discussed in the fourth report of the Intergovernmental Panel on Climate Change (IPCC 2007) highlights increases in worldwide surface air and ocean temperatures over recent decades. This can be seen in Figure 1, which shows an increase in surface air temperatures beginning around 1970, particularly in the northern hemisphere. Many scientists expect this trend to continue: the IPCC predicts that global surface air temperatures will increase by 1.1 to 6.4°C (2.0 to 11.5°F) between the years 1990 and 2100, accompanied by various changes in precipitation patterns as well. The wide range of projected temperature increases corresponds to alternative scenarios for future greenhouse gas emissions. This potentially high responsiveness of climate change to emissions forms the basis for policy interventions aimed at reducing emissions, but the substantial uncertainty surrounding their exact relationship makes such decisions challenging.

Additional complexity is introduced by geographic variation in the precise temperature and precipitation effects of climate change. At this point, scientists' understanding of such geographic variation largely is restricted to the continental and hemispheric levels. However, as discussed in the next section, there is substantial subcontinental variation in the potential impact of climate change, largely due to differences in the existing climate.

Geographic variation in climate change effects

Substantial differences in climate are evident at the subcontinental level throughout most of the world. For example, within the 48 contiguous U.S. states, the daily continental high and low temperatures can differ by over 38°C (100°F). One of the key bases for variation in the potential impact of climate change across geographic areas is the starting point from which climate change occurs: climate warming may have little or no impact within a range of temperatures, but the impacts may grow rapidly as temperatures rise above that range. This nonlinear or "threshold" pattern implies that climate change effects will be most pronounced for areas that are already near critical temperature boundaries. This principle is best illustrated by some examples from recent research on the potential economic effects of climate change.

The agricultural sector is a resource-intensive industry that is likely to be directly affected by rising temperatures and hence is among the earliest and most extensively studied sectors in regard to the potential economic impacts of climate change. Deschênes and Greenstone (2007a) assessed the possible impact of warming on the U.S. agricultural industry by examining the short-run relationship at the county level between random variation in weather conditions and agricultural profits. Their findings suggest that warming will have a very limited net impact on the U.S. agricultural sector, leaving aggregate profits largely unchanged. However, this aggregate finding masks substantial variation at the state level; to illustrate the range of effects, they report statistically significant estimates of a near doubling of profits in South Dakota and South Carolina and reductions on the order of 40–45% in Nebraska and North Carolina.

Schlenker and Roberts (2008) drill down further into the relationship between temperatures and growing conditions, identifying a nonlinear effect whereby crop yields decline rapidly as temperatures rise above estimated critical thresholds but increase little as temperatures drop below those thresholds. Their results imply that U.S. yields on corn, soybeans, and cotton are likely to decline by about 30–80% if the projected extent of warming occurs, with larger declines in yields expected in warmer (mostly southern) states than in cooler states.

Another potential source of economic costs due to climate change is through adverse impacts on human health and mortality. The most direct channel for such effects is an increased incidence of heat waves; research suggests that the elevated mortality rates associated with extreme heat events reflect a meaningful impact on human health rather than a minor shift in the timing of mortality. Evidence presented in Deschênes and Greenstone (2007b) suggests a small and statistically insignificant overall impact of warming on U.S. mortality rates, with a partial offset to elevated mortality arising from increased reliance on air conditioning. This small aggregate effect once again masks substantial cross-state variation: states with existing hot climates, such as Arizona and California, may see noticeable increases in mortality with climate warming (data limitations imply that these findings are based on moderate rather than high levels of statistical confidence).

An extreme case: winter sports

The discussion so far suggests that though the potential aggregate impacts of climate change may be small, they also may mask substantial underlying geographic variation, with some regions gaining and some losing. This is unsurprising for studies of the agricultural sector: warming and changes in precipitation have potentially ambiguous effects on growing conditions for different crops in different parts of the country. Moreover, existing estimates are mostly based on short-term industry responses to variation in weather, which may overstate the impact of climate change by ignoring the possibility of longer-term shifts in production techniques and resource use (e.g., crop shifting).

The effects of warming are likely to be clearer in the winter sports industry. Decreased snowfall and increased rainfall during the winter months—a trend in evidence in western North America since the middle of the 20th century—lower the quality of conditions for skiing and snowboarding (with the rare exception of ski resorts where conditions often are too cold for comfortable enjoyment of the slopes). Indeed, this industry is subject to an especially strong threshold effect of climate warming: as temperatures rise above 0°C, snow abruptly changes to rain, reducing the extent of slope coverage and the quality of existing snow. Moreover, whereas agricultural land has extensive alternative uses, alternative uses of ski resorts are limited and already largely embodied in existing warm weather activities, such as downhill mountain biking that relies on ski lifts to carry riders up the mountain. While the season for these activities may be extended as a consequence of foreshortened winters and longer summers, the benefits are likely to be small relative to the costs of unfavorable conditions throughout the winter sports season. As such, the winter sports industry is likely to experience significant net losses in consumer welfare and asset values if the climate warms (assuming that people's relative tastes for winter sports activities do not change).

Butsic, Hanak, and Valletta (2008) assess the impact of projected warming on ski resorts in western North America. Existing literature indicates that house prices reflect the demand for local land, and as such they are likely to represent a better metric for assessing the impact of long-term climate changes than do direct yet short-term measures of industry performance such as resort ticket sales (which in any case are difficult to obtain). They use "snowfall intensity" (the share of snowfall in winter precipitation) as their primary measure of climate conditions that are relevant for the ski industry. Using two sources of home price data, the statistical analyses uncover precise and consistent estimates of price reductions during years preceded by multiple ski seasons with low snowfall intensity. They then use daily weather observations to simulate snowfall intensity in the future under alternative global warming scenarios. With warming of 2°C, which is well within the range of scientific projections for this region, the implied

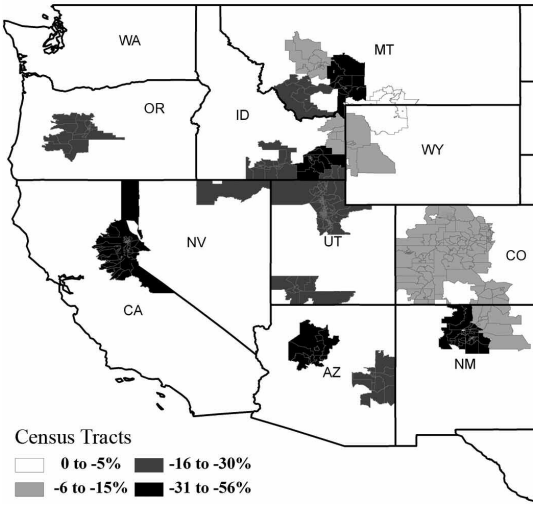
reduction in the value of homes near ski resorts is large, averaging 24% for a broad sample of census tracts in the western United States.

They also find substantial geographic variation in the impact of potential warming on resort-area house prices, as illustrated by the map of their in-sample census tracts in Figure 2. The map shows predicted price declines, expressed in ranges, based on the 2°C warming scenario. Areas where temperatures often are close to the 0°C threshold (due to climatic characteristics such as longitude, elevation, and proximity to the Pacific Ocean) are likely to see as much as a 56% reduction in home values due to warming. By contrast, resorts that are more favorably located, such as those in Colorado, will see little change in housing values. Indeed, they also uncover evidence suggesting that house prices in selected locations increase as the count of days with very cold weather declines, suggesting that resorts in very cold locations may benefit from warming. This possibility is further increased by the likelihood that existing demand for skiing and nearby real estate will shift away from warmer areas and towards colder areas as the worldwide climate warms.

Conclusion

The research discussed here suggests that the potential economic impact of climate change will vary in important ways at the subcontinental level. In the United States, it is possible that some states will see significant net economic benefits from warming, while others may see substantial losses. For winter sports activities such as skiing, there appears to be less ambiguity, although, even for this industry, some locations may see benefits through shifts towards warm-weather activities, reductions in the incidence of weather that is too cold for comfortable enjoyment of the slopes, and shifts in existing demand to areas where conditions remain favorable. The geographic variability discussed here suggests the need for state and local policies in some areas, rather than purely national policies, to prepare for the potential effects of climate change. Moreover, looking beyond U.S. borders, these economic effects are likely to be more challenging for less advanced economies in Africa and Asia, due to their heavier reliance on resource-based economic activity (especially agriculture), more limited economic infrastructure, and lower incomes, all of which intensify the severity of the economic tradeoffs involved (Dell, Jones, and Olken 2008).

Figure 2
Percent decline in housing values, 2°C increase in temperature



Van Butsic
Graduate Student, Forest & Wildlife Ecology
University of Wisconsin

Ellen Hanak
Associate Director
Public Policy Institute of California

Rob Valletta
Research Advisor
FRBSF

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ECONOMIC RESEARCH
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OF SAN FRANCISCO

P.O. Box 7702
San Francisco, CA 94120

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