NICK STOCKTON | SCIENCE 10.21.15 1:00 PM

CLIMATE CHANGE IS GOING TO BE EXPENSIVE—FOR EVERYBODY

A farmer examines his wheat field which failed due to drought in Rochester, Australia. JASON SOUTH/GETTY IMAGES

HOT WEATHER SUCKS. Crops droop. Work slows down. People get testy. And it's bad for business.

So bad, in fact, that higher temperatures from climate change are going to be an economic gut punch for many countries, according to a paper published today in *Nature*. The poorest countries—most of which are also already pretty warm—will suffer the most. But even rich countries with their cubicles and air conditioning are going to feel the burn.

Climate change will hit every level of an economy. Mentally and physically people work worse when they are hot. Rising seas and fiercer storms chew up infrastructure. And agricultural effects like crop failures reach far beyond borders. But all that stuff is years away, right?

Wrong. As deniers like to say (maybe even in the comments!), climate is always changing. And it turns out that these changes show up in the economic record. The new study compared annual temperature to annual GDP for every country. "What we found is that temperature has played an important role in shaping GDP output in the last 50 years," says Marshall Burke, economist at Stanford University and co-author of the study.

Of course, the relationship between temperature and GDP isn't linear. The study found that economic growth has a sweet spot: Around 55˚F. If the average annual temperature falls above or below that, GDP starts to taper off—slow at first, then very fast. "The graph looks like a strong inverted U," says Edward Miguel, economist at UC Berkeley and another co-author of the study. At either end, the GDP remains fairly stable between 32 and 77 degrees F, but drops rapidly beyond those boundaries.

This means that how poorly your country fares under climate change depends on its starting average temperature. "At colder temperatures, say Northern Europe, these countries grew a little bit faster when

temperatures were warmer," says Burke. By comparison, much of the developing world is already pretty warm, so its prospects are pretty grim.

But wait, is Northern Europe going to get richer because it gets warmer, or because it's already rich? "This is one thing we tried to be really careful with," says Burke. In their statistical analyses, he and his co-authors controlled for things like preexisting wealth. Temperature is only one variable affecting GDP. "Culture matters, institutions matter, policy choices matter," says Burke. "What we do find is looking historically, temperature matters a lot." Which is important if the future world responds to temperature changes like the past world has.

And not all rich countries are going to get richer. Part two of the study takes historical correlations between temperature and GDP and projects them forward under different climate models. In them, the economic wealth of countries like the US or China can't compensate for their latitudinal girth. Both fare poorly in the "business as usual" emissions scenario explored in the study. "There will still be a number of days where Alabama or Texas are really hot, even if all of the US is still kind of cold," says Miguel. And over the course of the year, as the years go on, the overall area of the US experiencing extremely hot days will increase. GDP suffers accordingly.

Previous attempts to put climate change in terms of GDP have tripped over the jump from micro to macro. For example, how do a heat-struck worker in Arizona and a failed soy crop in Kansas and a stronger-than-

average hurricane in Louisiana influence economic performance at a national level? In trying to add up all those microeconomic effects, studies can under- or overstate an inputs importance, or leave it out completely.

This paper skips past all that, and simply looks at average temperature and GDP. “This is a very significant study,” says Jonathan Harris, economist from Tufts University. “It’s based on real data from 1960 to 2010, not just hypothetical projections.”

Their verdict on how climate change will affect the global economy? “Overall economic production would fall by about 23 percent by 2100 if climate keeps changing under the current models,” says Miguel. That is a huge pile of money that never gets made; the deficit shared between countries both rich and poor.

Some argue that the first world will buffer itself against climate change with technological innovations—air conditioning is credited with saving the American South’s economy, and agricultural companies are already breeding heat resistant crops. But historically—and based on this analysis—that hasn’t been and won’t be true. “If you look back to the 1960s to now, any subset of time between now and then shows a consistent pattern of temperature correlating to GDP,” says Matthias Ruth, economist at Northeastern University. Which means that so far, innovation hasn’t done squat. “And as climate continues to change, keeping pace becomes more difficult, and we will fall ever more behind,” says Ruth.

This study put an even greater burden curbing international emissions. The world still has time to build a less dire future: The upcoming Paris emissions talks seem like the best time and place for a global wheel yank. But right now, the science is looking pretty dismal.

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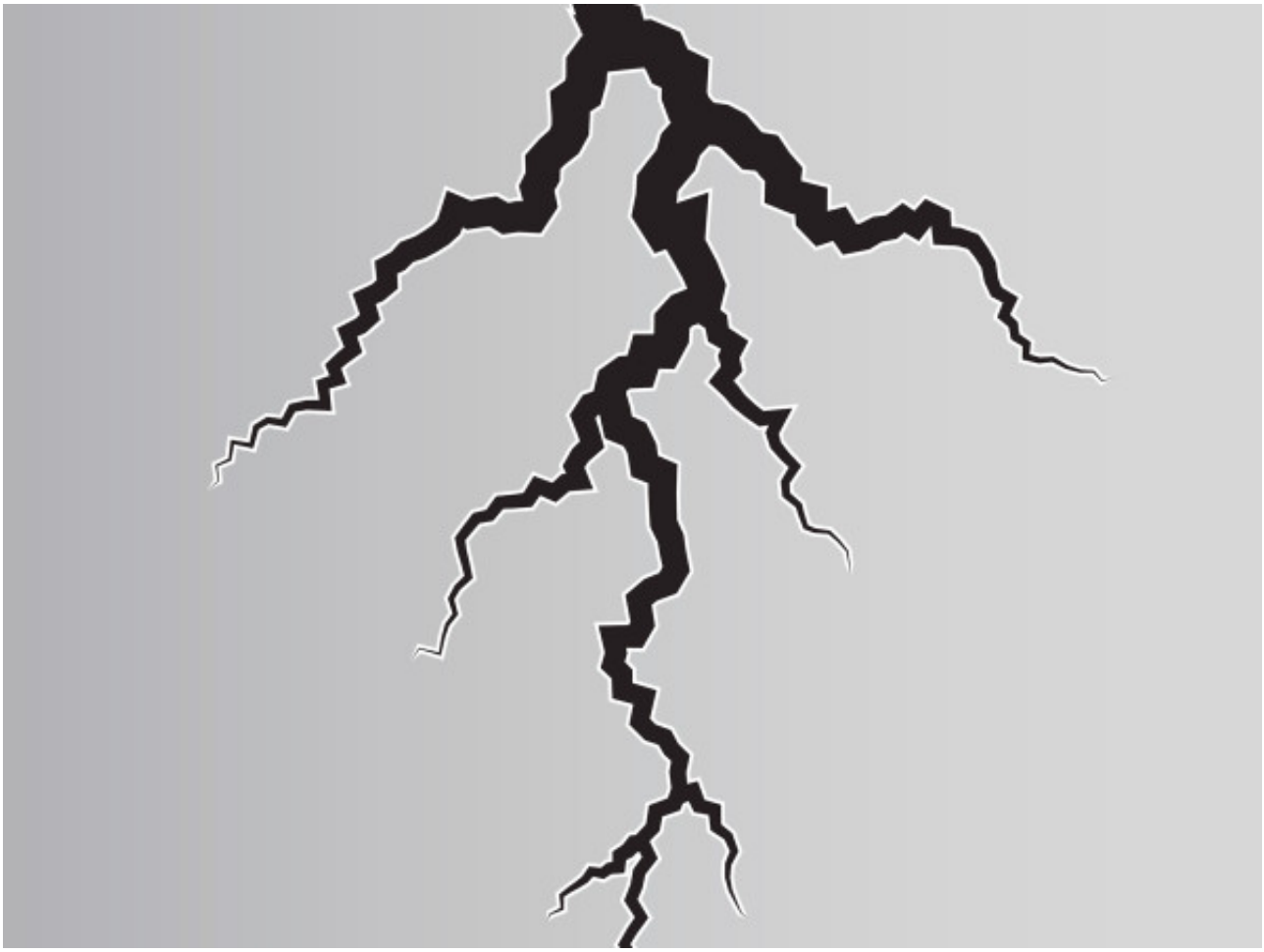

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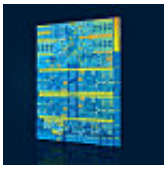

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