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Putting Goldilocks to work

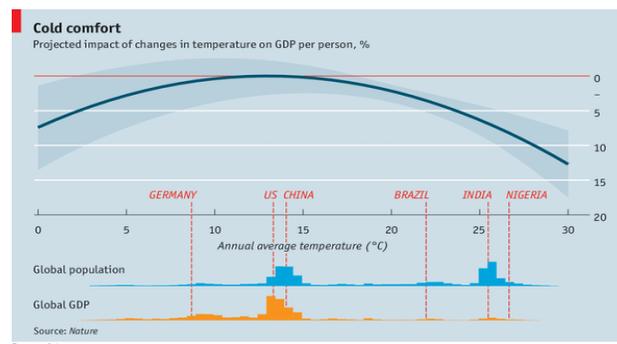
A new study shows that climate change is likely to sap productivity in the rich world

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“ALWAYS pack a sweater,” one local businessman advises visitors to Singapore, “because the best thing about our weather is the air conditioning.” Singapore’s first prime minister, Lee Kuan Yew, would have agreed—he considered the air conditioner the greatest invention of the 20th century. Another Singaporean politician once remarked that if it had not been for artificial cooling, local workers would be “sitting under coconut trees” rather than labouring away in high-tech factories.

Singapore is rich enough to keep its indoor spaces cool. Neighbouring Indonesia is not. Economists used to think that rich countries’ greater cooling power would enable them to limit the damage to their economies from the higher temperatures brought by global warming. A [cross-country comparison](http://scholar.harvard.edu/files/dell/files/aej_temperature.pdf) published in 2012 found that higher temperatures did not seem to sap growth in rich countries, but did in poor ones. It is hard to compare the impact of temperature on growth in hot and cold countries directly, since there are too many variables to control for. Instead, the study compared growth in a given country during hot years with that during colder ones. It found that in poor countries, on average, higher temperatures were associated with slower growth. But some rich countries grew faster in hot years, and some in cold ones, suggesting that there was no clear correlation between temperature and growth in the developed world.

A [paper](http://www.nature.com/nature/journal/vaop/ncurrent/full/nature15725.html) published this week in *Nature* challenges this finding. The authors—Marshall Burke, Solomon Hsiang and Edward Miguel—suspected that economists had been looking for the wrong thing: a linear relationship between temperature and growth. Instead, they looked for an optimal



temperature, on the assumption that excessive cold could harm growth as much as punishing heat. That is exactly what they found: hotter-than-usual years benefit countries, rich and poor alike, up to an average annual temperature of 13°C, after which hotter weather begins to sear growth. That allowed them to draw inferences about the likely effect of climate change: for Brazil, for example, an increase in temperature of 3°C will lead to a fall in output of 3% (see chart).

The apparent heat resistance of rich countries, it turns out, is simply because some of them, such as Germany and France, lie on the colder side of the optimum, so grow faster in hotter years, whereas others, such as America and Australia, lie on the hotter side, and so wilt as temperatures rise. Within individual countries in America, for instance, every hot day (with an average temperature over 24 hours of 24-27°C) lowers the average income per person that day by 20%, according to a [working paper](http://www.nber.org/papers/w20750) (<http://www.nber.org/papers/w20750>) from the National Bureau of Economic Research by Mr Hsiang and Tatyana Deryugina. Very hot days (over 30°C) lower income per person by 28%. Looking at the average impact of rising temperatures in rich countries as a group had obscured such strong responses.

Ironically, the fact that global temperatures are changing has prompted some economists to question these results, since it means there is no firm baseline for comparison. But there is plenty of evidence for an optimal temperature at the micro level. Crops, for example, flourish when it is neither too hot nor too cold. Workers, too, do better in mild settings. The British navy commissioned the first research on temperature and productivity in the 1940s. In one experiment, Morse-code operators were placed in rooms of varying temperature. Those in rooms heated to 40°C made more than ten times more errors than those in rooms that were 30°C.

In a similar vein, a [paper](http://www.jstor.org/stable/10.1086/671766) (<http://www.jstor.org/stable/10.1086/671766>) published in the *Journal of Labour Economics* last year found that American workers in construction, manufacturing and transport knocked off earlier when the temperature rose above 29°C, working an hour less per day on average. As the incidence of hot days increases, either more workers will be needed to finish the same project, or workers will need to be paid more to persuade them to stay on, just as workers are paid extra for the inconvenience of night shifts. Industries in which workers are exposed to the weather employ 28% of America's workforce, according to a recent [study](http://climateprospectus.org/) (<http://climateprospectus.org/>) looking at how climate change will affect America's economy.

Cool but costly

Countries can try to mitigate the effects of warming, but cooling things down is expensive. In Singapore, air conditioning consumes 40% of the power used in buildings. If nothing is done to

stop global warming, the world will see an 83% increase in electricity consumption between 2010 and 2100, due simply to greater use of air conditioning, fans and refrigeration, according to a [paper](http://www.pnas.org/content/112/19/5962.abstract) published in the journal *PNAS* in March by Lucas Davis and Paul Gertler. Richard Tol of the University of Sussex points out that homes and offices in cold countries are built to conserve heat, with large south-facing windows. Refurbishing such buildings could help keep people cool, but at great cost.

There are many other ways, of course, that global warming will harm rich countries besides falling productivity tied to higher temperatures. Climate change will not only heat up the planet, but will also lead to sea-level rises and an increase in extreme weather, such as hurricanes. Since many big cities are on the coast, they will require protection. Environmental economists have already been working for decades on Doomsday calculations, such as whether it would be better to build costly flood defences for Singapore's business district or let it be inundated.

Moreover, even if rich countries manage to fend off the worst effects of global warming, they will still feel its repercussions. Trade with more vulnerable places would decline; refugees would proliferate. The Paris climate conference this December is supposed to come up with policies to avoid such outcomes. The new findings on the baleful impacts of high temperatures should give rich countries an extra incentive to compromise.

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