RESEARCH SUMMARY

The Impact of Temperature on Productivity and Labor Supply: Evidence from Indian Manufacturing

by E. Somanathan, Rohini Somanathan, Anant Sudarshan and Meenu Tewari

KEY TAKEAWAYS

1. In hotter years, countries tend to produce less economic output. A number of factors might be at play: Crops don't grow as well when it is warm, heat-related illnesses or even death may increase, or people may become less productive on hot days.

2. This study examines the impact of temperature on worker productivity and absenteeism using data from India, the third largest economy in the world. The study puts together data from individual workers as well as factories, spanning labor-intensive and highly automated manufacturing processes.

3. Productivity drops by as much as 4 percent per degree when temperatures rise above 27° Celsius (80° Fahrenheit) in workplaces requiring manual labor. In highly automated settings, this effect is not observed.

4. A 1-degree increase in the ten-day temperature average raises the probability that a worker will be absent by as much as 5 percent. Absenteeism increases in both the labor-intensive and automated manufacturing processes.

5. Lower productivity and increased absenteeism influence the output of factories and the economy as a whole. When the average daily high over the year rises by 1 degree, output falls by about 3 percent. This decline is large enough to explain the entire reduction in India's economic output in hot years.

6. When employers cool the workplace they can prevent productivity losses, but it does not prevent workers from staying home during hot spells.

7. To sustain and grow worker productivity, businesses and governments must adapt to climate change. Climate control, such as air conditioning, is an expensive solution and may still be only a partial fix. In the long-run manufacturing sectors may migrate to cooler climates, or automation may increase to make up for less productive human employees.

Introduction

Recent research has uncovered a striking finding. In hotter years countries tend to produce lower economic output, an effect that is especially marked in developing countries. The fact that this is happening in many parts of the world suggests there may be a common cause.

Several hypotheses have been proposed. Agriculture is central to the economies of many developing countries, and crops do worse in the heat. Heat-related illnesses and mortality rates increase when it is warm, meaning fewer people contribute to the economy. Some research shows that conflicts may occur more frequently in hot years, causing economic unrest as well.

However, there may be a simple explanation. When it gets warm and humid, people work less effectively. Their ability to undertake both physical and cognitive tasks suffers, driven by the inescapable realities of human physiology and the physics of how bodies lose heat.

Research Design

This paper examines the effect of temperature on worker productivity using data from India, the third largest economy in the world. It examines how much the worker produces while at work, as well as how frequently they are absent from work. The effects of heat are studied using data from different manufacturing sectors and at different levels of output: individual workers, assembly lines, factories, districts, and the country as a whole.

At the worker level, the researchers obtained primary data directly from cloth weaving factories, garment sewing plants, and a large steel mill. These industries are important to India's manufacturing sector; together, they also provided diversity in the type of work analyzed in the paper. The cloth weaving and garment sewing industries are labor-intensive, whereas the steel industry relies on highly automated manufacturing processes. Comparing them allowed researchers to observe differences in productivity and absenteeism in both types of settings.

At the cloth weaving plants, where workers were paid every day based on the meters of cloth they actually produced, the authors obtained daily payment slips and digitized them to generate a worker-level dataset of attendance and daily meters of cloth woven.

The authors also obtained production and absenteeism data from a firm owning eight garment industry factories. In this case, workers were paid monthly wages and not directly penalized for small variations in productivity or occasional absences. They obtained similar data from a steel plant that is the largest producer of steel rails in the world.

The researchers augmented these records of worker output with 15 years of data from a nationally representative panel survey of more than 70,000 factories across India. These surveys provided detailed information on the value of plant output, the number of workers employed, the types of products manufactured, and so on. The authors then matched data from the plants being studied with local temperature and rainfall measures from public weather stations and the Indian Meteorological Department.

At the time of the research, the garment sewing plants in the study were undergoing a phased roll-out of air conditioning during the period studied. Comparing data from before and after installation allowed the researchers to compare how outside temperatures influenced the productivity of workers on those shop floors which had been cooled, relative to those in uncooled plants.

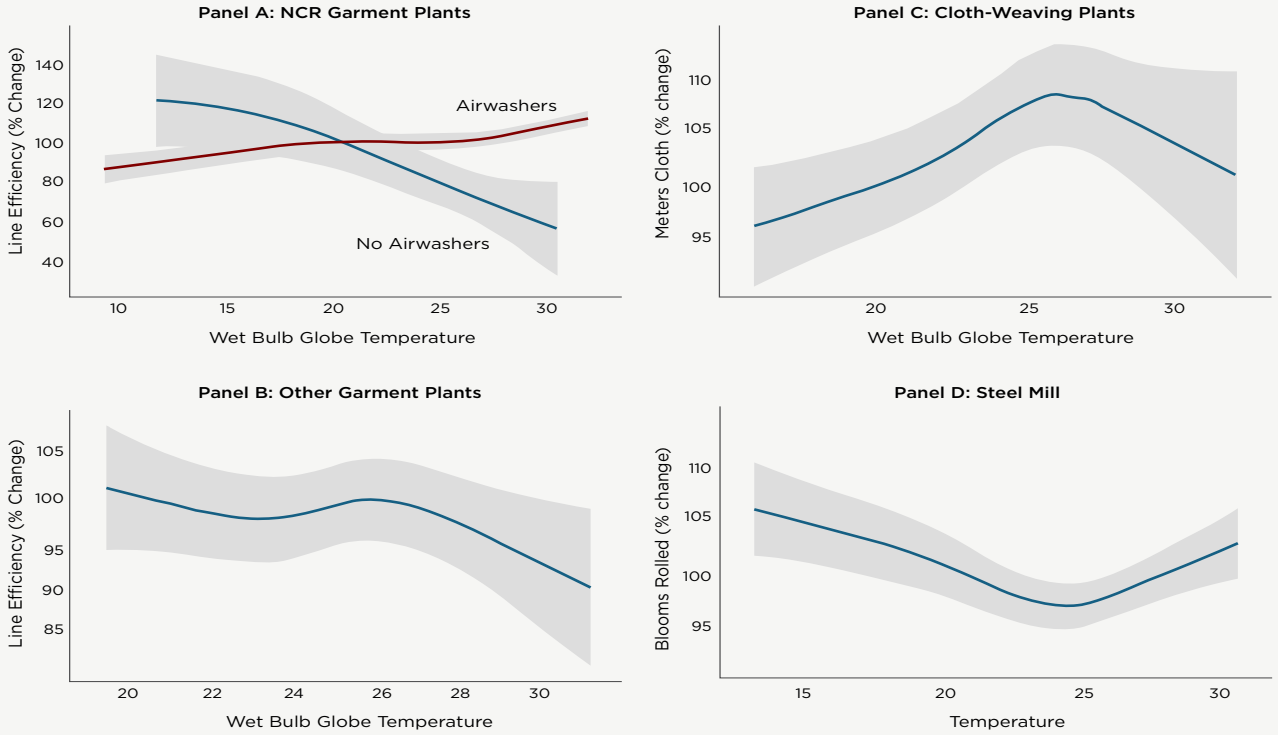
Lastly, the study sought to compare temperature effects on worker and factory output with aggregated national statistics on economic output at the district level. To do this, the researchers used manufacturing sector GDP for Indian districts over a 12-year period, and examined how district-level temperatures influenced this recorded output.

Findings

1. Worker productivity declines by as much as 4 percent for every 1 degree increase in temperature on a hot day. As temperatures rise above 27° Celsius (80.6° F), productivity declines in settings where manual labor is important. For those in the milder climate of South and Central India, productivity declines by about 2 percent per degree Celsius. For the hotter regions of Delhi and Gujarat, productivity declines by as much as 4 percent per degree. Importantly, productivity in the highly automated steel industry does not drop on hot days.

2. Workers are more likely to be absent during hot spells. While a single hot day can lower productivity, it takes a string of hot weather to cause employees to stay home from work.

Figure 1 · Predicted Temperature-Productivity Relationship



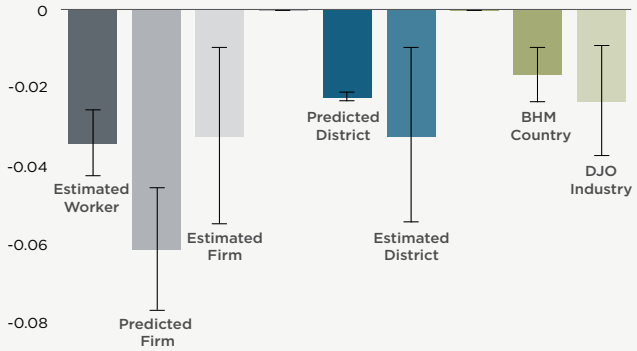
Note: Wet Bulb Temperature is a measure of heat that adjusts temperature to also account for the effect of humidity.

When temperatures rise above 27° Celsius (80.6° F), a 1° increase in the ten-day average raises the probability of garment workers being absent by 5 percent and increased the number of shift absences in the steel plant by 1 percent. In the case of cloth-weaving workers, who are paid only for the time they are at work, there is little change in absenteeism. This might be because their costs of missing one day are higher than for salaried workers. Increased absenteeism may occur because exposure to sustained heat inside and outside the workplace could induce fatigue or illness. This should affect workers in automated and manual workplace settings alike, as the study confirms.

3. Installing air conditioning or other climate control measures in the workplace mitigates productivity declines but not absenteeism. Plants that have climate control measures in place do not experience any impact on productivity on hot days. The same is not true, however, for absenteeism. Sustained hot temperatures continue to lead to higher rates of absenteeism even when the workplace has climate control measures.

4. The output value of factories in India falls during hot years. The decrease in worker productivity and increase in absenteeism during hot weather is mirrored in declines in the value of output from manufacturing plants. When the average daily high over the year rises by 1 degree, the value of output falls by about 3 percent. These declines are most prominent in labor-intensive firms employing many workers.

Figure 2 · Marginal Effect of Temperature on Log Output



Policy Implications

This study has fundamental implications for how to think about the costs of climate change going forward. Human physiology is the same everywhere in the world, so the effects of temperature on labor productivity are likely to be of widespread importance. Richer countries may be able to adapt by adopting climate control technology, but the study suggests this approach will not entirely address the effects of heat on worker productivity and the economy. In poor countries, air conditioning may be too expensive for small manufacturing plants to adopt. Searching for cheaper cooling solutions is therefore important.

Even when air conditioning is cheap, it is not always practical. For example, the construction industry must exist in all parts of the world, and there are limited ways for a necessarily strenuous, mostly outdoor industry to adapt. The physiological costs of climate change on workers will affect all labor-intensive activities throughout the world—not just those in developing countries—and adaptation is not always going to be easy.

In the long-run, countries may need to prepare for larger shifts. It is plausible that factories may decide to locate in cooler regions as an alternative to spending lots of money on air conditioning. Alternatively, when labor becomes less productive, it is possible that some manufacturing sectors may turn towards increased automation. These responses would move jobs within and across countries, or eliminate them entirely, with potentially large effects on the distribution of economic growth.

> "Because human physiology is the same whether you live in India, the United States or anywhere else in the world, the connection between hot temperatures and lower productivity has fundamental implications for how we should think about the costs of climate change going forward."
>
> **ANANT SUDARSHAN**
> **SOUTH-ASIA DIRECTOR, EPIC**

About EPIC

The Energy Policy Institute at the University of Chicago (EPIC) is confronting the global energy challenge by working to ensure that energy markets provide access to reliable, affordable energy, while limiting environmental and social damages. We do this using a unique interdisciplinary approach that translates robust, data-driven research into real-world impacts through strategic outreach and training for the next generation of global energy leaders.