

## Ask NUS Economists

# Productivity decline linked to high temperatures

**Eric Fesselmeyer  
and Tan Si Hui Jocelyn**

For The Straits Times

**Q** Do high temperatures decrease productivity?

**A:** Singapore's founding father Lee Kuan Yew famously proclaimed that air-conditioning was one of the most important inventions of the 20th century, enabling Singapore's success and, more generally, making development possible in the tropics.

Today, some workers are still routinely exposed to high temperatures in work environments that are not

amenable to climate control. Since high temperatures cause biological stress, there is a growing concern that the productivity of these workers may be affected as the climate warms. There are, however, few studies on the topic.

One of the challenges in studying the effect of temperature on productivity is the lack of data on worker output, especially quality of the output.

In our recent research, we turn to a context in which quality is objectively measured – rulings made by umpires in the professional baseball league of the United States, Major League Baseball (MLB).

As most MLB games are played outside, umpires make rulings under various weather conditions,

including extreme heat in summer. It is not unusual for game temperatures to reach over 37.8 deg C. We conjecture that heat stress causes umpires to make more mistakes. In other words, the quality of their work suffers when the weather is hot.

Some background on baseball: In a game, the pitcher throws the baseball and the batter decides whether to hit it. When the batter chooses not to hit a pitch, the umpire must judge whether the pitch was hittable by deciding whether the ball passed through the strike zone, a two-dimensional space defined by the MLB rule book, in which the batter is reasonably expected to be able to hit the ball.

If the batter chooses not to hit a

pitch and it passes through the strike zone, the pitch is considered a strike. If the batter chooses not to hit a pitch and the pitch passes outside the strike zone, the pitch is considered a ball.

Since the strike zone has to be visualised by the umpire and the pitches are very fast, umpires sometimes make mistakes by calling a ball a strike and vice versa.

To evaluate umpire performance, MLB uses a video technology installed in baseball stadiums called PITCHf/x, which tracks the path of each pitch and whether it is a ball or a strike. We collected PITCHf/x data from MLB to construct umpire accuracy: the percentage of correct ball and strike rulings the umpire made in a game.

In all, we collected data for 23,305 games played between 2008 and last year.

Using regressions analysis that controls for confounding factors such as individual umpire ability, pollution levels and other weather conditions, we do in fact find that umpires make more mistakes in extreme heat.

We estimate that if the game temperature is between 32.2 deg C and 37.8 deg C, the average umpire makes 0.64 percentage point more mistakes. If the temperature is above 37.8 deg C, the average umpire makes one percentage point more mistakes.

In an average game, the umpire evaluates about 150 pitches and about 88.7 per cent are made correctly. Our estimates indicate

that umpires make one or two more mistakes per game when the weather is hot.

Finding that umpires' work quality suffers due to heat stress is worrisome. Umpires are highly skilled and experienced workers conditioned to work in all types of weather. Finding that they cannot fully mitigate the effects of high temperatures suggests that there may be an even more pronounced effect in the rest of the population.

stopinion@sph.com.sg

• Eric Fesselmeyer is senior lecturer and Tan Si Hui Jocelyn is a student in the Department of Economics, National University of Singapore (NUS).

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