

# Reply to “Sato and Kohyama”

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We are grateful to Sato and Koyhama (2024, hereafter SK24) for their meticulous analysis of the relationship between temperature and home runs in Nippon Professional Baseball (NPB). Using data from 2005 to 2023 across 12 NPB stadiums, the authors show two key findings: first, that warmer gameday temperatures are associated with additional home runs in that game; and second, this effect is only present in open-air stadiums (i.e., those stadiums where gameplay is exposed to ambient air temperatures) but not in stadiums with domes. Both of these results are consistent with our findings on the relationship between temperature and home runs in Major League Baseball (MLB) in the United States and Canada over 1962–2019 (Callahan et al. 2023).

Of particular note is how similar the magnitude of the temperature–home run relationship is across both studies. Across all of their stadiums and observations in NPB, SK24 show a linear relationship whereby a 1°C increase in gameday temperature is associated with 0.014 additional home runs per game. A similar linear regression applied to our data from MLB yields an effect of 0.017 additional home runs per game per 1°C. That the magnitudes are so similar suggests a shared physical mechanism at work, most likely that air density declines with warmer temperatures, leading to lower drag and therefore farther carry for a batted ball.

One limitation of both studies is that neither directly analyze wind speed or direction. Winds certainly affect the likelihood that a given fly ball becomes a home run, but they can vary substantially over the course of a game and even at different locations within the same ballpark. As a result, high-quality long-term data on winds at baseball stadiums tend to be more limited than data on gameday temperatures. As research in this area develops, future work may be able to integrate wind and temperature information to assess their independent and potentially interacting effects on home runs.

Finally, a key contrast among the studies concerns the long-term trends in temperature and home runs. In contrast to MLB, SK24 show that NPB has not exhibited a long-term increase in home runs over time, despite global warming. In both leagues, changes in home runs are

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likely driven more by factors such as changes in the properties of the baseball and player skill than by trends in temperature. Indeed, in our analysis, we attributed only a 1% increase in MLB home runs to global warming over 2010–19. However, as fossil fuel emissions continue to rise, the influence of temperature on home runs could become stronger relative to these other factors in both MLB and NPB. Unless fossil fuel emissions are reduced or adaptive measures are taken, climate change may become an increasingly important factor in shaping sports, their gameplay, and their fans not just in North America and Japan, but globally.

## References

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