Temperature, Productivity, and Adaptation: Evidence from Survey Data Production

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Abstract

Global average temperatures are forecast to rise significantly over the next century, but availability of hourly or daily data on the activities of outdoor workers in developing countries needed to understand productivity impacts is rare. This paper uses household survey data to evaluate the productivity impacts of extreme temperature. The paper's innovation is that it studies the response of the *interviewer*, rather than the respondent, to weather on the day of interview. Using data from over 9,000 interviewers from 46 countries, I examine the impacts of daily average wet bulb temperature, which takes into account the interaction between temperature and humidity. I find that interviews completed per hour decline by 20 percent of the mean on the hottest and most humid days, relative to mild days. In addition, I find evidence that interviewers' productivity decreases more on tasks that are less easily observed by their supervisors and that they tend to complete more interviews in the cooler parts of the day at the expense of working more hours in the field. These findings suggest that certain types of short-term adaptation may exacerbate, rather than alleviate, the productivity consequences of climate change.

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1 Introduction

A growing literature documents a significant relationship between temperature fluctuations and aggregate output as well as labor income,[1] but little is known about the microeconomic mechanisms for these impacts and, more generally, how temperature fits into standard labor models of worker productivity. Temperature may impact labor output through worker productivity, the quantity of labor hours supplied, or worker effort (Heal and Park, 2014). The effect of temperature on labor effort remains unexamined in the literature, while the other two channels have been studied predominately in developed country and single-firm contexts. Temperature, meanwhile, may provide an excellent laboratory for studying worker effort with the right dataset: temperature provides a plausible source of variation in disutility of effort, which may interact with incomplete monitoring or weak incentives to significantly impact job performance. As previous studies have pointed out (Heal and Park, 2016), understanding the mechanisms for impacts on overall output as well as how they interact with workplace incentives is critical for generalizing the productivity effects of temperature out of laboratory and single-firm studies.

Few datasets can rise to this task: datasets with high-frequency productivity data that contain useful variation in worker incentives are rare, especially in developing countries. I overcome data constraints by using household survey data from throughout the developing world to study the enumerator (interviewer) rather than the respondent. In developing countries, interviewers' jobs require them to walk significant distances between households and conduct interviews face-to-face in non-climate controlled settings, making them members of the large set of workers in poor countries significantly exposed to outdoor temperatures. The rich data on interviewer activities and incentives make it possible to study the margins of adjustment on hot days and how workers minimize utility loss from high temperatures.

In this paper, I examine the relationship between fluctuations in daily average outdoor temperature and the quantity and quality of household survey data produced by Demographic and Health Survey (DHS) interviewers from 46 countries between 1990 and 2010. I link data from over 1.2 million interviews conducted in the DHS with gridded weather data on temperature and humidity. Each interview contains the interviewer's unique identifier, a start time and and end time in minutes, and a host of rich information on data quality, allowing me to reconstruct the daily work schedules and

[1] See, for example, Dell, Jones and Olken (2012), Heal and Park (2014), Hsiang (2010).

productivity of over 9,000 interviewers. Using this information, I quantify the effect of temperature on the total production of interviews in a day as well as per hour worked, controlling for survey by region of country fixed effects, a host of respondent characteristics, the average temperature for that place in that calendar month, and the number of daylight hours. Therefore, identification comes from variation in weather within a region of a country, accounting for usual local climate.

The DHS provides a useful setting for examining the impacts of temperature on productivity due to its enormous spatial and temporal coverage, but also due to the fact that the process for hiring interviewers, conducting interviews, and processing data is relatively constant across contexts. The DHS produces and publishes regular guidelines for field supervisors and editors for both managing fieldwork and evaluating interviewer performance. This documentation reports that it is the number of completed interviews that is the measure of productivity most observable to the interviewers' supervision teams, while data quality is arguably more difficult for the supervisors to observe. I exploit the multidimensional nature of interviewer jobs combined with differential quality of monitoring to test the theory that worker productivity may respond especially strongly to temperature fluctuations on dimensions with less intensive monitoring. Furthermore, the fact that the dataset contains dozens of countries allows me to compare standardized measures of worker productivity across institutional contexts and examine the effect of public sector corruption and other factors on the relationship between temperature and productivity.

This paper contributes to the previous literature on temperature, productivity, and worker effort along several dimensions. First, this paper ties into the literature on temperature and economic outcomes by estimating a reduced-form impact of temperature on the productivity of outdoor workers in 46 countries, providing the broadest estimate yet of the relationship between temperature and productivity at the individual level, particularly in climate-vulnerable developing countries. This estimate focuses on a set of workers whose job requires significant exposure to the outdoors in addition to successful interaction with respondents, making them a significantly different sample of workers from those in a manufacturing job, as have been previously studied.

Second, the paper examines margins of adjustment on hot days, adding to the growing literature on temperature and adaptative behavior in economics. Typically, as Graff Zivin and Neidell (2014) note, the literature has used the word "adaptation" to describe the long-term process by which regions with warmer climates are able to attenuate the negative effects of temperature on economic

outcomes through the adoption of technology such as air conditioning or through physical acclimation. Evidence from Graff Zivin and Neidell (2014) suggests that individuals may adopt short-term behavior to avoid some of the utility losses of extreme temperature as well, however. They find that individuals working in climate-exposed industries in the U.S. work fewer hours on hot days and spend less time on outdoor leisure. That paper conjectures that the impacts of temperature on labor supply may be larger in developing countries, where more workers are exposed to outdoor temperatures, which are also higher in developing countries on average; I examine this directly. In addition, most papers in this literature have used conventional measures of temperature to investigate the relationship between weather conditions and productivity, while I use wet bulb temperature, which incorporates both temperature and humidity.

Finally, the paper links to the literature on worker effort and monitoring. Standard principal agent models predict a decrease in effort if personal costs of effort increase, and task-based models predict that worker effort will be focused on tasks that are especially closely monitored or highly rewarded (Holmstrom and Milgrom, 1991). This paper examines whether an increase in costs of effort (caused by extreme temperature) will differentially affect tasks with different levels of monitoring, providing evidence on the relationship between disutility of effort, monitoring, and provision of effort in a real-world context.

Using a semi-parametric specification to allow for nonlinearities in the effects of temperature, I find that the total quantity of production is insensitive to temperature, but that the pace of production slows by approximately 20 percent in a day over 85 degrees wet bulb. I find that data quality problems, such as missing responses and flags for data quality added in the data processing stage, become more frequent on hot days. The fact that the number of completed interviews does not decrease suggests that workers protect themselves from utility loss on hot days by reallocating their effort to protect productivity in more observable dimensions. Finally, I find that impacts on productivity significantly vary with the level of public sector corruption in the implementing country. In corrupt countries, interviewers conduct shorter interviews by marking more questions as “not applicable," implying that the impacts of temperature vary significantly by institutional setting.

This paper also explores the allocation of interviewers’ time as a potential avenue for adaptive behavior. I find that interviewers’ days start monotonically earlier as average temperature increases. This is true both in the cross section and using the regression framework, but the slope is shallower

once region fixed effects and climate controls are accounted for. This suggests that workers in places that are warmer on average start their days earlier on average, not just on days that are surprisingly hot, providing evidence that some forms of adaptation to local climates exacerbate rather than alleviate the impacts of temperature on productivity. I also find that more interviews start in the early morning and late afternoon hours on hot days, while on cold days more interviews start mid-day, suggesting that interviewers allocate their work effort to hours with more pleasant temperatures. This form of adaptation behavior may come at a real utility cost as well: workers have fewer hours in a day for leisure if they are working more hours and must work longer to achieve the same output. This implies that adaptation behavior may not be uniformly costless: as climates change, individuals may adopt behaviors that, while reducing utility costs of temperature changes on net, have costs in other ways. On the other hand, I find that workers are less likely to conduct interviews at all on hot days, a form of adaptation that likely ameliorates the productivity effects of high temperature.

Of course, the interviewers' jobs require them to interact productively with another person who is also potentially exposed to the same variation in temperature: the respondent. It is therefore possible the interviewer's job becomes more difficult on hot days. The main result of this paper treats the impact of temperature on number of interviews per hour as inclusive of effects on the respondent and the interviewer; however, this paper aims to give a picture of the impacts of temperature on interviewer effort, so it is important to consider how respondents' behavior may be influencing my findings. The respondent could impact the results either through an effect on nonresponse, leading to selection into the sample or to more unsuccessful interview attempts, or by behaving differently during the interview. I show that there is little evidence of selection on observable characteristics driving the main results of this paper. Furthermore, the results suggest that interviewers' incentives are an important component of the results, suggesting respondent behavior is unlikely to be driving my results.

While data production is a unique context due, in part, to the role of the respondent, anecdotal evidence from the developing world suggests that lessons learned from household survey interviewers may generalize to other sectors. A recent report suggests that many workers in the developing world are subject to daily production targets and non-climate controlled workplaces, which may yield similar results: "Heat stress and the same daily production targets in all parts of the year means that the workers have to work longer each day in the hot season than in cool seasons; but the salaries

typically remain the same" (Kjellstrom et al., 2016). The results of this paper suggest that production quality may be another margin of adjustment on hot days.

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