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Temperature and Decisions: Evidence from 207,000 Court Cases†

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We analyze the impact of outdoor temperature on high-stakes decisions (immigration adjudications) made by professional decision-makers (US immigration judges). In our preferred specification, which includes spatial, temporal, and judge fixed effects, and controls for various potential confounders, a 10°F degree increase in case-day temperature reduces decisions favorable to the applicant by 6.55 percent. This is despite judgements being made indoors, "protected" by climate control. Results are consistent with established links from temperature to mood and risk appetite and have important implications for evaluating the influence of climate on "cognitive output." (*JEL* K37, K41, Q54)

We investigate the link from outdoor temperature to decisions made by experienced professional decision-makers, working in good-quality, climate-controlled, indoor spaces. If decisions with durable consequences are systematically influenced by irrelevant factors, the potential for welfare loss is obvious. The question we investigate is the following: do decision outcomes, the substance of which have nothing to do with contemporaneous temperature, depend causally on how hot it is outside on the day the decision is made? Examining the universe of files (just under 207,000) evaluated over a four-year period by the 266 immigration court judges at the 43 US Federal Immigration Courthouse locations spread across most major US cities our answer is a resounding yes—with high significance and robustness, and a substantial effect size. As such, we evidence a subtle and pernicious channel through which variations in climate (across space and through time) can damage well-being, by influencing decisions.

The analysis contributes to our developing understanding of how decisions can be sensitive to apparently irrelevant considerations. For example, Mani et al. (2013)

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show that poverty, by occupying scarce mental resources or "bandwidth," reduces cognitive function and reduces decision quality. Hunger negatively influences mental function (Weaver and Hadley 2009 and Weinreb et al. 2002) and perception of risk (Ferrarelli 2016). Tiredness reduces cognitive function (Tchen et al. 2003; Abd-Elfattah et al. 2015), increases risk-taking (Viner et al. 2003) and reduces self-control (Kahol et al. 2008).[1] A wider set of behavioral research, consistent with introspection, points to the importance of transitory emotions and mind-states in influencing decisions with long-term consequences (see Loewenstein 1996 for an early survey). For instance, while Ariely and Loewenstein (2006) show that sexual arousal can impact sexual decision-making, Jahedi et al. (2017) show that it can also influence a wider set of economic decisions by temporarily distorting risk attitudes. The results extend recent research that shows the effect of weather on student test performance (for example, Park 2016) to high-stakes, workplace "cognitive output." All of these fit into the "biology and economics" agenda that seeks to model the agents that populate economic textbooks as biological organisms ("wet machines"), sensitive to the environment in which they function.

Four things make the immigration court system setting an ideal test-bed for the theories that we investigate:

- The decisions that we observe are socially and economically important and the appropriate choice self-evidently has nothing to do with contemporaneous temperature. As such, any influence of temperature on decisions necessarily implies inefficiency and welfare burden;

- Our subjects are experienced decision-makers. While the precise characteristics of any individual file are unique, the setting in which they work and the broad parameters of case files are not novel. Furthermore, the setting mirrors the sort of repetitive-but-idiosyncratic decisions that agents such as consumers and managers face in the main economic models;

- The decision-makers that we observe work *indoors* and protected in their workplace by climate-control at a level typical of good-quality US Federal government buildings in the twenty-first century. In terms of protection, then, close to full application of the most obvious technological solution to mitigate temperature effects is already accounted for in the results. With regard to biological adaptation to prevailing conditions, judges move around very little—they are largely attached to a single court location—meaning that they are "used to" the prevailing temperature patterns in the city in which we observe them.[2]

[1] There is a philosophical debate about how to conduct welfare analysis in these settings (Diamond and Vartiainen 2007). Typically preferences (say with respect to risk) are regarded as having some longevity. If a person who has lost a night of sleep due to construction noise acts "as if" they have a higher risk appetite than they otherwise would, then emerging practice would be to treat the mis-decisions made as welfare-reducing (O'Brien and Mindell 2005, and Halleröd and Larsson 2008).

[2] Additionally, because location and dates of work are determined externally and in a way not sensitive to short-term temperature realizations, we do not face complications due to displacement that might be important in other

- The quality of data and the procedural details of the immigration system allow us to avoid a plethora of identification challenges, allowing for clean, persuasive causal inference.

Our main approach uses high-frequency data to estimate a linear probability model with a variety of fixed effects, though we also provide some nonparametric results. In addition, we develop variants in which the independent variables of interest are the Heat Index (a measure used by the US National Weather Service that combines temperature and humidity nonlinearly into a metric designed to capture how hot it "feels") and the difference between realized temperature on a particular date and local norms for that date. Our central identifying assumption is minimal—that temperature realizations are as good as random after accounting for spatial and temporal fixed effects.

The analysis uncovers a substantial effect of short-term (daily) variations in temperature on decision outcomes. In our preferred specification, which include city-by-month and judge fixed effects, as well as controls for case characteristics and other potential environmental confounders, same-day, outdoor temperature has an impact on decision outcomes. Our results suggest that a 10°F increase in temperature reduces the likelihood of a decision favorable to the applicant by 1.075 percent, which is equivalent to a 6.55 percent decrease in the grant rate (the grant rate in the data as a whole is 16.4 percent). To put this into perspective, in our sample, the difference in grant rate between a judge at the twenty-fifth percentile in terms of leniency, and one at the seventy-fifth percentile, is 7.9 percent. Consistent with some existing studies of temperature susceptibility varying by gender (Yu et al. 2010; Xiong et al. 2015) the effect is particularly pronounced for female judges. To allay concerns that there might be something unique to the immigration setting that is driving the results, we repeat the exercise for decisions made in 18,461 Parole Suitability Hearings at the 39 locations of the California Department of Corrections and Rehabilitation (CDCR), arriving at parallel conclusions.

Why are these results important? As a straight piece of law and economics the research contributes to an assessment of the consistency of US immigration (and California parole) practices. The Sixth Amendment to the US Constitution lays out "fair trial" as a fundamental right. The Administrative Procedurs Act (APA) (1946) determines that any adjudication or decision by an agent of the US government should not be "arbitrary or capricious." Agency decisions should be "... rationally connected to the facts before it" (Committee on Capital Markets Regulation (CCMR), 2016, 2). The immigration court system is "about" decisions, and natural justice, as well as the law, dictates that decisions on a particular file should be based solely on the merits of the case ("the facts and nothing but the facts"). There is no plausible reason why a particular file should have any different prospect of success

settings. For example, in some professions, an employee might choose to defer work from a hot day to a cooler day (or work in the evening), or decide to work at home in response to weather conditions.

if evaluated on a day unusually warmer for that location at that month of the year, than on a day with a different temperature realization.[3]

However, as our opening paragraphs suggest, cautiously we propose that the analysis provides a prima facie case that temperature may damage decision consistency and quality in a much wider set of settings. If experienced, professional judges, working in an environment in which they are protected from outdoor temperature with high-quality climate-control technology, are as subject to influence as our analysis suggests, what should we think might be the impact of temperature on the wider population of agents (consumers, investors, managers, etc.) making diverse decisions with long-lasting implications for welfare?

We are careful not to over-interpret the results, but it is tempting to juxtapose the findings with what we know about differences in temperature profiles across locations and through time. That we do not observe "right" and "wrong" decisions, even ex post, precludes definitive welfare analysis. Given that the correct arbitration does not depend on contemporaneous temperature, *the sensitivity of outcomes to changes in temperature in itself implies inefficiency*. However, it is not possible for us to point to particular type 1 and 2 errors.[4] Notwithstanding this, it is straightforward to infer ballpark estimates for "excess" wrong decisions based on an additional *assumption*, grounded in existing research, that human comfort and performance is optimized at a particular temperature range.

The rest of the paper is laid out as follows. In Section I, we provide a sketch of some existing research on the effect of temperature on humans, and the mechanisms that might underpin a link from outdoor temperature to indoor decision-making. Sections II and III detail data sources and methods. Section IV presents the results of the main analysis and a series of robustness and falsification checks. Section V concludes.

I. Literature

While mechanism is not going to be our central focus, it is worth highlighting several strands of research that link temperature to mental function, decision-making, risk attitudes, and mood.

Several studies have examined the role of *indoor* temperature on some measure of mental or cognitive acuity. The temperature in a space is manipulated by the researcher, who then observes some measure of performance. For example, Hedge (2004) and Fang et al. (2004) examines performance on simple visual tasks and abstract problem solving in a laboratory. Wyon et al. (1996) assesses vigilance, again in a temperature-manipulated laboratory setting. Chao et al. (2003) measures a set of more complex tasks in an office. Allen and Fischer (1978) measures student

[3] There has been a very long and much broader body of debate on arbitrariness in legal systems in the United States and elsewhere (Oakley and Coon 1986, Danziger et al. 2011).

[4] We do not have access to decision appeals which, at least superficially, might help identify errors. However, the rights to appeal and review in this area are much less developed than in those areas of law that relate to US citizens (which be construction immigration law does not). In addition, this is an area in which judges have wide discretion in interpreting case circumstances, and there is no right to appeal purely against how that discretion is exercised. Appeals (as in most areas of law) relate only to procedural errors.

learning in classrooms. Seppänen et al. (2006) conducts a meta-analysis of the 24 papers that a particular search protocol elicits on this topic (including those just listed). Of these, 9 take place in the lab, the rest are in offices or schools, and between them they generate just over 100 effect size estimates. Their systematic review of the literature generates an estimate of the indoor temperature associated with highest productivity being at 21.75°C (71.5°F), with a decrement of performance of around 9 percent when temperature is 30°C (86.1°F).[5] In general, heat stress has a much greater influence than does cold stress on the performance of cognitive tasks (see Hancock and Vasmatzidis 2003 for a review).

Turning to decision-making in particular, Cheema and Patrick (2012) presents five studies of consumer behavior in which they manipulate laboratory temperatures. In higher temperatures subjects are: (i) less likely to engage in gambles (particularly complex gambles), (ii) less likely to choose innovative products over established ones, and (iii) more likely to rely on "system 1" (heuristic or habit-based) processing (Pocheptsova et al. 2009). In our setting, in which the rejection rate of immigration applications is around 83 percent, such that the granting an applicant leave to stay can plausibly be regarded as the less-habitual, more innovative, and more risky choice, this would point to a negative relation between high temperatures and grant rates.

While evidence of the effect of contemporaneous indoor temperature on brain-intensive tasks is suggestive for us, none of it is directly relatable. Studies that cast light on how daily *outdoor* temperature affects indoor mental performance are rare. Graff Zivin et al. (2018) finds that an (outdoor) temperature above 79°F on a particular day damages performance of children on math (but not reading) tasks. Park (2016) investigates the relationship between daily outdoor temperature and high school exit exams in New York City, and finds that compared to a 72°F day, taking an exam on a 90°F day reduces a typical student's performance by 0.19 standard deviations.

Turning away from cognition, separate strands of research evidence: (a) a causal link from ambient temperature (and other dimensions of weather) to "mood," broadly defined, and then; (b) a causal link from mood to decision-making. Baylis (2015) links temperature to measures of hedonic state (mood) using geo-located Twitter activity. His four sentiment metrics based on phraseology, emoticon use, and profanity each become more negative once outdoor temperatures exceed 70°F (with little to no effect for colder temperatures). Denissen et al. (2008) finds a similar effect when they analyze online diary entries of 1,233 students. Relatedly, a number of behavioral finance papers (for example, Hirshleifer and Shumway 2003, Cao and Wei 2005, Floros 2011) link daily variations in weather—typically cloud cover and sunshine, but also temperature and humidity—to stock price movements via changes in emotional state.

[5] The first of these numbers accords with anecdotal introspection. In a more recent review, Cheema and Patrick (2012, 985) notes that: "Prior studies find that an ambient temperature of 72°F, one at which most people appear comfortable, may be most conducive for automatic tasks." For instance, Allan et al. (1979) finds that performance on a paired-association memory task peaks at 72°F. Other evidence suggests a difference between temperatures that are optimal for comfort and those that are optimal for performance. Specifically, Pepler and Warner (1968) shows that people perform office work best at 68°F, although they report feeling cold."

With particular focus on judicial outcomes, Guthrie et al. (2007) discusses the role that emotion and cognitive overload can have on the decisions made by judges. Chen (2016) finds that the probability of a decision in favor of the applicant by US immigration judges increases by 1.4 percent the day after a win for the home NFL team. Eren and Mocan (2018) finds that Louisiana juvenile court judges hand down sentences that are 6.4 percent longer following an unexpected loss by the Louisiana State University (LSU) NCAA football team, with the effects largest for judges who are based closest to the home of LSU. Danzinger et al. (2011) finds that the likelihood of favorable judgements by Israeli parole boards is higher after a food break. There are also various experimental papers identifying the unwanted influence of mood, cognition, fatigue, and emotion on judgment more generally (Englich and Soder 2009, Simon 2012, Dijksterhuis et al. 2011, and Wyer and Carlston 1979).

Turning to the question of this paper, the decision-maker in our setting is protected from outdoor temperature by climate control, but may "import" the effect of exposure to, for example, an extreme outdoor temperature when they move inside, coming in from the morning commute, or after a break.[6] Determining the physiological mechanisms through which this happens is beyond the scope of our paper.[7] Outdoor conditions could in principle affect the output of the subject even *if he never went outside and was exposed to it*. For example, if external temperature is very high, he might not venture outside during breaks "for fresh air." Anyone who has spent time in a city like Houston or Atlanta during a heatwave should understand that possibility. Lack of fresh air has been linked to reduced cognitive function (Chen and Schwartz 2009) and mood (Cunningham 1979).

II. Data

Our central analysis links US-wide data on outcomes of asylum applications with what we know about environmental conditions at the location of decision on the date in question. We also use statewide parole decisions from California to probe external validity.

A. *Immigration*

We use case-level administrative data on US asylum applications made to immigration courts from January 2000 through September 2004. Our final dataset includes the universe of 206,924 decisions made over this 58-month period by all 266 immigration judges across the 43 US cities in which courts are located (see Figure 1). Each court serves a specific geographical region. Decision data is merged with hand-collected data on judge gender. In our dataset, 34 percent of judges are

[6] We do not observe the time at which a particular file is adjudicated or know the movements of the judge during the day (when he or she is indoors or outdoors) so cannot speak to intra-day variation. However the scheduling of files within the day is done many months in advance and therefore unrelated to temperature realizations.

[7] There is also research on the effect of ambient temperature on a variety of animal behaviors. We do not survey it here. However, for one example among many, Mathot et al. (2015) finds that birds are less likely to engage in risky choices at higher-than-familiar temperatures. Elsewhere, Graff Zivin et al. (2018, 2) notes the existence of a more general "... neurological literature that documents the brain's sensitivity to temperature."

Figure 1. Location of Immigration Courts (Excluding Honolulu)

female. The mean grant rate (the rate at which a decision is made that favors the applicant) in the database as a whole is 16 percent.

Our data comes from asylumlaw.org. Asylumlaw no longer operates but was: "A website run by an international consortium of agencies that helps asylum seekers in Australia, Canada, the United States, and several countries in Europe. It provides links to legal and human rights resources, experts, and other information valuable for asylum seekers." [8] The data contains date of hearing, identity of judge, nationality of applicant, and category of application.[9]

Asylum decisions made by immigration judges are decisive and those that are denied asylum are subject to removal. Judges sit alone, and there are no formal quotas with respect to their grant rate. While the activities of judges are subject to the overall supervision of the US Attorney General, this is an area of law in which individual judges are widely regarded as having a high degree of personal discretion and independence in the way in which they evaluate files (see Ramji-Nogales et al. 2007, and Chen et al. 2016). Though the characteristics of cases that judges in different locations are likely to see will of course vary, the degree of discretion is supported anecdotally by the wide variation in grant rates of judges both between and within particular courthouses. For instance, over the study period in the Los Angeles courthouse there are five judges that granted asylum to fewer than 4 percent, while three others granted in over 67 percent.

Judges typically determine multiple cases on a given day. The judge is presented with a file, may (or may not) ask questions of the applicant, then enters an adjudication. Within a court all cases are in principle randomly assigned to the judges

[8] The dataset was kindly provided by Kelly Shue (University of Chicago Booth School of Business) in personal correspondence.

[9] There are two types of cases in immigration courts: affirmative cases in which the applicant presents in the courts on her/his own and defensive cases in which the applicant is instructed to attend on the initiative of the immigration authorities.

(Ramji-Nogales et al. 2007), however, we do not test for random assignment on observables, neither does our approach to identification rely on it. The setting of dates for cases and the rostering of judges is done well in advance. For instance, as of December 2016 more than 533,000 immigration cases had hearing dates scheduled, with the average delay from scheduling to hearing being over a year.

An important question is the extent to which adaptation might allow the impacts of temperature variations to be mitigated. The most obvious protective measures are building design and climate control. As such, it is useful to note in passing the context in which our subjects work. All of the courtrooms represented in the study are contained within climate-controlled buildings, as would be expected for important operational spaces of the US Federal government.[10] The effects of external temperature on internal behavior that we identify in this paper should be taken as already being adjusted for that level of adaptation embodied in buildings typical of this class.[11]

B. *Parole*

Data on all parole hearings conducted by the Board of Parole Hearing (BPH) between January 3, 2012 and December 18, 2015 are from the California Department of Corrections and Rehabilitation (CDCR).[12] The dataset includes 18,461 hearing decisions made by 12 BPH commissioners across the 39 venues in California. Figure 2 maps hearing locations.

The Board of Parole is responsible for evaluating the risk to public safety from the release of inmates incarcerated for serious crimes. A positive decision by the BPH means that a prisoner is released, so these are high stakes decisions. Parole hearings are conducted in-person with the inmate and at a facility located within that inmate's prison. Sessions are scheduled one year before an inmate becomes eligible for parole and conducted by a panel of two members, a Board Commissioner and Deputy Commissioner (Young et al. 2016). The former is a nonexpert appointed from a variety of professional backgrounds (law enforcement, academia, the military, politics), while the latter is a civil servant and expert in the legal process. Formally, the Commissioner is responsible for running the hearing and exercising discretion in determining outcome, while the Deputy Commissioner is responsible for legalities and post-release management of successful applicants. Despite this, that the panel is comprised of two members potentially complicates inference, obscuring *individual* decision-making. The grant rate in the dataset, the fraction of cases in which a decision is made that is favorable to the applicant, is 16.48 percent.

[10] In an unreported robustness check, we dropped venues one at a time and re-ran the preferred specification on the remaining sample. In no case did this substantially disturb the resulting estimates, implying that no single venue is driving results.

[11] In procuring space for judicial use, the Administrative Office of the United States Courts (AOC) sets stringent standards for many dimensions of the space, including the quality of climate control. Courtrooms are pre-cooled to 70°F degree before scheduled cases (Administrative Office of the United States Courts (AOC) 1996).

[12] The data can be obtained from http://www.cdcr.ca.gov/.

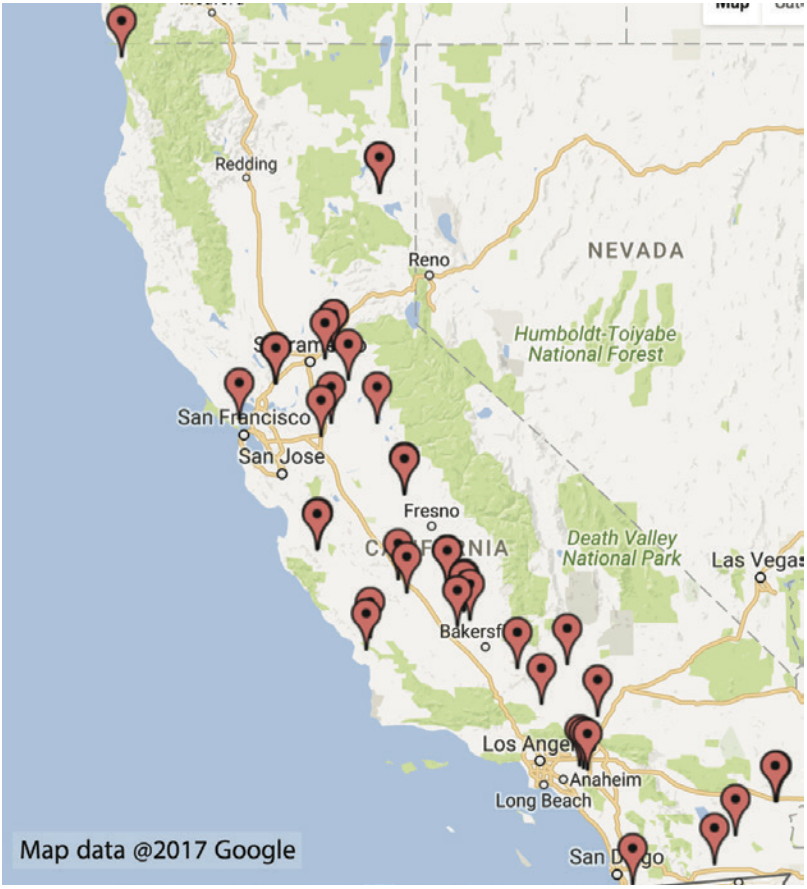

Figure 2. Location of Parole Hearing Venues

Our data contains the date of hearing, identity of panel members, inmate unique identifier, location of hearing, hearing type, and outcome.[13]

C. *Environment*

Our main research question is whether the adjudication on a file responds to the outdoor temperature on the day on which it is evaluated. To accomplish this, we combine our decision dataset with temperature and a variety of other environmental controls.

The location of asylum decisions from which we construct our dependent variable is drawn from the 43 US cities in which the US Department of Justice operates immigration courthouses. These are widely dispersed (see Figure 1) and subject to diverse weather conditions.

[13] There are two types of hearing that we consider: (i) Initial parole (which is scheduled one year before eligibility), and (ii) Subsequent parole that is scheduled if there is any consideration in the initial session.

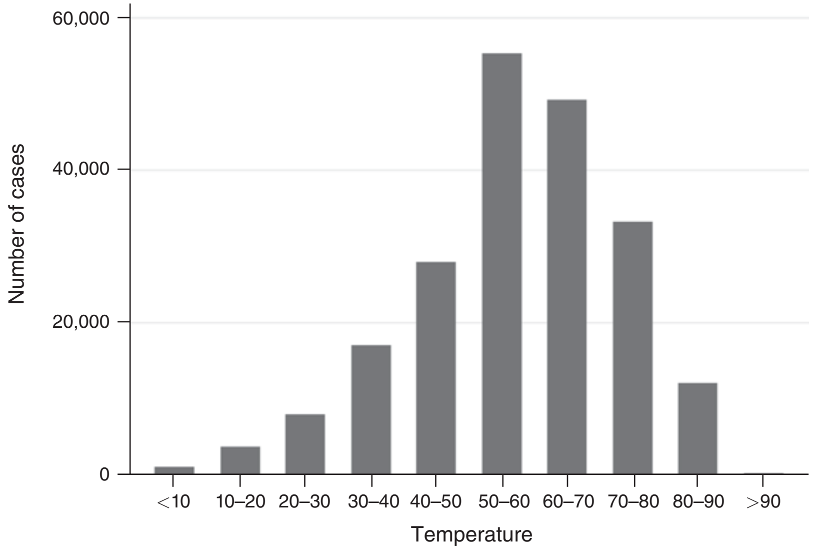

Figure 3. Distribution of Cases over 6 am–4 pm Temperature Bins

Notes: This figure plots number of cases adjudicated over 6 am to 4 pm temperature bins at 42 mainland US federal immigration courthouse locations from January 1, 2000 to September 30, 2004.

The exact date and location of each decision is known, which allows us to assign environmental measures (pollution and weather) to each. Temperature and other weather data is obtained from two sources. Hourly observations for air temperature, dew point, air pressure, precipitation, and wind speed are retrieved from the National Oceanic and Atmospheric Administration (NOAA).[14] Data for cloud cover comes from the Northeast Regional Climate Center (NRCC).[15] Weather information is assigned to each courthouse location from the closest monitoring stations, in no case further than 20 miles away. The average distance between weather monitoring stations and courthouses is 9.35 miles with standard deviation of 6.33.

For our central specifications we work with averages computed for the period 6 am to 4 pm each day. This is the period over which decision-makers are likely "up and about"—including travel to work, and workday. It excludes exposure that arises after courts close, which logically can have no effect on proceedings. Figure 3 plots the distribution of cases over 6 am to 4 pm mean temperature categories for the study period (2000 to 2004) across locations in 10°F bins. Most existing research on the effects of short-term temperature and pollution on a variety of outcome variables work with calendar-day data and, while we believe this to be an inferior approach, for purpose of comparison we also present analysis on that basis. In a further variant, that we do not report, we also conduct the exercise using eight-hour blocks (Midnight to 6 am, 6 am to 4 pm, 4 pm to midnight).

[14] The data is obtained from https://www.ncdc.noaa.gov/.
[15] The data is retrieved from http://www.nrcc.cornell.edu/.

Table 1—Summary Statistics

	Mean	SD
Grant indicator	0.164	0.371
Temperature (°F)	57.37	15.721
Heat index (°F)	57.77	16.423
Air pressure (pa)	29.688	0.759
Dew point (°F)	49.372	17.202
Precipitation (mm)	0.003	0.014
Wind speed (km/h)	4.557	3.441
Sky cover (percent)	55.44	0.276
Ozone (ppm)	0.0220	0.0120
CO (ppm)	0.917	0.496
$\text{PM}_{2.5}$ (μ/m^3)	14.957	11.569

We will also be controlling for air-quality conditions. Daily pollution data is published online by the United States Environmental Protection Agency (USEPA).[16] The dataset includes daily measures of particulate matter less than 2.5 microns in width $(PM_{2.5})$, carbon monoxide (CO), and ozone (O_3) throughout the United States for the period of 2000 to 2004.

Table 1 presents summary statistics.

III. Methods

A. *Empirical Strategy*

We estimate the following linear probability model:

$$(1) \qquad g_{it} = \beta_0 + \beta_1 \, temp_{it} + W_{it}\beta_2 + P_{it}\beta_3 + X_{it}\beta_4 + \gamma_i + \Psi_{ct} + \theta_t + \epsilon_{it},$$

where g_{it} is a binary variable that takes the value one if the judge's decision in an asylum application i on date t is granted, zero otherwise.

The key independent variable is the mean 6 AM to 4 PM temperature on the date the case is considered, $temp_{it}$. For most of our discussion, β_1 is the coefficient of interest.

To allow for the possibility that other dimensions of weather rather than temperature might impact decisions, we include a vector of weather controls, W_{it}. It contains dew point temperature (a standard measure of humidity), precipitation, wind speed, air pressure, and sky cover on date t, in the vicinity of the courthouse in which application i is adjudicated, all calculated on a 6 AM to 4 PM average basis. Pollution exposure can also influence cognitive function, mood, and/or decision-making (Archsmith et al. 2018, Chang et al. 2019, Ebenstein et al. 2016). To allow for this possibility we include P_{it}, which is a vector of pollution controls. It comprises mean daily measures of ozone (O_3), carbon monoxide (CO), and particulate matter $(PM_{2.5})$.

[16] The data is available at https://aqs.epa.gov/api.

Court and case context can be expected to impact case outcomes (Chen et al. 2016). We include a vector X_{it} of controls for a number of additional court and application characteristics. More specifically, we control for the category of application (affirmative or defensive) and nationality of applicant.[17] The vector γ_i contains judge fixed effects, which control for any time invariant variations in judge leniency.[18] The vector θ_t includes time fixed effects, day of week to account for possible changes in decision patterns across the day of the week, and year fixed effects to control for aggregate trend in the data and also to account for the likelihood of hotter work days due, for instance, to climate change. Finally, Ψ_{ct} is a vector of city-by-month fixed effects.

Error terms may be spatially- and serially-correlated. In our preferred specification, standard errors are clustered by city-month, which serves two purposes: to account for spatial correlation across cities and to allow for autocorrelation in decisions in each month. For the purposes of robustness, we establish later that the results are robust to a variety of other ways of calculating standard errors.[19]

As noted we include a rich set of fixed effects. Importantly, we include judge fixed effects in all of our main specifications, allowing for systematic differences in decisions between judges. Primarily, we are identifying off within-location, within-month variation. Our identifying assumption is that once location and time effects are controlled for, the realization of outdoor temperature on any *particular* day, and therefore the assignment of a temperature treatment to any particular decision, is as good as random.[20] That is to say, we can examine cases heard in Atlanta in June. But sometimes a case may be assigned a temperature treatment of 60°F, other times 90°F. It is that variation, plausibly exogenous, that we exploit for identification.

[17] The case characteristics that we observe are limited. It is clear that other unobserved characteristics are important determinants of case outcomes such that we have omitted variables. However, controlling for location and time fixed effects, it is plausible that those omitted characteristics would be uncorrelated with case-day temperature such that the OLS estimate of β_1 would be unbiased and the associated standard error remains undisturbed.

[18] Judges are appointed to a specific court and that court is where they adjudicate the vast majority of their cases. However, they may occasionally be reassigned to another location for a short period. In our sample, 168 of the judges adjudicated at least one case away from the court to which they were appointed (in total 12,245 of the 206,924 are heard by a judge away from his or her "home" location). Excluding these cases has no discernible impact on results.

[19] In online Appendix Table A.4, we present standard errors from nine alternative clustering strategies (columns 1 through 7) and heteroskedasticity-consistent Eicker-White and Newey-West standard errors (columns 8 and 9). In all cases, the level of significance of the estimated coefficient is unchanged. While alternative clustering makes little difference, the Eicker-White and Newey-West standard errors can be seen to be around 30 percent smaller, implying that our preferred approach can be regarded as conservative.

[20] To test our exogeneity assumption we re-estimate our preferred specification replacing decision outcomes as the regressand with, in turn: (i) the probability that an application is of type affirmative, (ii) the probability that the adjudicating judge is female, (iii) the probability that the applicant has a Middle Eastern country of origin and, (iv) the total number of cases heard by a judge on that day. In each case, we find no significant relationship. Results are presented in online Appendix Table A.5 and online Appendix Figure A.1.

Table 2—Fixed Effect Estimates: 6am–4pm Average

	Preferred (1)	1-Day lag (2)	1-Day lead (3)	All (4)
$Temperature_t/1{,}000$	−1.075	−1.454	−1.208	−1.617
	[0.274]	[0.406]	[0.382]	[0.486]
$Temperature_{t-1}/1{,}000$	–	0.361	–	0.372
	–	[0.278]	–	[0.277]
$Temperature_{t+1}/1{,}000$	–	–	0.139	0.159
	–	–	[0.260]	[0.260]
F-statistic of joint significance of weather variables	3.41	3.07	2.99	2.73
p-value	0.0026	0.0036	0.0044	0.0059
Observations	206,924	206,924	206,924	206,924

Notes: The unit of analysis is an immigration case. Dependent variable is a dummy taking value one if decision is favorable to applicant, zero otherwise. Temperature is the 6 am to 4 pm average in the city in which the case is adjudicated, on the day of adjudication, in Fahrenheit. The temperature measure is divided by 1,000 to reduce decimal places. All regressions control for weather, pollution, and time fixed effects. Weather covariates include dew point, air pressure, wind speed, precipitation, and cloud cover measured as 6 am to 4 pm averages in the city in which the case is adjudicated, on the day of adjudication. Pollutant covariates include controls for ozone, carbon monoxide, and $PM_{2.5}$, measured as calendar daily averages at the air quality monitoring station closest to the courthouse of adjudication, on the day of adjudication. Time fixed effects include day of week and year dummies relating to the day of adjudication. Regressions also include city-month fixed effects, name of judge adjudicating case, type of application, and nationality of applicant. Sample is all cases adjudicated at 42 mainland US federal immigration courthouse locations from January 1, 2000 to September 30, 2004. Standard errors are clustered on city-month in brackets.

IV. Results

A. *Linear*

The base results are summarized in Table 2. Column 1 is the preferred specification, incorporating the full suite of controls: time fixed effects, weather, and pollution controls.[21]

The coefficient in column 1, −1.075, implies that a 10°F increase in 6 am–4 pm temperature on the day a decision is made reduces the likelihood of a grant decision by 1.075 percent. Recall that the average grant rate in the sample is 16.4 percent, so this implies a 6.55 percent decrease in grant rate. The effect of a 10°F rise in temperature is comparable in size to those found by Eren and Mocan (2018) for an unexpected loss by the local NCAA football team (which induced a temporary 6.4 percent increase in severity of juvenile sentencing). Several studies point to between-judge variation in asylum grant rates (Ramji-Nogales et al. 2007 and Chen 2017). In our sample, the difference in grant rate between a judge at the twenty-fifth percentile in terms of leniency, and one at the seventy-fifth percentile, is 7.9 percent.

Columns 2 and 3 of Table 2 report the results of including lag or lead. In each case the point estimates on the lagged terms are much smaller in absolute value than those on the main measure, mixed in sign, and never approach significance

[21] All of our main specifications are estimated on the whole 58 months of data. The terrorist attacks of September 11, 2001 fall during our study period and can be expected to have impacted the operation of the immigration system in the United States. While we do not report them here, we have run the main specifications on the pre- and post-9/11 portions of the dataset, observing consistent patterns across them.

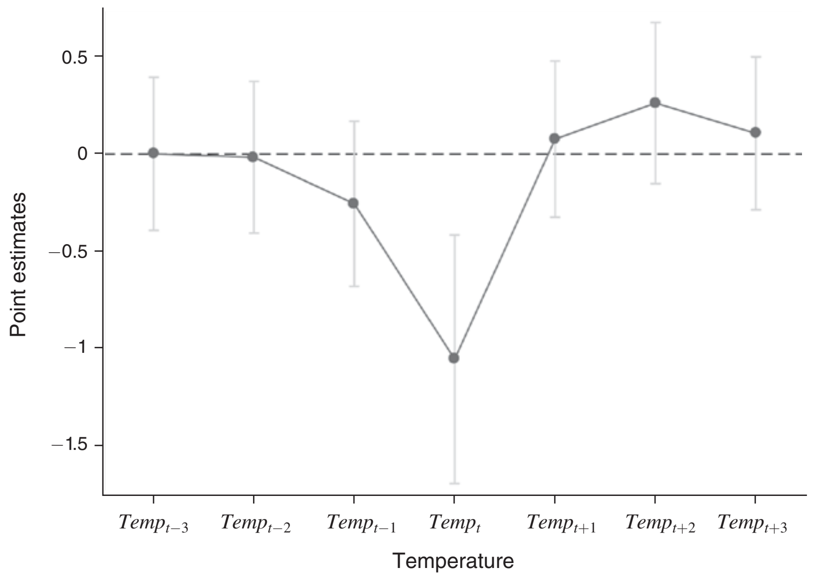

Figure 4. Timing of Exposure: 6 am–4 pm

Notes: This figure plots the coefficients that result from running the specification in column 1 of Table 2 but including three lags and three leads of the temperature variable. Gray lines show the 95 percent confidence intervals based on standard errors clustered on city-month.

at conventional levels. Column 4 includes both lead and lag terms. Figure 4 plots results when we add three lags and three leads simultaneously. As can be seen, none of the lags or leads achieve significance.[22] The F-statistic of joint significance of weather variables reported at the bottom panel of Table 2 rejects the null hypothesis of no effect for weather covariates treated jointly.[23]

Our main specification incorporates what we believe to be the most natural set of time fixed effects (year and city-month). However, Table 3 reports the results of other approaches. In columns 1 through 5, we build up to the preferred specification by adding fixed effects in sequence, while columns 7 to 8 present four other plausible alternatives. Column 9 repeats the preferred specification for purposes of comparison. The addition of city-by-month fixed effects in column 5 brings point estimates close to those from the preferred specification (-1.037 compared to -1.075), suggesting the importance of seasonal patterns.

To facilitate comparison, in the lower panel of Table 3 we also present Hausman statistics that in each case allow us to reject the null hypothesis of a significant difference between the estimated coefficient of interest in that column and that in the preferred specification. The stability of the estimated coefficient on temperature to so many alternative permutations of fixed effects is reassuring.

[22] We repeat the exercise replacing decision outcome with type of application and total number of cases heard by a judge on a given day. Results are summarized in online Appendix Figure A.2 and reveal no significant effect of leads or lags of temperature on these observables.

[23] Online Appendix Table A.3 presents point estimates for all environmental variables included in the preferred specification.

Table 3—Alternative Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Temperature_t/1{,}000$	−0.717	−0.727	−0.780	−0.806	−1.037	−0.893	−1.082	−0.939	−1.075
	[0.270]	[0.273]	[0.269]	[0.249]	[0.278]	[0.215]	[0.271]	[0.285]	[0.274]
Hausman-test	0.76	0.69	0.44	0.63	0.40	0.36	0.90	0.09	–
p-value	0.384	0.406	0.506	0.426	0.528	0.549	0.343	0.760	–
Observations	206,924	206,924	206,924	206,924	206,924	206,924	206,924	206,924	206,924
Nationality FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y
Day of week FEs	N	Y	Y	Y	Y	Y	Y	N	Y
Type of application FEs	N	N	Y	Y	Y	Y	Y	Y	Y
Judge FEs	N	N	N	Y	Y	Y	N	Y	Y
City-month FEs	N	N	N	N	Y	N	N	Y	Y
Judge-month FEs	N	N	N	N	N	N	Y	N	N
City FEs	N	N	N	N	N	Y	Y	N	N
Year FEs	N	N	N	N	N	N	Y	Y	Y
Year-month FEs	N	N	N	N	N	Y	N	N	N
Date FEs	N	N	N	N	N	N	N	Y	N

Notes: The unit of analysis is an immigration case. Dependent variable is a dummy taking value one if decision is favorable to applicant, zero otherwise. Temperature is the 6 AM to 4 PM average in the city in which the case is adjudicated, on the day of adjudication, in Fahrenheit. The temperature measure is divided by 1,000 to reduce decimal places. All regressions control for weather and pollution. Weather covariates include dew point, air pressure, wind speed, precipitation, and cloud cover measured as 6 AM to 4 PM averages in the city in which the case is adjudicated, on the day of adjudication. Pollutant covariates include controls for ozone, carbon monoxide, and $PM_{2.5}$, measured as calendar daily averages at the air quality monitoring station closest to the courthouse of adjudication, on the day of adjudication. Each specification contains other controls as indicated. Column 9 coincides with column 1 from Table 2, our preferred specification. Sample is all cases adjudicated at 42 mainland US federal immigration courthouse locations from January 1, 2000 to September 30, 2004. Standard errors are clustered on city-month in brackets.

Table 4 explores the sensitivity of results to some alternative but plausible specifications.

Much of the related literature on short-term effects of weather and air quality on human outcomes has used the calendar day as its unit of analysis (for example, Hirshleifer and Shumway 2003, Ebenstein et al. 2016, and Park 2016). While this is not our preferred approach, a substantial portion of each calendar day occurs after the court is closed; for example, for comparability, we report in Table 4, column 2 the results of repeating the exercise on a calendar day basis. As would be expected given the introduction of additional imprecision into the way in which the regressor of interest is measured, the estimated coefficients are attenuated somewhat, but retain sign and significance, and are similar in magnitude to Table 2 (−0.750 instead of −1.075 for the preferred specifications).[24]

Decision locations are dispersed widely across the country and in places that exhibit very different weather patterns. This implies that a 90°F day in Phoenix may not have the same effect as such a day in Boston. The inclusion of city-month and year fixed effects should control for unobservable characteristics of that location at that time of year (such as "normal" weather conditions). However, to probe this further, we estimate a variant in which the independent variable of interest is the deviation of 6 AM–4 PM temperature on decision day from the average 6 AM–4 PM temperature for that location in that week of the year. The results of this exercise are

[24] In a further variant, we conducted the exercise using eight-hour blocks (midnight–8 AM, 8 AM–4 PM, 4 PM–midnight). The results (not reported here) parallel those presented.

Table 4—Sensitivity Analyses

	Preferred spec. (1)	Calendar day (2)	Deviation from weekly avg. (3)	City × temp interactions (4)	Winter exclusion (5)	Rain × temp interactions (6)
$Temperature_t/1{,}000$	−1.075	−0.750	−0.618	−1.520	−1.160	−1.238
	[0.274]	[0.256]	[0.309]	[0.466]	[0.330]	[0.298]
$Temperature_t/1{,}000 \times Rain_t$	–	–	–	–	–	−0.336
	–	–	–	–	–	[0.274]
Observations	206,924	168,794	206,924	206,924	156,951	206,924
City × Temperature	N	N	N	Y	N	N
Temperature × Rain	N	N	N	N	N	Y

Notes: The unit of analysis is an immigration case. Dependent variable is a dummy taking value one if decision is favorable to applicant, zero otherwise. Temperature is the 6 am to 4 pm average in the city in which the case is adjudicated, on the day of adjudication, in Fahrenheit. The temperature measure is divided by 1,000 to reduce decimal places. All regressions control for weather, pollution, and time fixed effects. Weather covariates include dew point, air pressure, wind speed, precipitation, and cloud cover measured as 6 am to 4 pm averages in the city in which the case is adjudicated, on the day of adjudication. Pollutant covariates include controls for ozone, carbon monoxide, and $PM_{2.5}$, measured as calendar daily averages at the air quality monitoring station closest to the courthouse of adjudication, on the day of adjudication. Time fixed effects include day of week and year dummies relating to the day of adjudication. Regressions also include city-month fixed effects, name of judge adjudicating case, type of application, and nationality of applicant. Sample is all cases adjudicated at 42 mainland US federal immigration courthouse locations from January 1, 2000 to September 30, 2004. Column 1 repeats column 1 from Table 2, the preferred specification. In column 2, we re-estimate the preferred specification but with the temperature variable defined as calendar day average in Fahrenheit, divided by 1,000. In column 3, we re-estimate the preferred specification replacing the temperature measure with deviation of 6 am to 4 pm average temperature in city of adjudication on date of adjudication from what is average for that city for that week of the year. In column 4, we re-estimate the preferred specification but adding city times temperature interactions. In column 5, we re-estimate the preferred specification excluding cases adjudicated on dates in December, January, and February. In column 6, we re-estimate the preferred specification including rain times temperature interactions. Standard errors are clustered on city-month in brackets.

summarized in column 3. The point estimate on same-day temperature deviation is negative and significant at 5 percent.

The results of an additional exercise to address the concern that the impact of a given temperature treatment may vary by location is reported in column 4. Here we reestimate the preferred specification but now incorporating a vector of *city × temperature* interaction terms, with New York chosen as our reference city. Point estimates on 40 out of the 44 interaction terms are insignificant. As can be seen, inclusion of the interaction terms does not substantially disturb our conclusions.

Most of the evidence that we present points to the depressing effect of hot days on affirmative decisions (this will be confirmed in the non-parametric results that follow). Much of the United States is cold during the winter months, while the whole mainland is mild to hot during the rest of the year. Column 5 reports the results of reestimating the preferred specification but excluding the winter months. Again, the coefficient on temperature retains sign and significance, though it is now somewhat larger in absolute value.

To further confirm the mechanism of influence, in column 6, we perform another robustness check by including interaction term of *precipitation* and *temperature* into our preferred specification. As shown, the point estimate on temperature is negative and significant at 5 percent while the interaction term is statistically insignificant at conventional levels.

In an additional exercise, we explore the role of the gender of the judge. For this exercise we reestimate the preferred regression specifications on the subsample of decisions made by female judges (72,229 decisions made by 95 individuals) and male judges (134,695 decisions made by 171 individuals) separately. In Online Appendix Table A.2. the results of these exercises are summarized in columns 2 and 3, respectively. In each case the point estimate is negative and significant at the 5 percent level. However, the female coefficient is around 6 percent bigger in absolute value. The Hausman test (reported in the lower panel of onine Appendix Table A.2) confirms that the coefficient values are significantly different at the 5 percent level (p-value 0.0325). This is consistent with prior research that temperature-sensitivity is particularly pronounced amongst females (Yu et al. 2010, Xiong et al. 2015). The result also goes some way to address a concern that the patterns that we observe are driven not by the effect of temperature on judgement, but that temperature is instead influencing outcomes by impacting (for example) the comportment of the applicant or his lawyer. If that (or other external-to-judge mechanisms) were the channel we would not expect to see differences based on the gender of the judge.

B. *Nonlinear*

In addition to the conventional linear estimate, we also examine possible nonlinearity in the relationship between temperature and decision outcomes by reestimating using temperature bins 5°F in width, with the 50–55°F bin as the reference category.

The results of this exercise are presented in column 1 of Online Appendix Table A.2 and illustrated in Figure 5. Point estimates are statistically significant and positive when temperature is in the range of 25–30°F and 40–45°F and negative when it exceeds 55°F. They are also meaningful in size. Other things equal, taking a case heard on a day where outdoor temperature is between 50–55°F and dropping it instead into a day where the temperature exceeds 85°F reduces the likelihood of a favorable decision by 6.31 percent.

The negative effects of temperature appear close-to-linear and most of the robustness checks and other exercises that we conduct below will be centered on the linear results.

C. *Robustness*

Table 5 reports the results of a battery of robustness tests.

Pollution.—Recent research points to a possible link from short-term pollution exposure to mood and cognitive function, either of which might influence decision outcomes (Heyes et al. 2016; and Szyszkowicz et al. 2010). While our main specifications include controls for ambient levels of the main pollutants (O_3, $PM_{2.5}$, and CO), concern may remain that we have failed to control adequately for air-quality effects, and that these are confounding our results. If that were the case, then we would expect dropping the whole set of pollution controls to substantially affect our estimate of β_1. In column 1, we report the result of reestimating the preferred specification, but omitting the vector of pollution controls. The estimated coefficient

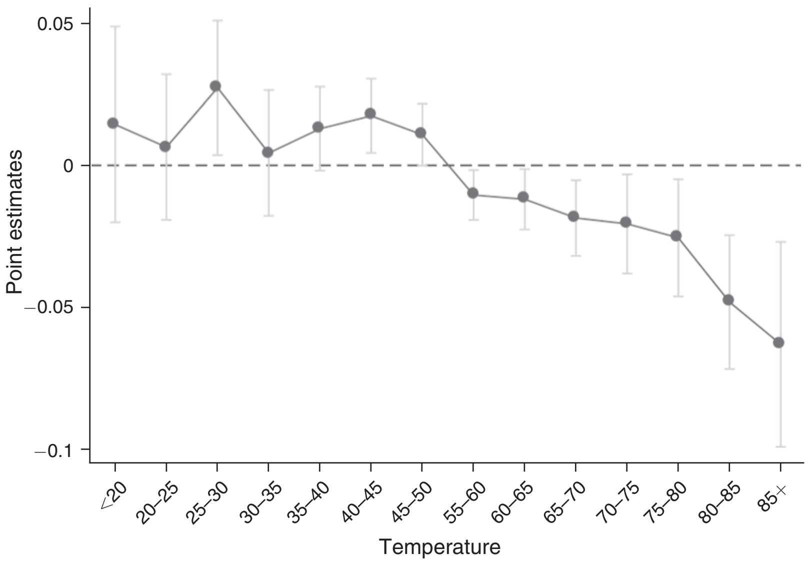

Figure 5. Nonlinear Estimates: Temperature, 6 am–4 pm

Notes: This figure plots the coefficients on the temperature indicator variables from estimation of the nonlinear specification reported in column 1 from Table A.3. Gray lines show the 95 percent confidence intervals based on standard errors clustered on city-month.

Table 5—Robustness

	Pollution exclusion (1)	CA exclusion (2)	Clear sky days (3)	Zero precipitation (4)	Zero precipitation including lag (5)	HI (6)	HI (> 75) (7)	Quartiles exclusion (8)	Deciles exclusion (9)
$Temperature_t/1{,}000$	−0.910	−1.159	−2.738	−1.304	−1.281	–	–	−0.707	−1.064
	[0.269]	[0.384]	[1.144]	[0.318]	[0.328]	–	–	[0.424]	[0.299]
$Heatindex_t/1{,}000$	–	–	–	–	–	−0.437	−1.991	–	–
	–	–	–	–	–	–	[0.195]	[0.772]	–
Observations	206,924	135,184	13,981	133,890	111,361	206,921	29,659	102,408	163,890

Notes: The unit of analysis is an immigration case. Dependent variable is a dummy taking value one if decision is favorable to applicant, zero otherwise. Temperature is the 6 am to 4 pm average in the city in which the case is adjudicated, on the day of adjudication, in Fahrenheit. The temperature measure is divided by 1,000 to reduce decimal places. All regressions control for weather, pollution, and time fixed effects. Weather covariates include dew point, air pressure, wind speed, precipitation, and cloud cover measured as 6 am to 4 pm averages in the city in which the case is adjudicated, on the day of adjudication. Pollutant covariates include controls for ozone, carbon monoxide, and $PM_{2.5}$, measured as calendar daily averages at the air quality monitoring station closest to the courthouse of adjudication, on the day of adjudication. Time fixed effects include day of week and year dummies relating to the day of adjudication. Regressions also include city-month fixed effects, name of judge adjudicating case, type of application, and nationality of applicant. Sample is all cases adjudicated at 42 mainland US federal immigration courthouse locations from January 1, 2000 to September 30, 2004. Column 1 repeats column 1 from Table 2, the preferred specification. Column 2 excludes pollution covariates. Column 3 excludes all cases adjudicated in California. Column 4 is estimated only on cases when 6 am to 4 pm cloud cover was below 10 percent in city of adjudication on day of adjudication. Column 5 is estimated only on cases where there was no precipitation in city of adjudication on day of adjudication. Column 6 is estimated only on cases where there was no precipitation in city of adjudication on day of adjudication or the day before. Column 7 repeats the preferred specification but replacing the temperature variable with heat index. Column 8 re-estimates specification in column 7 but only on cases adjudicated on days when heat index exceeded 75° F. Columns 8 and 9 re-estimate the preferred specification but excluding cases adjudicated by judges in the top and bottom quartile, or top and bottom decile, by overall leniency. Standard errors are clustered on city-month in brackets.

on temperature retains sign and significance, and value changes only a little (-0.910 instead of -1.075).

California.—Of our 43 venues, 6 are located in California (accounting for around 32 percent of all decisions). To rule out that we are picking up something idiosyncratic to California, particularly since our external validity exercise is going to rely on Californian parole data, we reestimate our preferred specification excluding decisions made at courts in that state. This excludes around 71,000 of the 207,000 decisions in the sample. The result of this exercise are reported in column 2 of Table 5. Again, when estimated on the restricted sample, the estimate of β_1 retains sign and significance, and is little-changed in value (-1.159 instead of -1.075). So the pattern that we observed in the data is not being 'driven' by anything particular to California.

Weather.—Columns 3, 4, and 5 probe further the potential confounding role of rain and cloud.

Existing research points to cloud cover as influencing mood (Lambert et al. 2002, Kent et al. 2009, and Hirshleifer and Shumway 2003). We include a continuous variable that captures extent of cloud cover in our main specification to control for this. However, as a further test we reestimate the central specification on those decisions made on "clear sky" days, the subset of days when daily cloud cover is less than 5 percent (results in column 3). The point estimate of β_1 for the subsample estimation remains negative and significant. Though larger in absolute value (-2.738 instead of -1.075), suggesting that elevated temperature has a more pronounced impact on the decision on blue sky days versus non-such days, the difference between the two values is not significant at the 5 percent level.

Similarly rain can influence mood (Denissen et al. 2008). While a continuous measure of precipitation is included in the vector of weather controls, column 4 reports the result of reestimating the preferred specification on the subset of decisions (133,890 of them) made on days in which local recorded precipitation is zero. On such days rain cannot plausibly be argued to have influenced outcomes. The estimated coefficient retains sign and significance and is changed slightly in absolute value (-1.304 compare to -1.075). Column 5 reports the results of pushing this further by repeating the same exercise this time excluding days on which recorded precipitation on either the day of decision or the day before were nonzero (111,361 decisions). Again, the point estimate on the coefficient of interest is somewhat larger in absolute value (-1.281 instead of -1.075), but retains sign and significance.

Heat Index (*HI*).—The way in which temperature is experienced by the human body can itself depend on the water content of the air. Humidity is known to affect both mood and labor productivity (Howarth and Hoffman 1984, Tsutsumi et al. 2007, and Wan et al. 2009). We therefore investigate the joint effect of temperature and humidity in our setting by dropping temperature and dew point from our preferred specification and replacing it with the Heat Index (HI). The HI is used by the US National Weather Service and combines air temperature and relative humidity, via a nonlinear algorithm, into a single metric designed to capture how

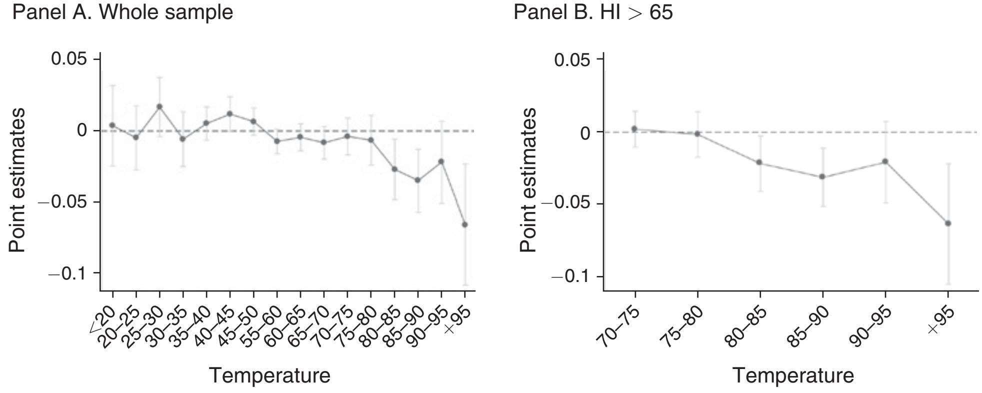

Figure 6. Nonlinear Estimates: Heat Index, 6 am–4 pm

Notes: This figure plots the coefficients on the heat index indicator variables from estimation of the nonlinear specifications reported in columns 2 and 3 from Table A.3. Gray lines show the 95 percent confidence intervals based on standard errors clustered on city-month.

hot it 'feels.' It effectively adjusts upward the dry air temperature for moisture content to provide an index of the discomfort associated with a particular temperature/humidity combination.[25]

Column 6 reports the results of reestimating our preferred specification, but with HI added, and temperature and dew point dropped. Consistent with earlier results, we find a negative and significant effect of heat index on decision outcomes. Though the coefficient here is not directly comparable to those from the various other specifications, the point estimate implies that a 10°F increase in HI reduces the probability of grant decision by 0.44 percent (recall that this is against an average grant rate in the sample of 16.4 percent). However, since HI is primarily regarded as a reliable measure of discomfort only in warm conditions, we also conduct this exercise once more on the subsample of days on which the local heat index exceeds 75°F (column 7). The estimated coefficient on heat index is negative and significant with an absolute value larger than in column 8, though estimated on a much smaller sample.

In Figure 6, panel A and column 2 of online Appendix Table A.2, we repeat this exercise for the HI variant of the analysis, with dew point temperature and temperature omitted as regressors, but HI added. As noted, this provides a plausible way for allowing for the combined effects of temperature and humidity on how heat is actually experienced (how it "feels"). Since HI is only regarded as reliable on warmer days, column 3 of online Appendix Table A.2 and Figure 6, panel B repeat the same exercise for the subsample of days on which HI exceeds 65°F, with the 65–70°F bin as the reference category. Again, the negative impacts of HI exhibit a

[25] Countries including the United Kingdom and France have an alternative index called Humidex that has the same intention and is highly correlated with HI, but is calculated by a slightly different formula. HI and Humidex references are often heard on media weather broadcasts during warmer times of year. The HI is typically seen as a relevant or reliable measure only in warm conditions.

close to linear pattern with the negative effect becoming significant for values of HI exceeding 80°F.

Outlier Judges.—We note in the data section that judges do not have specific quotas with respect to what their grant rates should be; indeed this is an area of the legal system in which judges, sitting alone, are regarded as exercising a very high degree of personal discretion (Ramji-Nogales et al. 2007). To convince ourselves that the result that we are claiming are not being driven by "extreme" judges, we conduct two outlier analyses.[26] In the first, we exclude those decisions made by judges who have a grant rate across the whole study period in either the top or the bottom quartile (just retaining the 'middle half' of judges when ranked in terms of moderation).[27] Column 8 of Table 5 reports the results of this exercise, again, sign and significance is retained and the value of the coefficient is little disturbed (−0.707 instead of −1.075). In the second, we conduct the same exercise but exclude the top and bottom deciles of judges.[28] The results of this is reported in column 9 of Table 5. Again, the sign and significance is retained and the value of the coefficient is little disturbed (−1.064 instead of −1.075).

D. *Placebos*

As further falsification tests we perform three placebo exercises.[29] First, we replace the decision-day temperature series with the temperature at the same location 100 days after decision day, and 100 days before. Second, we replace the decision-day temperature in the vicinity of the courthouse in which the decision was made with the temperature on the same day, but taken from the weather monitoring station *most distant from it* "as the crow flies." For example, for Hartford (Connecticut) the placebo temperature is taken from the NOAA measuring station at Davenport (California) 4,238.72 miles away and for Dallas (Texas) the placebo temperature values are taken from Port Angeles (Washington) 2,792.42 miles away.

The results of these exercises are reported in Table 6. In each case the absolute value of the estimate of the coefficient of interest is several times smaller, signs are mixed, and in no case is statistical significance achieved.

E. *Parole*

Until now we have focused on judges evaluating immigration files. We are not going to claim broad generality of results, though we believe they are highly

[26] For example, suppose there existed a judge who is so extreme that he never found in favor of the applicant (his grant rate was 0 percent). The grant rate of that judge could not go lower upon exposure to high temperature because he is already at the lower bound. Recall that we already have judge fixed effects in all of our main specifications.

[27] This excludes decisions made by judges who have overall grant rates below 8.1 percent or above 22 percent.

[28] This excludes decisions made by judges who have overall grant rates below 4.7 percent or above 31 percent. Note that while we exclude the top and bottom decile of judges, we do not lose exactly 20 percent of our sample of decisions. This is because different judges are associated with different numbers of decisions across the study period.

[29] For this exercise, we limit analysis to mainland US locations (exclude weather stations in Puerto Rico and Hawaii). We ran a wide variety of other placebos with similar (insignificant) results.

Table 6—Placebos

	Preferred (1)	+100 days (2)	−100 days (3)	Furthest monitor (4)
$Temperature_t/1{,}000$	−1.075	−0.000237	0.0000730	−0.00000945
	[0.274]	[0.000148]	[0.000157]	[0.000230]
Observations	206,924	206,924	206,924	206,924

Notes: All specifications coincide with column 1 in Table 2, our preferred specification. Column 2 re-estimates the preferred specification but replacing the temperature variable with the temperature in the city of adjudication 100 days after the case is adjudicated. Column 3 re-estimates the preferred specification but replacing the temperature variable with the temperature in the city of adjudication 100 days before the case is adjudicated. Column 4 re-estimates the preferred specification but replacing the temperature variable with the temperature on the date of adjudication at the courthouse location in mainland United States farthest from the courthouse of adjudication. significant at 10 percent significant at 5 percent significant at 1 percent.

suggestive of what is likely to be a wider phenomenon. However, to probe at least a little into whether the effects that we have identified are unique to the immigration setting, we repeat the central linear and nonparametric analysis for decisions made by parole commissioners in the context of Californian parole hearings.

Table 7 presents results that repeat the main part of our analysis on a calendar day basis using results from the universe of hearings for the period of January 3, 2012 to December 18, 2015 (18,461 in total) as the dependent variable. More concretely, the dependent variable is a dummy that takes the value one if a parole applicant is granted release, and zero otherwise.

The pattern of results presented in Table 7 proves similar to those earlier. Decision-day outdoor temperature has a significant, negative effect on likelihood of a decision to release the applicant. The effect is similar in magnitude to the immigration setting. In the preferred specification (column 1), a 10°F increase in outdoor temperature reduces the probability of a grant release decision by 1.56 percent. Against an average grant rate in the dataset of 16.48 percent this implies a 9.5 percent decrease in the rate of affirmative decisions. We also test the implications of adding a single lag or lead, both individually and concurrently (columns 2, 3, and 4), again finding coefficients on these that are much smaller, mixed in sign, and never achieve significance. That their inclusion or exclusion disturbs the estimated coefficient of interest more than in the immigration case likely reflects the lower day-to-day variation in the mid-California to southern Californian locations of the hearing venues.

Figure 7 depicts the results of nonparametric analysis applied to this setting. Point estimates are negative and statistically significant at 5 percent for temperatures exceeding 65°F. Consistent with the results from the immigration setting, there is close to linear effect of temperature on decision outcomes. Results suggest that compared to a day with average temperature in the 50°F to 55°F bin, the likelihood of releasing an inmate is 2.6 percent lower on a day when the temperature is higher than 85°F. In the context of an overall grant rate of 16.48 percent, this corresponds to a 15.8 percent fall in the rate of decisions favoring the applicant, a substantial effect.

Table 7—Parole: Calendar Day

	Preferred (1)	1-Day lag (2)	1-Day lead (3)	All (4)
Temperature$_t$/1,000	−1.560	−2.188	−1.586	−2.378
	[0.468]	[0.779]	[0.746]	[1.116]
Temperature$_{t-1}$/1,000	–	0.763	–	0.802
	–	[0.720]	–	[0.752]
Temperature$_{t+1}$/1,000	–	–	0.0319	0.194
	–	–	[0.762]	[0.793]
Observations	18,461	18,461	18,461	18,461

Notes: The unit of analysis is a parole case. Dependent variable is a dummy taking value one if decision is favorable to applicant, zero otherwise. Temperature is daily average at the monitoring station closest to the decision venue, in Fahrenheit. The temperature measure is divided by 1,000 to reduce decimal places. All regressions control for weather, pollution, and time fixed effects. Weather covariates include dew point, air pressure, wind speed, precipitation, and cloud cover daily averages. Pollutant covariates include controls for ozone, carbon monoxide and nitrogen dioxide, measured as daily averages at the air quality monitoring station closest to the venue of decision on the date of decision. Time fixed effects include day of week and year dummies relating to the day of decision. Regressions also include venue-month fixed effects, commissioners' name, type of application, and name of inmate. Sample consists of data on all parole hearings conducted by the Board of Parole Hearing (BPH) between January 3, 2012 and December 18, 2015 is from the California Department of Corrections and Rehabilitation (CDCR). Standard errors are clustered on venue-month in brackets. significant at 10 percent significant at 5 percent significant at 1 percent.

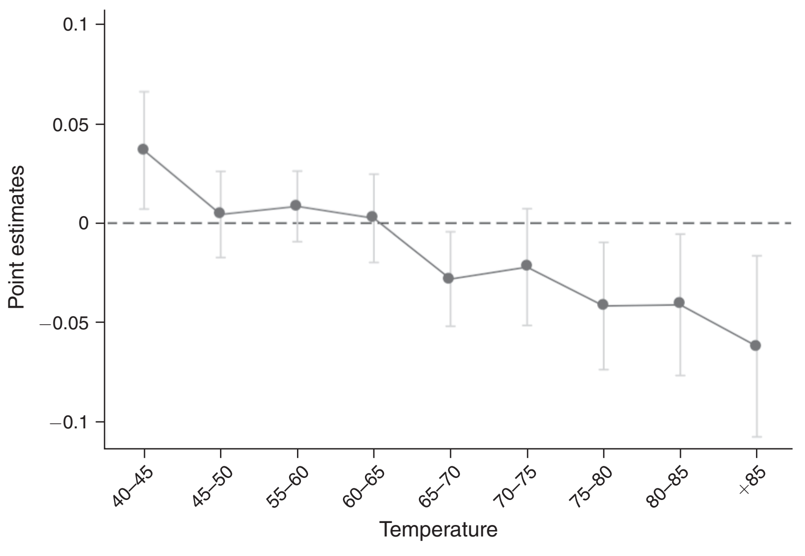

Figure 7. Nonlinear Estimates: Parole, Temperature, Calendar Day

Notes: This figure plots the coefficients on the temperature indicator variables from estimation of a nonlinear variant of the specification reported on column 1 from Table 7. The nonlinear variant replaces the continuous temperature measure with a series of temperature indicator variables of width 5° Fahrenheit. Gray lines show the 95 percent confidence intervals based on standard errors clustered on venue-month.

V. Conclusions

Temperatures vary across space and through time. We present what we believe to be the first evidence, in either a naturally occurring or artificial setting, that same-day outdoor temperature influences indoor decisions. The results extend the finding that outdoor temperature affects the test performance of students (for example, Park 2016) to a high-stakes, workplace 'cognitive output.' Effect sizes are large and robust. Our central estimate is that a 10°F increase in temperature reduces the likelihood of a decision favorable to the applicant by 1.075 percent, which is equivalent to 6.55 percent decrease in the grant rate (the grant rate in the data as a whole is 16.4 percent). To put this into perspective, and recollecting that this is an area of law where judicial discretion is substantial, and it is acknowledged that judges exercise that discretion in quite different ways, hypothetically reassigning a case from a judge at the twenty-fifth percentile in terms of leniency to one at the seventy-fifth percentile decreases the grant rate by 7.9 percent. That we study a naturally occurring setting populated by experienced subjects adds to the likelihood that the effects identified reflect a broader phenomenon.[30] While the evaluation of a file may be sensitive to the case-day behavior of the applicant, and we cannot rule out that part of the effect we uncover works through induced changes in that the heterogeneity of effect between male and female judges points to an internal-to-judge effect. If this was purely a story about overheated applicants changing their comportment, we would not expect the gender of judge in a particular case to matter.

While we don't observe their precise movements nor some other particularities of the indoor conditions in which they work, we can say that this group of professionals work in good quality, climate-controlled environments. Also, presumably, they travel to work and move around their cities in a manner consistent with better-off professional workers (have air conditioning in their cars, etc.). In other words, the subjects that we study are offered a level of protection against weather variations that most people, even office-based professionals, would find quite comprehensive. That despite this we still observe substantial and robust effects of ambient temperatures outdoors to how these individuals are going about their business indoors, makes a case against claims that climate control can be (fully) effective in ameliorating climate impacts.

There are different ways to think about the implications of the results. At the broadest, we provide a bridge from local climate to what is happening indoors, where most high-value employment is based, and where most important work and non-work decisions are taken, even when the agents and the buildings in which they work are adapted to local conditions.

As such, we can, amongst other things, provide a plausible link from local climate to workplace productivity. Of course we rarely have persuasive measures of individual, daily productivity in high-value employment settings (which is why existing research has focused on low-grade jobs such as picking fruit and answering routine calls in a job center). Our setting shares that shortcoming since the job of a judge is quality-driven and we do not observe "right" and "wrong" decisions, even ex post. However, given that the correct arbitration self-evidently does not depend on contemporaneous temperature, *the sensitivity of outcomes to changes in temperature in itself implies welfare inefficiency*. Insofar as the correct arbitration matters, in other

[30] The parole results provided some "out of sample" testing and reassurance that the patterns that we see in the immigration data are not unique to that setting.

words that this is from a societal perspective of a high-stakes setting, the large effect sizes imply that the welfare losses are, in turn, large.

Away from the world of work, decisions are central to human well-being. We all routinely make decisions about what to buy, how to invest, how to vote, when to quit our jobs, etc. If decisions with durable impacts are systematically affected by irrelevant, transient factors, then the potential for individual and welfare loss across many settings is obvious.

One area in which we have been agnostic throughout the paper is channels. Pinning down the mechanism(s) from outdoor temperature to indoor decision processes would be a useful ambition of future work, and probably initially best-suited to laboratory or laboratory-in-the-field methods. The two broad channels that we noted in the introductory review that are consistent with the results relate to mood and cognitive acuity. High temperatures may stimulate temper, irritability (for example in Baylis 2015, Twitter users are more likely to use profanity), and other emotions that might induce a judge to be less well-disposed toward a typical applicant. In addition, depressive mood has been linked to reduced risk appetite. In both the immigration and parole settings denying a request can be plausibly regarded as the risk-averse course of action. Mental fatigue and other effects of heat can reduce mental acuity, which can increase mistakes, and also themselves induce transient increases in risk aversion.

Just as we have sought not to oversell the results, neither should we overstate the limitations. It is widely believed that world average temperatures are rising, as are the frequency of very hot and very cold days. Understanding the full set of social and economic outcomes that extreme temperature can influence is crucial to forming a measured view of the implications of such climate change. That outdoor temperature can have a large, significant, and apparently robust effect on indoor decisions, even when subjects operate in a climate-controlled setting, has potential for how we think about the links from climate to human well-being. The bounds on those effects, and the mechanisms underpinning them, are important foci of ongoing research.

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