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Evidence-based policy making

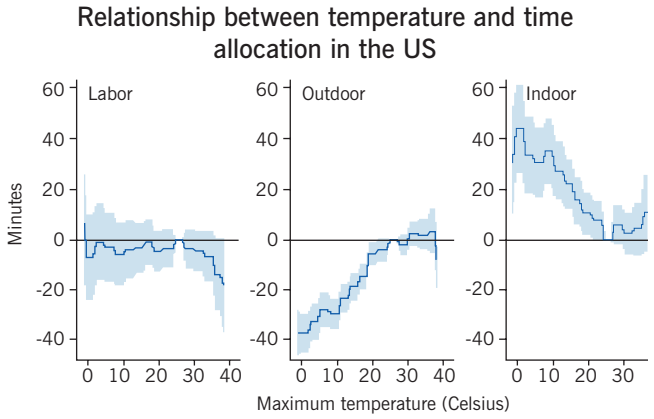
# Climate change and the allocation of time

## In various ways, climate change will affect people's well-being and how they spend their time

Keywords: climate change, weather, time use, well-being, adaptation

## ELEVATOR PITCH

Understanding the impacts of climate change on time allocation is a major challenge. The best approach comes from looking at how people react to short-term variations in weather. Research suggests rising temperatures will reduce time spent working and enjoying outdoor leisure, while increasing indoor leisure. The burden will fall disproportionately on workers in industries more exposed to heat and those who live in warmer regions, with the potential to increase existing patterns of inequalities. This is likely to trigger an adaptation, the scope and mechanisms of which are hard to predict, and will undoubtedly entail costs.




*Source*: [1]; Figure 2.

## KEY FINDINGS

### Pros

- Time spent working only decreases for very high temperature events, which rarely occur, though the effect is strong for workers in high-exposure industries.
- Up to 27°C (80.6°F), time spent outdoors generally increases with temperature.
- Higher winter temperatures may increase time spent on outdoor leisure activities, which bring people more happiness, and are generally more active and thereby healthier.
- Men have been found to work more on rainy days while women's labor supply is fairly stable.
- People, especially those who live in areas with hotter summers, are likely to adapt to changing climate and may thereby avoid significant decreases in well-being.

### Cons

- Predicting people's responses to climate change is inherently difficult.
- Studies have mainly focused on the US and Germany, but climate change is a worldwide phenomenon and results may not be generalizable to other countries.
- Relatively little is known about how time allocation is affected by weather volatility or extreme weather events.
- Warmer summer temperatures are likely to reduce well-being by shifting activities indoors and to have a negative effect on labor productivity.
- The scope and mechanisms of the adaptation to climate change are hard to predict and entail costs.

## AUTHOR'S MAIN MESSAGE

Anthropogenic climate change is predicted to affect the distribution of all climatic variables, including substantial increases in temperatures. Very hot days can lower time spent working and shift leisure from outdoors to indoors. Barring significant—and costly—adaptations, such as increased use of air conditioning or intraday shifting of activities, changing climatic conditions could affect well-being. Despite vast-reaching consequences for humans, little is known about this issue. Developments in terms of data and methodology are desperately needed to shed more light on these effects, which could impact social inequalities, both within and across countries.

## MOTIVATION

Climate change is an issue that will affect all human beings. Climate forecast models for the second half of the 21st century predict a dramatic rise in the number of days featuring temperatures above 35°C (95°F). Though the estimates vary, some models predict that over half of summer days in the US will reach maximum temperatures of above 35°C. How will this affect how people allocate their time? What are the direct and indirect consequences for human well-being and the implications for socio-economic inequalities?

Time is the ultimate finite resource, which puts time allocation at the heart of the human experience. In standard models of labor supply, individuals typically maximize utility, which is a function of their consumption and leisure. A higher wage brings more revenue with which to buy consumption goods, but also a higher opportunity cost of leisure, as measured by foregone earnings. Like any other economic decision, time use responds to various trade-offs regarding the marginal benefits of time spent engaging in various possible activities, subject to a total daily time budget constraint. How one spends his or her time is thus intimately related to economic well-being, since utility is defined by time use.

Ambient temperature has a direct effect on emotional states [2], and it can be conjectured that rising temperatures due to climate change will have a direct effect on well-being. But climate change will also induce changes in time allocation, which have the potential to further affect individual well-being, above and beyond the more direct effects of temperature itself [2]. The study of time use is therefore an important topic that addresses fundamental features of life: time, work, consumption, and well-being. Studies on how weather affects time allocation offer a framework for thinking about the consequences of climate change on well-being, both through direct impacts and through mechanisms via which weather can further affect it, by impacting on related downstream outcomes such as productivity and health.

## DISCUSSION OF PROS AND CONS

### Climate or weather?

While social scientists have long been interested in the relationship between climate and societies, it is only with the increasing availability of data and greater computer power that researchers have been able to perform sound quantitative research on the topic. Recent empirical studies have relied on short-term variations in some weather attributes, such as daily temperatures, to extrapolate the effect of climate (and climate change) on a given outcome, such as mortality. These short-term, or high-frequency, variations are often assumed to be random, or exogenous, and thus have the potential to generate credible estimates of a cause-and-effect response [3].

On the other hand, longer-term, or low-frequency, variations better approximate a permanent change in the climate, and may help capture the effect of beliefs about climate on top of its direct effects. However, the use of historical low-frequency variations is more problematic in terms of pinpointing causal effects, since societies tend to evolve faster than the more gradual changes in climate. As a result, there exists a fundamental

tension among researchers between the benefits of exploiting low-frequency variations and the desire for credible identification [4], [5].

In recent literature, weather variables such as daily maximum or average temperature, rainfall, and wind speed have been linked to health outcomes, agricultural yields, productivity, energy consumption, income, economic growth, migration, crime, and conflict, among others [3]. These linkages enable empirical researchers to enter the response functions of these outcomes to weather shocks in climate projections from the natural sciences, allowing them to predict the effect of climate change [5]. However, this type of projection exercise has not yet been done with respect to time allocation.

## Limited evidence

There is only limited evidence on the role of weather in determining time allocation, probably in part due to the fact that large-scale time use surveys are relatively recent, and that data from such surveys need to be matched with meteorological information at a fairly fine geographical level. Three studies have looked at the direct relation between weather and time use. The first two rely on the American Time Use Survey, conducted annually in the US since 2003 [1], [6]; the third uses time use data from Germany, available from a survey conducted in 2001 and 2002 [7]. However, as climate change is a global phenomenon, studies pertaining to other countries, especially the developing world, would be useful.

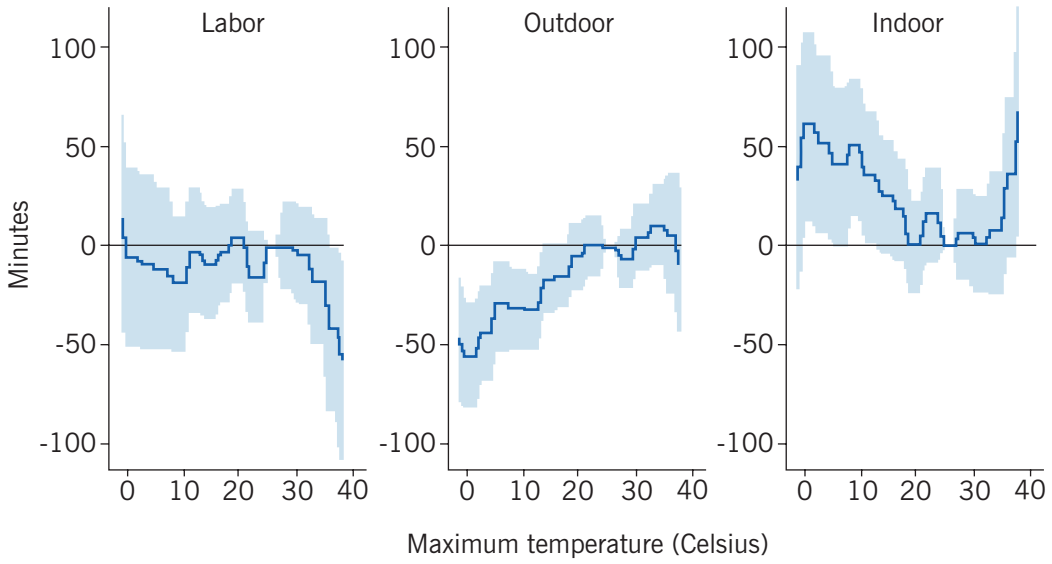
Additionally, only one of the above studies discusses what its findings mean in the context of climate change, but even then it shies away from using climate projections to make predictions about the evolution of time use [1]. The other two use exogenous temporary variations in the weather to proxy a change in the shadow cost of leisure, which can be thought of as a wage rate, and thus focus on the estimation of the effect of a wage change in one period on future hours of work [6], [7].

Despite limited evidence on the narrow topic of the impacts of weather and climate changes on time use, there are some studies where time allocation, though not the direct focus, is at the heart of the mechanisms explored. For example, in one study that estimates the preferences of US households over local climate attributes, it is clear that the value of climate amenities is determined by the exposure to climate, which itself depends on time allocation [8]. This study finds that a daily average of 18°C (65°F) is the most preferred temperature, and that households are on average ready to pay more to avoid excess heat than cold, together implying that welfare losses will result from climate change that brings higher average temperatures. Behavioral adjustments, including changes in time use, have also been argued to be at the center of the relationship between temperature and morbidity, specifically in a study looking at US emergency hospital visits in California [9]. In this study, hotter days are associated with increased hospital visits, and colder ones with a concurrent decrease followed by a total net increase over the next 30 days. The author posits that if people spend more time indoors during colder days, they could face more exposure to contagious illnesses due to indoor crowding, thus leading to poorer health outcomes in the following days.

## Temperature's impact on work time and leisure

For the general population in the US, temperature does not have a marked effect on time spent working: a downward trend can be observed (with less work at higher temperatures) in the illustration on page 1, but the magnitudes of the effects are small and the estimates are not statistically different from zero [1]. However, as can be observed in Figure 1, the impact is larger for workers in industries that feature a high exposure to heat, defined here as agriculture, forestry, fishing and hunting, mining, construction, manufacturing, and transportation and utilities. For this group, which represents about 15% of the sample, a decline in work time is seen for temperatures above 29°C (85°F), reaching an hour less of daily work time for days with maximum temperatures above 38°C (100°F) compared with those when the mercury only reached 24–27°C (76–80°F). This is consistent with a declining marginal productivity of labor at very high temperatures [10], and is reinforced by findings showing that the effect is more likely to happen at the end of a work day [1]. Estimates from Germany do not differentiate between high- and low-exposure industries, but consider differences in gender as well as the flexibility of the work contract [7]. Men do not appear to reallocate their time in response to daily temperature shocks, while women report working less on cold days—below 4°C (39°F)—and more on the hottest days—above 34°C (93°F)—though it is not clear how many observations fall in that high temperature range. Interestingly, the flexibility of the work arrangement does not seem to matter for the responsiveness of time allocation to temperature.

Figure 1. Relationship between temperature and time allocation for high-risk industries




*Note*: High risk industries are agriculture, forestry, fishing, and hunting, construction, mining, transportation and utilities, and manufacturing.

*Source*: Graff Zivin, J., and M. Neidell. "Temperature and the allocation of time: Implications for climate change." *Journal of Labor Economics* 32:1 (2014): 1–26 [1]; Figure 3.

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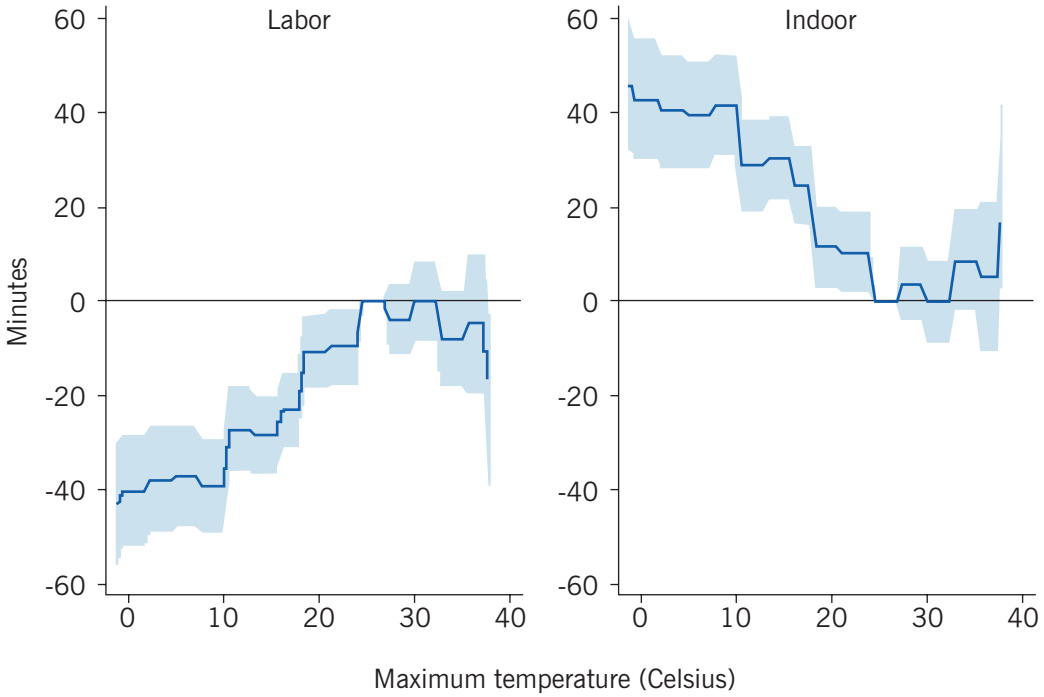
As seen in the illustration on page 1, time spent in outdoor leisure by those in the US declines steadily when maximum temperatures drop under the 24–27°C (76–80°F) range [1]. At −4°C (25°F), outdoor leisure averages 37 minutes less than at

24–27°C. Above that range, the time spent outdoors is fairly stable for the general population, while a decrease is observed for the non-employed, who generally display larger responses (Figure 2). Indoor leisure follows an inverse relationship, with one main difference: very high temperatures are associated with an increase in indoor leisure time. At temperatures above 38°C (100°F), time spent on indoor leisure is 27 minutes longer than for the 24–27°C range. The availability of indoor air conditioning allows individuals to avoid exposure to very high temperatures, by shifting leisure from outdoors to indoors. In the German study, women appear to substitute their work time for leisure at very low temperatures, but high temperatures do not trigger a statistically significant response [7].

Figure 2. Relationship between temperature and leisure time allocation for the non-employed




*Source*: Graff Zivin, J., and M. Neidell. "Temperature and the allocation of time: Implications for climate change." *Journal of Labor Economics* 32:1 (2014): 1–26 [1]; Figure 5.

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## Milder winters, hotter summers, and changes in precipitation patterns

Taken together, the estimated direct effects of temperature on outdoor and indoor leisure could imply significant changes in the type of leisure that people will engage in in the future. Hotter summers are likely to mean less time outdoors and more time indoors, to avoid intensive heat exposure. Conversely, milder winters could trigger a shift from indoor to outdoor leisure. The combined welfare effect of hotter summers and milder winters is unclear, and depends on the extent to which one balances the other. Outdoor activities are generally associated with higher subjective well-being than indoor ones, and with more physically active recreation [11]. There is also a geographic component to be considered: areas that are already warmer, such as the southern US, may see more declines in well-being than areas in the northern parts of the country, with potential consequences for inequality [1]. However, this only considers direct effects,

which are the narrowly defined consequences of climate change on well-being operating through changes in time allocation. Indirect effects cascading from changes in time allocation could have a far wider range of impacts, affecting, for example, health and productivity (though these channels have not yet been fully worked out). There are also costs associated with avoidance behavior, whether done through shifting of activities or reliance on air conditioning.

Rainy days are associated with, on average, 30 more minutes of work and 25 fewer minutes of leisure for men in the US [6]. While magnitudes vary slightly, this result is fairly robust across a variety of subgroups defined by attributes such as occupation, region, or type of climate. Women display significantly lower responsiveness to precipitation, with the only result being a small increase in time spent in leisure on rainy days. This could potentially be explained by the fact that, compared with men, women spend less of their leisure time in active sports participation, thus relying less on outdoor sports time. Indeed, women spend, on average, more of their home production and leisure time indoors rather than outdoors on rainy days, whereas men reduce both indoor and outdoor non-work time, to compensate for the extra time spent at work. Findings for Germany, however, do not show much responsiveness to precipitation [7]. These results have been used, based on the intensity of rain for a given day, to estimate the response of hours of work to a change in the wage rate over time, and have found small effects, in line with most of the literature in labor economics [6]. Consequences of climate change include more frequent extreme weather events, an increased variability of precipitation, and a change in the geographical distribution of rain. As such, the impacts of climate change on precipitation are anticipated to be far more varied than the impacts on temperature, and the implications for time allocation have yet to be carefully studied.

## Adaptation strategies and substitution behavior

When trying to predict the effects of climate change on time allocation, the question of adaptation must be considered: people are likely to adapt by modifying their behaviors and making investments to avoid the unpleasant consequences of rising temperatures. Although little evidence is available when it comes to time use, researchers have investigated adaptation to climate change for a number of different outcomes, such as crop yields and damage from tropical storms [3]. Comparing how various populations respond to climate variables has made the study of adaptation possible: a more highly adapted group will have a flatter response to a given weather variation, given its ability to adapt and avoid. From this literature an interesting puzzle has emerged: the so-called "adaptation gaps." Some groups appear already quite well adapted to shocks in certain dimensions. For instance, mortality resulting from very hot days has been found to be lower in hot climates than it is in colder climates, where such hot days are less common and adaptive behaviors (such as the availability of air conditioning) are less developed. But in other dimensions, very little adaptation has been documented: in the US, responses of crop yields and economic productivity to heat have not changed much over time, despite technological innovations. These adaptation gaps have been attributed to various factors, such as costs of adaptation, incentives, credit constraints, or weak governments, but the evidence on the topic is still developing. A better understanding of what makes certain populations adapt more effectively and under which circumstances

is a top priority, given the potentially large and unequally distributed impacts of climate change on well-being [3].

In the context of time allocation, a number of adaptation responses have been investigated, starting with interday substitution: individuals may shift activities across days in order to avoid unpleasant weather, or to take advantage of pleasant days. This intertemporal substitution has been the focus of studies on precipitation which found significant interday substitution between labor and leisure on rainy days [6]. When it comes to temperature responses, time spent working for high-exposure workers do not display patterns of interday substitutions; however, the time spent outdoors for the non-employed does [1]. This suggests that people who do not work spend less time outdoors on very hot days, but then increase their outdoor leisure on following days to make up for the lost time.

Another form of avoidance behavior is intraday substitution, where activities are shifted to times of day when temperatures are lower. To investigate how much this intraday shifting occurs, the responses to temperature can be estimated separately for daytime activities and for twilight activities, where daytime is defined as the time interval from two hours after sunrise to two hours before sunset, and twilight is in the first two hours after sunrise and the two hours right before sunset. Time at work for workers in heat-exposed industries responds to twilight high temperatures much more than it does to daylight temperatures, and that is particularly true for twilight hours at the end of the day [1]. This would seem to indicate that these workers are constrained in their labor supply decisions during core business hours, but that they are able to avoid unpleasantly high temperatures at the end of the work day. The non-employed also display patterns of intraday substitution, by reducing their outdoor leisure time more during daylight than during twilight.

Short-term adaptation can occur as individuals get used to rising temperatures in a relatively short period of time. One way to look at this is to see if people display flatter responses in high temperatures in August compared to June, that is, toward the end of the summer when they have had more exposure to heat over the course of the season. Both work time for the high-exposure workers and outdoor leisure time for the non-employed display responses to very high temperatures of larger magnitudes in June than in August, though because of smaller sample sizes the differences do not turn out to be statistically significant [1].

Adaptation can also occur over a longer time period: people who live in areas with hotter summers may already be better equipped to deal with very high temperatures when compared with people who reside in cooler climates. This adaptation is perhaps the type that would be expected to be more important when considering climate change, given its longer time horizon. To investigate this dimension of adaptive behavior, one can look at people's responses to high temperatures depending on whether they live in a US county that historically has had hot or cool summers. The overall pattern of less time at work for workers in high-risk industries and less outdoor leisure time for the non-employed holds for both warm and cool summers; however, the responses displayed by individuals in counties with cool summers are markedly larger, though still not statistically different to the warm-summer ones, given the smaller sample sizes [1]. This again is coherent with a form of adaptation, whereby people who are more used to extreme heat become better prepared to deal with such events.

## LIMITATIONS AND GAPS

Time use is central to the human experience, since hours of work and hours of leisure determine basic well-being in standard labor supply models. Yet, there is scant evidence regarding the consequences of climate change on time use. A good start is to use short-term variations in weather conditions to estimate responses to meteorological conditions. While this is a challenge in itself, it raises additional questions when attempting to use this technique to project people's behavior in the future, because the projections will be based on existing data that cover the current range of temperatures. Careful analysis is needed to make the leap toward climate change and the uncertain changes in temperature and weather patterns that this will entail.

Methodological concerns notwithstanding, researchers' knowledge on this topic so far covers only two countries, the US and Germany. Moreover, despite what is already known about adaptive behaviors, there is still much uncertainty, as all the current evidence on this matter is based on a single study using US data. The possibility and consequences of, for instance, migration to cooler regions, both within and across countries, has not been formally studied in the context of time allocation. Neither have the costs been taken into account when comparing the various adaptation mechanisms described previously, nor the effects on the existing patterns of socio-economic inequality. Finally, dimensions that have been largely absent from the study of climate change and time use are those related to the increased variability of weather patterns or increased likelihood of extreme weather events.

A very real possibility exists that current patterns of inequality could rise as those with the means to adapt (both within a country like the US, and between developed and developing economies) use their resources to avoid the most unpleasant effects of increasing temperatures. An interesting approach might be to think of time allocation as a mediating variable between climate change and outcomes like health or subjective well-being; this is pointed to in recent research that investigates the relationship between temperature and morbidity, which concludes that behavioral changes in response to weather can affect health [9]. Another avenue for expanding current knowledge would be to update the existing study for the US [1] by including additional years of data from the American Time Use Survey, which currently offers an additional nine years of data at the time of writing. These additional data points would give researchers more power to identify desired effects.

## SUMMARY AND POLICY ADVICE

Predicting the implications of climate change on time allocation is a difficult task. Previous work using US data has shown that people respond to short-term higher temperatures by reducing time spent at work and engaging in outdoor leisure, and by increasing indoor leisure. However, a leap has to be made to infer responses to long-term, gradual climate change. By its very nature, climate change will bring temperatures and other weather elements outside of their current ranges, making inference difficult. Moreover, societies can, and will have to, adapt to their new realities. Understanding this adaptation is crucial to be able to distinguish the short-term effects of climate change from its longer-term ones. Furthermore, most of the research has focused on the US, whereas the

impacts of climate change will be felt globally. Developing economies likely have fewer resources to invest in adaptive strategies, with potentially substantial consequences for increasing inequality. Policies that facilitate adaptation will help reduce associated costs. For example, allowing more flexible working hours would enable people to adapt more easily to hot temperatures, by shifting their working hours to cooler moments of the day or to cooler days.

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## Competing interests

The IZA World of Labor project is committed to the *IZA Guiding Principles of Research Integrity*. The author declares to have observed these principles.

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## Further reading

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