Here Comes the Rain Again: Weather and the Intertemporal Substitution of Leisure

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I revisit the intertemporal labor supply framework, using exogenous variations in daily weather to see how time at work varies with rain. In my model, a rainy day is associated with a lower enjoyment of leisure, effectively increasing wages and bringing more hours at work. I test the model using data from the American Time Use Survey, supplemented with daily weather. I find that, on rainy days, men shift on average 30 minutes from leisure to work. Computations give a rough estimate of the intertemporal elasticity of labor supply of around 0.01, in line with the rest of the literature.

I. Introduction

Weather and climatic conditions more generally affect everyday life considerably. Some activities can only be engaged in or are more enjoyable during particular weather conditions. People rarely decide to make a trip to the beach or play tennis outdoors on a rainy day. However, a majority

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of Americans work indoors, where the weather does not matter. Casual observation suggests that workers might want to modify their work schedule in order to take advantage of good weather conditions. Suppose that an individual knows that today will be a great day while tomorrow it will rain. If at all possible, he or she might decide to leave work early in order to enjoy an outdoors activity, postponing work to a future date. In this article I will try to measure the extent to which workers respond to daily fluctuations in weather conditions by substituting future leisure for current leisure. Following Lucas and Rapping's (1969) seminal paper, I will first develop a model of intertemporal labor supply in which weather conditions affect the enjoyment of leisure. I will then use the American Time Use Survey (ATUS) 2003 and 2004 data—which have the distinctive feature of reporting daily time diaries for Americans all over the United States for every day of the year—coupled with weather records from over 8,000 individual weather stations, to test the weather-influenced behavior described in the model. Weather here is considered as an exogenous shock, about which individuals may have an idea ahead of time but whose actual realization is only known the same day.

Lucas and Rapping (1969) proposed a model that aimed to reconcile two divergent assumptions: the long-run labor supply that seems to be inelastic to the wage rate and the short-run, infinitely elastic, labor supply. Within a two-period intertemporal labor supply framework, they modeled unemployment (hours of work variations) as being voluntary leisure, a response to temporarily low wages. This model has become the basis for much of the subsequent work on labor supply and the intertemporal substitution effect, particularly the effect of wage variations (see Blundell and MaCurdy's [1999] *Handbook* survey). Macroeconomists often rely on intertemporal labor supply in the labor market part of their general models, and they have typically needed to assume unrealistically high elasticities for simulations to yield credible results. Labor economists, on the other hand, have argued that Lucas and Rapping's model has not fared too well empirically. In an appraisal of the research on intertemporal labor supply, David Card (1994, 72) concludes: "My assessment is hardly positive: the only real success for the model has come as a description of aggregate patterns in wage and hours during the post-1970 period. Even here, my suspicion is that a careful consideration of wealth effects undermines the success of the model." Ham and Reilly (2002) also reject the intertemporal substitution model, using data from the Panel Study of Income Dynamics (PSID) and the Consumer Expenditure Survey (CES). Labor economists by and large only find support for a low elasticity of labor supply.

Farber (2005, 46–47) points out that "one criticism of this literature is that the standard neoclassical model assumes that workers are free to set their hours in response to changes in the wage or, alternatively, can select a job with the optimal wage-hours combination from a dense joint distribution of jobs. Evidence that neither of these are credible assumptions is that the distribution of hours is quite lumpy, with a substantial fraction of workers reporting usual weekly hours of precisely forty." Biddle (1988, 347) estimates an intertemporal labor supply model, looking separately at constrained and unconstrained workers, and argues that "the assumption that workers are in general free to vary their hours of work on a period-to-period basis leads to a misspecification in the standard empirical life-cycle labor supply model." Challenging the conventional view of labor supply, a few recent papers have looked at jobs held by individuals such as taxi drivers (Camerer et al. 1997; Farber 2004, 2005) and bike messengers (Fehr and Goette 2002), in which workers can effectively choose their daily hours of work. Oettinger (1999) studies stadium vendors who, while unable to choose how many hours they want to work on a particular shift, have total freedom in their daily participation decision.

The ATUS data provide a unique opportunity to take a fresh look at labor supply. With daily work time calculated in minutes, the lumping at 8 hours a day or 40 hours a week should be greatly reduced. I propose to abstract from wage considerations and look at how the labor supply is affected by a truly exogenous variable: the weather. The time horizon I consider is the very short run, where wages do not vary and workers do not change employer or renegotiate their wage-hour contract. I do not examine how much an individual wants to work weekly or yearly at a given wage rate but rather examine how much he would adjust, on the margin, his daily working hours in reaction to the weather. I assume that the traditional labor supply decision has been made previously, upon the signing of the job contract. In this case, I am interested only in the marginal adjustments on a given day in response to exogenous weather shocks. In a similar vein, Neidell (2006) found that Californians respond to smog alerts by avoiding outdoor leisure activities on the smog alert days.

The only other study about the effect of the weather on time use of which I am aware is the one by Huysmans (2002), which uses the Netherland's Time Budget Survey. This survey is conducted every 5 years during the first 2 weeks of October. Huysmans noticed that, while in 1975, 1980, 1985, 1990, and 1995 the weather was quite pleasant, it was rather dreary in 2000. He controls for temperature, precipitation, sunshine, and wind, and he finds that the weather has a significant effect on the time spent sleeping, watching television, reading, participating in sports, walking and cycling outside, using transportation of various forms, as well as on spending leisure time spent outside the home. The weather did not seem to have any influence on the amount of free time or the time spent going out to restaurants or cultural or sporting events. While Huysmans's results are interesting, they do not shed much light on the question I want to explore in this article. First, Huysmans's time-use data cover only 2 weeks of the year. Second, data on weather conditions come from only one weather station in the Netherlands. The data used in this study cover a much longer time span, 2 years, and the weather information is much more precise since it comes from over 8,000 individual weather stations located across the United States.

In my study, I define a rainy day as a day with at least 0.10 inches of rain in 24 hours. My findings show that men work 30 more minutes and have an average of 25 minutes less leisure on rainy days. The findings for women are mixed. The magnitude of the response varies by region, with men in very dry climates working 48 minutes more. The impact of a rainy day on the previous day is also examined, in order to discover if an intertemporal substitution can be observed. Indeed, a rainy day yesterday reduces the time spent at work by an average of 6 minutes for men. A rough estimate of the intertemporal elasticity of labor supply is computed, with a result of about 0.01, which is in line with the rest of the labor economics literature.

The article is organized as follows. Section II describes the theoretical model of intertemporal labor supply. Section III presents the data and the empirical strategies. Section IV discusses the findings of this study, and Section V presents its conclusions. There is also a data appendix.

II. A Model of Intertemporal Labor Supply

My model of intertemporal labor supply is based on Lucas and Rapping's (1969) classic model, which they apply to unemployment. In this model, an individual's utility is a function of current and future leisure, L_t and L_{t+1}, where the index t indicates the time period.[1] The individual's problem is to maximize utility with respect to his intertemporal budget constraint, which depends on wages W_t and W_{t+1} and on the discount rate r. The time horizon is reduced to two periods, t and $t+1$. While in the original model a time period is a long interval, here I will consider a period to be 1 day. Today is t, tomorrow is $t+1$. It may seem that a longer time horizon (multiple days or infinite horizon) needs to be taken into account, but since I am looking at the impact of high-frequency shocks, I argue that two periods are enough to convey the intuition of the model. Moreover, the idea here is to investigate the intensive margin of work (minutes of work in a day), not the extensive margin (taking a vacation day). Workers may be constrained in the horizon over which they reallocate their effort, perhaps because of job-specific deadlines or a behavioral explanation, such as not wanting to appear to be shirking. This constraint means that the elasticity of labor supply will be underestimated. The budget constraint here differs from Lucas and Rapping's

[1] For simplicity of argument, consumption is left out of the picture, as the analysis of leisure remains unchanged.

as it refers to a situation where a worker has a fixed commitment to his employer and is supposed to work a certain number of hours today (N_t) and tomorrow (N_{t+1}).[2] The worker has the ability to allocate more of his time to one day or the other, as long as his total income reaches a set lower bound, C, that was previously established when the job contract was entered into. There is an additional time constraint, which says that total daily time, T, is equal to time devoted to leisure, L_t, and time in market work, N_t.

Now suppose that in each period there is a randomly drawn state of nature, s_t, that represents the quality of the weather. A value of s above one, its expectation, would mean a better day than usual. This state of nature enters directly into the utility function and affects the utility obtained from leisure. The weather is drawn separately each day. I do not worry about modeling the possibility of persistence (tomorrow's weather being a function of today's) since, in the data, shocks to the weather, conditional on month, county, and normal levels of precipitation, are transitory. I assume that the weather does not affect wages, does not increase the demand for labor, and does not put an additional constraint on time at work. This is clearly restrictive, since certain types of occupation are directly affected by the weather. For example, in his study of stadium vendors, Oettinger (1999) finds that, through their effect on baseball game attendance, temperature and rainfall have an impact on the wage and thus on the participation decision of the vendors. Other workers might simply see their workday cancelled or shortened because of inclement weather. I will keep this in mind when the time comes to look at the data, but in the case of the theoretical model, I will continue to assume that only leisure enjoyment is affected by the weather. Casting the problem in terms of leisure, I have the following:

$$\max_{L_t, L_{t+1}} U(s_t L_t, s_{t+1} L_{t+1}) \tag{1}$$

subject to the budget constraint

$$W_t N_t + \frac{W_{t+1}}{1+r} N_{t+1} \geq C \tag{2}$$

and the time constraints

$$\begin{aligned} T &= N_t + L_t, \\ T &= N_{t+1} + L_{t+1}, \end{aligned} \tag{3}$$

[2] In Lucas and Rapping (1969), the budget constraint states that current and future discounted consumption expenses need to be covered by current and future discounted labor income plus initial wealth.

where T is total available time in a day.

Assume that $U(.)$ is concave and has negative double derivatives, the utility function being twice continuously derivable and behaving nicely. Only internal solutions are considered since I am solely interested in workers and their marginal adjustments of time at work. Under certainty, the problem can be solved to obtain the following relationship between current and future leisure:[3]

$$\frac{\partial U/\partial L_t}{\partial U/\partial L_{t+1}} = \frac{W_t/s_t}{W_{t+1}/s_{t+1}}(1 + r). \tag{4}$$

If the weather today and tomorrow is average, that is, $s_t = s_{t+1} = 1$, then we are back to the original Lucas and Rapping model, where the ratio of the marginal utilities of current and future leisure is equal to the ratio of the current and future (discounted) wages. What I am interested in here is the effect of today's weather, s_t, on the leisure decision. If a worker wakes up one day and observes that s_t is greater than s_{t+1}, meaning that the weather is nicer today than it will be tomorrow, in order to preserve the equality in equation (4), he will need to lower $\partial U/\partial L_t$ and increase $\partial U/\partial L_{t+1}$ (compared to a case of $s_t = s_{t+1} = 1$). This will amount to increasing current leisure and decreasing future leisure, or, in other words, to substituting present for future leisure. I will assume here that wages do not change between t and $t + 1$ and that r is, for all practical purposes, zero. The model implies that the demand for leisure crucially depends on the ratio of current to future s.

The model presented above assumes that workers have flexible working hours, which will not be true for every worker. Evidence from the May 2004 Current Population Survey (CPS) Supplement shows that 27.5% of full-time and salaried workers (note that the data exclude self-employed workers) report having a flexible schedule and that flexibility varies a great deal among occupations and somewhat among other covariates, such as race or sex (Bureau of Labor Statistics, 2005a). In a comparison of work schedules in the United States and Germany, Hamermesh (1996, 24) notes that self-employed workers, possibly the most flexible type of worker, demonstrate a much greater variance and skewness in both work hours per day and days worked per week. Devine (2001, 246) finds, in a study of self-employed women using SIPP (Survey of Income and Program Participation) data that their distribution of work hours is quite different from that of wage-and-salary women. She attributes this fact to the hypothesis that self-employed women have much greater control over their work schedule. In light of the above evidence, I will compare the responsiveness to weather shocks for workers in different occupations,

[3] I formulate the problem under certainty, since no real insight is gained by looking at it under uncertainty.

whether they are self-employed, paid by the hour, or salaried, to take into account the fact that not all workers may be able to marginally adjust their work hours.

III. Data and Empirical Strategy

A. ATUS Data

The American Time Use Survey is a time diary study that collects information about how people spend their time during a day. The first wave of data, covering the calendar year 2003, was made publicly available in January 2005, while the 2004 data was released in September 2005. The ATUS sample is drawn from households that have completed their final (eighth) month in sample for the Current Population Survey (CPS). One individual (age 15 or over) from each selected household is randomly chosen to answer the ATUS questionnaire, and he or she is interviewed only once about his or her time use during the previous day. Some variables from the eighth month in sample in the CPS are included in the ATUS data; a few are also updated during the ATUS interview. To get geographical information, however, it was necessary to go back to the last CPS interview to have the county or MSA/PMSA code.[4] Activities are coded using a three-tiered system, with 17 major (first-tier) categories. For the current analysis, the total number of minutes spent at work, in home production, and in leisure were compiled. Table A2 in the appendix lists which activities fall into each of the time variables. The appendix also contains some additional information about the data. Excluded from the three main aggregates (work, home production, and leisure) are the following time-use activities: sleeping, eating, personal care, personal activities, education, and other/unable-to-code activities.[5] Together they account for around 10 hours a day on weekdays and 11 hours on weekends, sleeping alone taking 7.7–9 hours a day and eating about 1 hour per day. Because the rain pattern may also influence sleeping, eating, and the other omitted categories, the effect of a rainy day on the main activities may not sum up to zero.

B. Weather Data

The data on weather come from the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA).[6] For data on the actual weather conditions, daily summaries

[4] The data appendix contains a discussion on supplementing the ATUS data with geographical identifiers.

[5] Except for education, these activities are what Burda, Hamermesh, and Weil (2007) call *tertiary activities*. Education only accounts for 3 minutes a day in my sample.

[6] The data can be downloaded from http://www.ncdc.noaa.gov/oa/ncdc.html.

from over 8,000 weather stations located across the United States were used. These correspond to the data sets 3200 and 3210, which contain information on four types of meteorological elements: maximum and minimum daily temperatures, daily precipitation, and daily snowfall. A rainy day is defined as a day with 0.10 inches of rain or more, to avoid classifying as rainy a day featuring a little morning dew or a very short drizzle. It would be interesting to obtain cloud cover data, especially since cloudiness has been documented in the psychological literature as having a significant effect on mood. Unfortunately, this information is only collected at a few stations, making the sample size too small for the purposes of this analysis. Data on normal temperatures and precipitation levels are also available from the data set CLIM84, which is based on the weather from 1971 to 2000. A list of the variables, as well as their summary characteristics, can be found in table 1.

C. The Twain Hypothesis

Mark Twain is famous for saying "Everybody talks about the weather, but nobody does anything about it."[7] The model of intertemporal labor supply presented in Section II suggests that workers actually *do* do something about the weather. To estimate the impact of the weather on time allocation, the time spent on each of the three major time-use categories—work, home production, and leisure—is regressed on the weather variables. Home production, while not explicitly part of the model, represents a major possible use of time and an alternative to work or leisure, and thus it makes sense to include it in the analysis. All regressions are weighted using the ATUS sampling weights.[8] I will dub the null hypothesis that the coefficients on the weather variables are zero as the Twain hypothesis. The following section presents the findings testing this hypothesis. Could a potential bias affect the results if people chose where they lived based on the climate and on which leisure activities they enjoy? Rappaport (2004) observes that local population growth in the United States is highly correlated with warmer winter weather and cooler, less humid summer weather. He argues that people are moving to areas with better weather due to an increasing valuation of this factor's contribution to their quality of life, which is, in turn, due to rising real incomes.

[7] The exact origin of this quote could not be found, except in Robert Underwood Johnson's book, *Remembered Yesterdays* (1923, 322): "Nor have I ever seen in print Mark's saying about the weather 'We all grumble about the weather, but (dramatic pause) . . . but nothing is done about it.' He was a master in the piquant use of the pause at the right moment." Some also say that it is actually Twain's collaborator on *The Gilded Age*, Charles Dudley Warner, who wrote the statement.

[8] Following the Bureau of Labor Statistics guidelines (Bureau of Labor Statistics 2005b, 10), the weights used were TU04FWGT for 2003 and TUFINLWGT for 2004.

Table 1
List of Variables and Their Summary Characteristics

Variable	Males (N = 6,585) Mean	Males (N = 6,585) Standard Deviation	Females (N = 6,921) Mean	Females (N = 6,921) Standard Deviation
Partner present	.704	.456	.646	.478
No child	.551	.497	.536	.499
Age	40.434	11.171	41.215	11.292
Hourly worker	.458	.498	.531	.499
Salaried	.420	.494	.386	.487
Self-employed	.123	.328	.083	.276
Union covered or member	.148	.356	.127	.333
Student	.038	.192	.059	.236
Education:				
Less than high school	.106	.308	.074	.261
High school	.289	.453	.278	.448
Some college	.173	.378	.184	.388
College	.310	.463	.337	.473
More than college	.122	.327	.128	.334
Occupation:				
Management, professional, and related	.382	.486	.433	.496
Service	.115	.319	.175	.380
Sales and office	.162	.368	.323	.468
Farming, fishing, and forestry	.007	.081	.002	.047
Construction and maintenance	.172	.377	.007	.085
Production, transportation, and material moving	.164	.370	.059	.236
Weekend day	.299	.458	.288	.453
Weekday time use (in minutes):				
Work (including commute)	503.781	225.125	410.308	237.420
Leisure	228.378	155.598	207.281	148.029
Home production	117.758	136.613	208.161	178.343
Commute	43.226	48.888	31.994	42.330
Weekday time use, proportion reporting zero hours:				
Work (including commute)	.096	.294	.164	.370
Leisure	.039	.192	.048	.214
Home production	.185	.388	.066	.249
Commute	.177	.381	.259	.438
Daily normal precipitation	10.520	5.485	10.485	5.395
Rainy today dummy (t)	.243	.429	.240	.427
Rainy yesterday dummy ($t-1$)	.252	.434	.240	.427
Rainy tomorrow dummy ($t+1$)	.222	.416	.236	.424

Note.—The means and standard deviations are weighted using the ATUS sampling weights. Precipitation is measured in hundredths of an inch. A day is considered rainy if it rained 0.10 inches or more in a 24-hour period.

However, the model tested here is not interested in the effect of the climate on time allocation but rather on the impact of an exogenous weather shock, which cannot be predicted and which is not part of an individual's residential choice, so I believe that the estimates should not be biased but should be seen as conditional on the potential sorting.

IV. Findings

A. Regression Results

This analysis will focus on the impact of rain. Data on temperature, temperature normals, and snowfall were available, but no clear pattern emerged from the inclusion of these variables in the regressions. Different specifications were tried, using the mean temperature, the normal mean temperature, dummies for whether the day's temperature was above or below the normal, and dummies for 10-degree temperature bands and for extreme weather. None of these attempts produced a conclusive result. However, precipitation, rather than temperature, has a much more unambiguous effect on the enjoyment of leisure. I assume that no rain and no snow is what makes a nice day. Tables 2 and 3 present the coefficients of ordinary least squares regressions of time use on precipitation variables for men and women, respectively.[9] The regressors include an indicator of whether or not the day surveyed was on a weekend, the daily normal precipitation (to partially control for different climates across the country and across the seasons), and indicators for all possible interactions of the rain dummies, that is, variables indicating whether the previous day, the day surveyed, or the following day were rainy days. There are eight (2^3) possible scenarios, and we will focus on the following: no rain at all, rain only today, and rain only yesterday. No rain at all is the omitted category in the regressions. Other controls include age and age squared, dummies for level of education, presence of partner, children, union status, student status, month, and region. An *F*-test of the joint significance of the rain dummies is reported (to test the Twain hypothesis).

Table 2 contains coefficients from the regressions for men only, where each column reports a separate regression. The *F*-tests show that the rain dummies are jointly significant in the time at work estimation and the home production one, but not so in explaining leisure.[10] However, individual dummies are significant in the leisure equation (col. 2), notably the one for rain today. The picture for women in table 3 appears to be different from the one for men: the only significant *F*-test is the one in the leisure regression. To make sense of the coefficients, the following tables will report the fitted values $\bar{x}\hat{\beta}$ for different weather scenarios, thus

[9] Ordinary least squares are preferred to regressions that take into account the censoring at zero (since time cannot be negative), because I am interested in the overall effect. Tobits and Powell's estimator of a censored LAD (implemented using Buchinsky's suggestion, with 20 repetitions) were tried, but the results are not presented. See Deaton (1997, 89) for more details on Buchinsky's method. The findings are similar, mostly due to the small number of zeroes in the data (almost none for leisure and home production and around 10% for work).

[10] The time at work includes commuting time. Regressions were run using only work, excluding commuting, and the results are similar. There does not appear to be an effect of rain on overall commuting time.

Table 2
OLS Regressions of Time Use on Precipitation Variables, Males Only

Dependent Variable (in Minutes)	Work (1)	Leisure (2)	Home Production (3)
Daily normal precipitation	.511	.426	−.586
	(.628)	(.481)	(.417)
Rainy today dummy (t)	29.525*	−25.051*	−10.877
	(12.784)	(9.801)	(8.491)
Rainy yesterday dummy ($t-1$)	−5.917	−3.566	2.948
	(9.831)	(7.537)	(6.529)
Rainy tomorrow dummy ($t+1$)	12.287	−7.061	−7.368
	(10.852)	(8.320)	(7.208)
Rainy yesterday and today dummy	−50.585**	27.621+	33.287**
	(18.887)	(14.480)	(12.544)
Rainy yesterday and tomorrow dummy	−2.268	22.663	9.134
	(23.531)	(18.041)	(15.629)
Rainy today and tomorrow dummy	−15.654	19.52	11.07
	(19.814)	(15.191)	(13.160)
Rainy everyday dummy	47.675	−28.808	−55.484*
	(32.979)	(25.284)	(21.904)
Weekend day	−360.949**	176.220**	99.241**
	(6.217)	(4.767)	(4.129)
Constant	371.592**	363.567**	10.917
	(41.401)	(31.741)	(27.497)
F-test of rainy dummies	2.890	1.430	3.090
Pr > F	.010	.190	.000
R^2	.35	.20	.12

NOTE.—Robust standard errors are in parentheses. Regressions are weighted using the ATUS sampling weights. Precipitation is measured in hundredths of an inch. A day is considered rainy if it rained 0.10 inches or more in a 24-hour period. The regressions also include controls for education, age, and age squared, and dummies for presence of partner, children, union and student status, region, and month. $N = 6{,}534$.
+ Significant at the 10% level.
* Significant at the 5% level.
** Significant at the 1% level.

showing the expected time spent in the various activities (on weekdays). For each regression, the p-value associated with the F-test of the joint significance of the rain dummies is reported. The top line of table 4 shows that men respond to a rainy day by working 30 more minutes, having 25 fewer minutes of leisure and 11 fewer minutes in home production activities.[11] For women (table 5), a rainy day is associated with 3 more minutes at work and 6 more minutes in leisure, and 2 minutes less in home production, a response far less than the men's. Rain of the day before the survey brings 6 minutes less work than no rain at all for men, a hint at intertemporal substitution: if it rained the previous day and more work was done, then today time may be freed up to have more leisure. The evidence for women is weak.

[11] The effects do not necessarily sum up to zero because of the omission of some tertiary activities (see comment at the end of Sec. III.A). The influence of the rain on these other activities remains small and is generally not significant.

Table 3
OLS Regressions of Time Use on Precipitation Variables, Females Only

Dependent Variable (in Minutes)	Work (1)	Leisure (2)	Home Production (3)
Daily normal precipitation	1.402*	−.555	−.218
	(.605)	(.439)	(.474)
Rainy today dummy (t)	3.065	6.715	−2.117
	(12.401)	(9.002)	(9.706)
Rainy yesterday dummy ($t-1$)	3.734	1.54	−7.109
	(9.703)	(7.044)	(7.595)
Rainy tomorrow dummy ($t+1$)	9.377	−9.259	3.568
	(9.745)	(7.074)	(7.627)
Rainy yesterday and today dummy	−19.342	17.089	−6.445
	(18.338)	(13.312)	(14.353)
Rainy yesterday and tomorrow dummy	22.292	−23.382	−12.81
	(22.063)	(16.017)	(17.269)
Rainy today and tomorrow dummy	−2.521	−6.751	−5.717
	(18.630)	(13.524)	(14.582)
Rainy everyday dummy	−42.251	43.237+	18.801
	(31.229)	(22.671)	(24.443)
Weekend day	−317.925**	136.653**	87.418**
	(5.971)	(4.334)	(4.673)
Constant	134.174**	344.495**	156.354**
	(38.658)	(28.064)	(30.258)
F-test of rainy dummies	1.790	4.680	.910
$\Pr > F$	.080	.000	.500
R^2	.31	.15	.15

NOTE.—Robust standard errors in parentheses. Regressions are weighted using the ATUS sampling weights. Precipitation is measured in hundredths of an inch. A day is considered rainy if it rained 0.10 inches or more in a 24-hour period. The regressions also include controls for education, age, and age squared, and dummies for presence of partner, children, union and student status, region, and month. $N = 6{,}859$.
+ Significant at the 10% level.
* Significant at the 5% level.
** Significant at the 1% level.

While the analysis focuses on the overall effect of a rainy day, a few words about the extensive margin are in order here. To delve into the issue of weather-related absenteeism and to figure out the relation between the overall effect described by the OLS results and the decision of workers to skip work altogether on a nice day, probits were run, regressing presence at work on the weather and control variables. For men, a rainy day is associated with a significant 5.2% rise in probability of work. If the extra men working on a rainy day spend the average time at work, 504 minutes, then the extensive margin would account for 5.2% × 504 = 26 minutes of the total effect, that is, most of the 30-minute total effect. Interestingly, when the same effect is calculated for different subgroups of the data, only the full-time workers and men outside of the Sunbelt have a significantly higher probability of working on a rainy day (by 6.2% and 8.0%, respectively). There does not appear to be an effect of the rain on the extensive margin of work for women. Results obtained by using subsamples of the data are presented next.

Starting with the responsiveness to weather shocks across weekdays, a difference is observed, with the men's response to a rainy day on Monday and Friday being larger: up to 50 more minutes of work and 30 minutes less in home production, as compared to 31 more minutes of work during midweek. The fitted values $\bar{x}\hat{\beta}$ do not change substantially between those obtained using only weekdays and those using all days and adding the β corresponding to weekdays.

The next cut of the data is by type of worker, that is, if the worker reported being hourly paid, salaried, or self-employed. Surprisingly, the effects are much stronger for hourly workers than for the other types, with a rainy day bringing about 65 more minutes of work and 52 fewer minutes of leisure. It even seems that the hourly workers are driving the results for the whole sample. This is surprising because we would expect salaried workers to have a more flexible schedule and, since they are not paid by the hour, they should be more inclined to respond to transitory shocks. The findings suggest the contrary, which means that another factor comes into play. A behavioral explanation, such that hourly workers have fewer responsibilities and therefore less commitment to their jobs, could explain this result. Men in hourly jobs might find it easier to cut out from work early and not feel like they should be working instead.

Next, the data are split according to occupation groups. Apart from results for the few men in farming, fishing, and forestry, who unsurprisingly work considerably less on rainy days, most of the results confirm the overall trend: there is more work and less leisure on rainy days, less work and more leisure on days after a rainy day. The one exception is for workers in sales and office occupations, who significantly report 6 fewer minutes of work on a rainy day.[12] The interesting result is that they report even less work when the previous day was rainy as well. Perhaps long spells of rain reduce the affluence in stores, thus sending some of the sales and office workers home on these days, akin to the farmers who drastically reduce work time on rainy days. Not too much weight should be placed on the results for the farming and fishing occupations, however, due to the very small sample size.

It seems logical to think that the weather affects people differently in different areas of the country. Some places have a much more unpredictable climate than others. Southern California and Florida, for example, can be thought to be usually sunny, just as Seattle in the winter is likely to be wet. Other places, such as the Northeast, have more variable, less predictable, weather patterns. Would that influence the reaction of workers to weather shocks? The regressions were run separately for dry and

[12] The results hold for both of the subgroups of sales and office workers.

Table 4
Expected Time at Work, in Leisure, and in Home Production, under Various Rain Scenarios, by Characteristics, Males Only

	Expected Time in Activity on Weekdays (in Minutes)												
	Work				Leisure				Home Production				
	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	N
All	500.8	530.3	494.8	.005	231.3	206.3	227.8	.188	117.9	107.0	120.8	.003	6,534
Day of week:													
Weekday	496.4	536.0	504.1	.086	231.3	207.9	227.4	.717	118.4	106.0	120.1	.004	3,135
Weekend	151.1	151.7	111.5	.004	408.1	377.6	403.3	.237	214.0	213.5	222.5	.531	3,399
Monday/Friday	470.1	520.3	505.9	.060	238.2	215.7	203.5	.034	130.3	99.8	105.9	.004	1,253
Midweek	514.1	545.3	498.8	.121	225.8	200.3	245.4	.042	111.7	114.0	127.6	.074	1,882
Type of worker:													
Hourly	468.8	533.7	464.2	.006	250.5	198.1	233.7	.004	121.1	101.4	132.4	.000	2,743
Salaried	535.7	543.4	529.8	.288	212.7	206.2	208.7	.683	112.1	106.2	108.9	.876	2,954
Self-employed	493.7	472.4	470.9	.645	224.7	230.0	283.1	.024	129.1	131.7	124.3	.790	837
Occupation:													
Management, professional, and related	526.6	563.8	524.6	.026	218.9	191.6	209.0	.064	114.7	111.3	114.8	.906	2,779
Service	428.7	464.6	485.9	.251	257.5	235.4	196.6	.066	126.6	117.8	126.3	.001	666
Sales and office	493.6	487.6	467.1	.028	244.6	211.0	262.0	.024	114.9	120.8	110.5	.761	1,055

Farming, fishing, and forestry	804.4	709.6	234.9	.389	45.2	677.1	−229.2	.235	66.5	−75.2	394.0	.239	37
Construction and maintenance	511.5	532.1	465.0	.036	225.4	190.0	235.1	.078	114.6	96.1	139.9	.190	990
Production, transportation, and material moving	485.3	535.0	486.8	.358	242.2	208.9	260.3	.280	122.7	106.5	123.3	.498	1,007
Climate:													
Dry climate	493.2	539.5	492.7	.085	232.4	180.4	223.6	.009	121.1	118.0	118.2	.328	3,201
Wet climate	508.7	522.3	497.9	.094	231.1	226.1	231.1	.848	113.4	98.7	121.0	.002	3,333
Very dry climate	490.9	538.3	460.6	.143	230.5	164.6	238.3	.368	116.9	109.4	133.2	.474	1,615
Very wet climate	482.0	512.6	484.4	.008	246.8	218.3	251.7	.224	121.7	102.5	117.3	.605	1,791
Region:													
Sunbelt	518.0	538.5	452.6	.012	221.5	189.2	241.4	.369	105.6	100.1	137.7	.004	2,420
Non-Sunbelt	489.4	525.1	506.9	.017	237.4	213.7	226.4	.154	125.7	112.7	117.1	.006	4,114

NOTE.—A day is considered rainy if it rained 0.10 inches or more in a 24-hour period. The *p*-values are for *F*-tests of joint significance of the eight rain dummies. Time on weekdays, except for the weekend only specification. States in the Sunbelt are AL, AZ, CA, FL, GA, LA, MS, NM, NV, SC, and TX. The regressions also include controls for education, age and age squared, presence of partner and children, union and student status, region, and month.

Table 5
Expected Time at Work, in Leisure, and in Home Production, under Various Rain Scenarios, by Characteristics, Females Only

	Expected Time in Activity on Weekdays (in Minutes)												
	Work				Leisure				Home Production				
	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	N
All	410.8	413.9	414.5	.084	205.1	211.8	206.6	.000	209.8	207.7	202.7	.498	6,859
Day of week:													
Weekday	412.2	415.4	405.5	.318	204.1	215.2	206.5	.000	235.4	229.4	230.9	.382	3,355
Weekend	89.5	95.1	115.2	.136	344.0	337.2	342.5	.803	212.1	208.4	206.2	.621	3,504
Monday/Friday	400.3	354.1	395.9	.399	213.4	245.9	215.6	.054	292.0	293.1	284.6	.252	1,302
Midweek	419.7	453.0	410.7	.415	198.8	197.6	204.5	.012	212.4	216.4	211.4	.942	2,053
Type of worker:													
Hourly	385.5	407.3	393.6	.119	214.4	198.2	217.2	.000	214.7	222.3	205.9	.670	3,534
Salaried	457.1	466.6	463.5	.882	191.6	214.8	191.4	.309	189.8	162.5	180.5	.196	2,742
Self-employed	352.5	296.4	333.5	.756	203.0	277.8	209.4	.169	275.2	273.0	269.0	.995	583
Occupation:													
Management, professional, and related	431.2	443.6	435.1	.805	200.3	183.7	201.7	.274	207.6	203.6	190.5	.184	3,136
Service	344.4	346.9	325.9	.070	229.5	282.3	238.5	.000	238.0	233.5	230.6	.165	1,077
Sales and office	413.2	427.7	418.6	.338	202.0	204.7	200.8	.235	198.1	191.7	207.4	.841	2,201

Construction and maintenance	450.1	451.7	537.1	.459	184.0	320.7	215.4	.021	189.5	.4	63.1	.649	48
Production, transportation, and material moving	433.5	404.9	426.4	.519	191.3	189.5	185.2	.905	205.3	228.2	237.3	.046	381
Climate:													
Dry climate	405.2	412.1	407.0	.004	204.7	224.0	211.1	.029	210.7	200.4	209.1	.931	3,303
Wet climate	417.4	416.7	421.3	.495	205.2	202.1	205.8	.003	209.0	213.5	198.2	.581	3,556
Very dry climate	406.3	447.4	408.3	.335	210.2	210.1	215.4	.272	204.8	155.8	197.1	.456	1,690
Very wet climate	416.5	432.1	411.5	.374	214.3	205.1	199.5	.002	201.4	209.5	213.1	.914	1,948
Region:													
Sunbelt	404.3	419.5	402.5	.061	201.6	204.0	214.7	.000	210.4	184.7	209.9	.023	2,433
Non-Sunbelt	414.8	411.4	420.6	.021	207.5	216.6	203.5	.000	209.3	213.9	201.3	.264	4,426

NOTE.—See note for table 3. Farming, fishing, and forestry occupations are not shown because too few observations fall in that category.

wet climates, as well as for Sunbelt and non-Sunbelt states.[13] Do workers react differently to the weather if they live in a generally nice climate? The normal number of rainy days in a month were used to determine the type of climate: a climate was considered dry if in the bottom half of the number of rainy days per month, and wet if in the upper half. Very dry and very wet climates were identified by using the bottom and top quartiles, respectively. While the significance of the rain dummies is confirmed only in the very wet climate regressions, it is also interesting to note that the extent of the responsiveness is larger at the extremes of the distribution and in the dry climate more generally. In very dry and very wet climates, a rainy day is associated with 48 and 30 more minutes at work, respectively, relative to 47 and 14 extra minutes for dry and wet climates. A striking difference also comes when looking at Sunbelt versus non-Sunbelt states. A rainy day in the Sunbelt is, for men, associated with 20 more minutes at work, 32 less in leisure, and 6 less doing house work. The effect on the time at work is larger outside of the Sunbelt, reaching 36 minutes. However, men outside the Sunbelt are also more prone to absenteeism, with the extensive margin accounting for $8.0\% \times 498 = 40$ minutes, so all of the effect. With this in mind, the intensive adjustment caused by a rainy day is higher in the Sunbelt, with its 20 minutes, as compared to no effect outside of it.

Looking now at table 5, the equivalent of table 4 but for women, it appears that the most robust result is indeed that women spend more time in leisure on rainy days, contrary to men. All but two of the regressions of time at work are insignificant (the only significant ones show that women work 7 minutes more on rainy days in dry climates and 3 minutes less outside of the Sunbelt), and few of the ones of home production are insignificant, with a rainy day generally being associated with less time in home production. The regressions were also run separately for women with children and women without children, but few differences emerged, and significance was harder to obtain. The theory of Section II posits that rain reduces the value of leisure. But surely it depends on which type of leisure, whether indoor or outdoor leisure. The same could be said for home production: outdoor housework is probably not as pleasant on a rainy day. Women's leisure time is composed of less active sports participation than men's, which could explain why they report more leisure on rainy days. Table 6 presents the expected time spent in outdoor home production and leisure versus non-outdoor home production and leisure and separately in television watching, which is part of non-outdoor leisure and by far the single greatest leisure activity of

[13] States in the Sunbelt are California, Nevada, Arizona, New Mexico, Texas, Louisiana, Mississippi, Alabama, Georgia, South Carolina, and Florida.

Table 6
Expected Time in Outdoor and Non-outdoor Home Production and Leisure, and TV Watching, under Various Rain Scenarios, by Characteristics

	Expected Time in Activity on Weekdays (in Minutes)												
	Outdoor Home Production and Leisure				Non-outdoor Home Production and Leisure				TV Watching				
	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	N
A. Men:													
All men	7.2	1.8	4.6	.254	342.0	311.5	343.9	.005	114.3	109.4	115.3	.374	6,534
Type of worker:													
Hourly	6.9	−2.5	3.5	.104	364.7	302.0	362.6	.000	127.3	114.8	116.1	.315	2,743
Salaried	7.2	4.2	4.7	.692	317.6	308.2	312.8	.744	99.1	107.0	101.9	.455	2,954
Self-employed	8.5	7.6	8.6	.525	345.3	354.1	398.8	.157	116.6	102.1	161.6	.245	837
Region:													
Sunbelt	6.5	−2.2	.7	.332	320.6	291.5	378.4	.002	110.9	112.6	115.6	.145	2,420
Non-Sunbelt	7.3	3.7	6.5	.779	355.8	322.6	337.0	.037	116.0	109.6	117.3	.359	4,114
B. Women:													
All women	7.4	4.7	5.0	.135	407.4	414.7	404.3	.046	96.1	95.2	94.6	.000	6,859
Type of worker:													
Hourly	8.0	3.6	4.5	.210	421.1	416.8	418.6	.058	106.1	91.9	106.3	.000	3,534
Salaried	6.4	6.0	5.4	.538	375.0	371.2	366.5	.898	86.1	91.6	80.5	.119	2,742
Self-employed	8.8	6.8	7.7	.405	469.3	544.0	470.7	.444	79.6	126.0	77.9	.130	583
Region:													
Sunbelt	7.3	4.6	6.7	.259	404.7	384.1	417.9	.080	98.9	79.9	100.3	.000	2,433
Non-Sunbelt	7.7	4.9	4.1	.295	409.1	425.6	400.7	.005	94.7	99.3	92.7	.040	4,426

Note.—A day is considered rainy if it rained 0.10 inches or more in a 24-hour period. States in the Sunbelt are AL, AZ, CA, FL, GA, LA, MS, NM, NV, SC and TX. The regressions also include controls for education, age and age squared, and dummies for presence of partner, children, union and student status, region, and month. The p-values are for F-tests of the joint significance of the eight rain dummies.

Americans.[14] Overall, women appear to reduce outdoor activities by 3 minutes on a rainy day and to increase their indoor activities by 7 minutes, while television watching is mostly unaffected (reduction of less than a minute). Most of the different cuts of the data confirm these findings, with the responsiveness appearing larger in the Sunbelt, as well as for self-employed women. The results for men consistently show less participation in home production activities and leisure on rainy days, whether indoor or outdoor. None of the *F*-tests for the television watching regressions comes out as significant, but if anything, men appear to watch less television on rainy days. Perhaps it could be due to baseball games that get postponed because of the rain, thus giving sports fans less interesting things to watch on the tube. Of course, the response here is to rain at the home location, not necessarily the game location, so the effect might be mitigated.

Finally, a comparison between full-time and part-time workers is made. Table 7 presents those results. The previous conclusion about men—more work and less leisure on rainy days—seems to hold for full-time workers but not for part-time workers. Part-time male workers display 36 fewer minutes of work and 37 fewer of leisure on rainy days. Interestingly, home production then sees an increase of 40 minutes for part-timers, whereas there is a drop of 12 minutes for full-timers. This suggests that those who work part time have much more flexibility in their nonwork time. Results for nonworkers are presented as a point of comparison: they show roughly no change in leisure and slightly less home production on a rainy day. For part-time women, who form a greater fraction of workers than part-time men, a rainy day brings about 41 more minutes of work, 1 more minute of leisure, and 29 fewer minutes of home production, while nonworkers engage in significantly more home production on rainy days.

B. An Intertemporal Elasticity Estimate

In order to compare my findings with those of others in the intertemporal labor supply literature, I convert the half hour effect of a rainy day into a rough, but informative, elasticity estimate. To derive the elasticity, I need $d\ln \text{hours}/d\ln \text{wage}$, or $(dh/h)/(dw/w)$. Table 2 provides an estimate of $d\,\text{hours}/d\,\text{rainy day}$ for men, and thus the missing part to compute the

[14] I say non-outdoor and not indoor because, while the data identify activities that occur in an outdoor location unequivocally, indoor locations are not as well defined. In particular, home and yard are identified as the same location, and here they both fall into the non-outdoor category unless the specified activity was yard work.

Table 7
Expected Time at Work, in Leisure, and in Home Production, under Various Rain Scenarios, by Worker Status

	Expected Time in Activity on Weekdays (in Minutes)												
	Work				Leisure				Home Production				
	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	No Rain at All (000)	Rain Only Today (010)	Rain Only Yesterday (100)	p-Value	N
A. Men:													
All men	500.8	530.3	494.8	.005	231.3	206.3	227.8	.188	117.9	107.0	120.8	.003	6,534
Full-time men	519.1	551.4	508.5	.004	220.9	195.9	228.4	.080	115.9	103.3	112.3	.153	6,108
Part-time men	295.4	259.2	351.6	.390	358.7	321.7	209.6	.000	125.7	165.2	226.3	.000	426
Nonworking men	. . .	. . .	. . .	. . .	479.2	473.8	436.7	.005	235.9	234.6	241.7	.436	850
B. Women:													
All women	410.8	413.9	414.5	.084	205.1	211.8	206.6	.000	209.8	207.7	202.7	.498	6,859
Full-time women	465.7	457.9	465.5	.643	190.3	198.0	193.9	.281	177.8	186.4	172.2	.560	5,131
Part-time women	248.0	289.4	262.6	.328	248.6	250.0	247.4	.000	304.6	275.3	288.2	.021	1,728
Nonworking women	. . .	. . .	. . .	. . .	337.8	322.7	357.0	.376	420.0	467.8	439.2	.038	2,353

Note.—A day is considered rainy if it rained 0.10 inches or more in a 24-hour period. The regressions also include controls for education, age and age squared, and dummies for presence of partner, children, union and student status, region, and month. The p-values are for F-tests of the joint significance of the eight rain dummies.

elasticity is an estimate of the value of a rainy day, or the effect of a rainy day on wages, as seen in equation 5:

$$\eta = d\ \ln \text{hours}/d\ \ln \text{wage} \tag{5}$$
$$= \left(\frac{d \ln \text{hours}}{d \text{ rainy day}/\text{rainy day}}\right) \times \left(\frac{d \text{ rainy day}/\text{rainy day}}{d \ln \text{wage}}\right).$$

For that, I turn to the literature on quality of life and compensating differentials, in which wages or earnings and rents or housing prices are regressed on local attributes. The idea here is that, in order to accept employment in an area with disamenities, workers require a compensating wage differential. Roback (1982) estimates the value of various amenities using data from the May 1973 CPS Supplement, and one of the amenities is number of cloudy days. I use this as an approximation of rainy days and compute the elasticity η (evaluated at the mean) as follows:[15]

$$\eta \approx \left(\frac{d \text{ hours}}{d \text{ rainy day}}\right) \times \left(\frac{\text{rainy day}}{\text{hours}}\right) \times \left(\frac{d \text{ cloudy day}}{d \ln \text{wage}}\right) \times \left(\frac{1}{\text{cloudy day}}\right)$$
$$\approx 0.5 \times \frac{0.243}{8.3} \times \frac{1}{0.0072} \times \frac{1}{146.98} = 0.0138. \tag{6}$$

The intertemporal elasticity of labor supply for men that I find is very small, which is in line with that elasticity found in the rest of the labor literature (Pencavel 1986; Card 1994; Blundell and MaCurdy 1999). Turning the problem around and looking at the impact of an exogenous and transitory shock to the value of leisure instead of to the wages gives the same result, which is reassuring. Even though this elasticity estimation is only a rough approximation and uses data from more than 30 years ago, it would be hard to get a much larger elasticity. Indeed, one can see by looking at the results from table 2 that the elasticity of hours with respect to rainy days is about 0.015, and one would need an improbably much smaller elasticity of wages with respect to rainy days to arrive at a larger intertemporal elasticity.

V. Conclusion

This study proposed a model of intertemporal substitution of labor in which the enjoyment of leisure is a function of the weather. Bad weather shocks would induce workers to forgo some leisure today and work longer. Using American Time Use Survey data for 2003 and 2004 matched with weather reports, the impact of a rainy day on the time spent in work, home production, and leisure was examined. For men, a rainy day shifts

[15] The variance of η is computed using the delta method and gives a standard error of .00705.

about half an hour from leisure and home production to work. This effect varies greatly by region, with very dry areas showing the largest effect. There, the impact of a rainy day on work reaches 48 minutes. The Twain hypothesis, expressed as the *F*-test of the joint significance of the weather variables, in most cases is rejected. Some evidence of an intertemporal effect is found. On average, men work less when yesterday was rainy, which I attribute to the fact that, since they got more work done yesterday, they can enjoy more leisure today. Different subgroups of the population seem to have different responsiveness to the weather shocks. In particular, part-time workers appear to shift more of their time between home production and leisure, as compared to full-time workers for which rain has more of an impact on work and leisure. Contrary to intuition, hourly workers have a much larger response to the rain than do salaried workers.

While the model presented in this article is about weather conditions in general, only rain seems to have a clear impact. It would be interesting, especially for work on absenteeism, to have a better idea of what makes a good day in terms of temperature and other meteorological elements. This would enable a better testing of the model. Furthermore, the model made a complete abstraction of the effect of the weather on mood, which is well documented in psychology. It would also be of interest to investigate how weather, through mood, affects time allocation, or the impact of weather on productivity at work, which is not measured in the ATUS. My findings also suggest that weather has a direct effect on work time, as bad weather can close down workplaces or prevent people from doing their work. A more complete model would include that effect, as well as the possibility of weather affecting wages and labor demand.

Adequate modeling of intertemporal substitution effects is important to evaluate the impact of various policies on the labor market. While the intertemporal labor supply model has generally fared poorly in empirical tests (Card 1994), in this article I find significant evidence of intertemporal adjustment to a high-frequency exogenous shock, the rain. However, the intertemporal elasticity computed from the results is very small, in line with the rest of the literature. The model tested here considers a very short horizon, and the findings raise the question of which time horizon is relevant when studying labor supply. Looking at too long a horizon may dampen effects that matter in the short run, while very-short-run models such as the one used here may only be applicable to lower-frequency events under stringent conditions. Future work needs to be done to shed more light on the interactions between the short run and the long run if more plausible labor supply models want to be tested.

In the end, I reject the Twain hypothesis that "everybody talks about the weather, but nobody does anything about it." I might not know how much they talk about it, but I do find that the weather does have an impact on workers' time allocation.

Appendix

Data Appendix

With data from the American Time Use Survey (ATUS), it is not possible to identify precisely the geographical location of all respondents. When no geographical identifier other than the state was available, the observations were dropped. The top panel of table A1 shows the number of observations lost in the process. It may be of concern that I dropped individuals who systematically differ from those I kept. To address this concern, I tested for differences between the group of observations that are dropped and those that are kept. It was not surprising that a major difference between the two groups is the proportion living in a metropolitan area, since counties with fewer than 100,000 inhabitants (those for which the ATUS does not contain precise geographical information) are much more likely to be in a rural area. The differences in the mean characteristics of the two groups follow the direction expected from an urban versus rural population. Urban people are, overall, more educated, and they tend to work more in management, professional, sales, and office-related occupations. Rural people are more likely to be in farming, fishing, and forestry occupations, as well as in construction, maintenance, production, transportation, and material moving jobs. More business and farm owners are in the group that I have dropped. I have also retained relatively more people from the Northeast and the West. How many of these differences can be explained by metropolitan status alone? When controlling for metropolitan status, most of the differences became insignificant, especially those pertaining to the time-use categories of work, home production, and leisure. Thus, when looking at the analysis, please bear in mind those characteristics of the subgroup with which I am working. I believe it was preferable to look at mostly urban people, rather than to imperfectly impute state-level weather to the observations for which no geographical identifier other than the state of residence was available.

Once I had the geographical information, I matched the observations with county-, MSA-, or PMSA-level weather data, depending on which identifier I had. When multiple weather stations were within the same area, an average of the weather measurements was used. From my sample size of 24,526, I then dropped observations according to a few criteria. First, observations that correspond to a holiday (New Year's Day, Easter, Memorial Day, the Fourth of July, Labor Day, Thanksgiving Day, and Christmas Day) or a semi-holiday (Martin Luther King's Birthday, Presidents' Day, Columbus Day, Veterans Day, and the day after Thanksgiving) were dropped, because they probably do not reflect the usual behavior of workers. For a similar reason, the days between Christmas and New Year's were also dropped, because even though they are not holidays per se, many people take that week off, which could have distorted the results.

Then, because I am only interested in the reaction of workers to the weather, I dropped nonworkers, as well as retirees and full-time students. I kept the part-time students. Finally, I dropped individuals below 20 years of age and those age 65 and above. The bottom panel of table A1 shows how I arrived at the final sample size of 13,506 individuals.

The ATUS uses a three-tiered coding system for the activities it lists. Transportation is listed as a separate activity in the first tier, with the second tier showing the purpose of the transportation. Time in transportation is lumped with the activity it is related to. Table A2 shows which activities make up each of the three main time-use categories of work, home production, and leisure, as well as the ATUS codes for those activities.

Table A1
Sample Information

		Source of Geographical Information				
Survey Year	ATUS Sample Size	FIPS County Code	MSA Code	PMSA Code	Our Sample Size	Observations Dropped
2003	20,720	8,200	5,139	2,562	15,901	4,819
2004	13,973	5,616	1,993	1,016	8,625	5,348
Total	34,693	13,816	7,132	3,578	24,526	10,167
	Categories Dropped from the Sample					
	Day Was a Holiday	Between Christmas and New Year's Day	Nonworker	Retired	Full-Time Student	Ages Below 20 and 60 and Above
2003	342	246	5,577	2,439	3,666	8,882
2004	301	66	3,117	769	2,023	4,624
Total	643	312	8,694	2,090	5,689	13,506

NOTE.—Due to the overlap of certain categories, the sum of observations in excluded categories does not equal the total number of observations that were dropped from the sample.

Table A2
Time Variables and the Activities They Encompass

Time Variable	Activities	Codes	Exclusions
Work	Working, work-related activities, other income-generating activities, and travel related to work	05xxxx, 1705xx	0504xx (job search)
Leisure variables:			
Active recreation	Participating in sports, exercise, or recreation, and waiting, security procedures, and travel related to it	1301xx, 130301, 130401, 1399xx, 171301	
Passive recreation	Socializing, relaxing, and leisure, attending sporting/recreational events (and waiting and security related to it), personal communications, and travel related to passive recreation	12xxxx, 1302xx, 130302, 130399, 130402, 020903, 020904, 160101, 160201, 1712xx, 1713xx	171301
Religious and civic activities	Government services and civic obligations, religious and spiritual activities, volunteer activities, phone calls to/from government officials, and travel related to those activities	10xxxx, 14xxxx, 15xxxx, 160108, 1710xx, 1714xx, 1715xx	
Leisure	Recreation and religious and civic activities		
Home production variables:			
Indoor housework	Housework, food and drink preparation, interior maintenance, repair, and decoration, pet and animal care, appliances and tools, household management (except personal communications)	0201xx, 0202xx, 0203xx, 0206xx, 0208xx, 020901, 020902, 020905, 020999	
Outdoor housework	Exterior maintenance, repair, and decoration; lawn, garden, and houseplants	0204xx, 0205xx	
Other nonmarket work	Vehicle repair and maintenance, other household activities, travel related to household activities	0207xx, 0299xx, 1702xx	
Shopping	Consumer purchases, professional services, household services, phone calls to/from service providers, and travel related to shopping	07xxxx, 08xxxx, 09xxxx, 1707xx, 1708xx, 1709xx, 160103, 160104, 160105, 160106, 160107	0805xx, 170805
Caring	Caring for and helping household and nonhousehold members, and travel related to care	03xxxx, 04xxxx, 1703xx, 1704xx	
Home production	Indoor and outdoor housework, other nonmarket work, shopping, and caring		

Note.—The codes correspond to the variables TUTIER1CODE, TUTIER2CODE, and TUTIER3CODE from the ATUS Activity File.

References

Biddle, Jeff E. 1988. Intertemporal substitution and hours restrictions. *Review of Economics and Statistics* 70, no. 2:347–51.

Blundell, Richard, and Thomas MaCurdy. 1999. Labor supply: A review of alternative approaches. In *Handbook of labor economics*, ed. Orley Ashenfelter and David Card, vol. 3A, 1559–1695. Amsterdam: North-Holland.

Burda, Michael, Daniel S. Hamermesh, and Philippe Weil. 2007. Total work, gender, and social norms. Working Paper no. 13,000, National Bureau of Economic Research, Cambridge, MA.

Bureau of Labor Statistics. 2005a. Public use data dictionary: American Time Use Survey (ATUS) interview data. Variables collected in ATUS, 2004. September 2005. U.S. Department of Labor. http://www.bls.gov/tus/atusintcodebk04.pdf.

———. 2005b. Workers on flexible and shift schedules in May 2004. *News*, Friday, July 1, 2005, USDL 05-1198. Washington, DC: U.S. Department of Labor.

Camerer, Colin, Linda Babcock, George Lowenstein, and Richard Thaler. 1997. Labor supply of New York City cabdrivers: One day at a time. *Quarterly Journal of Economics* 112 (April): 407–41.

Card, David. 1994. Intertemporal labour supply: An assessment. In *Advances in econometrics*, ed. Christopher A. Sims. Cambridge: Cambridge University Press.

Deaton, Angus. 1997. *The analysis of household surveys: A microeconometric approach to development policy*. Baltimore: Johns Hopkins University Press for the World Bank.

Devine, Theresa J. 2001. Self-employment and schedule flexibility for married females: Evidence for the United States from SIPP. In *Working time in comparative perspective*. Vol. 2, *Life-cycle working time and nonstandard work,* ed. Susan Houseman and Alice Nakamura. Kalamazoo, MI: Upjohn Institute for Employment Research.

Farber, Henry S. 2004. Reference-dependent preferences and labor supply: The case of New York City taxi drivers. Working Paper no. 497, Industrial Relations Section, Princeton University.

———. 2005. Is tomorrow another day? The labor supply of New York City cabdrivers. *Journal of Political Economy* 113, no. 1:46–82.

Fehr, Ernst, and Lorenz Goette. 2002. Do workers work more if wages are high? Evidence from a randomized field experiment. Working Paper no. 125, Institute for Empirical Research in Economics, University of Zurich.

Ham, John C., and Kevin T. Reilly. 2002. Testing intertemporal substitution, implicit contracts, and hours restriction models of the labor market using micro data. *American Economic Review* 92, no. 4:905–27.

Hamermesh, Daniel S. 1996. *Workdays, workhours, and work schedules: Evidence for the United States and Germany*. Kalamazoo, MI: Upjohn Institute for Employment Research.

Huysmans, Frank. 2002. Influence of the weather on time use. http://www.scp.nl/onderzoek/tbo/english/achtergronden/weather.pdf.

Johnson, Robert Underwood. 1923. *Remembered yesterdays*. Boston: Little, Brown.

Lucas, Robert E., Jr., and Leonard A. Rapping. 1969. Real wages, employment, and inflation. *Journal of Political Economy* 77, no. 5:721–54.

Neidell, Matthew. 2006. Public information, avoidance behavior, and health: Do people respond to smog alerts? Unpublished manuscript, Department of Health Policy and Management, Mailman School of Public Health, Columbia University.

Oettinger, Gerald S. 1999. An empirical analysis of the daily labor supply of stadium vendors. *Journal of Political Economy* 107, no. 2:360–92.

Pencavel, John. 1986. Labor supply of men: A survey. In *Handbook of labor economics*, ed. Orley Ashenfelter and Richard Layard, vol. 1, 3–102. Amsterdam: North-Holland.

Rappaport, Jordan. 2004. Moving to nice weather. RWP 03-07, Research Division, Federal Reserve Bank of Kansas City.

Roback, Jennifer. 1982. Wages, rents, and the quality of life. *Journal of Political Economy* 90, no. 6:1257–78.