

Labor Supply Elasticities: Overcoming Nonclassical Measurement Error Using More Accurate Hours Data

Garry F. Barrett and Daniel S. Hamermesh*

ABSTRACT

We measure the impact of measurement error in labor-supply elasticities estimated over recalled usual work hours, as is ubiquitous in the literature. We employ data on hours of work in diaries collected by the American Time Use Survey, 2003-15, along with the same respondents' recalled usual work hours. Estimates using the latter yield elasticities that are positively biased. We argue that this bias arises from the salient effects of differences in wage rates on recalled hours.

*Garry Barrett is a professor of economics at the University of Sydney and a research fellow at IZA. Daniel Hamermesh is Distinguished Scholar at Barnard College, professor emeritus at the University of Texas at Austin and Royal Holloway, University of London, and research associate, IZA and NBER. We thank Kadir Atalay, Colin Cameron, Jay Stewart, Felix Weinhardt and two referees for helpful comments. Corresponding author: Garry Barrett, School of Economics, University of Sydney 2006, Australia, garry.barrett@sydney.edu.au. The data used in this article can be obtained beginning six months after publication through three years hence from Daniel Hamermesh, University of Texas at Austin, hamermes@austin.utexas.edu.

I. Introduction

The elasticity of labor supply is one of the most studied parameters describing individual behavior in the sub-field of labor economics and, because of its importance for explaining macroeconomic fluctuations, perhaps in the entire discipline of economics. Knowledge of the elasticity of labor supply is central to many public policy issues. Keane (2011) provides an illustrative example based on an optimal tax model, where the optimal top-bracket income tax rate varies from 100 percent when the labor supply elasticity is 0 to a low of 25 percent when the elasticity is 2.0. In addition to the efficient design of income-tax systems, the labor supply elasticity is pivotal to the assessment of the disincentive effects of wage subsidies (such as the Earned Income Tax Credit), child-care programs (such as the Child Care and Development Fund) and universal basic-income schemes. Given the fundamental importance of this elasticity, it is unsurprising that an immense literature has been devoted to estimating this parameter.

Large numbers of elasticity estimates have been summarized over the past three decades (Pencavel, 1986; Killingsworth and Heckman, 1986; Blundell and MaCurdy, 1999; and Keane, 2011). In all studies based on representative samples of employees the measure of the intensive margin of labor supply has been the survey respondent's recalled hours worked in the previous week (typically in monthly labor-force surveys), month or year (typically in longitudinal annual household surveys). The use of such longer-recall data to measure labor-supply elasticities remains ubiquitous (e.g., Bargain, Orsini, and Peichl 2014; Blundell, Pistaferri, and Saporta-Eksten 2016; Cherchye, de Rock, and Vermeulen 2012; Goux, Maurin and Petrongolo 2014).¹

In this study we examine estimates of labor supply elasticities using a data set for the United States that, in addition to requiring only very short recall, imposes adding-up restrictions upon respondents' perceptions of their time allocated to different activities. Estimation of labor

supply elasticities based on this different measure, which is arguably more accurate along several dimensions, is novel and of independent interest. Our main purpose, however, is to use this alternative measure of hours of work to compare and assess the reliability of estimates of elasticities that are based on diary and the traditional measures of usual hours. While distinctions between an individual's work hours on a particular job reported by the employer have been noted among workers in one firm to differ from what the worker recalls (Duncan and Hill, 1985; Bound et al. 1994), the differences between these measures were not and, indeed, could not be used to analyze generally the impact of measurement errors on estimated labor-supply responses.²

II. Time-Use Data in the Estimation of Labor Supply

The American Time Use Survey (ATUS) provides a roughly one-eighth sub-sample of recent respondents to the monthly household Current Population Survey (CPS) in the United States. On some morning two to five months after their final (eighth-month) appearance in the CPS, ATUS respondents answer the usual CPS questions, including initially providing a recollection of their usual weekly work hours, H^{CPS} . They are given a specific day of the week on which to complete a diary detailing their activities at each minute from 4:00AM of the previous day to 3:59AM of the current day. Diurnal aggregation of the time reported working yields total hours worked on the diary day (defined below in various ways), H^A . (See Hamermesh, Frazis, and Stewart 2005 for a discussion of the ATUS).

We use time diaries of all diarists aged 16+ in the ATUS from 2003-15 who reported having worked on the diary day. The ATUS was initially fielded in 2003 and has been in operation continuously since then. Having over a decade of observations creates large samples in each of the separate demographic groups that we analyze. Given the relatively few hours worked

on weekend days, most of which are by those whose workweek consists mainly of weekday work, diaries reporting work on a weekend day would not be commensurable with reported usual weekly hours.³ We thus use only diaries completed for weekdays.

Perhaps most important, because of the division bias induced in calculating the hourly earnings of salaried workers (see Borjas 1980), we limit the sample to hourly-paid workers, who unlike other workers report an hourly wage rate directly. These restrictions generate samples of 4,777 married and 5,628 unmarried women. Although the literature on women's labor supply elasticities is larger, that on men's is also huge. We thus also create samples of male ATUS respondents using the same restrictions, yielding 4,819 married and 4,069 unmarried men.

Columns (1) - (3) of Table 1 present statistics describing H^{CPS} and H^A . Throughout we use two measures of H^A , one reporting total work time on the diary day, H^{A1} , including time spent traveling to the workplace, the other, H^{A2} , excluding travel to work. In both cases the reported minutes are converted to daily hours. The correlations between these latter two measures are nearly one. While we present labor-supply elasticities estimated using both measures, we thus expect fairly small differences between the results. These statistics and all the estimates that we generate in this study are produced using the ATUS final weights.

Assuming a five-day workweek (and regrettably there is no information on days worked during the week in the ATUS, nor in almost all monthly CPS data sets), multiplying the mean daily reported hours of work less commuting time, H^{A2} , shown in Column (3) of Table 1, yields averages of weekly hours that differ only very slightly from the averages of recalled usual weekly hours shown in Column (1).⁴ This result repeats similar findings by Juster and Stafford (1991, Table 5), using the 1975-76 Americans' Use of Time Survey; by Frazis and Stewart

(2004), using the ATUS, and by Gershuny and Robinson (2013) for Europe. The correlations between the diary measures and usual weekly hours, however, are not high.

The hourly wage rates of hourly-paid diarists are the responses that they provided in their eighth month in the CPS if at the time the diary was collected they continued to be employed paid hourly. In our sub-samples about 92 percent of these diarists were also employed and paid hourly in their eighth CPS month. Only those who were not hourly-paid employees in their eighth month in the CPS recorded their hourly pay at the time they completed their diary. In terms of the temporal relationship of CPS Month 8 and the time diary, 13 percent of diarists were in the ATUS two months after their final CPS interview; 70 percent three months later; 16 percent four months later, and 1 percent five months later. Thus the measure of hourly wages precedes responses about both H^{CPS} and H^A by three months on average.

Mean hourly earnings in each of the four groups of hourly-paid workers are presented in Column (4) of Table 1. Not surprisingly, given selectivity into hourly-paid employment, the means of hourly wages of these ATUS respondents are well below the ratios of weekly earnings to usual weekly hours reported by non-hourly paid workers in the ATUS over this time period, which averaged \$25.98, \$22.77, \$32.70 and \$24.35 for the four demographic groups respectively.

Since our main purpose here is to compare estimates of labor supply elasticities using H^{CPS} and H^A , we use simple stylized labor-supply models that only adjust for obviously exogenous covariates. We thus estimate:

$$(1) \quad h^i = \alpha^i w + \beta X + e, \quad i = \text{CPS, A1 or A2},$$

where lower-case h and w indicate logarithms, the vector X contains a quadratic in age, indicators of race and ethnicity, and fixed effects for state of residence, day of week, and year of

the survey, the α^i and β are parameters to be estimated, and e is an error term. The estimated α^i are shown for married and unmarried women and men separately in Table 2

The estimated elasticities using h^{CPS} , shown in Column (1) of Table 2, are fairly low, ranging from 0.067 among married men to 0.191 among unmarried women and men. The elasticity among unmarried men seems a bit high; but that the elasticity among married men is lower than among married women is consistent with prior research. Our estimate using h^{CPS} for married women is low compared with estimates in the entire large literature that has been produced over the last half-century; but it is nearly identical to that suggested by Heim (2007) for the early 2000s and is consistent with Blau and Kahn's (2007) evidence that labor supply elasticities among married women in the U.S. have declined substantially.

In Columns (2) and (3) we present results for both h^{A1} and h^{A2} , although the evidence comparing their means in Table 1 to that of H^{CPS} suggests that the latter is the more appropriate dependent variable to compare to h^{CPS} . The estimated elasticities using h^{A1} uniformly exceed those based on h^{A2} , but none of the differences between them is statistically significant. Those differences, given the definitions of these two measures, reflect the elasticity of commuting time with respect to hourly wages. Their positive signs are consistent with evidence in the urban economics literature on the income elasticity of commuting costs (e.g., Glaeser, Kahn, and Rappoport 2008).

Comparing the estimated elasticities in Column (2) or Column (3) to those in Column (1) of Table 2, $\hat{\alpha}^{\text{CPS}} > \hat{\alpha}^{\text{A}}$ for both time-diary measures of work time, for both married and unmarried people, and for both women and men. The absolute differences between $\hat{\alpha}^{\text{CPS}}$ and $\hat{\alpha}^{\text{A}}$ are not huge, but they exceed conventional levels of statistical significance in three of the four demographic groups.⁵ Even the difference among unmarried women approaches conventional

levels of statistical significance. These estimated elasticities from the ATUS imply an even greater divergence between the micro- and macro-based estimates of the elasticity of labor supply than has been previously suggested.

One might be concerned that the elasticities for h^{CPS} are biased because the hourly wages of the large majority of respondents are measured several months before the CPS measure of hours that is asked of them. To examine this possibility we restricted the sample to those respondents who were paid hourly and who worked in Month 8 of their CPS rotation, and we re-estimated Equation (1) using h^{CPS} observed in Month 8 rather than at the time of the ATUS. The elasticities, presented in Column (4) of Table 2, differ little from those shown in Column (1). Some are larger, some smaller, and each is still well above the estimates based on h^A .⁶

Whether the ATUS diarists we use are representative of CPS respondents is important to generalizing our results. An early and careful examination of this issue (Abraham, Maitland and Bianchi 2006) suggests that, despite the high unit non-response rate in the ATUS, the diarists are generally similar to CPS respondents in their major measurable characteristics. To examine this issue in the context of this study, we took all hourly-paid workers in the same four demographic categories from the CPS-MORG extracts (eighth CPS month alone to avoid including the same people twice) from 2003-15 and re-estimated Equation (1) for h^{CPS} using these samples. The estimated labor-supply elasticities are presented in Column (5) of Table 2 for each of the four demographic groups. They too match the estimates shown in Column (1) based on h^{CPS} of ATUS respondents at the time they completed their diaries quite closely.

The R^2 in the equations based on h^{CPS} consistently exceed those using h^A as the dependent variable. The central question thrown up by these results is why this difference arises? If, as we believe, the diary records of yesterday's work time are less error-prone than the one-

week recalls of usual hours of work, the existence of classical measurement errors in the latter would suggest that the R^2 would be lower, not higher. Moreover, classical measurement error in the dependent variables cannot account for the systematic differences in the estimated elasticities.

III. Nonclassical Measurement Error

The clear implication from the estimation of the labor supply elasticities using ATUS data is that the CPS question eliciting information on usual weekly work hours introduces nonclassical measurement error. There are three sources of measurement error in H^{CPS} relative to H^A . They may be categorized as relating to recall error, the specificity of the observation period (the ATUS covers a single day—yesterday, while the CPS refers to hours usually worked in a week), and the constraint due to the application of a 24-hour time budget.

Recall error is likely greater in H^{CPS} than in H^A , as the report is based on the recall of usual hours over a prior week, in contrast to recorded hours worked on the previous day. A further source of measurement error arises from the specificity of the ATUS diary (the actual hours at work in a specific 24-hour time period) relative to the more general usual week reference period for H^{CPS} . Finally, H^A from the time diary includes an explicit aggregate 24-hour time constraint on all activities over the previous day, which imposes additional discipline on the diary measure that is absent from H^{CPS} .

Of these sources of measurement error, the lesser specificity and clarity of H^{CPS} is likely to introduce only random noise, which would tend to make the R^2 using this measure lower compared to those based on H^A . In contrast, recall error and the absence of a requirement that the respondent must list all of his/her activities so that they add to 24 hours are likely to introduce nonclassical measurement error into H^{CPS} . Reported work hours, H^{CPS} , may be related to

salience, as suggested by Akerlof and Yellen (1985) in their analysis of measurement error in CPS responses about labor-force status in the previous year compared to contemporaneous measures. The issue of the salience or importance of behaviors recalled by survey respondents is discussed more generally in the survey by Bound, Brown, and Mathiowetz (2001, Section 5). More salient behaviors require less cognitive effort to retrieve information from memory, resulting in lower levels of errors of omission and overestimation. The Becker (1965) and Gronau (1980) models of household production incorporate an explicit time constraint, in which higher income and wage individuals face a higher shadow price of time.⁷ Therefore work hours may be more salient and relevant for higher wage individuals, potentially contributing to systematic measurement error in H^{CPS} .

These different sources of measurement error have also been considered in the literature examining the reliability of information from family expenditure surveys, such as the U.S. Consumer Expenditure Surveys. Like the ATUS used here, the two main approaches to measurement in those surveys are based on either longer-term recall interviews or short-recall diary methods. Analogous to our discussion, this literature considers how estimates generated by short-term diaries, precisely specified reporting periods and expenditure items, and an aggregate budget constraint (based on reported cash flow or total spending) relative to longer-term recall may yield higher quality data (see the essays in Carroll, Crossley, and Sabelhaus 2015).

To develop intuition on the nature of the measurement error here, we assume that the time diary measures work hours with classical measurement error only, which implies $\hat{\alpha}^A$ is unbiased. The measurement error in h^{CPS} , denoted by $e^{CPS} = h^{CPS} - h^A$, leads to:

$$(2) \quad \text{Bias}(\hat{\delta}^{CPS}) = (Z'Z)^{-1}E[Z'e^{CPS}],$$

where $Z = [w, X]$ and $\delta = [\alpha, \beta]'$.

The effect of nonclassical measurement error in h^{CPS} is analogous to an omitted variable, leading to bias in the estimation of α . To simplify further, assume a bivariate relationship between h^{CPS} and w (equivalently, no linear relationship between w and X). Then the bias in $\hat{\alpha}^{\text{CPS}}$ can be expressed as:

$$(3) \quad \text{Bias}(\hat{\alpha}^{\text{CPS}}) = \rho_{we} \frac{\sigma_{we}}{\sigma_w}.$$

The relative bias in $\hat{\alpha}^{\text{CPS}}$, where the bias is expressed as a fraction of the unbiased $\hat{\alpha}^A$, is given by:

$$(4) \quad \text{Relative Bias} = \left(\frac{\hat{\alpha}^{\text{CPS}} - \hat{\alpha}^A}{\hat{\alpha}^A} \right).$$

Relative bias is a simple way to express the proportional effect of the nonclassical measurement error in h^{CPS} on the estimation of the labor supply elasticity.

The magnitude of this bias is shown in Table 3 for each demographic group and each ATUS measure of hours. These relative biases appear fairly substantial, especially in the case of married males. In absolute terms none is immense, however; but each does provide an admonition about the upward biases obtained when estimating these elasticities using the longer-recall and less specific weekly usual hours measure.

Our discussion is based on the strong prior that the difference in the elasticity estimates reflects nonclassical measurement error in H^{CPS} . There are, however, alternative explanations which we cannot rule out *a priori* that are not based on nonclassical measurement error. For instance, assume respondents work the same hours per day on each weekday worked, with H^{CPS} accurately measuring hours per week and H^{A2} accurately measuring hours per day.

Consequently $H^{\text{CPS}} = H^{\text{A2}} * \text{Days}$, and the $\hat{\alpha}^{\text{CPS}}$ will be greater than $\hat{\alpha}^{\text{A2}}$ ($\hat{\alpha}^{\text{CPS}} - \hat{\alpha}^{\text{A2}} = \hat{\alpha}^{\text{Days}}$) if the wage elasticity of days worked per week, holding hours per day constant, is positive. For all groups in our sample except unmarried women an elasticity of days per week that is nearly equal

to or even larger than $\hat{\alpha}^{A2}$ could then account for the discrepancies between the two sets of estimates.

This explanation would require a large wage elasticity of days per week, which seems unlikely in light of inflexible work schedules and of the larger fixed time costs of commuting facing higher-wage workers. To examine it with appropriate data (which, as noted earlier, the ATUS does not contain), we need to use one of the few roughly quinquennial May CPS Supplements in which there are independent reports of usual hours per day, usual days per week and usual weekly hours. We thus estimate the relevant equation using hourly-paid workers in the May 1991 CPS Work Schedule Supplement. With the logarithm of days per week as the dependent variable and the logarithm of hourly pay as the crucial independent variable (and holding constant the logarithm of daily hours, state indicators, a quadratic in age, and indicators of race, gender and marital status) we find an estimated days-wage elasticity of -0.016 (s.e.= 0.007). While we cannot examine this explanation using the data in the main part of this study, this extraneous estimate suggests that it does not account for our findings.

IV. Conclusion

The labor supply elasticity is a fundamental parameter for designing optimal income taxes and for assessing the efficiency of conditional transfer programs, such as the EITC and CCDC, and unconditional transfers, such as a universal basic-income scheme. In this study we have provided alternative estimates of elasticities describing labor supply using recalled usual weekly hours and time worked from a one-day diary kept by the same respondents. Estimates using the latter measure are lower, which we argue results from measurement errors induced by the greater salience of recalled work time among higher-earning workers.

Measures of usual hours, recalled either for the previous week, or even for the past year (as in the major household longitudinal surveys), underlie nearly all studies of labor supply. Our results suggest that the nature of surveys producing data on usual work hours creates measurement errors that are positively correlated with the respondent's wage rate. Using these measures to estimate elasticities of labor supply then generates upward biases. The differences we have shown between these biased estimates and others that avoid this difficulty are not huge, but they do suggest care in interpreting standard estimates of labor-supply elasticities.

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Table 1.
Descriptive Statistics, Working Time and Wages, Hourly Paid Women, and Men, CPS/ATUS
2003-15, Weekday Diaries

	CPS Usual Weekly Hours H^{CPS} (1)	ATUS Daily Total Work Hours H^{A1} (2)	ATUS Daily Work Hours Working H^{A2} (3)	Hourly Pay (4)
WOMEN				
Married (N=4777):				
Mean	36.22	7.99	7.41	\$15.96
S.E.	(0.15)	(0.04)	(0.03)	(0.14)
Correlation:				
ATUS Total	0.50			
ATUS Time Working	0.51	0.98		
Unmarried (N=5628):				
Mean	36.11	7.87	7.28	\$12.98
S.E.	(0.15)	(0.04)	(0.03)	(0.10)
Correlation:				
ATUS Total	0.54			
ATUS Time Working	0.56	0.97		
MEN				
Married (N=4819):				
Mean	42.97	9.23	8.45	\$18.72
S.E.	(0.15)	(0.04)	(0.03)	(0.15)
Correlation:				
ATUS Total	0.44	0.95		
ATUS Time Working	0.45			
Unmarried (N=4069):				
Mean	39.36	8.58	7.88	\$14.27
S.E.	(0.18)	(0.04)	(0.04)	(0.13)
Correlation:				
ATUS Total	0.54			
ATUS Time Working	0.55	0.96		

Note: The equations also include a quadratic in age, indicators of race and ethnicity, and indicators for day of week, state and year.

Table 2.
 Labor Supply Elasticities, Hourly Paid Women, and Men, CPS/ATUS 2003-15, Weekday Diaries, and Other CPS-Based Estimates

	Usual hours h^{CPS} (1)	ATUS Total h^{A1} (2)	ATUS Working h^{A2} (3)	CPS-8 Usual hours h^{CPS8} (4)	CPS-MORG Usual hours $h^{CPS-MORG}$ (5)
WOMEN					
Married (N=4777)	0.133 (0.012)	0.078 (0.019)	0.072 (0.020)	0.113 (0.012)	0.099 (0.002)
R ²	0.062	0.022	0.022	0.068	0.042
t-statistic: $\alpha^{CPS} = \alpha^A$		3.03	3.25		
Unmarried (N=5628)	0.191 (0.014)	0.166 (0.020)	0.155 (0.020)	0.200 (0.013)	0.215 (0.003)
R ²	0.180	0.075	0.068	0.267	0.223
t-statistic: $\alpha^{CPS} = \alpha^A$		1.25	1.80		
MEN					
Married (N = 4819)	0.067 (0.010)	0.037 (0.016)	0.010 (0.017)	0.082 (0.008)	0.091 (0.001)
R ²	0.121	0.048	0.042	0.130	0.127
t-statistic: $\alpha^{CPS} = \alpha^A$		1.87	3.36		
Unmarried (N=4069)	0.191 (0.014)	0.139 (0.019)	0.124 (0.021)	0.167 (0.014)	0.230 (0.002)
Adj R ²	0.190	0.084	0.073	0.240	0.219
t-statistic: $\alpha^{CPS} = \alpha^A$		2.83	3.38		

Note: The equations also include a quadratic in age, indicators of race and ethnicity, and indicators for day of week, state and year.

Table 3.
 Relative Bias in Labor Supply Elasticities Estimated Using h^{CPS} , Based on Equation (4) and
 Results in Table 2, Columns (1) – (3).

Demographic Group	Based on:	
	h^{A1} (1)	h^{A2} (2)
Married Women	0.705	0.847
Unmarried Women	0.151	0.232
Married Men	0.811	5.700
Unmarried Men	0.374	0.540

Endnotes

¹The main exception to this pattern has been a spate of studies on the responses of independent contractors' effort to variations in the price of the product they sell (e.g., most recently Stafford, 2015)

²French (2004) considered the effect of nonclassical measurement error in recalled annual hours and wages for the estimation of the intertemporal elasticity of substitution based on the Panel Study of Income Dynamics.

³In an unpublished Appendix available from the second author, however, we report results that are based on expanded samples that include all diaries in which work is reported, both weekdays and weekends. The results shown in the text tables do not change qualitatively when the weekend diaries are added.

⁴Very occasionally Supplements to the May CPS have collected information on days worked. In the May 1991 Supplement the mean days worked was 4.75 among female and 5.07 among male workers (Hamermesh, 1998).

⁵We test this by calculating the statistics generated after using STATA's *sureg* procedure to estimate Equation (1) for h^{CPS} and h^{A1} (h^{A2}) jointly.

⁶Similarly small changes were produced when we deleted the roughly 10 percent of each sample who report holding more than one job.

⁷The link between earnings and time stress is analyzed in Hamermesh and Lee (2007).