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ABSTRACT: We examine monthly variation in weekly work hours using data for 2003-10 from the Current Population Survey (CPS) on hours/worker, from the Current Employment Survey (CES) on hours/job, and from the American Time Use Survey (ATUS) on both. The ATUS data minimize recall difficulties and constrain hours of work to accord with total available time. The ATUS hours/worker are less cyclical than the CPS series, but the hours/job are more cyclical than the CES series. We present alternative estimates of productivity based on ATUS data and find that it is more pro-cyclical than other productivity measures.

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I. Measuring Hours Over the Cycle

A lively discussion has flared up over the role of labor productivity in the Great Recession (e.g., Jordi Galí and Thijs Rens 2010, Casey Mulligan 2011, Marcus Hagedorn and Iourii Manovskii, 2011; Ellen McGrattan and Edward Prescott 2012; Valerie Ramey, 2012). Resolving this issue depends critically on the measurement of the denominator, i.e. hours worked. In this study we report new estimates of work hours based on the American Time Use Survey (ATUS) that are significantly different from more conventional measures. These differences potentially shed new light on the behavior of labor productivity over the business cycle.

In the U.S. work hours are generally measured using either the establishment-based CES, which reports hours paid per job, or the household-based CPS, which reports hours worked per employed person. These measures have been used by macro- and labor economists in countless research studies, and are used by government officials and the financial press to draw inferences about the health of the economy. They tell different stories about long-term changes in work hours (Harley Frazis and Jay Stewart 2010), but less is known about their cyclical properties. How do they compare to those derived from a new household-based source of information on hours of work, the ATUS? In particular, does their cyclical variation properly measure the extent of declines in hours as unemployment rises?

II. Using the American Time Use Survey Over the Cycle

Between 2003 and 2010 the ATUS collected over 110,000 time diaries, about 1700 per month in 2003 and about 1000 per month thereafter.[1] Of the respondents, over 68,000 reported working during the seven-day period ending on their diary day. The 96 months of data, coupled

[1]See Daniel Hamermesh et al. (2005) for a description of the survey methods and potential uses. The ATUS is the only ongoing time-use survey in the world.

with eight years of macroeconomic fluctuations, allow us to begin to examine cyclicality in hours of work from these time diaries and to compare them to that in other measures. The effects of cyclical variations in market work on non-market time reported in the time diaries have been examined (Michael Burda and Hamermesh 2010; Mark Aguiar et al. 2011). Our focus here is on the cyclical properties of work hours themselves in these data.

In this initial look at the data, we compare the ATUS estimates to the conventional monthly CPS and CES series. The CPS estimates, *CPSALL*, are actual (not usual) weekly hours on all jobs estimated over individuals 16+ who were employed and worked during the CPS reference week. The establishment-based CES publishes two weekly hours series, one covering production and non-supervisory workers (*CESPNS*), one covering all employees (*CESALL*). Both series measure hours paid and are computed on a per-job basis. The all-employee series is more comparable to *CPSALL*, but it is only available since March 2006. We thus use *CESPNS* for a comparison covering the entire 2003-10 period and *CESALL* for the shorter period 2006:03 - 2010:12. The CES does not include any demographic information, so both CES series include workers of all ages.

Our ATUS sample includes all respondents 15+ who reported that they were employed and worked in the last seven days.[2] For each job we calculated work time as minutes of work on that job plus work breaks of 15 minutes or less plus travel between job sites (same job), and multiplied by 7/60 to convert from minutes per day to hours per week.[3] For the comparison to

[2]Note that the CPS and ATUS samples include unpaid family workers and the self-employed. The inclusion of 15-year-olds should not affect the CPS-ATUS comparison.

[3]*AJOB* thus includes the aggregate coded 0501 in the ATUS, excluding 050102, which is added to form *APERS*, as are the small amounts of break and travel time. We also experimented with narrower measures that exclude short breaks and within-job travel, and even broader measures that add in work-related activities (coded 0502). The broader measures performed almost identically to their counterparts used here, while the narrower measures behaved slightly differently. The ATUS averages are all calculated using the ATUS final sampling weights. We exclude time spent on other income-generating activities.

the CPS series we summed hours worked on all jobs that each worker held and computed average weekly hours on a per-person basis (*APERS*). For the comparisons to CES hours we treated each job as a separate observation and computed average weekly hours on a per-job basis using the CPS weight for each worker for that job (*AJOB*).

While our main interest is in differences in the cyclical behavior of these series, a comparison of their levels, presented in Table 1, is also interesting. *AJOB* hours are slightly higher than *CESPN*S hours. The difference, however, almost disappears in the comparison to *CESALL* (as the inclusion in the latter of supervisors, whose paid hours are longer, suggests it would). *APERS* reports about 1 hour less per week on average than does *CPSALL*. This difference is large, but it is consistent with results in Frazis and Stewart (2004) that average weekly hours computed over CPS reference weeks are about 1.3 hours higher than when the average is computed over all weeks, and with the difference between diary hours and responses to a CPS-like question in F. Thomas Juster and Frank Stafford (1991, p.483). Finally, monthly time-series variation in the ATUS measures is greater than in any of the other measures, not surprising given the relatively few observations each month compared to the numbers of workers in the CPS and establishments in the CES.

Figure 1 graphs smoothed seasonally unadjusted measures of *AJOB*, *CESPNS* and *CESALL*, and the seasonally adjusted aggregate unemployment rate.[4] The CES series clearly rose slightly from 2003 to the cyclical peak in 2007 and dropped during the Great Recession. While it is less clear because of the ATUS sampling variability, it appears that *AJOB* shows similar

[4]The filter attaches weights of 1, 2, 3, 2 and 1 to the monthly observations centered on the current observation. The figures show the smoothed measures only to make the relationships to aggregate unemployment somewhat less opaque by reducing the sampling variance in the ATUS measures.

cyclical patterns. Figure 2 graphs *APERS* and *CPSALL* along with the aggregate unemployment rate. As with the jobs-based measures, both series are pro-cyclical.

That the series within each pair appear to move in the same directions is interesting. But if they always moved identically, the ATUS data would not add much to our understanding of cyclical variations in work time. To examine this issue we regressed *APERS* on *CPSALL* and *AJOB* on *CESPNS*. All of the series in both equations are smoothed and seasonally unadjusted, and both equations include a vector of monthly indicators. Tests for stationarity of the unsmoothed series soundly reject the null hypothesis of unit roots—we are not just demonstrating that there are trends in these series.[5]

Table 2 lists the estimates and their standard errors, for the entire sample period, then for the shorter period using *CESALL* in addition to *CESPNS*.[6] Examining first the relationship between *APERS* and *CPSALL*, ATUS reports of total hours worked vary less cyclically, and significantly so (p=0.04) than those in the standard CPS data. This suggests that the cyclical variability of hours is stronger in the standard recall data than in time diaries, in particular exhibiting a larger decline during the Great Recession.[7]

Cyclical variations in the relations between the ATUS measures and the two unadjusted CES measures tell the opposite story. *AJOB* varies more cyclically than does *CESPNS*, but not statistically significantly so over the whole period. Examining the shorter period using the more

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[5]The augmented Dickey-Fuller statistics for *AJOB*, *APERS*, *CESPNS*, *CESALL* and *CPSALL* are -11.09, -10.87, -4.66, -3.50, and -3.90 respectively.

[6]We also estimate the equations without monthly indicators, with the result that the estimated impacts and their statistical significance changed little. The vector of seasonal indicators was not statistically significant. This is reassuring, because it implies that the seasonal factors are similar for each pair of series. Re-estimating the equations using the raw rather than the smoothed data also hardly altered the estimates for *APERS*, but, due to the sampling variability in the ATUS measures, the statistical significance of the coefficient on CPS hours fell sharply. The unsmoothed estimate for *AJOB* was essentially zero.

[7]Mulligan (2011) does compare annual averages 2007-10 of an ATUS and CPS measure and notes that they do not differ much. The comparison necessarily misses most of the cyclical variation in the difference.

closely comparable *CESALL* series, the time-diary measure shows significantly greater cyclical variation than *CESALL*; and we also find significantly greater cyclical variability in *AJOB* than in *CESPNS* over this shorter period.[8]

The differences in the cyclical variations in the hours measures are not tiny: For example, a decline from the highest to the lowest point in the smoothed CPS hours over this period (a drop of 2.11 hours per week) is accompanied by a predicted decrease in *APERS* of only 1.33 hours. A change from the highest to the lowest point in the smoothed CES hours (a drop of 1.10 hours) is accompanied by a decrease in *AJOB* of 1.44 hours. In short, weekly hours of market work reported in time diaries, which have short recall and require the respondent to account for all 24 hours in the previous day, suggest different cyclical responses of hours worked than do our standard measures.

III. Implications for Measuring Labor Productivity over the Cycle

Differences between aggregate measures of time worked and time paid derived from the ATUS, CES and CPS surveys are potentially important for interpreting the cyclical behavior of labor productivity as well as for answering more fundamental questions about causes and effects of the business cycle. Standard neoclassical production theory implies that output and labor hours should co-vary over the cycle, but hours worked should move with greater proportional amplitude as diminishing returns set in. Arthur Okun (1962) was one of the first to note that labor productivity measures (output per full-time worker equivalent, or output per hour paid) actually exhibit pro-cyclical behavior. This implies that the elasticity of labor input with respect to output is significantly less than unity, a regularity that appears robust across industrial

[8]The difference in cyclicality declines if we use a measure of *AJOB* that excludes short breaks and within-job travel. Implicitly, and quite sensibly, these are more cyclical than normal work time and more cyclical than payment for that time (CES hours).

countries.[9] Leading macroeconomic paradigms have accounted for this pro-cyclicality either by appealing to productivity shocks - exogenous shifts in total factor productivity that lift output, hours and productivity along a path of economic expansion - or to a combination of demand shocks, sticky nominal wages and/or prices, and monopolistic competition, possibly under increasing returns to scale.

While a positive correlation between labor productivity and output over the cycle was readily observable in U.S. data in the half-century following WWII, since the late 1980s researchers have found that this correlation has disappeared or recently perhaps even reversed. This has given rise to considerable theoretical efforts to rationalize these developments (e.g. Galí and Rens 2010, Mulligan 2011, McGrattan and Prescott 2012).

Besides shocks to total factor productivity, pro-cyclical labor productivity results from some combination of three factors. First, true output or labor input may be mis-measured, since firms often reallocate workers to less productive work in periods of low output, and the output of these workers may not be observed (for example, work in such activities as equipment maintenance, cleaning, painting, etc.). Arthur Okun invoked the image of "labor hoarding" to explain the reluctance of employers to shed workers in a downturn. Second, poorly measured or unobservable inputs that complement workers' time – such as workers' effort or capital utilization – will also affect the productivity of hours worked. Third, fixed labor-input requirements (so-called overhead labor) can induce pro-cyclical labor productivity over a range of labor input, even if the marginal product of labor is declining for all positive levels of

[9] In quarterly U.S. data for 1969:1-2012:1 the contemporaneous correlation of HP-de-trended labor productivity (business-sector output per hour) with real GDP is 0.349, rising to 0.451 and 0.368 at two- and four-quarter lagged productivity. The contemporaneous correlation of first differences is 0.634. Burns-Mitchell diagrams for OECD countries confirm the pro-cyclicality of labor productivity in annual data (Burda and Charles Wyplosz 2013).

production. Our results shed the most light on the first possibility and may help illuminate the others.

The CES production-worker hours series is the main source of hours data for the official BLS estimates of productivity growth. BLS adjusts these data to arrive at a measure that covers all workers. Simplifying the discussion slightly, to estimate average weekly hours for non-production workers BLS computes the ratio of non-production worker hours to production worker hours from CPS data and applies that ratio to CES production-worker hours, also adding hours worked by the self-employed and by unpaid family workers.

We compare cyclicality in the BLS productivity series for the business sector to two other series. The second productivity measure is a quarterly index proposed by Simona Cociuba et al. (2012) based on CPS hours worked on all jobs. The third is our transformation of that series based on ATUS hours per person, which we have back-casted from the regression relating *APERS* to *CPSALL* for 2003:1 - 2010:12 presented in Table 2.[10] We recognize the fragility underlying the back-casting, but the demonstrated difference in the cyclicality of *APERS* and *CPSALL* between 2003 and 2010 and the appeal of a short-recall diary approach to recording work hours suggests that this calculation may be instructive. Given our findings that responses to the CPS recall questions about hours differ cyclically from hours reported in the ATUS diaries,

[10]We construct the first measure from the BLS series PRS84006092, the annualized seasonally adjusted quarterly change in business-sector labor productivity. The third productivity measure is a modified version of the Cociuba et al. series into which we substituted the back-casted ATUS average weekly hours for their average weekly hours series. The "predicted" ATUS weekly hours series is constructed from the regression of *APERS* on the monthly smoothed CPS hours series rate and monthly indicators, with the prediction being back-casted as 13.48663+.6274202**CPSALL* (the constant term chosen so that predicted hours equal the average of APERS2 for 2003:1 – 2010:12). Specifically, we divided the Cociuba et al. productivity series by our back-casted hours series and then multiplied it by the weekly hours measure originally used to construct the series. Our series is available at https://webspace.utexas.edu/hamermes/www/HoursRecession.xlsx. The main difference between the Cociuba et al. measure and the official BLS measure is that the former includes nonprofits, government and the military. Their inclusion tends to push productivity growth toward zero, because inputs are used to estimate output, which makes productivity growth in these sectors equal to zero by construction. The ATUS weekly hours measure includes non-profits and government, but not the military. Thus in the third series we are implicitly assuming that average weekly hours in the military are about the same as hours outside of the military.

this alternative productivity series will lead to different and perhaps more reliable inferences about the historical record of the cyclicality of productivity.

Regressing logarithms of each of the three productivity series--the official BLS series, the Cociuba et al. series, and a series based on the **actual** *APERS*--on the unemployment rate and a time trend for 2003:I - 2010:IV, we do find that each of these series **increases** with unemployment over this eight year period--but only the second series increases significantly. Using logarithms of the first two series and of our new productivity measure based on the **back-casted** *APERS* over the entire period 1961:I - 2011:IV, Table 3 presents estimates of regressions relating each of these to the quarterly average of the CPS unemployment rate. Each equation also includes a time trend, which should be superior to using de-trended productivity series. The BLS series appears remarkably a-cyclical. While the Cociuba et al. series does appear to move pro-cyclically over the half-century, falling when unemployment rises, this relationship is not statistically significant. The ATUS-based series, however, does vary significantly with the cycle; and the size of the relationship implies that a 5.5 percentage-point rise in the unemployment rate, essentially what was observed in the Great Recession, is associated over this half-century with a 1.8 percent drop in business-sector labor productivity.

IV. Conclusion

The apparently counter-cyclical behavior of labor productivity in the Great Recession has re-opened the debate on the role of productivity in macroeconomic fluctuations. Although labor productivity during the Great Recession is weakly counter-cyclical if the denominator is measured using the ATUS hours per employee series, it is the only series of the three that we considered that exhibits pro-cyclical behavior over the past 50 years. Furthermore, the cyclical changes in the difference between establishment and diary measures of labor input suggest that the productivity shock description of the business cycle might be augmented by a careful modeling of the labor hoarding phenomenon, which appears to be a central feature of firms' behavior over the business cycle (e.g., Jon Fay and James Medoff, 1985). Our new monthly series on labor productivity, based on novel evidence on hours worked, may be useful in this regard.

Our analysis shows that the inferences that one draws about the cyclicality of hours differ when one uses what workers record about their work time in their diaries for the previous day rather than what they recollect about their work hours in the previous week. Given the differences between these hours series, and possible difficulties of recalling longer-ago activities unconstrained by any adding-up restriction, diary-based measures of work time might give a better picture of levels and cyclical changes in workers' well-being than does information about variation in work-hours based on one-week recall.

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Table 1. Means and Standard Deviations of Hours Measures*

2003:01-2010:12

APERS	*CPSALL*	*AJOB*	*CESPNS*
37.87	38.82	34.41	33.63
(2.00)	(0.57)	(1.87)	(0.34)

2006:03-2010:12

AJOB	*CESPNS*	*CESALL*
34.50	33.58	34.31
(2.07)	(0.39)	(0.37)

*These are unsmoothed seasonally unadjusted series.

Table 2. Variation of ATUS Hours with Other Hours Measures, Based on Five-Month Centered Moving Averages*

2003:03-2010:10

	Dep. Var.:	*APERS*		*AJOB*
Ind. Var.:	*CPSALL*	0.627	*CESPNS*	1.308
		(0.178)		(0.307)
Adj. R^2		0.124		0.204

2006:05-2010:10

	Dep. Var.:	*AJOB*		*AJOB*
Ind. Var.:	*CESPNS*	1.865	*CESALL*	1.940
		(0.328)		(0.335)
Adj. R^2		0.366		0.376

*Standard errors in parentheses here and in Table 3. Regressions also include a vector of monthly indicators.

Table 3. Estimated Cyclical Responsiveness of Three Measures of ln(Labor Productivity), 1961:I - 2011:IV

Productivity Measure:	BLS Business Productivity (1)	Cociuba et al. Productivity (2)	(2) Adjusted Using Back-casted *APERS* (3)
CPS Unemployment Rate	-0.0000626	-0.000817	-0.00329
	(0.00150)	(0.00144)	(0.00136)
Trend	0.00498	0.00375	0.00371
	(0.00004)	(0.00004)	(0.00004)
Adj. R^2	0.987	0.978	0.981

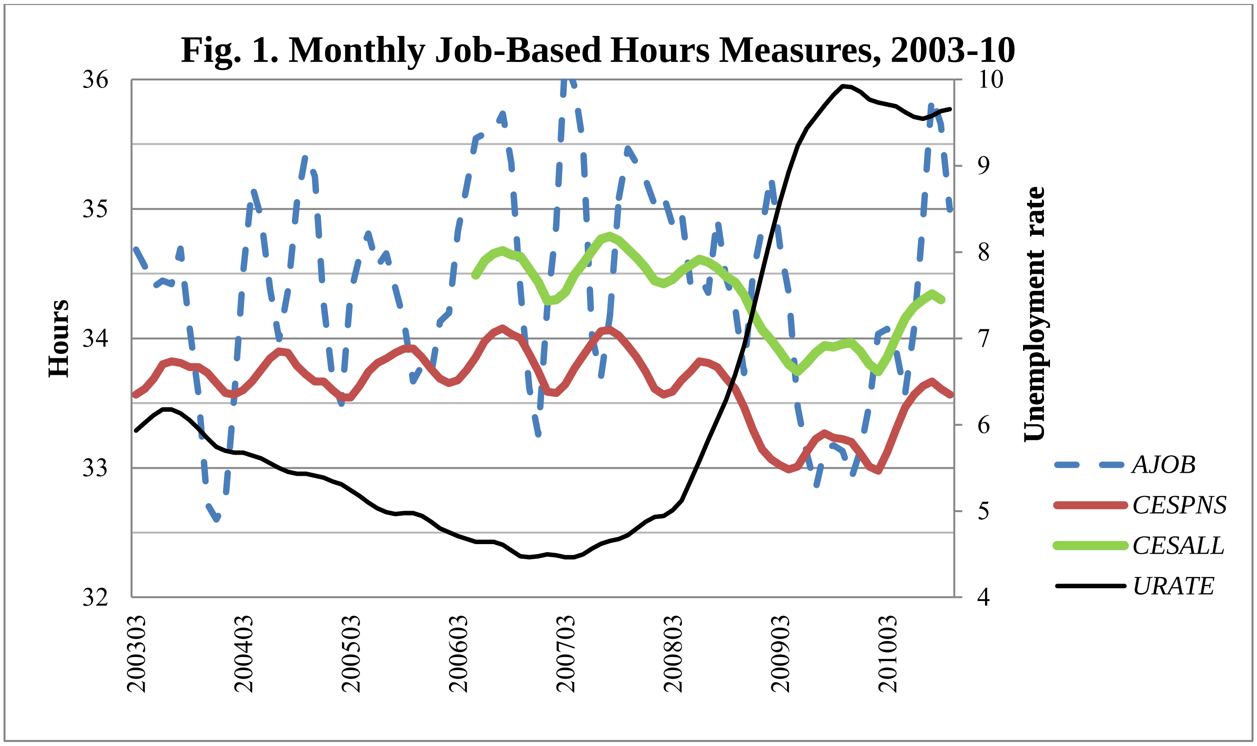

Fig. 1. Monthly Job-Based Hours Measures, 2003-10
Hours
Unemployment rate
36
35
34
33
32
10
9
8
7
6
5
4
200303
200403
200503
200603
200703
200803
200903
201003
AJOB
CESPNS
CESALL
URATE

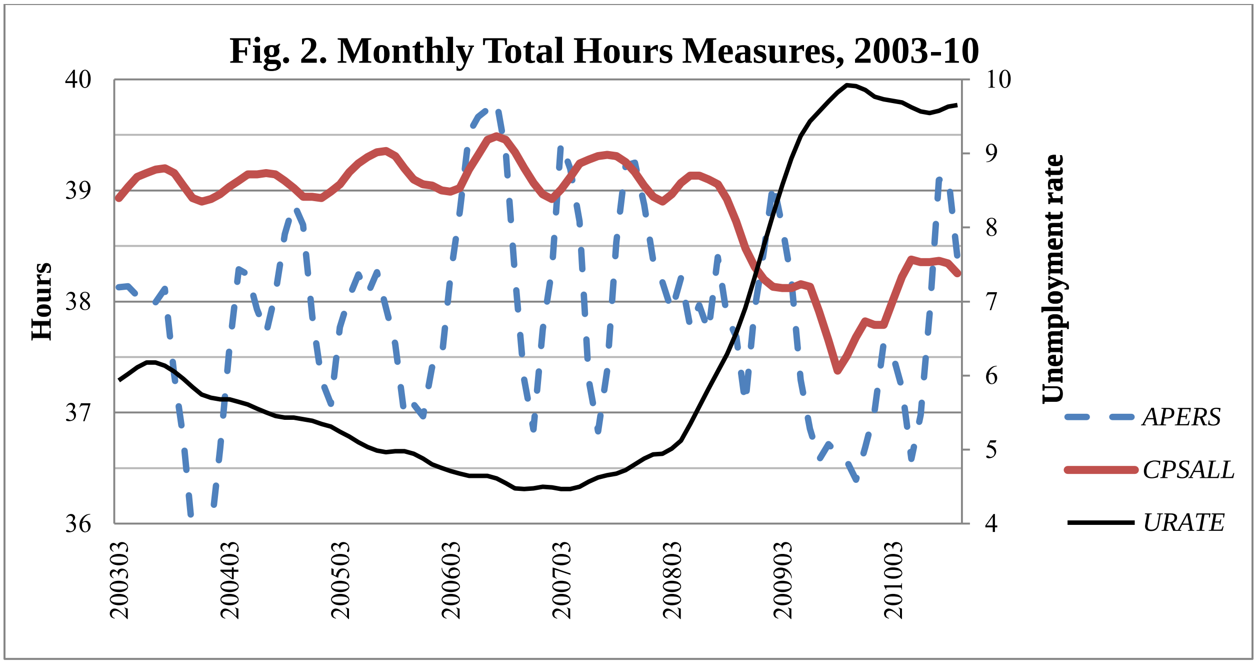

Fig. 2. Monthly Total Hours Measures, 2003-10
Hours
Unemployment rate
40
39
38
37
36
10
9
8
7
6
5
4
200303
200403
200503
200603
200703
200803
200903
201003
APERS
CPSALL
URATE