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HOW BIASED ARE MEASURES OF CYCLICAL MOVEMENTS IN PRODUCTIVITY AND HOURS?

by Stephanie Aaronson and Andrew Figura*

Board of Governors of the Federal Reserve System

The movement of hours worked over the business cycle is an important input into the estimation of many key parameters in macroeconomics. Unfortunately, the available data on hours do not correspond precisely to the concept required for accurate inference. We study one source of mismeasurement—that the most commonly used source data measure hours paid instead of hours worked. In particular, we focus our attention on salaried workers, a group for whom the gap between hours paid and hours worked is likely to be large. We show that the measurement gap varies significantly and positively with changes in labor demand. As a result, we estimate that the standard deviations of the workweek and of total hours worked are 27 and 5 percent larger, respectively, than published measures of hours suggest. We also find that this measurement gap is unlikely to be the source of the acceleration in published measures of productivity in the early 2000s.

Introduction

The movement of hours worked over the business cycle is an important input into the estimation of many key parameters in macroeconomics—from firms' costs of adjusting hours, to markups of price over marginal cost, to returns to scale, to the growth of multi-factor productivity—as well as an important indicator of economic conditions both by itself and when combined with output to produce measures of productivity. Unfortunately, the available data on hours do not correspond precisely to the concept required for accurate inference. We study one source of mismeasurement—that the most commonly used source data measure hours paid instead of hours worked. In particular, we focus our attention on salaried workers, a group for whom the gap between hours worked and hours paid is likely particularly large. We show that the measurement gap varies significantly and positively with changes in labor demand. As a result, we estimate that the standard deviations of the workweek and of total hours worked are 27 and 5 percent larger, respectively, than published measures of hours suggest. We also find that this measurement gap is unlikely to be the source of the pickup in measured productivity growth in the first part of this decade.

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*Correspondence to: Andrew Figura, Mail Stop 80, Board of Governors of the Federal Reserve System 20th & C Streets, NW Washington DC 20551, USA (Andrew.Figura@frb.gov).

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1. The Importance of the Cyclical Variation in Hours Worked

Many researchers have used the cyclical variance of hours relative to the cyclical variance of output to infer the existence of important economic phenomena. Sims (1974) and Wilson and Eckstein (1964) attribute the fact that hours vary less over the business cycle than output to the cost of adjusting labor. Under this interpretation, the cyclical movement in hours, given the cyclical movement in output, is inversely related to the cost of hours adjustment.

The cyclical variance of hours relative to output, along with information on the revenue share of labor, has been used by Hall (1988) to gauge the size of the markup of price over marginal cost. Movements in hours coinciding with movements in output that are more than proportional to labor's revenue share (a measure of the elasticity of output with respect to labor input under perfect competition) is evidence of a markup, and the degree of the markup is inversely related to the variation in hours given the variation in output and labor's share.

Proceeding further, Hall (1990) uses hours combined with other inputs to find evidence of increasing returns to scale. The estimated size of increasing returns is influenced by the estimated changes in hours, holding changes in output and other inputs constant. Subsequent research (e.g. Burnside *et al.*, 1995; Basu, 1996; Basu and Fernald, 1997) has attempted to improve on Hall's methodology and has concluded that returns to scale are close to constant. With constant returns to scale one can use a growth accounting framework, in which cost shares are used to weight inputs, to derive an estimate of MFP growth, provided one accounts for all margins of input adjustment (cf. Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000). In this setting measured changes in hours directly influence estimates of MFP growth, and the cyclical variation in hours is inversely related to cyclical fluctuations in MFP growth.

In this framework, multifactor productivity (MFP) growth can be mismeasured if one fails to account for changes in worker effort over the cycle. To correct for unobserved variation in effort in these estimates, Basu *et al.* (2001) use average weekly hours, under the hypothesis that effort and the workweek should vary together over the cycle. Here again, accurate inference relies on correct measurement of the workweek.

In any of these studies, mismeasurement of hours would lead to bias in estimates of important economic relationships. It could also lead to bias in published statistics, such as productivity and compensation per hour. Previous studies have used a variety of measures of hours per worker and total hours.[1] Despite their variety, all these hours data have as an important component estimates of the average weekly hours of production workers from the Current Employment

[1]Early empirical studies of the cost of hours adjustment, for example, typically used hours of production workers in manufacturing industries (e.g. Wilson and Eckstein, 1964; Nadiri and Rosen, 1969; Sims, 1974). Studies estimating markups, aggregate returns to scale, or multifactor productivity have used the hours of all workers in manufacturing industries, the private nonfarm sector, or the private nonfarm business sector (e.g. Hall, 1988, 1990; Oliner and Sichel, 2000; Basu *et al.*, 2001).

Statistics (CES) survey, also known as the establishment survey.[2] However, the correspondence between average weekly hours measured by the survey and the concept of average weekly hours needed to estimate important macroeconomic parameters is not exact. In particular, while most research conceptually requires a measure of average weekly hours *worked*, the survey collects data on average weekly hours *paid*.

Because of the importance of accurately measuring hours worked, the Bureau of Labor Statistics (BLS) has taken a number of steps to bridge the gap between concept and measurement. For example, the BLS recently implemented a new method for calculating the workweek of nonproduction workers, for whom hours data are not collected in the CES, based on the methodology presented in Eldridge *et al*. (2004).[3] In addition, as is discussed in more detail below, the BLS has long adjusted data on hours paid by removing an estimate of paid leave. However, the BLS does not account for less formal deviations between hours paid and hours worked, primarily time worked off the clock. The remainder of this paper is devoted to quantifying the importance of the failure of published hours data to adequately measure time worked for salaried employees, for whom the difference between hours paid and hours worked is likely to be particularly important.

2. How Data on Hours Paid are Used to Construct Measures of Hours Worked

To make the problem more concrete we start with a brief description of how these commonly used BLS hours data are collected and processed.[4] Each month the BLS collects data from establishments on the total number of workers, the number of production workers, and total hours *paid* for production workers[5] on their payrolls for the pay period including the 12th of the month.

Using these data, the BLS's productivity and costs program calculates total private nonfarm employee hours as the sum of the hours of production workers and the hours of nonproduction workers. For production workers, average weekly hours paid come from the establishment survey. Using data from the National Compensation Survey, the BLS converts production worker hours paid to hours worked by multiplying hours worked by 1 minus the fraction of hours paid consisting of vacation and holiday hours and sick, personal, or administrative

[2]One exception is Jorgenson *et al*. (1987) who derive annual measures of hours per worker from the Current Population Survey. Basu and Fernald (1997) use this data for their analysis of industry-level returns to scale.

[3]In the paper we use "production workers" to refer to production workers in mining and manufacturing, construction workers in the construction industry, and non-supervisory workers in private service-providing industries. The complement, nonproduction workers in goods-producing industries and supervisory workers in other sectors, we refer to as nonproduction workers. It is important to keep in mind that production workers are not synonymous with hourly workers. In the CPS, 23 percent of production workers are salaried, as are 56 percent of nonproduction workers. In fact, given that production workers are a much larger group, there are actually more salaried production workers than salaried nonproduction workers.

[4]A more detailed description of the procedure is included in the Appendix.

[5]The CES began to collect hours paid for all workers beginning in 2007 for publication in 2010.

leave. The hours of nonproduction workers are constructed using detailed industry-level data on nonproduction-worker employment from the CES, production worker workweeks (with the hours paid/hours worked adjustment) from the CES, and the ratio of nonproduction worker workweeks to production worker workweeks from the Current Population Survey.[6]

As is clear, the hours paid/hours worked correction accounts for formal deviations of hours paid from hours worked, but it does not account for less formal deviations, such as when an employee works off the clock. Informal discrepancies between hours paid and hours worked are likely to be particularly large for salaried workers, who account for approximately 30 percent of all jobs on private nonfarm payrolls. Paychecks for these workers are fixed under their employment contracts and do not vary along with hours of work. Thus, it is likely that employer-reported hours paid per worker do not change over the cycle for these workers, while hours worked per worker may.[7] To assess the extent of mismeasurement from this source and the consequence of this mismeasurement for the cyclical variance of private nonfarm hours, we use data on hours worked per worker from the Current Population Survey (CPS).[8]

3. Using the CPS to Estimate Hours Worked for Salaried Workers

The CPS is an alternative source of data on average weekly hours worked. Although the sample size is much smaller than the CES—a monthly sample of about 110,000 individuals aged 16 and over versus approximately 40,000,000 jobs—the CPS collects information not available from the CES. For our purposes the most useful information collected is the data on hours *actually worked* during the survey reference week. Crucially, the CPS also asks whether or not the worker is paid on an hourly basis at their primary job. With this information we can construct a measure of hours worked for salaried workers and compare its behavior to that of an alternative measure that approximates the CES data. It is worth noting that while the CPS began collecting data on hours worked in the 1960s, the survey underwent an extensive redesign in 1994. This redesign improves our ability to conduct our current analysis, but also creates a

[6]Specifically, the BLS estimates the ratio of nonproduction to production worker workweeks at the detailed industry level using data from the Current Population Survey. The BLS then applies these ratios to the CES production worker workweek (with the hours paid/hours worked adjustment) (see Eldridge *et al*., 2004), to produce an estimate of average weekly hours paid for nonproduction workers. Multiplying this workweek by CES nonproduction worker employment produces an estimate of nonproduction worker hours.

[7]According to client services at ADP, which handles the paychecks of 1-in-6 private sector workers in the U.S., firms often report a fixed number of hours for salaried workers. The value typically ranges from 35 to 40 hours for a full-time employee.

[8]As described in footnote 6, because the BLS currently uses data from the CPS to estimate workweeks for nonproduction workers, current estimates of private nonfarm workweeks may, in part, reflect movements of salaried-worker workweeks, at least for nonproduction workers. However, because the BLS's objective in using the CPS data is not to account for movements in salaried-worker workweeks but, instead, to estimate a nonproduction worker workweek that is consistent with the CES production worker workweek, it is unlikely that the BLS's current procedures account for much of the variation in salaried worker workweeks. We describe the reasons for this in the Appendix.

substantial break in the hours data.[9] For this reason we begin our analysis in 1994.

We use the 1994 through 2007 Outgoing Rotation Group data from the CPS for all of our analysis, but, as noted above, research and statistics using hours or the workweek primarily rely on data from the CES. Thus, for our findings to be relevant to the concerns of other researchers there should be some broad agreement between cyclical movements in the CPS and CES workweeks, after accounting for measurement differences. So we first try to make our CPS data as similar as possible to the CES data.

The most important adjustment is to convert the data from an individual basis (the unit of observation in the CPS) to a job basis (the unit of observation used in the CES). The CPS collects substantial information on an individual's first job, including hours worked during the reference week. The CPS also collects data on the number of additional jobs a person has and how many hours he or she works at these additional jobs collectively. So to determine the workweek for these remaining jobs we divide the total number of hours worked at these additional jobs by the number of additional jobs held. Just under 6 percent of individuals in our sample are multiple job holders.

We also limit our sample to wage and salary jobs in the private nonfarm sector, to be more similar to the scope of the CES.[10] For the first two jobs we make use of the information in the outgoing rotation group files on the industry and class (e.g. self-employed worker) of an individual's jobs to identify those in scope for the CES survey. For third and fourth jobs, which account for less than 2 percent of the jobs in our sample, data on industry and class are unavailable. However, we do know that 54 percent of individuals who are private nonfarm wage and salary workers on one of their two main jobs are also private wage and salary workers on the other. So we assume that 54 percent of the third and fourth jobs (chosen at random) meet these criteria.

Next, we categorize workers as hourly or salaried. For the primary job, individuals who report being paid at a frequency other than hourly are considered to be salaried. Although salaried workers are generally thought of as those paid annually, for our purposes defining them as those paid other than hourly is preferable, since we are interested in individuals whose wages will not vary over the week even if their hours do. For this same reason, we consider individuals who work part-time to be nonsalaried, regardless of how they are paid, since their pay could be adjusted if their hours deviated significantly from the specified hours for any length of time (e.g. workers who switch from working three days a week to working four

[9]Prior to 1994, individuals in the outgoing rotation groups were asked to report hours worked on all jobs and were not asked if they were multiple job holders. Thus, it is not possible to construct a measure of hours per job prior to 1994. Questions about multiple job holding were asked of individuals in special supplements to the CPS, but these supplements were irregular and too infrequent to construct reliable time series. However, from 1989 to 1993 individuals in the outgoing rotation group of the CPS who worked 35–48 hours per week were asked whether they worked overtime or multiple jobs during the survey week. We use responses to this question along with reported hours worked to construct an estimate of the salaried workweek. Results of this analysis are reported below.

[10]The CES collects data on wage and salary employees in the nonfarm sector. Most studies that make use of the data further limit the sample to private employees. The productivity data are further limited to the nonfarm business sector, but include self-employed and unpaid family workers.

days a week and receive a proportionate increase in pay). Part-time workers who are not paid hourly make up only 6 percent of our sample and our analysis is not sensitive to this assumption. For jobs beyond the first, we have to make an assumption about how the individual is paid. We tried two possibilities: assuming that all secondary jobs are nonsalaried, and assuming that they have the same pay structure as the person's first job. Our results are not sensitive to the assumption and in the following we assume the former. If a person has more than two jobs, we assume the third and fourth are hourly. In the end, salaried jobs constitute 30 percent of all jobs in our sample, similar to other estimates (cf. Hamermesh, 2002).

Finally, since we believe that in the CES employers report a fixed number of hours for salaried workers, we create a similar CPS measure. Specifically, we set the average workweek for salaried (non-hourly) workers equal to a constant 40 hours per week, our assumption of how hours paid for salaried workers are reported in the CES. Note that since our analysis is largely concerned with the behavior of the variance of the workweek, our results are not sensitive to the choice of a 40 hour workweek. The point is that the salaried workweek is fixed. In order to distinguish this measure from the CPS workweek incorporating the reported hours for salaried employees in the text, we refer to it as the CPS-SAL40 (or counterfactual) workweek.

A few more details: all the data are reported at a quarterly frequency, by taking the weighted average of weekly hours per job across individuals for each month (using the earner-study weights) and then taking the average of months within a quarter (in an attempt to eliminate some high-frequency noise caused by the CPS's relatively small sample size). Finally, the data are seasonally adjusted using the X-12 procedure.

As can be seen in the top panel of Figure 1, the CPS-SAL40 workweek for private nonfarm wage and salary workers exceeds the CES-based workweek by 3–3.5 hours over our sample.[11] This discrepancy could be due to overreporting of hours worked in the CPS, although the evidence suggests this is not a significant problem (cf. Rodgers *et al.*, 1993; Jacobs, 1998; Frazis and Stewart, 2004). The difference could also be due to how the workweeks are reported. The reference period for the CPS workweek is the *week* containing the 12th day of the month, a week that contains fewer holidays than other weeks (cf. Frazis and Stewart, 2004). The CES workweek refers to the *pay period* containing the 12th of the month. To the extent that pay periods in the CES are not weekly (although most of them are) and depending on exactly how the hours paid/hours work adjustment accounts for holidays, it is possible that this could cause the CES workweek to be lower than the CPS workweek. It could also be the case that salaried workers are paid for less than our assumed 40 hours per week.

Nonetheless, the CPS-SAL40 workweek and the CES-based workweek have similar cyclical properties, which is the important feature for our purposes. To isolate the cyclical components of these series, we remove the lower-frequency and higher-frequency components. First, to remove very low frequency variation, we apply a Hodrick–Prescott (HP) filter with λ set equal to 10,000. The resulting series

[11]The CES-based workweek data are taken from table B-10 ("Hours of wage and salary workers on nonfarm payrolls") in Bureau of Labor Statistics (2008).

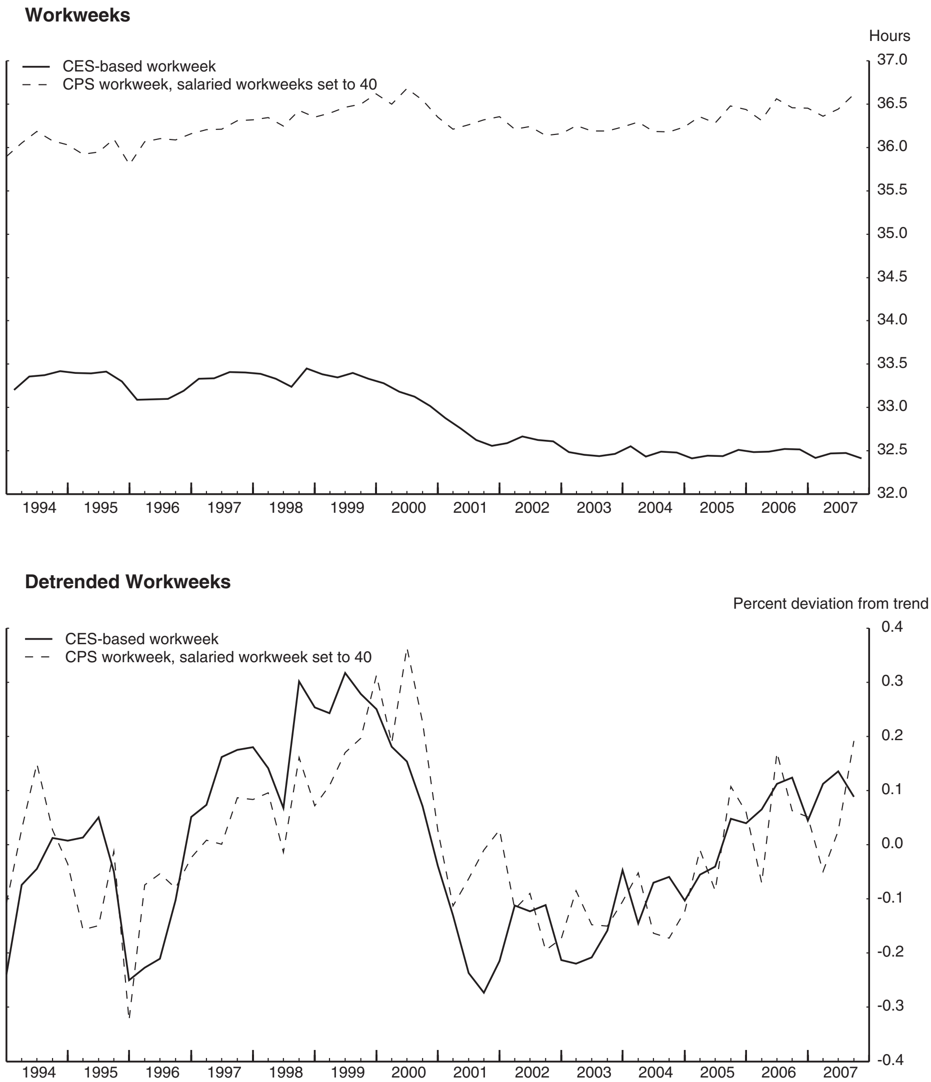

Figure 1. Workweeks for All Private Nonfarm Workers

are shown in the bottom panel of Figure 1. The correlation between the two detrended workweek measures is 0.70. Next, we remove the high-frequency variation by applying a four-quarter moving average to the HP-filtered series. After removing higher-frequency variation, the correlation between the two series increases to 0.82. The similarity in cyclical movements suggests that the differences in cyclical behavior between our counterfactual and actual CPS workweeks should be broadly similar to the differences in cyclical behavior between the actual CES workweek and a hypothetical CES workweek that incorporated variation in salaried-worker workweeks.

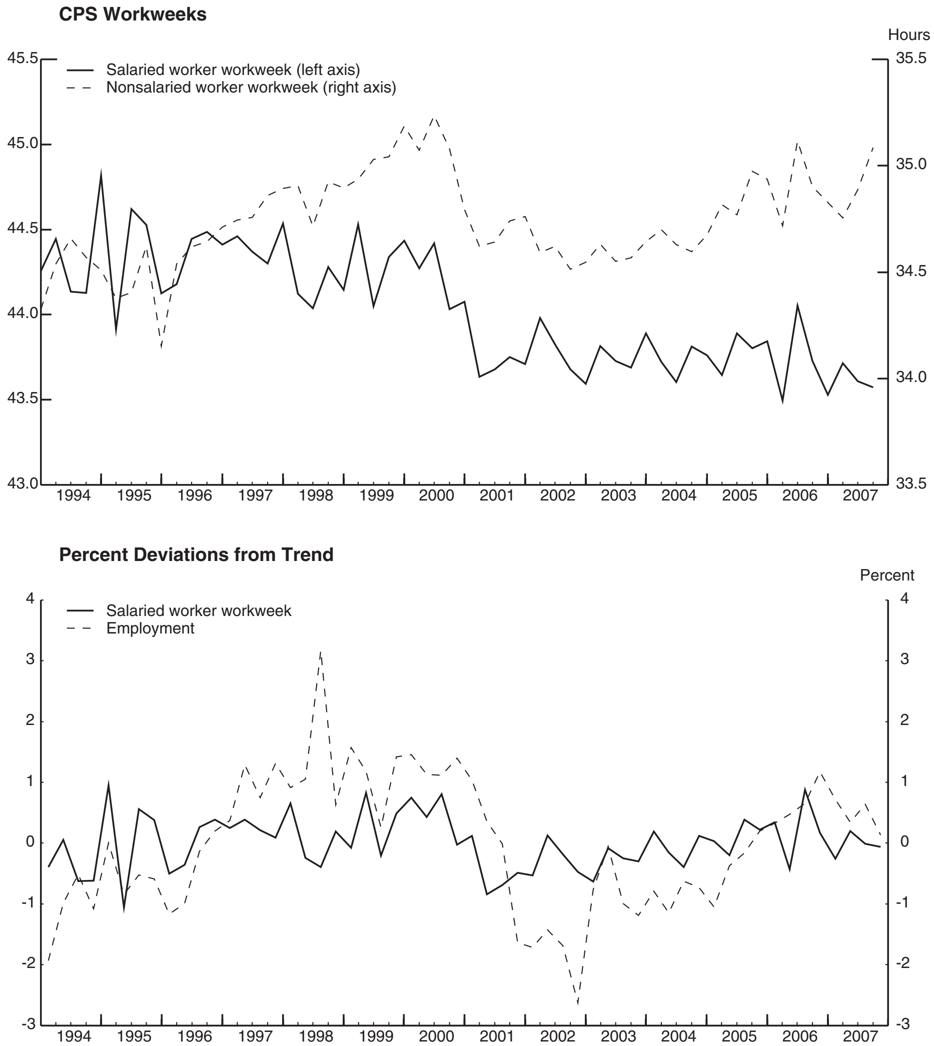

Figure 2. CPS Workweeks for All Private Nonfarm Workers

Next, we examine some important characteristics of the workweek of salaried workers. The solid line in the top panel of Figure 2 plots our estimate of the workweek for private nonfarm salaried workers. A constant workweek appears to be a bad approximation of the actual behavior of salaried workweeks. The actual workweek is quite variable; when detrended (not shown) its variance is similar to the nonsalaried workweek, which is also plotted in the top panel. As shown in the top panel, it also positively covaries with the nonsalaried workweek: the correlation between the two detrended series is 0.54. As shown in the bottom panel—which compares the percent deviations from trend of the private nonfarm salaried workweek and private nonfarm wage and salary employment (trend employment is estimated using an HP filter with λ equal to 10,000)—it also covaries positively with employment (the correlation is 0.42). Due to the break in the CPS data we cannot observe additional cycles, but over the past decade and a half the salaried workweek appears to be procyclical, averaging above trend levels for much of the late 1990s and falling below trend in 2001 and 2002.

4. Salaried-Worker Hours and the Cyclical Behavior of the Workweek and Hours

With data in hand, we are now ready to examine the question of whether it is misleading to use the CES-based workweek of employees on private nonfarm payrolls to examine the cyclical properties of hours and productivity. We answer this question by comparing the CPS workweek (which includes variable salaried workweeks) with our counterfactual workweek, which sets the salaried workweek equal to 40 hours per week (CPS-SAL40). The top panel of Figure 3 shows the resulting series, expressed as percent deviations from their respective trends.[12] The two series look similar, which is unsurprising given that over two-thirds of employees are hourly. However, the counterfactual series appears to vary less than the actual series, and this impression is supported statistically: the standard deviation of the percent deviation of the actual series from trend is about 27 percent larger than that of the counterfactual series (0.47 versus 0.37) (see Table 1). Smoothing the series with a four-quarter moving average to remove high-frequency noise does not change this ratio.

It is also interesting to consider the channels by which variable salaried workweeks contribute to aggregate workweek variation. Equation (1) shows that the variance of the percent deviation of the workweek from its trend can be decomposed into two variance terms and a covariance term. One variance term depends on the percent deviation from trend of the employment-share-weighted salaried workweek; the other variance term depends on the percent deviation from trend of the employment-share-weighted nonsalaried workweek; and the covariance term depends on the covariance of the salaried and nonsalaried workweeks.

$$
\begin{aligned}
(1)\qquad & \operatorname{var}\left(\frac{ww - ww_{trend}}{ww_{trend}}\right) = \operatorname{var}\left(\frac{ww_n^{sh} + ww_s^{wh} - ww_{n,trend}^{sh} - ww_{s,trend}^{sh}}{ww_{n,trend}^{sh} + ww_{s,trend}^{sh}}\right) = \\
& \operatorname{var}\left(\frac{ww_n^{sh} - ww_{n,trend}^{sh}}{ww_{n,trend}^{sh}}\frac{ww_{n,trend}^{sh}}{ww_{trend}} + \frac{ww_s^{sh} - ww_{s,trend}^{sh}}{ww_{s,trend}^{sh}}\frac{ww_{s,trend}^{sh}}{ww_{trend}}\right) = \\
& \operatorname{var}\left(\frac{ww_n^{sh} - ww_{n,trend}^{sh}}{ww_{n,trend}^{sh}}\frac{ww_{n,trend}^{sh}}{ww_{trend}}\right) + \operatorname{var}\left(\frac{ww_s^{sh} - ww_{s,trend}^{sh}}{ww_{s,trend}^{sh}}\frac{ww_{s,trend}^{sh}}{ww_{trend}}\right) + \\
& 2\operatorname{cov}\left(\frac{ww_n^{sh} - ww_{n,trend}^{sh}}{ww_{n,trend}^{sh}}\frac{ww_{n,trend}^{sh}}{ww_{trend}}, \frac{ww_s^{sh} - ww_{s,trend}^{sh}}{ww_{s,trend}^{sh}}\frac{ww_{s,trend}^{sh}}{ww_{trend}}\right)
\end{aligned}
$$

where subscript n denotes nonsalaried, subscript s denotes salaried, and superscript sh denotes that workweeks are multiplied by employment shares. One obvious channel through which the variation in salaried-worker workweeks affects

[12]Again, we estimate trends with HP filter setting $\lambda = 10{,}000$.

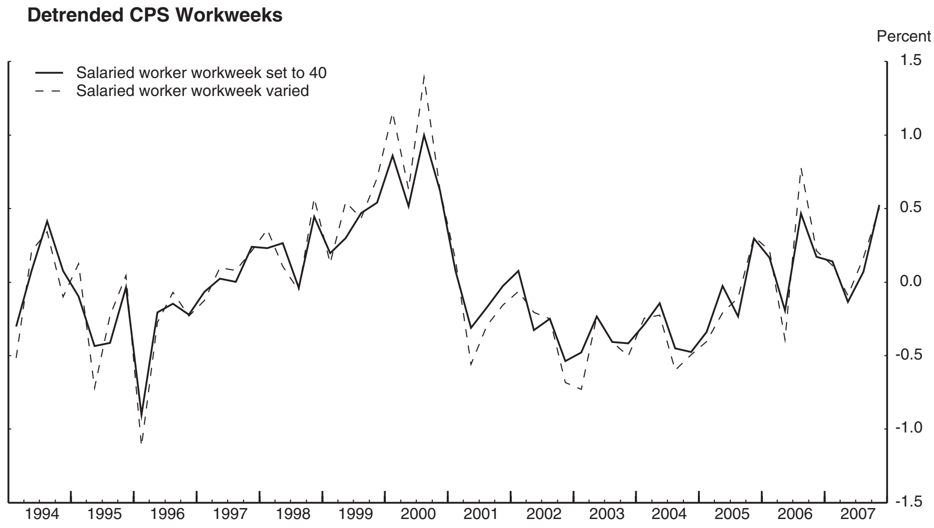

Figure 3. Detrended CPS Workweeks for All Private Nonfarm Workers

TABLE 1

Effect of Varying Salaried Workweek on Aggregate Workweek and Hours

	Standard Deviation of Cyclical Component of Counterfactual Series	Standard Deviation of Cyclical Component of Actual Series	Difference
Workweek	0.37	0.47	27%
Hours	1.40	1.47	5%

Notes: Authors' calculations from the Earner Study of the Current Population Survey, 1994–2007. The counterfactual series holds the workweek of salaried workers constant at 40 hours.

TABLE 2

Accounting for Effect of Varying Salaried Workweek

	Percent of Difference in Variance between Actual and Counterfactual Series due to:	
	Variance Term	Covariance Term
Workweek	29%	71%
Hours	42%	58%

Notes: Author's calculations from the Earner Study of the Current Population Survey, 1994–2007. The counterfactual series holds the workweek of salaried workers constant at 40 hours.

the variance of the aggregate workweek is the variance of the employment-share-weighted salaried workweek. Less obvious is the presence of an indirect channel—the covariance between the employment-share-weighted salaried and nonsalaried workweeks. Because the salaried workweek is procyclical, it positively covaries with the procyclical nonsalaried workweek, adding to the variation in the aggregate workweek. Assuming a constant salaried-worker workweek shuts down this channel. Thus, the distortion imparted by removing variation in the salaried-worker workweek will increase as the variance of the salaried-worker workweek increases and as the covariance between the salaried-worker workweek and the nonsalaried-worker workweek increases.

To assess the relative importance of these two channels, we detrend the two components of the workweek (ww_n^{sh} and ww_s^{sh}) separately. The aggregation of these two detrended series matches that of the detrended aggregate workweek closely. We then calculate the contribution of each term in equation (1) to the difference in variance between the actual workweek and the CPS-SAL40 workweek as the difference between the value of the term when computed using the actual workweek and the term computed when using the counterfactual workweek.

While both terms that depend on the salaried workweek are important, the covariance term accounts for most of the added variance. As shown in Table 2, the covariance between the salaried and nonsalaried workweeks accounts for 71 percent of the additional variance of the total private nonfarm workweek, while the variance of the salaried worker workweek accounts for 29 percent of the added variance. Thus, if it were not for the fact that salaried workweeks are procyclical, the distortion imparted by removing variation in the salaried workweek would be relatively small.

A more variable salaried workweek also affects the variance of total weekly hours. To estimate this effect, we again construct actual and counterfactual measures of hours, where the counterfactual measure sets the workweek for salaried workers equal to 40 and uses the CPS-based measure of jobs we used to construct our workweeks. To isolate the cyclical component of the variance of hours we detrend each measure using an HP filter. The bottom panel of Figure 3 plots the two series. As shown in Table 1, the standard deviation of the percent deviation of the actual series from its trend exceeds that of the counterfactual series by 5 percent. (Smoothing the two series with a four-quarter moving averages does not alter this difference.)

Again, it is interesting to consider the channels through which variable salaried workweeks affect the variance of total hours. The variance of hours can be decomposed as follows:

$$(2)\qquad \operatorname{var}\left(\frac{H-H_{trend}}{H_{trend}}\right)\approx \operatorname{var}\left(\ln\left(\frac{H}{H_{trend}}\right)\right)=\operatorname{var}\left(\ln\left(\frac{e}{e_{trend}}\right)+\ln\left(\frac{w}{w_{trend}}\right)\right)=$$
$$\operatorname{var}\left(\ln\left(\frac{e}{e_{trend}}\right)\right)+\operatorname{var}\left(\ln\left(\frac{w}{w_{trend}}\right)\right)+2\operatorname{cov}\left(\ln\left(\frac{e}{e_{trend}}\right),\ln\left(\frac{w}{w_{trend}}\right)\right).$$

To compute this decomposition we first extract the trend components of the workweek and employment using an HP filter.[13] To estimate the contribution of the variable salaried workweek to the components of hours variation in (2) we take the difference between the component using the actual workweek and the component using the counterfactual workweek. Results show that both components that depend on the salaried workweek are important: the covariance of the workweek with employment accounts for 58 percent of the additional variance of total hours (confirming the importance of the salaried workweek's procyclical behavior), while the variance of the workweek itself accounts for the remaining 42 percent. In sum, while the effect is not large, assuming that the salaried worker workweek is constant, as the respondents to the establishment survey appear to do, mutes the cyclical variance of both the workweek and total hours. This in turn affects the volatility of productivity, a consequence we explore further below.

One limitation of our results is that we only have one cycle over which to examine the behavior of the salaried-worker workweek. To check the robustness of our results, we examine differences in seasonal variation between our actual and counterfactual workweeks and also examine the behavior of an inferior measure of salaried workweeks that we can compute using data from 1989 to 1993.

We look first at seasonal variation. Although post-1994 data includes only one business cycle, it includes 14 seasonal cycles. Because seasonal changes in hours are of shorter duration and more predictable than cyclical changes, one cannot directly infer cyclical behavior from seasonal measures. Nonetheless, as shown by Beaulieu *et al.* (1992), seasonal variances are significantly correlated with cyclical variances for a number of important economic variables, including production worker hours and employment. Thus, a finding of significant seasonal variation in the salaried workweek, would strengthen our conclusion that there is a significant cyclical variance.

Table 3 shows the average seasonal factors created by X-12 for the CPS salaried and non-salaried workweek over the period 1994 to 2007 (for all private nonfarm workers).[14] As can be seen, the salaried workweek appears to exhibit

[13]As a check on our computations, we compared the measure of detrended hours built up from detrended employment and the workweek with hours detrended directly. The two series are very similar.

[14]We also regressed the salaried worker workweek on four quarterly dummy variables. An *F* test that the dummies are jointly 0 reveals that seasonal variation in the series is significant at only the 30 percent level of confidence. However, it is likely that restricting seasonal variation to be constant across time understates seasonal movements. A comparison of seasonal movements estimated with dummy variables and with the X-12 procedure shows that seasonal variation is three times larger when seasonal patterns are allowed to change over time (as in the X-12 procedure).

TABLE 3
Average Seasonal Factors for Salaried and Nonsalaried Workweeks

	Private Nonfarm Workers			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Salaried Workweek	0.999	1.001	0.997	1.002
Nonsalaried Workweek	0.989	1.004	1.012	0.995
Employment	0.995	1.000	0.993	1.012

Note: Author's calculations from the Earner Study of the Current Population Survey, 1994–2007.

seasonal movements, with relative peaks in the second and fourth quarters.[15] Moreover, these movements are positively correlated with seasonal movements in CPS employment: the actual correlation is 0.71. As a point of comparison, the table also shows the seasonal factors for the nonsalaried workweek. The workweek for nonsalaried employees is more variable with a clear peak in the third quarter and a clear trough in the first quarter. The ratio of the standard deviation of the salaried workweek to the standard deviation of the nonsalaried workweek at seasonal frequencies is about 0.28, about one quarter of the ratio at cyclical frequencies (using percent deviations from trend).

To measure the contribution of the salaried workweek to the seasonal variance in workweeks and hours, we perform the same counterfactual exercise we undertook above for data at business cycle frequencies. First consider the seasonal variance in the workweek. Interestingly, seasonal movements in salaried workweeks are somewhat negatively correlated with seasonal movements in nonsalaried workweeks (–0.19). As a consequence, the effect of variable salaried workweeks on workweek variation is actually negative: the seasonal variance in the actual workweek is 29 percent less than the seasonal variance in the counterfactual workweek. This demonstrates that more variable salaried workweeks do not necessarily imply more variable total workweeks. That they do at business cycle frequencies owes to the positive covariance between salaried workweeks and nonsalaried workweeks at that frequency.

For total hours, the standard deviation of the actual series is a little over 3 percent greater than the counterfactual series. This is because the actual salaried workweek is highly positively correlated with seasonal movements in employment. This outweighs the negative correlation between salaried and nonsalaried worker workweeks discussed above. On balance, data at the seasonal frequency offer some support for the hypotheses that salaried-worker workweeks covary significantly and positively with labor demand (assuming that at seasonal frequencies changes in employment are a reasonable proxy for changes in labor demand) and, thus, add to the cyclicality of hours.

Our second robustness test extends our data back to 1989 in order to capture an additional business cycle. While, as described in footnote 9, it is not possible to construct comparable measures of hours per job prior to 1994, it is possible to

[15]The point of this exercise is to use the seasonality of the workweek data to gain insight into how variation in the salaried workweek affects the variation of the aggregate workweek and aggregate hours. The actual pattern of seasonality in the CPS data, which may differ from the seasonality of the CES data, is not important.

TABLE 4

Dynamic Correlations of Workweeks with Employment

	All Private Nonfarm Workers								
	Correlation at Time t with Actual CPS Workweek at Time $t+i$								
	$i=-4$	$i=-3$	$i=-2$	$i=-1$	$i=0$	$i=1$	$i=2$	$i=3$	$i=4$
CPS workweek salaried hours set to 40	0.33	0.47	0.48	0.63	0.97	0.59	0.53	0.44	0.30
	Correlation at Time t with CPS Wage and Salary Employment at Time $t+i$								
CPS workweek	0.40	0.49	0.55	0.61	0.70	0.75	0.76	0.72	0.63
CPS workweek salaried hours set to 40	0.45	0.54	0.59	0.65	0.73	0.78	0.79	0.74	0.65
Memo: Correlation between salaried worker workweek at t and nonsalaried worker workweek at $t+i$	0.23	0.44	0.23	0.38	0.54	0.28	0.23	0.1	–0.06

Note: Author's calculations from the Earner Study of the Current Population Survey, 1994–2007.

construct an inferior measure from 1989–93. In this period, individuals in the outgoing rotation group of the CPS who worked 35–48 hours per week were asked whether they worked overtime or multiple jobs during the survey week. Restricting our sample to individuals responding "no" to this question, we computed an average workweek for nonhourly (salaried) workers. Thus this measure provides a clean read of hours for individuals with a single job, but omits multiple job holders.

The behavior of the salaried workweek over this period was qualitatively similar to the behavior we estimate for the post-1994 period. Most importantly, in both periods the salaried workweek covaries positively with employment. As a result, workweek measures that do not account for variation in salaried worker hours likely understate the variation in the workweek and hours over the business cycle.

Turning back to the post-1994 sample, we now consider the question of whether mismeasurement of salaried-worker workweeks affects the timing of workweek movements. As discussed above, the workweek has been used as a proxy for unobserved effort (see Basu *et al.*, 2001). Significant differences in the timing of cyclical movements in salaried and nonsalaried workweeks would indicate potential problems with estimates of MFP growth that use measures of the workweek that do not reflect movements in salaried-worker workweeks to control for effort. The memo line of Table 4 shows dynamic correlations of the salaried-worker workweek with the nonsalaried-worker workweek. The peak correlation occurs at $i=0$, suggesting that the timing of cyclical movements in salaried and nonsalaried workweeks is quite similar. To see if this is the case, the top line of Table 4 reports dynamic correlations of actual and counterfactual (salaried workweek set equal to 40) workweeks. As expected, the peak correlation is large and occurs at $i=0$. Thus, the timing of the two series appears to be very similar. Furthering this impression are the dynamic correlations between the two series and employment, our proxy for the state of the cycle, reported in the second and third

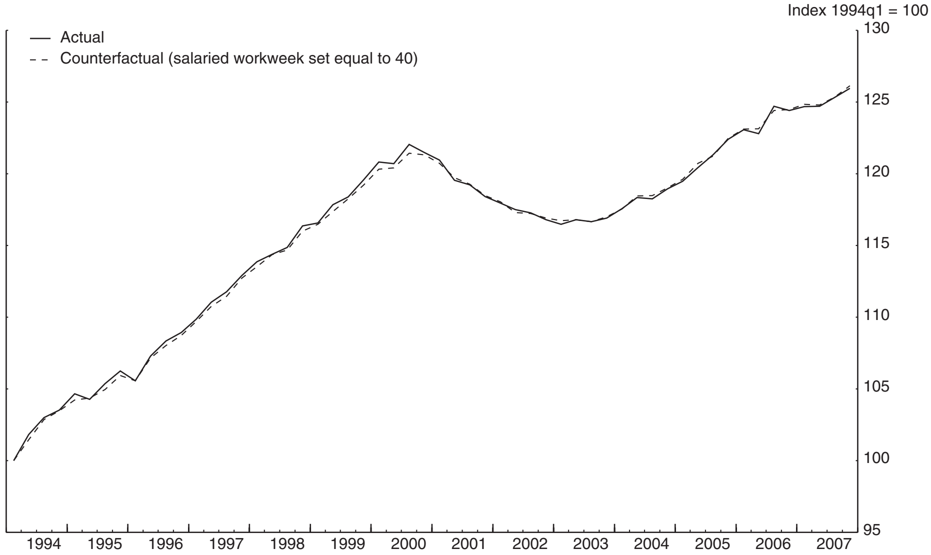

Figure 4. Actual and Counterfactual Hours

rows of the table. Notably, both the actual CPS workweek and the CPS-SAL40 workweek have their peak correlations when leading employment by two quarters. Apparently, the positive correlation between salaried and nonsalaried workweeks leads our counterfactual workweek to be highly correlated with the actual workweek, and it, therefore, appears unlikely that mismeasurement of salaried workweeks significantly affects the timing of movements in the aggregate workweek.

Next, we examine the effects of mismeasuring the salaried workweek on the recent behavior of productivity (both labor productivity and multifactor productivity). To assess the effects of mismeasurement on labor productivity, we compare the movement of the hours of private nonfarm employees calculated using CES nonfarm private employment and the CPS workweek to an alternative, or counterfactual, series calculated using our CPS-SAL40 workweek. The difference between these two measures is the difference between productivity measured with a constant salaried workweek and productivity measured with a variable salaried workweek, and reflects both the cyclical variation in the salaried workweek, which we have examined above, as well as the trend movement in the salaried workweek.[16]

As shown in Figure 4, both measures of hours reach a cyclical peak in 2000:Q3, with the level of the series using the actual CPS workweek about 0.5 percent higher. Over the next several years, the series using the actual workweek declines more quickly, leaving the two series at about the same level by the end of 2004. These data suggest that using actual hours worked of salaried workers decreases productivity growth (increases employee hours) from 1994:Q1 to 2000:Q3 by about

[16]The private nonfarm sector hours measures we use are not directly comparable to the nonfarm business (NFB) hours measures used to construct published productivity measures. NFB hours exclude the hours of workers in non-profit institutions and include the hours of workers in government enterprises. Employee hours in the nonfarm business sector are about 90 percent of private nonfarm hours.

0.5 percentage points and increases productivity growth (decreases employee hours) from 2000:Q3 to 2004:Q4 by an equal amount. Differences since 2004 are small.

Some observers have speculated that an increase in unmeasured off-the-clock work, largely stemming from improved information technologies, explains, at least in part, the strong performance of productivity during the first part of this decade (cf. Roach, 2003). Our analysis offers little support for this hypothesis. As shown in Figure 4, accounting for variation in the hours of salaried workers actually increases the growth in productivity after 2000. While the CPS may not capture all of any supposed increase in recent off-the-clock work activity, it should have picked up at least some of it, and, as a result, should have trended upward over this period, relative to the constant level, which we believe is reflected in the CES data. Instead, the salaried workweek has fallen on balance since 2000.

Mismeasurement of salaried workweeks also affects the behavior of measured MFP growth. The understatement of hours growth from 1994 to 2000 and the overstatement of hours growth from 2000 to 2004 causes MFP growth calculated using a constant salaried workweek to be overstated by about 0.35 percent (0.5 percent times labor's share) over the earlier period and understated by a similar amount over the latter period.

Also of interest is whether mismeasurement of the workweek distorts attempts to remove the effect of cyclical utilization on MFP growth using variation in the workweek, as in Basu *et al.* (2001; henceforth BFK). Data constraints prevent us from directly assessing the effect of mismeasurement on BFK-style estimates of MFP growth.[17] However, the very high correlation between the actual and counterfactual workweeks (see Table 4) suggests that BFK-style estimates of the total effect of cyclical utilization on MFP growth are not likely to be significantly distorted by mismeasurement of salaried workweeks, although structural parameters may be mismeasured.

To see why, note that BFK show that under plausible assumptions, the workweek should be positively correlated with unobserved worker effort and capital utilization, and, thereby, with observed MFP growth. As a result, BFK can use the workweek to purge MFP growth of the component related to cyclical changes in utilization in the following regression:

(3) $$\Delta \ln(y_t) = \alpha + \beta \Delta \ln(x_t) + \gamma \Delta \ln(\tilde{w}_t) + \varepsilon_t$$

where x denotes factor inputs, $\tilde{w}$ denotes the ratio of the workweek to its trend, and ε is an i.i.d. error. If one assumes constant returns to scale, then this equation reduces to

(4) $$\Delta \ln(MFP_t) = \alpha + \gamma \Delta \ln(\tilde{w}_t) + \varepsilon_t.$$

The estimated coefficient will be $\hat{\gamma} = \frac{\sigma_{mfp}}{\sigma_{\tilde{w}}} \rho_{mfp,\tilde{w}}$, where σ_x denotes the estimated standard deviation of variable x, and ρ_{xy} denotes the estimated correlation between

[17]While it would be a simple matter to run a BFK-style regression using published annual data on MFP growth from 1995 to 2006, the sample period is too small to yield informative coefficient estimates. Moreover, movements in MFP growth over the 1995–2006 period are dominated by the 2001 recession and its aftermath, when changes in MFP apparently had little to do with cyclical changes in utilization, as modeled in BFK, and probably much to do with corporate restructuring.

variables x and y. If the two workweeks are perfectly correlated, $\tilde{w}_t^a = g * \tilde{w}_t^c$, where superscript a denotes actual and superscript c denotes counterfactual, then $\hat{\gamma}^a$ will equal $\frac{\sigma_{\tilde{w}}^a}{\sigma_{\tilde{w}}^c}\hat{\gamma}^c = \frac{1}{g}\hat{\gamma}^c$. As a result, the quantities $\hat{\gamma}^c\tilde{w}_t^c$ and $\hat{\gamma}^a\tilde{w}_t^a$ will be identical, as will estimated MFP growth purged of utilization.

However, if the researcher is interested in $\hat{\gamma}$, instead of $\hat{\gamma}\tilde{w}_t$, then mismeasurement of the workweek could be problematic. For example, Shapiro (1986) estimates the parameters of the following dynamic production function:

$$Y_t = \alpha_H \ln(H_t) + \alpha_L \ln(L_t) + \alpha_N \ln(N_t) + \alpha_K \ln(K_t) + Z_t \tag{5}$$

where Y is output, H is average weekly hours for production workers, L is production workers, N is nonproduction workers, K is capital, and Z includes adjustment cost terms and a productivity parameter. Our estimate of $\frac{\sigma_{\tilde{w}}^a}{\sigma_{\tilde{w}}^c}$ suggests that $\hat{\alpha}_H^c \approx \frac{\sigma_{\tilde{w}}^a}{\sigma_{\tilde{w}}^c}\hat{\alpha}_H^a = 1.27 * \hat{\alpha}_H^a$, so that estimates of $\hat{\alpha}_H^c$ would overstate the true parameter value by 27 percent.

Before concluding, we speculate on what mismeasurement of the workweek might imply about important labor market statistics in the most recent labor market downturn. It is likely that the cyclical bias in movements in the workweek and hours that we estimate above has also affected published estimates of the workweek, hours, and productivity from the fourth quarter of 2007 to the fourth quarter of 2009. Over this period, the workweek for production and nonsupervisory workers fell 2 percent. Given that this measure of the workweek and the workweek for the nonfarm business sector, which is largely based on the production/nonsupervisory workweek, do not reflect variation in the workweeks of salaried workers and the positive correlation in the workweeks of salaried and nonsalaried workers that we documented above, we would expect that the published declines in these workweeks, as well as the published decline in total hours, have understated the true decline. As a result, the nearly 10 percent drop in hours worked from the fourth quarter of 2007 to the fourth quarter of 2009 was likely even larger. Productivity growth over these two years has held up remarkably well. Despite the negative shock to economic activity, published productivity, which is typically procyclical, posted a surprisingly rapid average annual increase of close to 3 percent, somewhat above its average pace over the past 10 years. Our research suggests that the actual increase in productivity may have been even more surprisingly rapid.

5. Conclusion

Accurate measurement of the cyclical behavior of hours worked is necessary for correct inference about many important macroeconomic phenomena. Because the most commonly used workweek statistics derive from measures of hours paid rather than hours worked, they likely understate the cyclical movements of salaried-worker workweeks. We estimate that as a result published data understate the cyclical movements in the workweek and aggregate hours by 27 and 5 percent, respectively. Our hours estimate suggests that researchers should examine carefully the sensitivity of parameter estimates to hours variation. If parameters are not very sensitive, then using standard published measures of hours likely yields a close-to-unbiased measure of the relevant parameters. If parameters are very sensitive, then researchers should consider treating their estimates as upper or lower bounds, depending on the context. Focusing on the period from 1994 through the early 2000s, mismeasuring the salaried-worker workweek likely had a small effect on the behavior of hours and productivity. Productivity growth would likely have been somewhat greater from 2000 to 2004 and somewhat smaller from 1994 to 2000 if actual hours worked of salaried workers had been used to construct measures of productivity.

Appendix

Employee Hours in the Private Nonfarm Sector and the Nonfarm Business Sector

Each month the establishment survey asks approximately 400,000 worksites to provide the total number of workers, the number of production workers, and total hours paid for production workers on their payrolls for the pay period including the 12th of the month.[18] The BLS uses information on an establishment's pay period length and the number of production workers to convert the hours paid data to average weekly hours paid for production workers. Then the BLS uses a "weighted link and taper" estimator to produce estimates of average weekly hours paid for each estimation cell, where the cell is based on detailed industry. Aggregate average weekly hours (AWH) are calculated by summing the product of AWH and PW employment (aggregate hours) for each basic cell, then diving by the total number of production workers in the basic cells. The indexes of aggregate hours are calculated by dividing aggregate hours for a given month by the annual average aggregate hours for 2002 (index year = 100) and then multiplying by 100.[19]

Production worker hours paid are used to construct estimates of total employee hours worked in the private nonfarm sector. The BLS's productivity and costs program calculates total private nonfarm employee hours as the sum of the hours of production workers and the hours of nonproduction workers. For production workers, the BLS uses data from the National Compensation Survey to convert hours paid from the establishment survey to hours worked by multiplying hours worked by 1 minus the fraction of hours paid consisting of vacation and holiday hours, sick, personal, or administrative leave. The hours of nonproduction workers are constructed using data from the Current Population Survey, as described in the main text and below.

To construct estimates of hours worked in the nonfarm business sector, the BLS subtracts from private nonfarm hours the hours of employees in nonprofit organizations serving individuals and adds in an estimate of hours for workers in the nonfarm business sector but not covered by the CES (e.g. self employed hours, hours worked at government enterprises).

[18]Response rates to the survey are close to 90 percent. Respondents account for about one-third of private nonfarm employment.

[19]For more detail on the methods used to estimate hours per worker and total hours for production workers, see Bureau of Labor Statistics (2008).

Nonproduction-Worker Workweeks and Overtime

BLS's current procedures for estimating nonproduction-worker workweeks are unlikely to fully reflect movements in salaried-worker workweeks because the BLS does not estimate the nonproduction-worker workweek directly from CPS data but instead estimates a ratio of nonproduction to production-worker workweeks from the CPS data and applies this ratio to the CES production worker workweek:

$$ww_n^{CES} = \frac{ww_n^{CPS}}{ww_p^{CPS}} ww_p^{CES} \tag{A1}$$

where subscript n denotes nonproduction and subscript p denotes production. This procedure would only fully reflect variation in nonproduction salaried worker workweeks if production workers were all nonsalaried—in this case, the CES and CPS measures of production worker workweeks would be conceptually similar (in terms of whether they measured variation in salaried-worker workweeks) and the two measures of production-worker workweeks (ww_p^{CES}, ww_p^{CPS}) would cancel in the above expression, abstracting from other measurement differences between CPS and CES workweeks. However, as noted in footnote 3, nonproduction workers and salaried workers are not identical groups, and, as a result, this condition does not hold. In this case, we can express the measured nonproduction workweek as

$$ww_n^{CES} = ww_n^{CPS} \frac{ww_{p,c}^{CPS}}{ww_p^{CPS}} \frac{ww_p^{CES}}{ww_{p,c}^{CPS}} \approx ww_n^{CPS} \frac{ww_{p,c}^{CPS}}{ww_p^{CPS}} \tag{A2}$$

where $ww_{p,c}^{CPS}$ is our counterfactual production-worker workweek, and the second equality is approximate because the counterfactual CPS production-worker workweek is only approximately equal to the CES production-worker workweek. The expression on the right-hand side of the second equality shows that the CES nonproduction worker workweek is distorted by a term reflecting the ratio of the counterfactual to the actual production-worker workweeks. That is, if the production-worker workweek is affected by mismeasurement of salaried production-worker workweeks, then this mismeasurement will also distort BLS estimates of the nonproduction workweek.

Nevertheless, it is true that ww_n^{CES} may reflect some of the variation in the salaried nonproduction-worker workweek, which would imply that our estimate of the variance of the counterfactual workweek is biased downward. To examine this possibility, we also computed an alternative counterfactual CPS workweek that estimates nonproduction workweeks similarly to current BLS procedures. Specifically,

$$ww_c^{CPS} = \frac{e_p}{e_p + e_n} ww_{p,c}^{CPS} + \frac{e_n}{e_p + e_n} \frac{ww_n^{CPS}}{ww_p^{CPS}} ww_{p,c}^{CPS} \tag{A3}$$

where ww_c^{CPS} is our alternative counterfactual workweek. The variance of the alternative counterfactual workweek and the variance of the counterfactual workweek reported in the main body of the paper are almost identical.

Theoretically, it may also be possible for the CES to capture variation in salaried worker workweeks through changes in overtime. However, if an employer is paying an employee overtime, it is also required under the Fair Labor Standards Act to record for the employee an hourly wage rate, hours worked each day, and hours worked each week, among other items. Thus, almost by definition, workers receiving overtime are hourly, not salaried, workers, and we would not expect variation in overtime payments to capture much of the variation in salaried-worker workweeks.

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