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Stephanie Aaronson and Andrew Figura

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Stephanie Aaronson and Andrew Figura*
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Abstract

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—focusing our attention on salaried workers, a group for whom the gap between hours paid and hours worked 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 25 and 6 percent larger, respectively, than standard measures of hours suggest. We also find that this measurement gap is an unlikely source of the acceleration in published measures of productivity since 2000.

*Mail Stop 80, Board of Governors of the Federal Reserve System, Washington DC 20551. Email: saaronson@frb.gov, jfigura@frb.gov. The views presented are solely those of the authors and do not necessarily represent those of the Federal Reserve Board or its staff. We thank Bill Wascher, Darrel Cohen and Phyllis Otto for helpful comments and Leslie Carroll for excellent research assistance.

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—focusing 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 25 and 6 percent larger, respectively, than standard measures of hours suggest. We also find that this measurement gap is an unlikely source of the acceleration in published measures of productivity since 2000.

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 mark-up 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 mark-up, 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. Basu (1996), Basu and Fernald (1997), and Burnside, Eichenbaum and Rebelo (1995)—has attempted to improve on Hall's methodology and has concluded that returns to scale are close to constant. In such an environment, 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. Oliner and Sichel (2000) and Jorgenson and Stiroh (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, 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, Fernald, and Shapiro (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, where mismeasurement of the phase of the workweek relative to output could bias estimates.

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 or compensation per hour. Thus the choice of a measure of hours has important implications for the results. 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 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 based on the methodology presented in Eldridge, Manser and Otto (2004).[3] In addition, as is discussed in more detail below, the BLS has long adjusted

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[1] Early empirical studies of the cost of hours adjustment, for example, typically used hours of production workers in manufacturing industries—e.g. Sims (1974), Nadiri and Rosen (1969) and Wilson and Eckstein (1964). Other 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), and Basu, Fernald, and Shapiro (2001).

[2] One exception is Jorgenson, Gollop, and Fraumeni (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 the goods-producing sector and nonsupervisory workers in other sectors of the economy. 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 57 percent of nonproduction workers. In fact, given that production workers

data on hours paid by subtracting out 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 it is likely to be a particular problem.

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

To make the problem more concrete we start by describing how these commonly used BLS hours data are collected and processed. Each month the establishment survey asks approximately 400,000 worksites to provide information on the number of workers, both production and nonproduction, and the total hours paid for production workers on their payrolls for the pay period including the 12th of the month.[4] 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. Summing across estimation cells, weighted by employment shares, produces industry-level and aggregate estimates of the production worker workweek. These estimates are then multiplied by production worker employment to produce

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are a much larger group, there are actually more salaried production workers than salaried nonproduction workers.

[4] Response rates to the survey are close to 90 percent. Respondents account for about 1/3 of private nonfarm employment.

indexes of industry-level and aggregate total hours paid for production workers.[5]

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 taken directly from the establishment survey and the hours of nonproduction workers, which are constructed.[6] Using data from the National Compensation Survey, the BLS also converts hours paid to hours worked in the nonfarm and nonfarm business sectors by multiplying hours worked by 1 minus the fraction of hours paid consisting of vacation and holiday hours, sick and personal or administrative leave.[7]

As is clear, this 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 reported hours paid

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[5] For more detail on the methods used to estimate hours per worker and total hours for production workers, see the Bureau of Labor Statistics' *Employment & Earnings*.

[6] To generate an estimate of nonproduction worker hours the BLS first estimates the ratio of nonproduction to production worker workweeks using data from the Current Population Survey. Then the BLS applies this ratio to the CES production worker workweek, see Eldridge, Manser, and Otto (2004), to produce an estimate of average weekly hours paid for nonproduction workers. The BLS then multiplies this workweek by CES nonproduction worker employment to produce an estimate of nonproduction worker hours. Because nonproduction workers and salaried workers are not identical groups, the BLS imputation of the nonproduction worker workweek does not fully account for the hours of salaried nonproduction employees. However, given the difference in shares of production and nonproduction workers accounted for by salaried workers (see footnote 2 above), it could be that the BLS procedure does capture some of the movement in salaried nonproduction worker workweeks.

[7] The BLS uses Bureau of Economic Analysis data on compensation by legal form of organization to convert total private nonfarm hours into hours for the nonfarm business sector.

per worker does not change over the cycle for these workers, while hours worked per worker may. To assess the extent of likely mismeasurement from this source and the consequence of this measurement for the cyclical variance of private nonfarm hours, we use data on hours worked per worker from the Current Population Survey (CPS).

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 age 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 comes from questions asking for 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 improved our ability to conduct our current analysis, but also creates a substantial break in the hours data.[8] For this reason we begin our analysis in 1994.

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[8] 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.

We use CPS data 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. To make the CPS data more similar to the CES data we make several adjustments. The most important is that we convert the data from an individual basis to a job basis—the concept used in CES measures of the workweek—by dividing the total number of hours worked by an individual by the number of jobs she holds. 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. For the first two jobs the CPS collects sufficient information to identify such jobs. For 3rd and 4th jobs, which account for less than ½ percent of the jobs in our sample there is no such information. However, we do know that 66 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 66 percent of the 3rd and 4th 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 whose salaries are quoted on an annual basis, for our purposes defining them as those paid other than hourly is preferable, since we are interested in individuals whose wages won't 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 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.

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. 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 workweek. All the data are reported at a quarterly frequency, by taking the mean of average weekly hours per job across individuals for each month (using the basic CPS 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 chart 1, the CPS-SAL40 workweek for private nonfarm wage and salary workers exceeds the CES-based workweek by 3 to 3-1/2 hours over our sample.[9] This discrepancy could be due to overreporting of hours worked in the CPS, although

[9] The CES-based workweek data are taken from table B-10: Hours of Wage and Salary Workers on nonfarm payrolls in "Employment & Earnings," Bureau of Labor Statistics, Washington, DC.

the evidence suggests this is not a significant problem (cf. Frazis and Stewart, 2004; Jacobs, 1998; Rodgers et al., 1993). 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. We detrend the two series using a Hodrick-Prescott (HP) filter with λ set equal to 10,000 to remove the very low frequency variation. The resulting series are shown in the bottom panel of chart 1. The correlation between the two detrended workweek measures is 0.64. If we take the four-quarter moving average of the cyclical components, which further reduces the noise in the CPS series, the correlation becomes 0.78. Thus, it appears that results taken from analysis of movements in CPS workweeks should be applicable to measures of workweeks based on CES data.

Next, we examine some important characteristics of the workweek of salaried workers. Chart 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, though not as variable as the nonsalaried workweek, which is also plotted in the top panel. As shown in the top panel, it moves with the nonsalaried workweek (the correlation is 0.18) and, 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 0.49). Over the past decade 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 all employees on private nonfarm payrolls to examine the cyclical properties of hours and productivity. We answer this question by comparing our estimate of the actual workweek (which includes variable salaried workweeks) with our constructed CPS-SAL40 workweek. The top panel of chart 3 shows the resulting series, expressed as percent deviations from their respective trends.[10] 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 25 percent larger than that of the counterfactual series (0.49 versus 0.39), see table 1. Smoothing the series with a four-quarter moving average to remove high-frequency noise does not change this ratio.

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	0.39	0.49	25%
Hours	1.29	1.36	6%

It is also interesting to consider the channels by which variable salaried workweeks

[10] Again, we estimate trends with HP filter setting λ=10,000.

contribute to aggregate workweek variation. Equation (1) shows that the variance of the percent deviation of the workweek (*ww*) 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.

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

where subscript *n* denotes nonsalaried, subscript *s* denotes salaried and superscript *sh* denotes that workweeks are multiplied by employment shares. If the procyclical movement of the salaried workweek is significant, then its covariance with the procyclical nonsalaried workweek should be an important source of variation in the aggregate workweek.

To compute this decomposition, 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 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 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 term measuring the covariance between the salaried and nonsalaried workweeks accounts for 66 percent of the additional variance of the total private nonfarm workweek, while the salaried worker workweek variance term accounts for 34 percent of the added variance.

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	34%	66%
Hours	40%	60%

A more variable salaried workweek also affects the variance of total 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. To construct measures of the cyclical variance of hours we, first, detrend each measure using the HP filter. The bottom panel of chart 3 plots the two series. The standard deviation of the percent deviation of the actual series from its trend exceeds that of the counterfactual series by 6 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 (H) can be decomposed as follows:

$$\begin{aligned}
&\operatorname{var}\left(\frac{H-H_{trend}}{H_{trend}}\right)\approx \operatorname{var}\left(\log\left(\frac{H}{H_{trend}}\right)\right)=\operatorname{var}\left(\log\left(\frac{e}{e_{trend}}\right)+\log\left(\frac{ww}{ww_{trend}}\right)\right)= \\
&\operatorname{var}\left(\log\left(\frac{e}{e_{trend}}\right)\right)+\operatorname{var}\left(\log\left(\frac{ww}{ww_{trend}}\right)\right)+2\operatorname{cov}\left(\log\left(\frac{e}{e_{trend}}\right),\log\left(\frac{ww}{ww_{trend}}\right)\right)
\end{aligned} \tag{2}$$

To compute this decomposition we first compute the trend components of the workweek and employment (*e*) using an HP filter.[11] To estimate the contribution of 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 60 percent of the additional variance of total hours (confirming the importance of the salaried workweek's procyclical behavior), while the variance of the workweek accounts for the remaining 40 percent. In sum, while the effect is not large, assuming that the salaried worker workweek is constant, as the establishment survey would 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. However, we observe 10 seasonal cycles in our sample. Because seasonal changes in hours are of shorter duration and more predictable than cyclical changes, one cannot directly infer cyclical behavior from seasonal measures.

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

Nonetheless, as shown by Beaulieu, MacKie-Mason and Miron (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. Average Seasonal Factors for Salaried and Nonsalaried Workweeks

	Private Nonfarm Workers			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Salaried Workweek	0.998	1.002	0.998	1.002
Nonsalaried Workweek	0.987	1.004	1.014	0.994
Employment	0.994	1.001	0.994	1.010

Table 3 shows the average seasonal factors created by X-12 for the salaried and non-salaried workweek over the period 1994 to 2004 (for all private nonfarm workers). As can be seen, the salaried workweek appears to exhibit seasonal movements, with relative peaks in the second and fourth quarters.[12] Moreover, these movements are positively correlated with seasonal movements in employment: The actual correlation is 0.79. As a point of comparison, the table also shows the seasonal factors for the nonsalaried workweek. The workweek for nonsalaried employees is more cyclical 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

[12] 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 the 20 percent level of confidence.

the nonsalaried workweek at seasonal frequencies is about 0.25, about 30 percent 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 slightly negatively correlated with seasonal movements in nonsalaried workweeks (-0.06). As a consequence, the effect of variable salaried workweeks on workweek variation is actually negative: The seasonal variance in the actual workweek is 27 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 about 7 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 slightly negative correlation between salaried and nonsalaried worker workweeks discussed above. Interestingly, the difference in total hours variances at seasonal frequencies is quite similar to the difference at business cycle frequencies, though, as described above, the factors behind the greater variance of the actual workweek are different. 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).

While, as described in footnote 8, it is not possible to construct comparable measures of hours per job prior to 1994, it is possible to construct an inferior measure from 1989-1993. 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. The behavior of the nonsalaried 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.

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	0.52	0.66	0.64	0.73	0.96	0.66	0.62	0.52	0.45
	Correlation at time *t* with CPS Wage and Salary Employment at time *t+i*								
CPS Workweek	0.36	0.44	0.48	0.53	0.64	0.69	0.72	0.69	0.61
CPS Workweek salaried hours set to 40	0.42	0.50	0.52	0.58	0.67	0.72	0.73	0.70	0.60
Memo: Correlation between salaried worker workweek at *t* and nonsalaried worker workweek at *t+i*	0.09	0.56	0.14	0.35	0.45	0.22	0.21	-0.08	-0.11

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, Fernald, and Shapiro (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 published measures of the workweek 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=-3 and the pattern of correlations indicates that movements in salaried workweeks tend to lead movements in nonsalaried worker workweeks. The relative timing of movements in the two workweek series suggests that the published workweek series may lag somewhat actual workweek movements.

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 actual workweek appears to be shifted backward in time relative to the counterfactual workweek (correlations between the lagged actual and contemporaneous counterfactual workweeks are slightly larger than correlations between the led actual and contemporaneous counterfactual workweeks), but the apparent shift is quite small. Overall, 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 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 differences in timing of salaried and nonsalaried workweeks is small enough that the assumption of constant salaried worker workweeks does not significantly affect the timing of movements in aggregate workweeks and seems unlikely to bias estimates of MFP that use published workweeks to control for employee effort, e.g. Basu, Fernald and Shapiro (2001).

Finally, we examine the effects of mismeasuring the salaried workweek on the recent behavior of productivity. To do this, 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.[13]

As shown in chart 4, both measures of hours reach a cyclical peak in 2000:Q3, with the level of the series using the actual CPS workweek about 1/2 percent higher. Over the remainder of the sample, 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 1/2 percentage point and increases productivity growth (decreases employee hours) from 2000:Q3 to 2004:Q4 by an equal amount.[14]

Some observers have speculated that an increase in unmeasured off the clock work,

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[13] 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 non-profit institutions and include the hours of government enterprises.

[14] Employee hours in the nonfarm business sector are about 90 percent of total hours.

largely stemming from improved information technologies, explains, at least in part, the strong performance of productivity during the recent recession and recovery (cf. Roach, 2003). Our analysis offers little support for this hypothesis. As shown in chart 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 any 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 time, relative to the constant level, which we assume is reflected in the CES data. Instead, the salaried workweek has fallen on balance since 2000.

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 measure 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 25 and 6 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 recent labor market downturn and recovery, 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.

References

Basu, Susanto (1996) “Procyclical Productivity, Increasing Returns, or Cyclical Utilization,” *Quarterly Journal of Economics*, vol. 111, no. 3, pp. 719-42.

Basu, Susanto and John G. Fernald (1997) “Returns to Scale in U.S. Production: Estimates and Implications,” *Journal of Political Economy*, vol 105, no. 2, pp. 249-283.

Basu, Susanto, John G. Fernald and Matthew D. Shapiro (2001) “Productivity Growth in the 1990s: Technology, Utilization, or Adjustment?” *Carnegie Rochester Conference Series on Public Policy*, vol. 55, pp. 117-65.

Beaulieu, John Joseph and Jeffrey K. MacKie-Mason and Jeffrey A. Miron (1992) “Why Do Countries and Industries with Large Seasonal Cycles also Have Large Business Cycles?” *Quarterly Journal of Economics*, vol. , no. 2, pp. 621-656.

Bureau of Labor Statistics, *Employment & Earnings*, Washington, D.C.

Burnside, Craig, Martin Eichenbaum and Sergio Rebelo (1995) “Capital Utilization and Returns to Scale, *NBER Macroeconomics Annual*, pp. 67-107.

Eldridge, Lucy P., Marilyn E. Manser and Phyllis Flohr Otto (2004) “Alternative Measures of Supervisory Employee Hours and Productivity Growth,” *Monthly Labor Review*, April, pp. 9-28.

Frazis, Harley, and Jay Stewart. 2004. “What Can Time-Use Data Tell Us about Hours of Work?” *Monthly Labor Review,* December, pp. 3-9.

Hall, Robert E. (1988) “The Relationship Between Price and Marginal Cost in U.S. Industry” *Journal of Political Economy*, vol. 96, no. 5, pp. 921-947.

Hall, Robert E. (1990) “Invariance Properties of Solow’s Productivity Residual,” in: Peter

Diamond, ed., Growth/Productivity/Employment, Cambridge, MA: MIT Press.

Jacobs, Jerry A. (1998) "Measuring Time at Work: Are Self-Reports Accurate?" *Monthly Labor Review* December, pp. 42-53.

Jorgenson, Dale W., Frank M. Gollop, and Barbara Fraumeni (1987) Productivity and U.S. Economic Growth, Cambridge, MA: Harvard University Press.

Jorgenson, Dale W. and Keven Stiroh (2000) "Raising the Speed Limit: U.S. Economic Growth in the Information Age," *Brookings Papers on Economic Activity*, vol. 0, no. 1, pp. 125-211.

Nadiri, Ishaq and Sherwin Rosen (1969) "Interrelated Factor Demand Functions," *The American Economic Review*, vol. 59, no. 4, pp. 457-471.

Roach, Stephen S. "The Productivity Paradox" *The New York Times*, November 30, 2003.

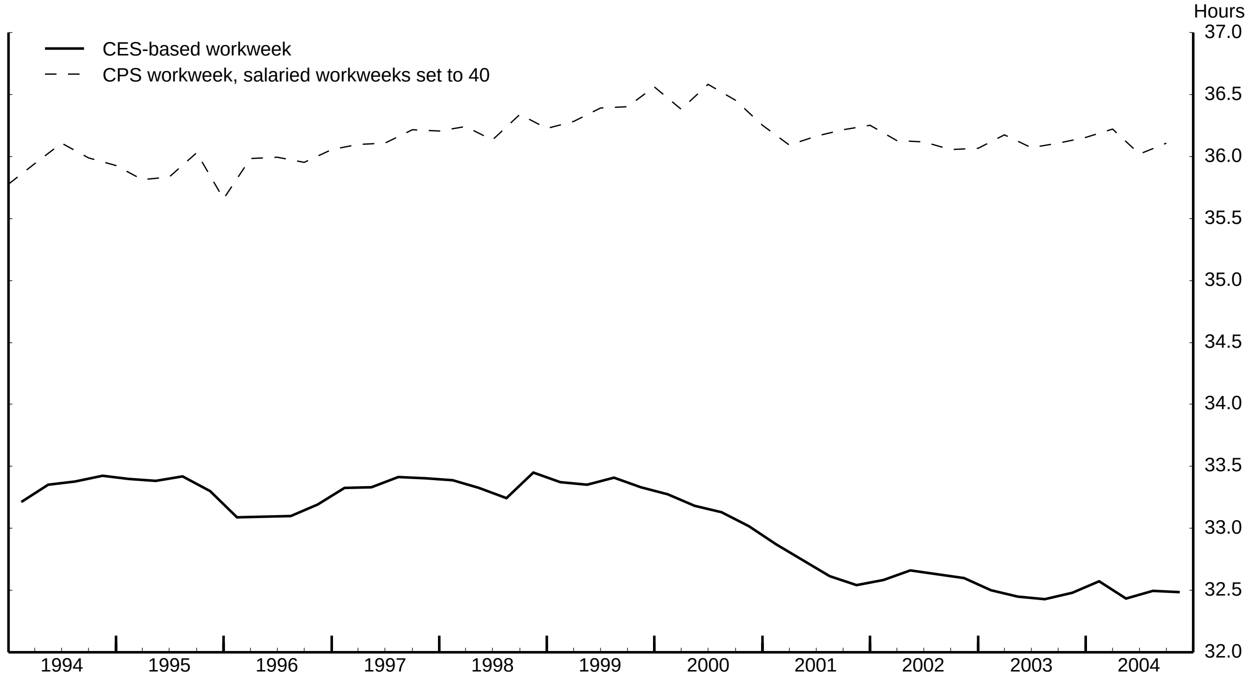
Rodgers, Willard L., Charles Brown and Greg J. Duncan (1993) "Errors in Survey Reports of Earnings, Hours Worked, and Hourly Wages." *Journal of the American Statistical Association*, vol. 88, no. 424, pp. 1208-18

Sims, Christopher A. (1974) "Output and Labor Input in Manufacturing," *Brookings Papers on Economic Activity* no. 3, pp. 695-735.

Wilson, Thomas A. and Otto Eckstein (1964) "Short-Run Productivity Behavior in U.S. Manufacturing," *Review of Economics and Statistics*, vol. 46, no. 1, pp. 41-54.

Chart 1
All Private Nonfarm Workers

Workweeks



Detrended Workweeks

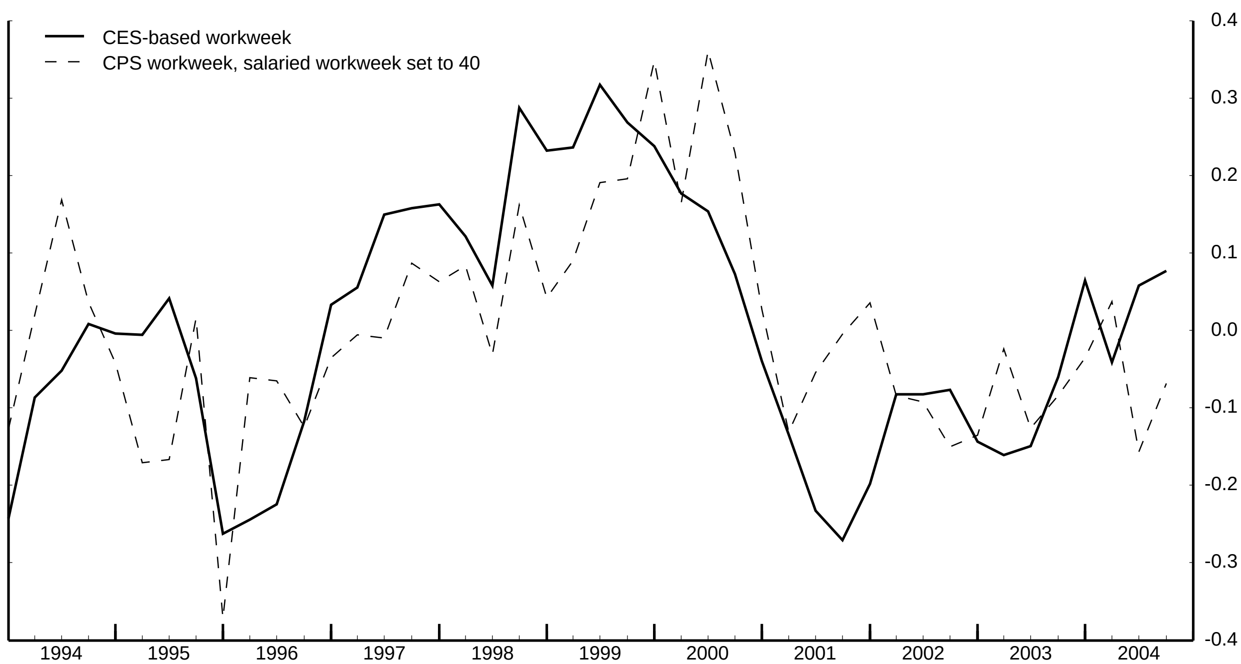
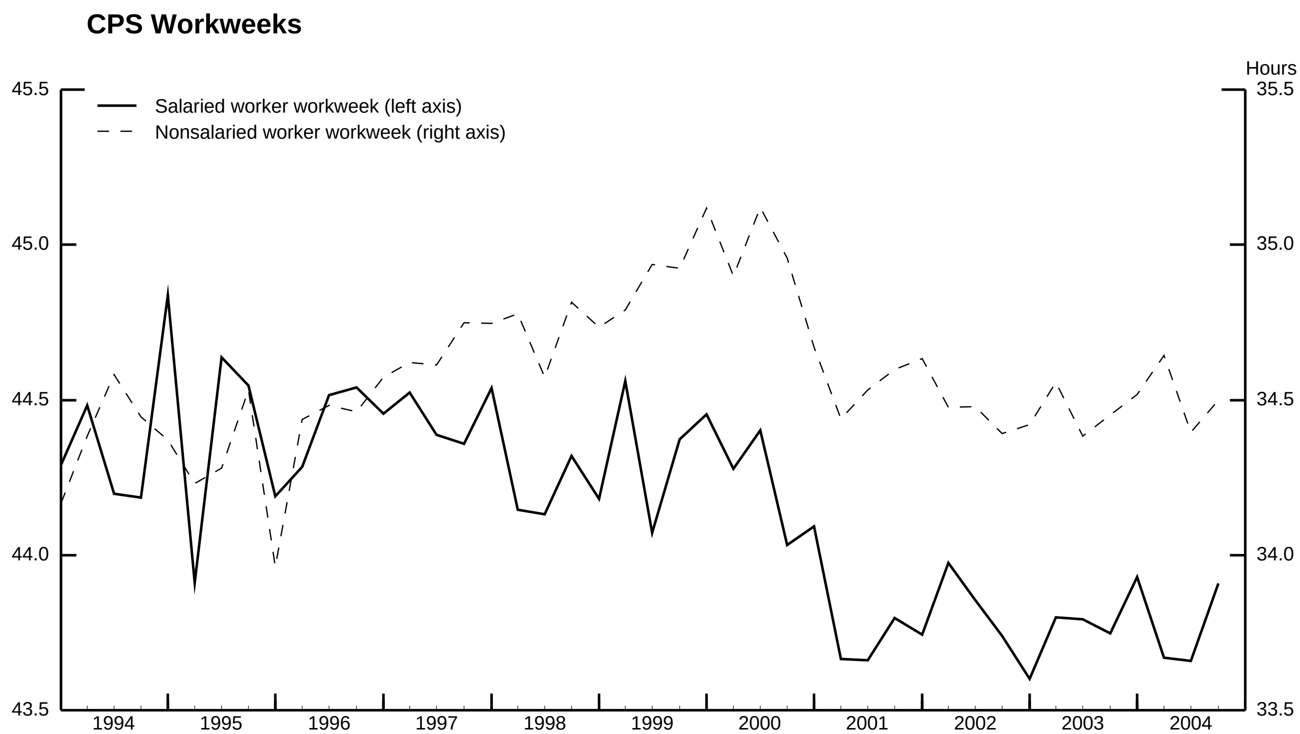


Chart 2
All Private Nonfarm Workers



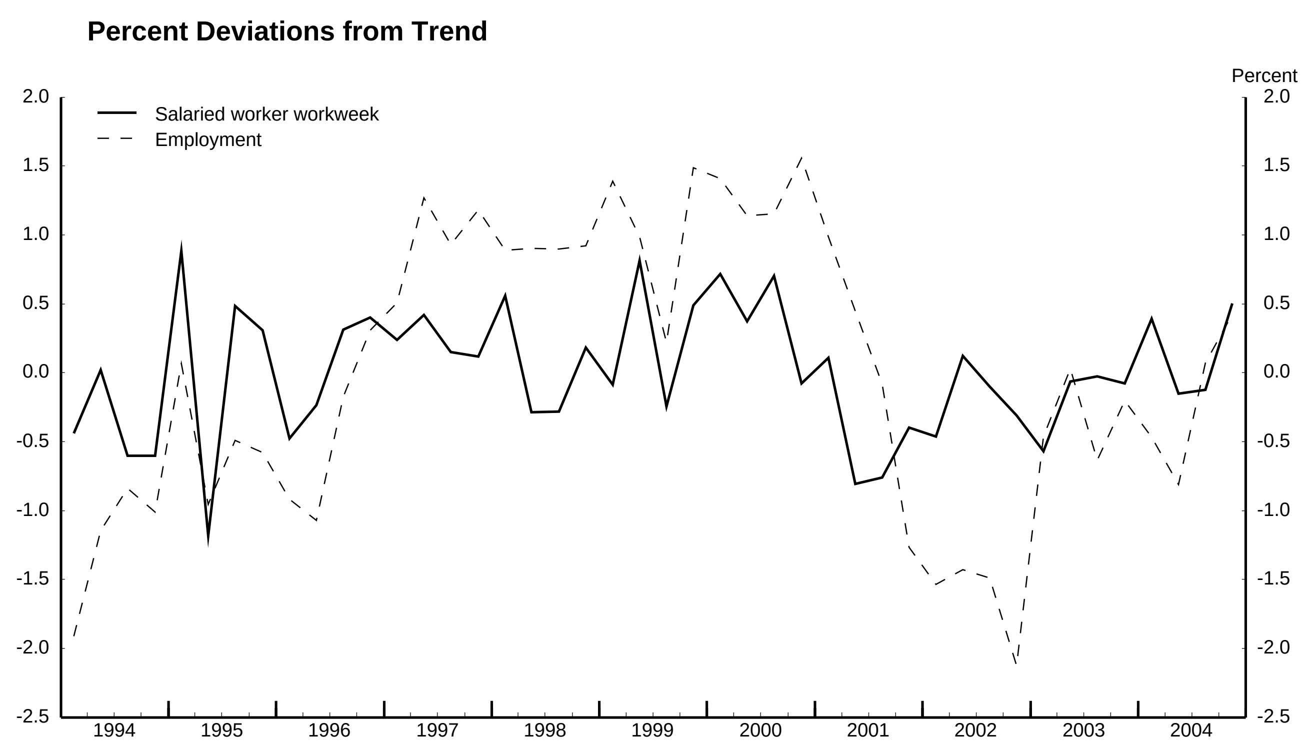
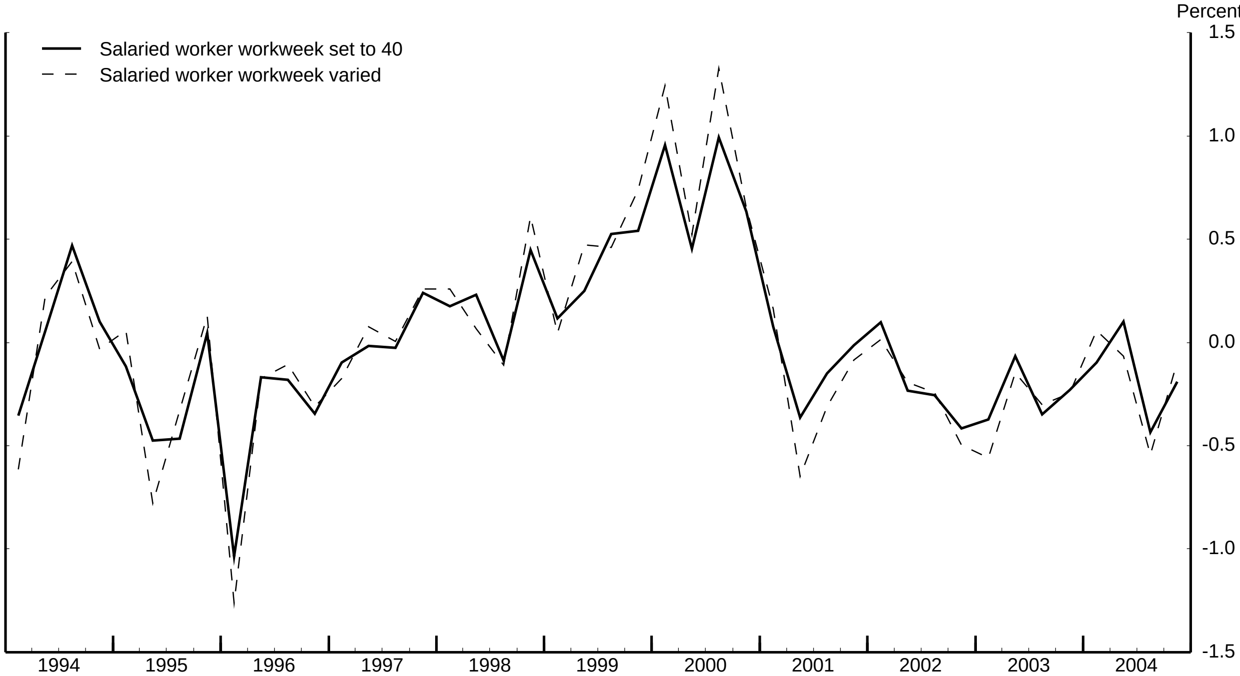


Chart 3
All Private Nonfarm Workers

Detrended CPS Workweeks



Detrended CPS Aggregate Hours

Chart 4
Actual and Counterfactual Hours