Seasonal Adjustment and Calendar Effects Treatment in All Employee Hours and Earnings Estimates

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Expansion of Hours and Earnings Estimates

The Division of Current Employment Statistics has historically published estimates of average weekly hours and average hourly earnings of production and nonsupervisory employees. While continuing estimation and publication of these existing series, in 2005 CES expanded data collection on average hourly earnings and average weekly hours to cover all nonfarm private-sector employees. The definitions of these new data items are unchanged; the sole difference being that the new data types are all-inclusive, as opposed to the more selective production and nonsupervisory employee concept. Publication of all employee hours and earnings series began on an experimental basis in 2007 with the release of data from March 2006 forward.

Conversion from Experimental to Official Status

As CES gained experience editing and reviewing sample reports and estimates of all employee hours and earnings, these series shifted from experimental to official status effective in February 2010 with the release of the January Employment Situation. Effective with the conversion from experimental to official status, CES also initiated the publication of seasonally adjusted estimates of all employee hours and earnings.

Existing Seasonal Adjustment Methods for Hours and Earnings Estimates

CES uses X-12 ARIMA software for all its seasonal adjustment processes.[1] Once per year, series are seasonally adjusted with automatic model selection enabled in X-12 ARIMA. During this annual process, CES utilizes 10 years of history in the development of seasonal factors. The resulting factors are applied only to the most recent five years of history, as it is CES policy that seasonally adjusted data older than five years are final.

In addition to the annual seasonal adjustment procedure described above, CES performs seasonal adjustment on a monthly basis in order to ensure the relevance of seasonal factors in light of current economic trends. The monthly seasonal adjustment procedure utilizes the same 10 year span of data as the annual adjustment procedure; however, it also incorporates the latest year's estimates up to and including the most recent preliminary estimate. Automatic model selection is disabled during monthly seasonal adjustment processing, as CES holds constant the ARIMA model chosen for each series during annual processing. Seasonal factors produced during monthly processing are applied only to the most recent preliminary, revised, and final estimates – a maximum of three months of estimates.

Presence of Calendar Effects in Hours and Earnings Estimates

To effectively seasonally adjust time series data, it may be necessary to remove series' calendar effects prior to determining seasonal factors. Calendar effects are recurring anomalies in time series data that follow predictable patterns that are driven by the nature of the time interval between observations. The CES survey is tied to the calendar in that all CES estimates are reflective of the pay period that includes the 12th day of each month (hereafter referred to as the "reference period").

All CES estimates are analyzed for the presence of calendar effects and, where present, treated during the seasonal adjustment process to remove these effects.[2] It is standard CES practice to evaluate hours and earnings estimates for the presence of the calendar effects described in the following sections.

4 vs. 5 Week Effect

Variations in the number of weeks (4 or 5) between CES reference periods in any given pair of months may cause inconsistencies in seasonally adjusted series. Months with an extra week between reference periods have the potential for additional change in estimates' values. In highly

seasonal months and industries, this variation can be an important determinant of the magnitude of seasonal hires or layoffs that have occurred at the time the survey was taken. This is the most commonly treated calendar effect in the adjustment of CES estimates.

Length of Pay Period Effect

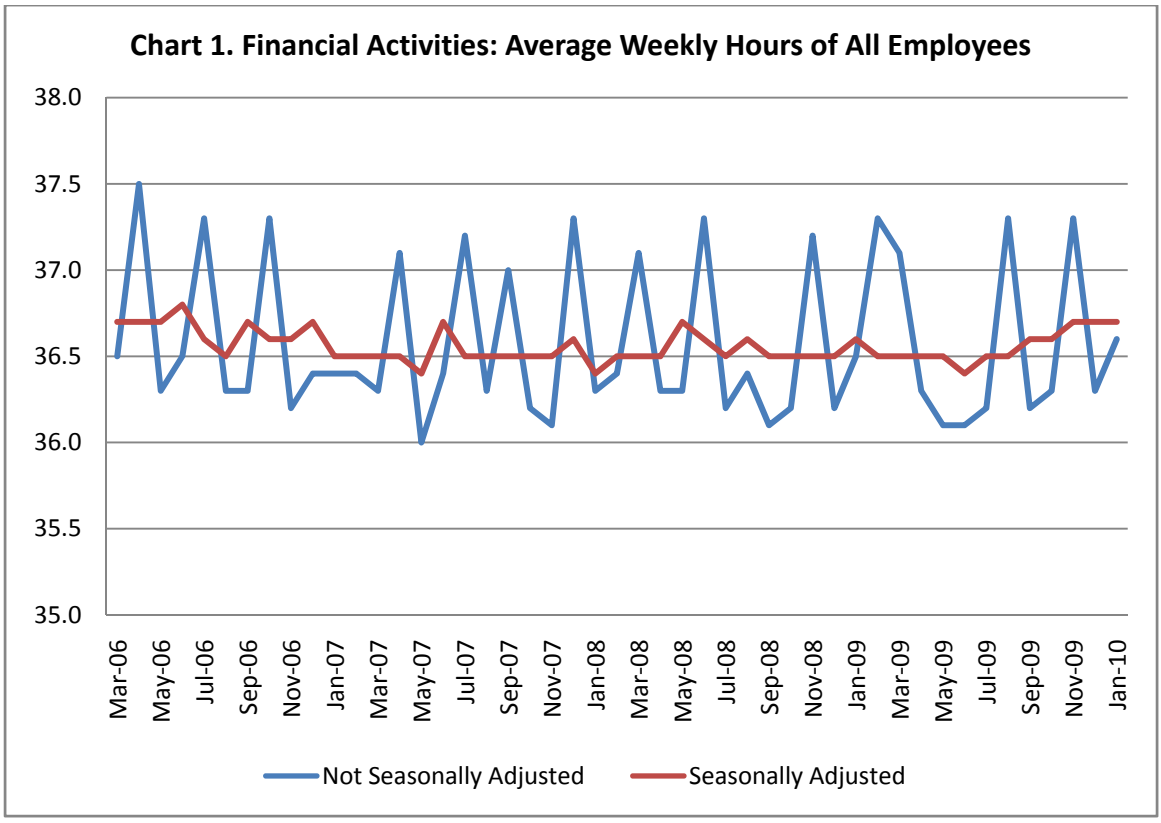
Also known as the 10/11 day effect, this calendar effect is a result of variations in the number of days in the pay period that includes the 12th of the month. The standard semi-monthly pay period runs from the 1st through the 15th of the month and always has either 10 or 11 weekdays. If a survey respondent reports the same fixed number of hours in both 10 and 11 day payroll periods, there will be an artificial spike in estimates of hours worked once the data are normalized to a weekly equivalent. This effect is likely to be stronger in series that include higher percentages of salaried employees, as employers are less likely to keep detailed records of salaried employees' paid work hours.

Floating Holiday Effect

Good Friday and the Labor Day holiday typically fall outside of the CES reference period; however, they occasionally occur during it. The presence of these holidays within the CES reference period leads to volatility in estimates of hours worked that is purely a function of the calendar and is not indicative of series' seasonality.

Treatment of Calendar Effects During Seasonal Adjustment

Hours and earnings estimates are treated to remove calendar effects by including user-defined regressions. This approach, involving the use of weighted dummy variables, remains the standard method by which CES treats calendar effects when seasonally adjusting estimates.[3] By weighting the regression variables appropriately, calendar effects are dampened while preserving the level of the unadjusted series – that is, the average of the adjusted series is nearly identical to that of the unadjusted series. Note that in keeping the level of the adjusted series consistent with that of the unadjusted series, it is implicit that CES defines the true level for each series as that of its unadjusted data. As can be seen in chart 1, the average levels of the unadjusted and adjusted data are equal (at 36.6 hours in this example).



There are strong similarities between all employee and production and nonsupervisory estimates of hours and earnings. However, the inclusion of employees not counted in the production and nonsupervisory concept often results in an upward level shift of the all employee earnings estimates, with varying but similar impact on hours estimates. Calendar effects may be more prominent in all employee hours and earnings series due to the higher percentage of salaried employees captured by the all employee concept.

Applicability of Existing Seasonal Adjustment Methods to All Employee Hours and Earnings

Although the seasonal adjustment process used by CES has proven effective for many years, the shortness of the history of the new estimates complicates the use of existing adjustment techniques. As of early 2010, CES has fewer than four years of history for the new hours and earnings series. A minimum of five years of estimate history is required to apply standard CES calendar effects treatments to a series.

There are several additional concerns associated with seasonally adjusting the new series with such limited history available. First, there is insufficient history to utilize the automatic model selection feature of X-12. Second, there is a risk of the irregular component affecting the seasonal component.

In order to provide seasonally adjusted all employee hours and earnings estimates despite the short available history, CES evaluated options to overcome the challenges preventing the application of standard adjustment and calendar effects treatment methods to the new estimate types.

ARIMA Model Selection

Unable to utilize X-12 ARIMA's automatic model selection due to the short length of the new series, CES elected to utilize an (0 1 1)(0 1 1) model in the interim.[4] This model diminishes noise in time series by using an exponentially weighted moving average of past values. As hours and earnings data tend to exhibit fluctuations around slowly-varying means, use of the exponential smoothing model proved a sensible choice – experimental results confirmed that this model is highly effective and will suffice until series reach the necessary length to allow the integration of automatic model selection.

Choice of Seasonal Filter

By default, X-12 ARIMA uses a 3x3 moving average to calculate the initial seasonal factors in each iteration, and a 3x5 moving average to calculate final seasonal averages. However, the shortness of the new series imposes a technical limitation in that the only available option is the use of a stable seasonal filter. A stable seasonal filter computes a single seasonal factor for each month by first calculating the average of all the values for each month, which reduces the chance of the irregular component affecting the seasonal component (a concern with short series). The effectiveness of the stable filter was demonstrated in experimental testing; CES will re-examine its options and choice of seasonal filters as series' histories lengthen.

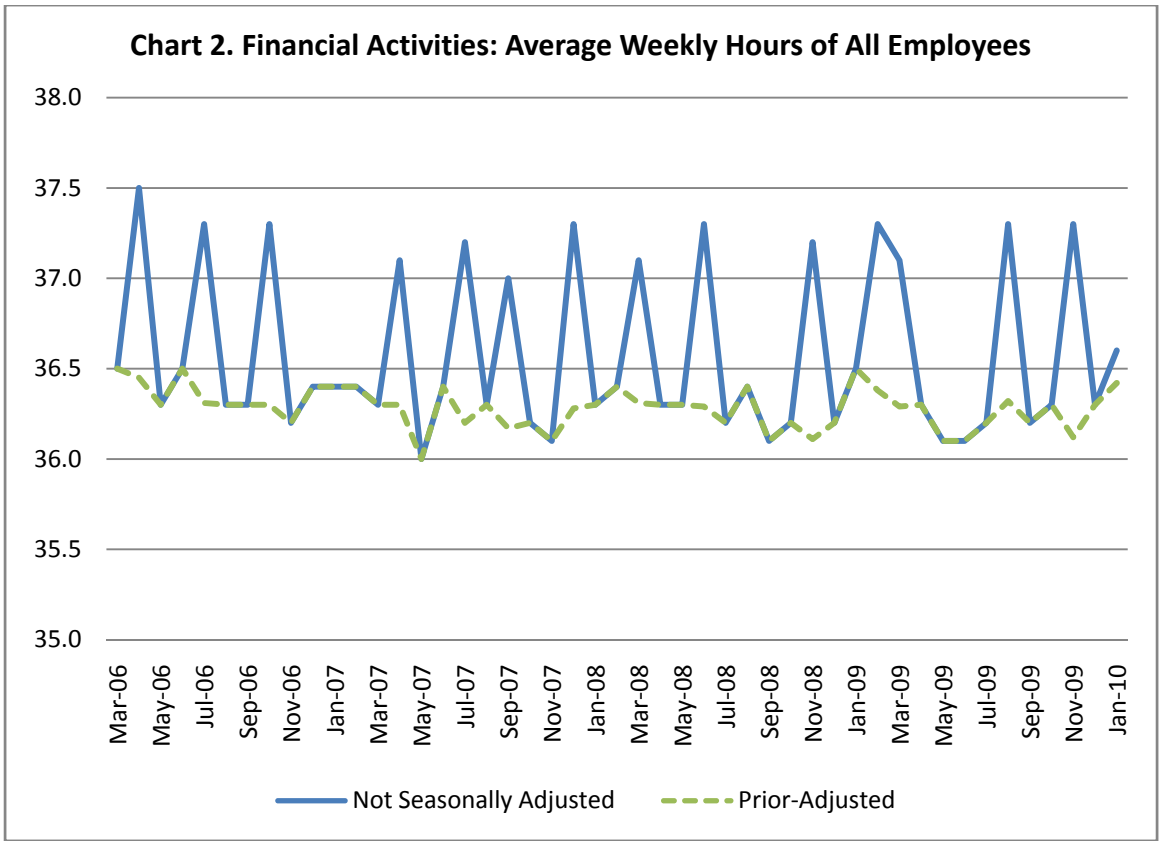
Development of New Approach

CES initially tested alternative seasonal adjustment and calendar effects treatment on production and nonsupervisory employee hours and earnings data, as the lack of history of all employee hours and earnings data prevented CES from utilizing the new series in the early testing phase. Techniques were evaluated in part on their ability to replicate the results of the standard CES approach to seasonal adjustment. Closeness of fit between experimentally-adjusted series and official seasonally adjusted series was taken as evidence in support of the experimental adjustment methodology.

Treatment of Calendar Effects in All Employee Hours and Earnings Estimates

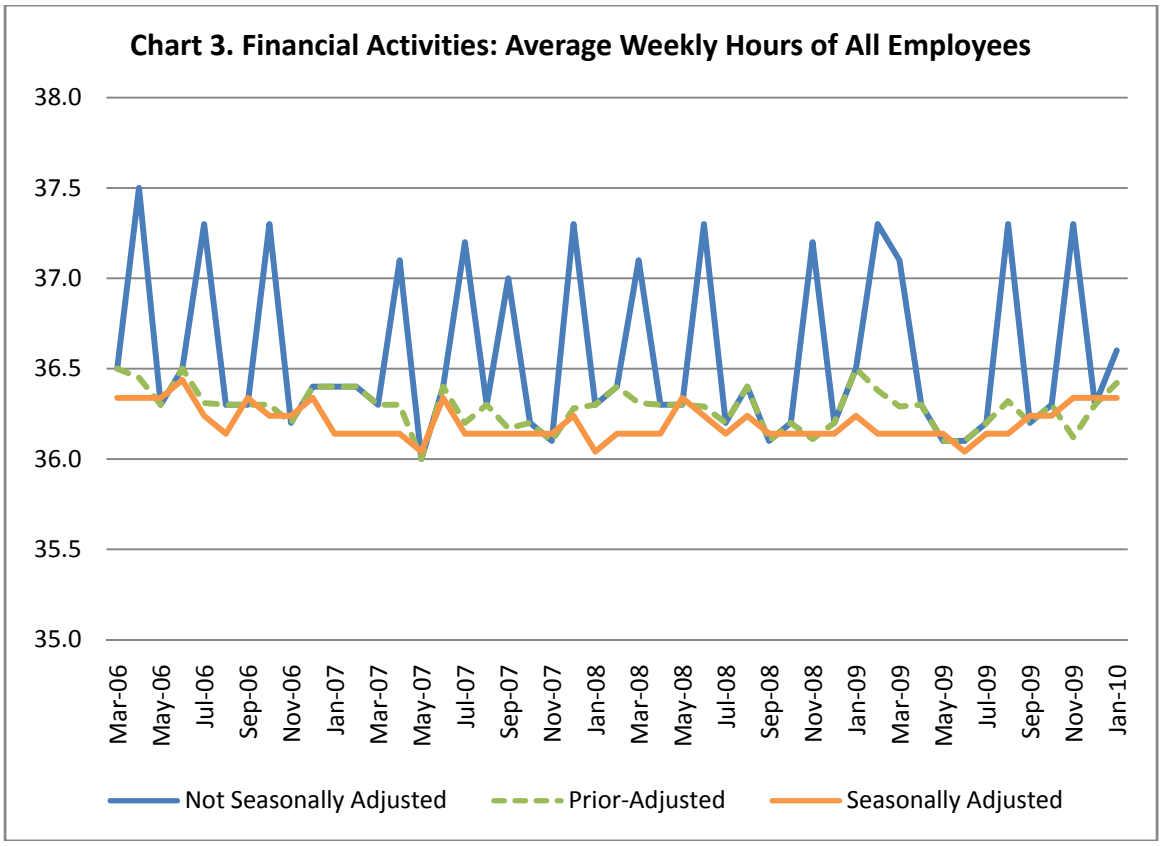
The interim approach selected by CES is based on one key concept – monthly observations that are subject to variation due to calendar effects are to be treated as outliers. This differs from the existing approach used by CES in that no user-specified regressions are performed; rather we rely upon X-12 ARIMA to produce a "prior-adjusted" series.

Taking into account manually-designated outliers, X-12 ARIMA produces a prior adjusted series by imputing for outlier observations based on the trend of the non-outlier observations, as shown in chart 2.[5]



By default, X-12 ARIMA relies upon this prior-adjusted series when decomposing seasonality and estimating seasonal factors for time series; however, it then applies those factors to the original time series rather than the prior-adjusted series. Under normal circumstances, application of seasonal factors to the original time series is sensible, as the original time series consists of the series' true values.

In the context of CES' efforts to eliminate calendar effects from these estimates, it is undesirable to apply the seasonal factors to the original time series. Because the calendar effects are part of the original series – and because we cannot remove these effects with standard treatment procedures – it is therefore necessary that the seasonal factors be applied to the prior-adjusted series. Applying seasonal factors to the prior-adjusted series produces a seasonally adjusted series devoid of calendar effects (denoted by the orange line in chart 3).



Need for a Correction Factor

Reliance upon the prior-adjusted series poses a difficulty in that the level of the prior-adjusted series may differ from that of the original, not seasonally adjusted history. The greater the magnitude of any calendar effects present, the larger these level differences may be. In the above example the average level of the original series differs by that of the seasonally adjusted series by nearly four-tenths of an hour.

It is CES' goal to maintain series' levels pre- and post-seasonal adjustment. This goal is accomplished by smoothing seasonal fluctuations across the given time span such that some observations are elevated while others are diminished depending on the direction of the seasonality, such that the net change is offsetting. Therefore, application of seasonal factors to prior-adjusted series – series which may exhibit lower means than their unadjusted analogues – can result in adjusted series with lower means than those of the corresponding unadjusted series.

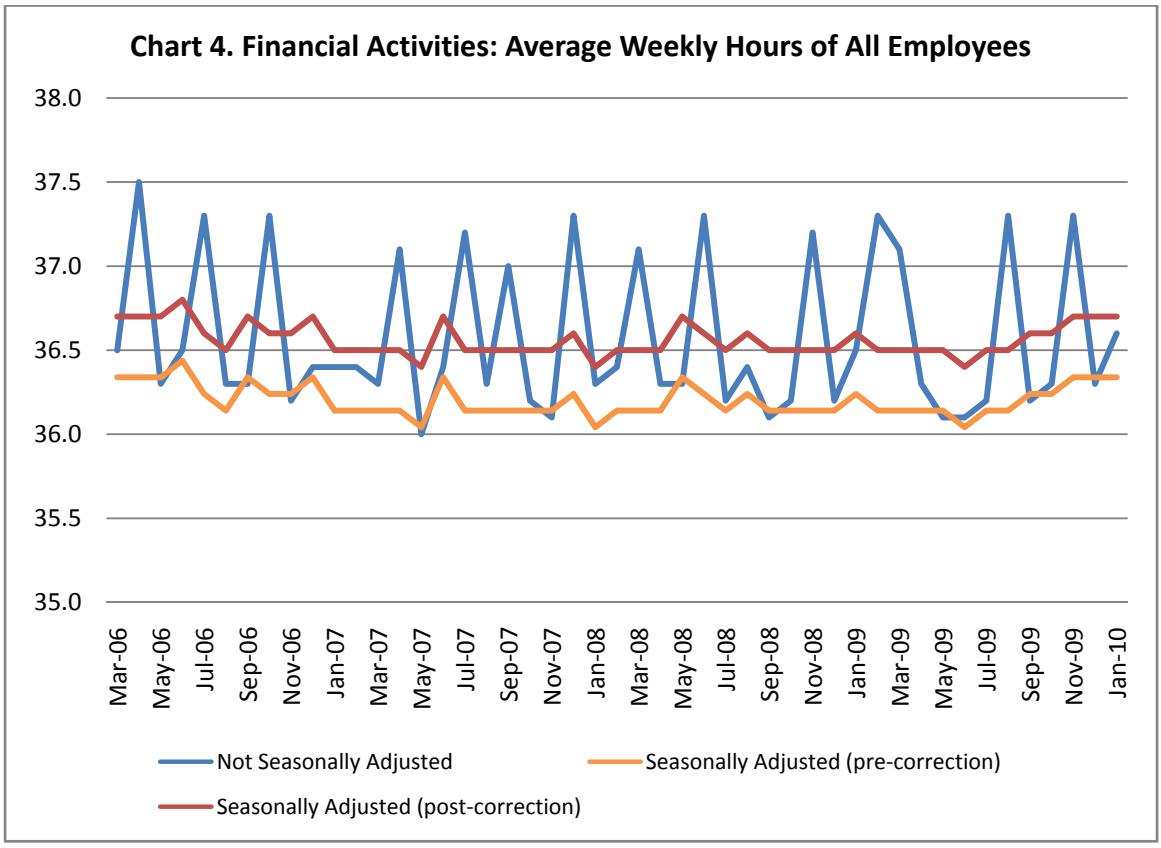
To restore the levels of the seasonally adjusted all employee hours and earnings series to those of their unadjusted counterparts, CES elected to apply a correction factor to produce a final, level-shifted set of seasonally adjusted data. This series-specific factor is computed annually for each series and is multiplied to all observations in each seasonally adjusted series.[6] The formula for this factor is as follows:

$$\text{Correction Factor} = \frac{\sum_{t=1}^{n} X_t}{\sum_{t=1}^{n} \hat{X}_t}$$

X_t = Unadjusted value of series at month t

$\hat{X}_t$ = Seasonally-adjusted, calendar-effect-treated value of series at month t

The correction factor is proportional to the level difference between the unadjusted and adjusted series. Series with minimal level differences will therefore be unaffected by the application of the correction factor, while those with larger differences will see their average level return to that of their unadjusted counterparts. Applying the correction factor to the series depicted in the earlier examples yields a final seasonally adjusted series (shown in red in chart 4).



Transition to Standard CES Seasonal Adjustment Methodology

CES implemented the aforementioned seasonal adjustment technique for all employee hours and earnings estimates with the release of the January 2010 Employment Situation. Effective with the release of the January 2011 Employment Situation, CES will begin to use of the automdl{} option within X-12, as additional estimate history will allow its introduction.

Effective with the release of January 2012 CES employment estimates, all employee hours and earnings histories will be of sufficient length such that standard CES seasonal adjustment and

calendar effect treatment methods will be applicable. At that time, the interim methodology discussed above will be discontinued in favor of the standard CES methods.

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[1] X-12 ARIMA software is developed by the Census Bureau. Version 0.2.9 is used in CES production processes. X-12 ARIMA is publicly available with documentation at http://www.census.gov/srd/www/x12a/

[2] For additional information on calendar effect treatments in CES data, see https://www.bls.gov/ces/cesfltxt.htm and https://www.bls.gov/ore/pdf/st960190.pdf

[3] Further documentation on the seasonal adjustment methods used by CES, including X-12 ARIMA specification files and dummy variable matrices used in the treatment of calendar effects, can be found at https://www.bls.gov/ces/cesseasadj.htm

[4] (p d q)(P D Q) notation is defined as follows: (p d q) represents the non-seasonal autoregressive, differencing, and moving average operators, respectively. (P D Q) represents the seasonal autoregressive, differencing, and moving average operators, respectively. The (0 1 1)(0 1 1) model, commonly referred to as the "airline" model, is frequently utilized in the seasonal adjustment of time series with linear trends.

[5] Manually-designated outliers are defined in the spec file for each series. The prior-adjusted series produced by X-12 ARIMA is noted as "table B1" in the program output.

[6] A list of correction factors is available at ftp://ftp.bls.gov/pub/suppl/empsit.ces.spec.aehe.zip