Direct vs. Indirect Seasonal Adjustment for
CPS National Labor Force Series[1] October 2009

Thomas D. Evans, Bureau of Labor Statistics,
Statistical Methods Staff, 2 Massachusetts Ave. NE,
Room 4985, Washington, DC 20212

An aggregate series can be seasonally adjusted either directly or indirectly by adjusting its components and adding the results, or dividing in the case of ratios. The results will rarely be identical. To preserve additivity, it is often preferred to indirectly adjust many series. However, in some instances this may lead to an adjustment with residual seasonality, large revisions, or less stable results than direct seasonal adjustment. To test these possibilities, I directly adjust the 392 national Current Population Survey (CPS) series (that are currently indirectly adjusted) with X-13A-S and summarize the results. Key diagnostics for comparison include the spectrum and revisions. Further discussion deals with cases where a direct adjustment might be more appropriate than indirect adjustment.

1. Introduction

The Bureau of Labor Statistics (BLS) has long performed seasonal adjustment of CPS labor force data. BLS directly seasonally adjusts series on the basis of age, sex, industry, occupation, education, and other characteristics, and also provides seasonally adjusted totals, subtotals, and ratios of selected series. Not surprisingly, there is much discussion in the seasonal adjustment literature on how to compare and evaluate these two types of adjustment—without full agreement. The purpose of this study is to examine the adequacy of the indirectly adjusted series using seasonal adjustment diagnostics. A difference here from other studies is that my main interests are whether the indirect adjustments are adequate and how they compare to the direct. Since the series in this study are already indirectly adjusted, a change to direct adjustment is only likely if the indirect adjustment is not adequate.

What is indirect seasonal adjustment? It is simply a way of seasonally adjusting a series by directly seasonally adjusting its parts. For example, an employment series can be indirectly adjusted by directly adjusting males and females separately, and then aggregating the results. A nice property of indirect adjustment is that the accounting relationships are preserved. Rarely will indirect and direct adjustments be the same. This can occur for many reasons. Some of the reasons are 1) seasonal patterns can vary across series; 2) some series require additive adjustments and some multiplicative adjustments; 3) some series are ratios; and 4) there are many inherent nonlinearities in the seasonal adjustment process.

Which approach is better? It depends. If the parts of a series have very different characteristics, the seasonal factors for the components are likely to be more stable than factors for the aggregate series. There can be issues with indirect adjustment. Differences in outliers and calendar effects might lead to problems with the aggregate. In short, most researchers suggest that you compare the two in some fashion.

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[1] Disclaimer: Opinions expressed in this paper are those of the author and do not constitute policy of the Bureau of Labor Statistics.

There are many articles in the literature discussing indirect vs. direct issues, and many are worth exploring. Dagum (1979) makes a case study of the U.S. unemployment rate in terms of direct vs. indirect. Pfefferman, et al. (1984) is another useful study that gives an example where the direct and indirect can be equal. They go further by comparing smoothness, revisions, and the similarity between the seasonal adjusted series and the trend (or trend-cycle). Hood and Findley (2001) is an example of a more recent paper that discusses diagnostics to compare the two methods, with diagnostics such as the spectrum and revisions. Astolfi, et al. (2001) examine component roughness, X-11 quality statistics, revisions, etc. The paper that has the most unique perspective is by Maravall (2005), arguing that direct adjustment is preferred, as it produces smoother estimators and since the comparison of the usual diagnostics may not always solve this dilemma—especially as results may vary as new data are added.

The approach set forth in this paper utilizes some of the diagnostic tools from the above papers. Section 2 explains the data; Section 3 covers the seasonal adjustment procedures; Section 4 discusses possible diagnostics and shows the overall results; Section 5 gives an example using the U.S. total unemployment rate; Section 6 goes over some issues that arose; and Section 7 offers a summary.

2. Data

The data used in this study are from the CPS, a comprehensive monthly labor force survey of around 60,000 eligible households that is cosponsored by the U.S. Bureau of Labor Statistics and the U.S. Census Bureau. Information from roughly 100,000 people from the civilian noninstitutional population aged 16 and over (educational attainment series are for those 25 and over) is included each month. The design is complex with a multistage stratified sample designed to capture demographic and labor force characteristics.

For seasonal adjustment purposes, data are typically used back to 1976 if available (December 2008 is the study's endpoint). If a series was created later, all of the data are used in seasonal adjustment. Long series can be especially desirable when outliers and calendar effects are present. Adjusting long CPS series is possible as the data tend to be consistent in definition over time and also tend to have few outliers. Arbitrarily truncating a series can lead to larger revisions from the forecasts, more frequent model and outlier changes, etc. It can also preclude the use of some diagnostics that require longer series. Another issue that is often ignored by adjusters is that long series can give insights into a series' time series properties.

Most of the outliers in CPS data are from known causes, such as changes in population controls, changes to the survey, or from weather-related events. CPS series do not have trading day effects and tend to be little influenced from major holidays since none fall directly in the reference weeks with the exception of Easter. Easter is a moving holiday that appears to only affect two directly adjusted series in which a prior adjustment is made (see Tiller and Evans 2009). Calendar effects can arise from the varying amount of weeks between reference weeks, but these are unlikely to have a significant effect on any of the indirect series examined here.

Each month, BLS seasonally adjusts 129 national CPS series directly. Using these series and various population control series, another 392 are indirectly adjusted. There

are many different types of indirectly adjusted series as seen in Table 1 below. Note that population controls are developed independently from the sample and are not seasonal (see U.S. Bureau of Labor Statistics and U.S. Census Bureau 2006 for a description of how population controls are made).

Table 1: Types of CPS Indirectly Adjusted Series	
Number of Series	**Series Type**
83	Unemployment Rate
71	Civilian Labor Force
64	Employment-to-Population Ratio
63	Labor Force Participation Rate
45	Unemployment Level
43	Employment Level
9	Not in Labor Force
1	Percent of Civilian Labor Force
1	Percent of Employment
1	Percent of Unemployment
392	

3. Seasonal Adjustment Methodology

In 2003, BLS converted from the X-11-ARIMA program to X-12-ARIMA (U.S. Census Bureau 2002) for official direct adjustments of national CPS series. Concurrent seasonal adjustment was introduced the next year, replacing the projected-factor method, which updated seasonal factors twice a year. With concurrent adjustment, the program is run monthly as new data become available in order to utilize all available information. BLS policy is not to revise previous months, except at the end of the year for the most recent 5 years of data. During the CPS end-of-year processing period, all directly seasonally adjusted series are reevaluated for ARIMA model fit, outliers, residual seasonality, seasonal factor stability, etc. See Tiller and Evans (2009) for more information on how CPS seasonal adjustment is performed.

For this study, the 392 series are also directly seasonally adjusted using a beta version of the X-13A-S program (U.S. Census Bureau 2009). One of the advantages of X-13A-S over X-12-ARIMA is the improved automatic model selection procedure that is now based on the TRAMO program as described in Gomez and Maravall (1997). Parameter adjustments are the same as those used in the direct adjustments, except that the automatic procedures for ARIMA model, outlier detection, transformation, seasonal filter, and trend filter selections are invoked. Seasonal factors for the indirectly adjusted series are derived either multiplicatively or additively depending on the results from the direct runs.

4. Diagnostics

In general, the various papers in the literature on indirect adjustment have their own set of preferred diagnostics to compare or choose between direct and indirect. Findley, et. al. (1990) suggest the use of sliding spans to decide. Unfortunately, sliding spans cannot

be used for most employment series as the seasonal factors are too small. Plots are always useful, especially for the spectrum and seasonal factors. X-13A-S has diagnostics for deterministic seasonality with the traditional Stable F-test, a chi-squared test, and the new model-based F-test (Lytras, et al. 2007). While CPS series usually do not exhibit fixed seasonality, summaries of the results for the tests are in Section 7 for comparison purposes.

For this paper, I examined many diagnostics to see if the direct series are adequately adjusted. As seen in Table 2 below, almost of the directly adjusted series are adequate. A few of the indirectly adjusted series have seasonal peaks but almost all of those are a result of data issues or computational errors. Nine indirectly adjusted series show significant results from the model-based F-test of the seasonally adjusted series, but all of these are a result of data issues described in this paper (These same nine series also are significant for the Chi-squared tests). Examples of diagnostic plots are shown in Section 5. In all, few important differences were found between the direct and indirect adjustments.

TABLE 2: DIAGNOSTIC TESTING SUMMARY		
Test	**Number of Direct Series Flagged**	**Number of Indirect Series Flagged**
Stable F $\leq$ 7	2	—
M7 $\geq$ 0.8	5	—
Q2 $\geq$ 0.8	26	—
Peaks at Seasonal Frequencies	0	24
Chi-squared, # sig	0	11
Model-based, #sig	0	9
Total # of Series	392	392

5. Unemployment Rate Example

The official seasonally adjusted total unemployment rate (TUR) is probably the most examined labor force series and is a good example of CPS indirect adjustment. Seasonally adjusted total employment level (TEM) is obtained by summing the results of directly adjusting four major employment series (the same method is used for the seasonally adjusted total unemployment level or TUN). The series used are:

TEM
Employed males ages 16-19
Employed females ages 16-19
Employed males ages 20+
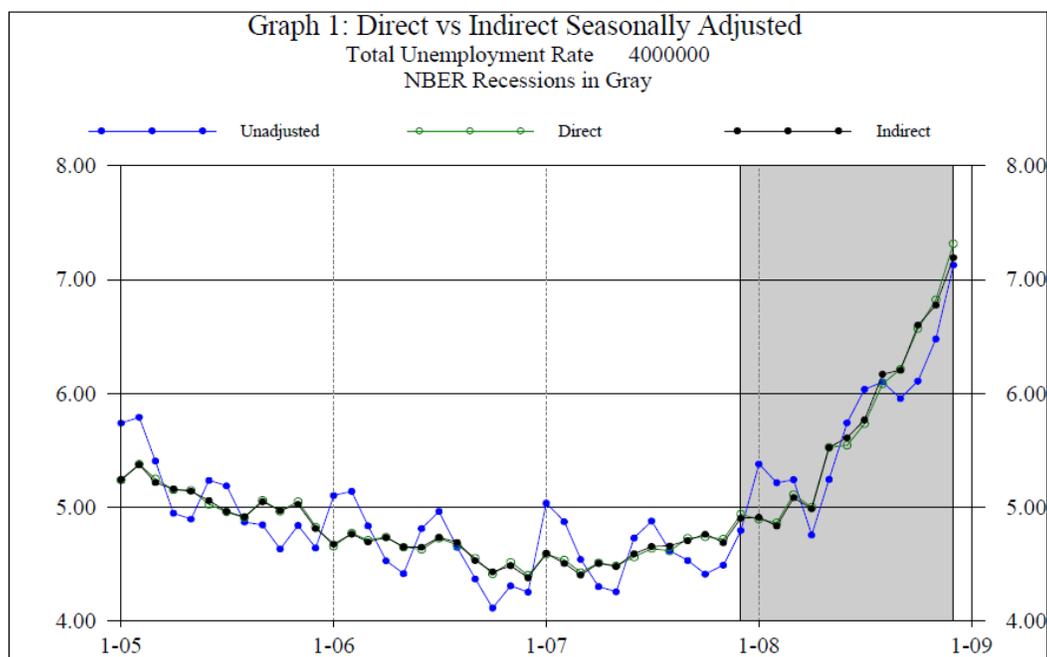Employed females ages 20+

TUN
Unemployed males ages 16-19
Unemployed females ages 16-19
Unemployed males ages 20+
Unemployed females ages 20+

The formula for TUR is: $100 * TUN / (TEM + TUN)$.

Obviously, other combinations could be used, but this combination appears to be reasonable and preserves basic additivity.

To show an example of how much an important series will be affected in the choice of direct or indirect adjustment, results for the TUR are presented below. The below graph plots both the direct and indirect series against the unadjusted series over the 2005-2008 time period. The differences are small. The data in Graph 1 show little differences between the direct and indirect[2]. The largest difference over this time period is in December 2008 where the direct value is 7.31% compared to 7.19% for the indirect. Since TUR is rounded to the tenths place, most differences disappear—but this difference rounds to 0.1%. (In 2009, as the rate continues to climb, differences in the unrevised estimates are similar but can be as high as 0.2%. Of course, the differences may change after end-of-year revisions.)
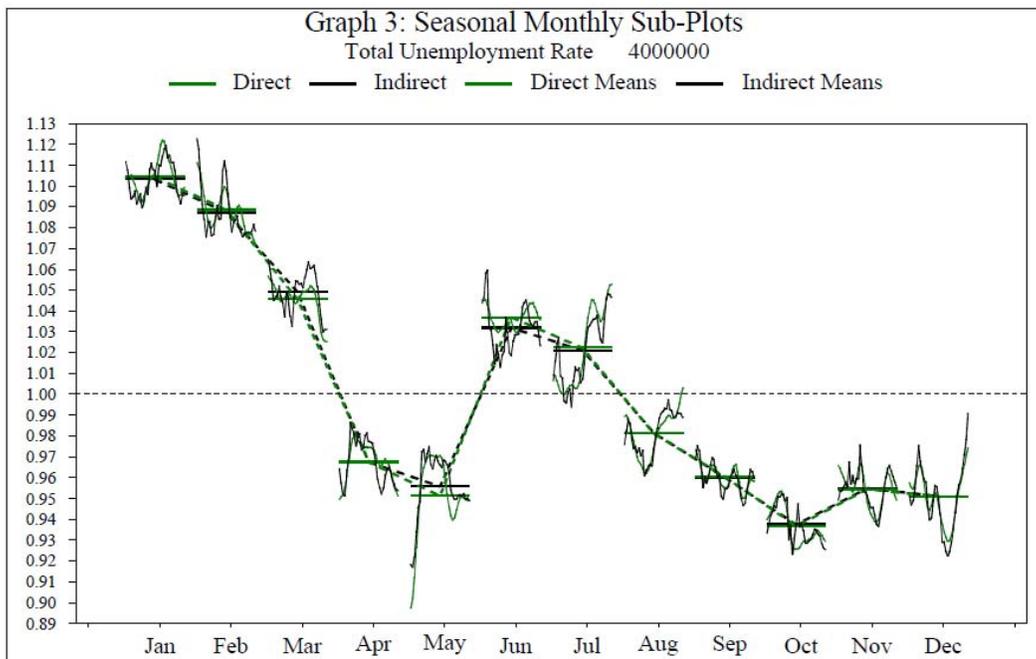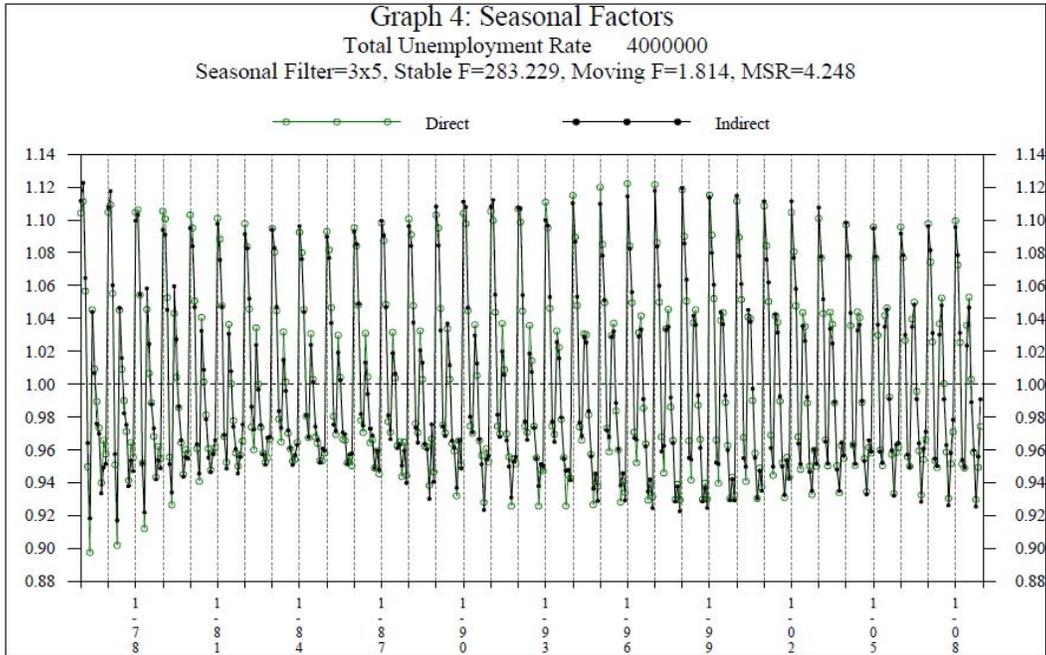

Graph 1: Direct vs Indirect Seasonally Adjusted
Total Unemployment Rate   4000000
NBER Recessions in Gray

Graph 2 shows the autoregressive spectrum for the series with stars indicating "visually significant peaks" at seasonal frequencies. (Details on tests for significant peaks are in Evans, et al. 2006.) Naturally, the unadjusted series has seasonal peaks, but the seasonally adjusted series do not, indicating no residual seasonality. While the spectrum for the direct series tends to be lower than that for the indirect, a visual inspection shows little difference. Away from the seasonal frequencies, the two series appear to be reasonably consistent with the unadjusted series.

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[2] The current recession period as defined by the National Bureau of Economic Research does not have an end date as of this time.

Graph 2: Autoregressive Spectrum (Decibels)
### Total Unemployment Rate   4000000
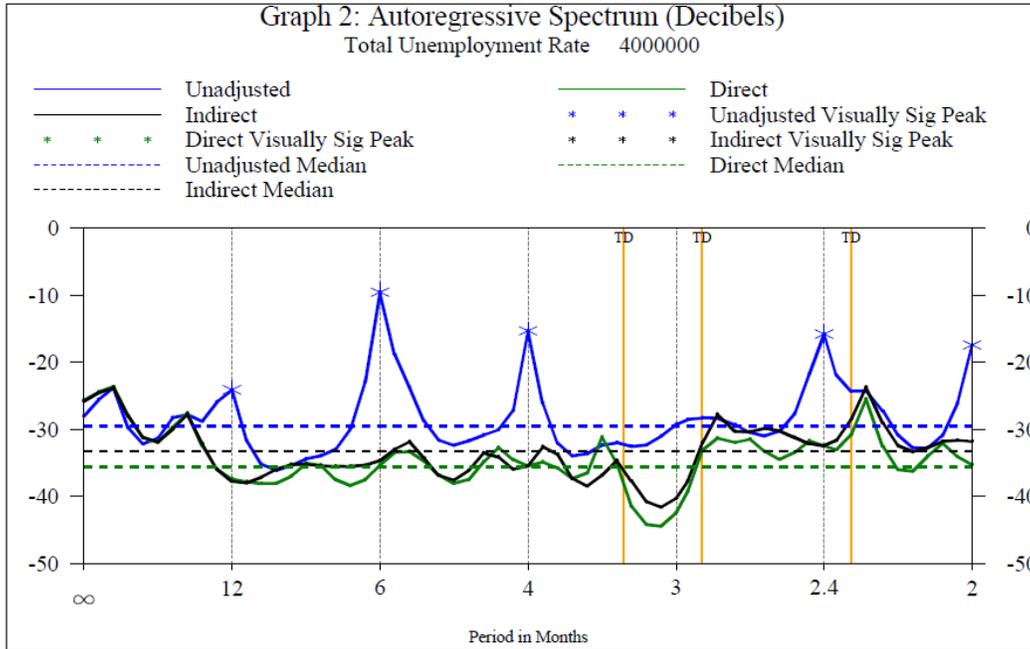
The seasonal sub-plots for the two series are in Graph 3. Again, note the differences are fairly small and the seasonal patterns are roughly the same. Graph 4 has the seasonal factors displayed over time and, as before, the differences are fairly small.

Graph 3: Seasonal Monthly Sub-Plots
Total Unemployment Rate   4000000

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Graph 4: Seasonal Factors
Total Unemployment Rate   4000000
Seasonal Filter=3x5, Stable F=283.229, Moving F=1.814, MSR=4.248

A comparison of trends is helpful and is shown in Graph 5. The indirect trend is derived by using the trends from the eight series used to compute TUR. Again, there are only small differences in the two trends.

Graph 5: Direct vs Indirect Trends
Total Unemployment Rate   4000000
NBER Recessions in Gray
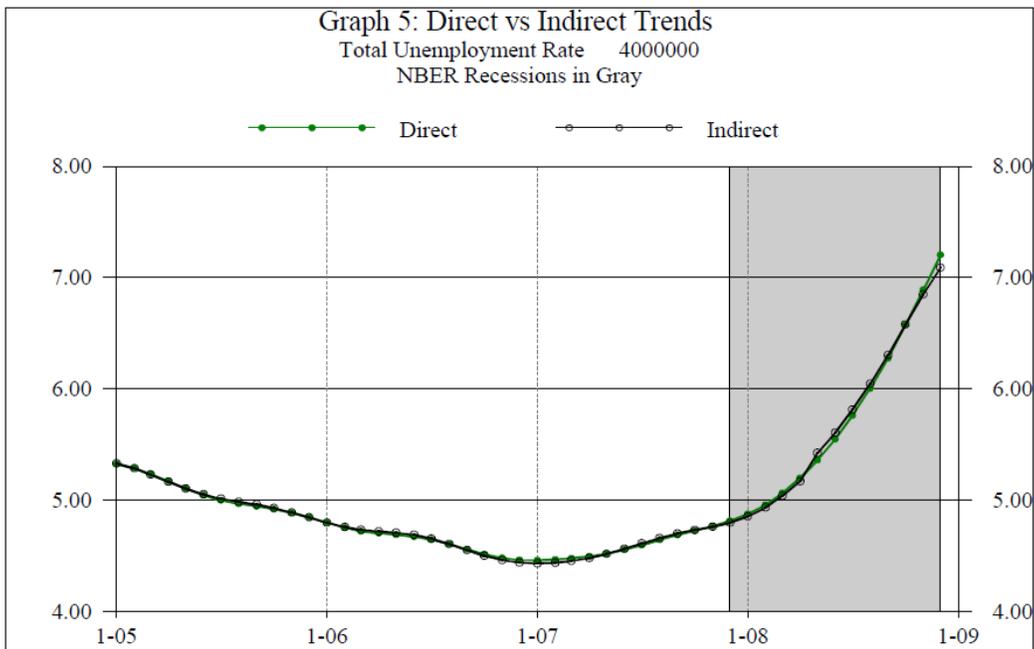
Revisions for the year 2008 are in Table 2. As the official indirect series are produced with the concurrent method, the directly adjusted rates are computed in the same way.

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There are no differences between the unrevised indirect and direct values; however the revised estimates are different (after rounding) for February, June, and July. Remember that rounding can have a big impact here on differences. (December has no revision since it is the last month of the year).

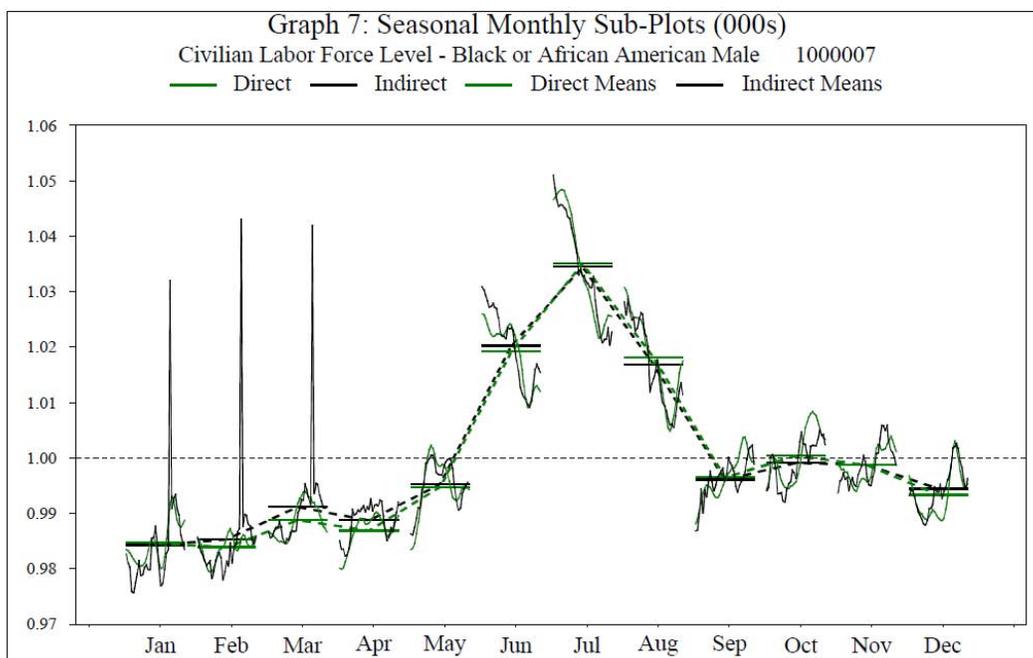| Table 3: 2008 Revisions for Total Unemployment Rate					
Month	**Indirect Unrevised**	**Direct Unrevised**	**Indirect Revised**	**Direct Revised**	**Indirect Change**	**Direct Change**
January	4.9	4.9	4.9	4.9	0.0	0.0
February	4.8	4.8	4.8	4.9	0.0	**0.1**
March	5.1	5.1	5.1	5.1	0.0	0.0
April	5.0	5.0	5.0	5.0	0.0	0.0
May	5.5	5.5	5.5	5.5	0.0	0.0
June	5.5	5.5	5.6	5.5	**0.1**	0.0
July	5.7	5.7	5.8	5.7	**0.1**	0.0
August	6.1	6.0	6.2	6.1	**0.1**	**0.1**
September	6.1	6.1	6.2	6.2	**0.1**	**0.1**
October	6.5	6.5	6.6	6.6	**0.1**	**0.1**
November	6.7	6.7	6.8	6.8	**0.1**	**0.1**

6. Issues

While almost all of the indirectly adjusted series have reasonable diagnostics, a few show serious problems. Most that show problems are simply a result of errors in the formulae for the indirect adjustments. These series will be reexamined and corrected as necessary. A few others show evidence of residual seasonality that is not in any of the directly adjusted series. Again, these series will be reexamined in more detail. I was unable to find any specific examples where outliers are an issue for any indirectly adjusted series but not for a direct adjustment. Series with Clear examples of issues are below.

Graph 6 is quite unusual since the spectrum for the unadjusted series (in blue) shows no seasonal peaks, yet the spectrum for the indirect (in black) has peaks at all of the seasonal frequencies. The series in question is a labor force participation rate for an educational attainment series. It is indirectly adjusted by dividing the civilian labor force for those (ages 25+) with some college or an associate degree by its population. Unfortunately, there is no available population control for this series. The denominator actually has the sample-based population which is seasonal. This series might be a candidate for direct adjustment (if at all).

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Graph 6: Autoregressive Spectrum (Decibels)
Labor Force Participation Rate - Some College or Assoc Degree   1327689
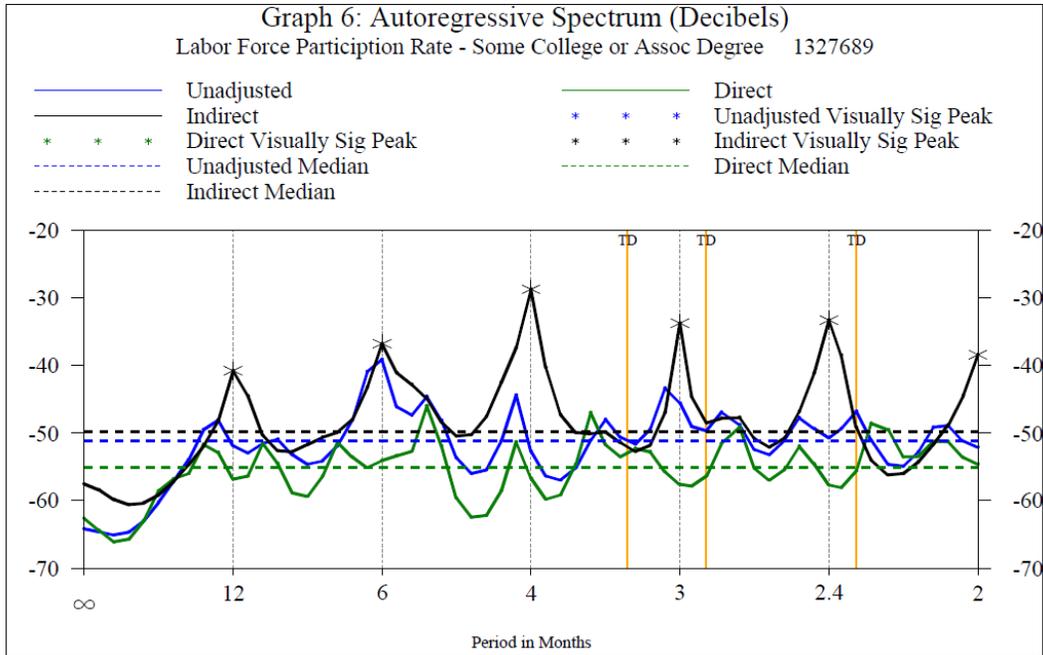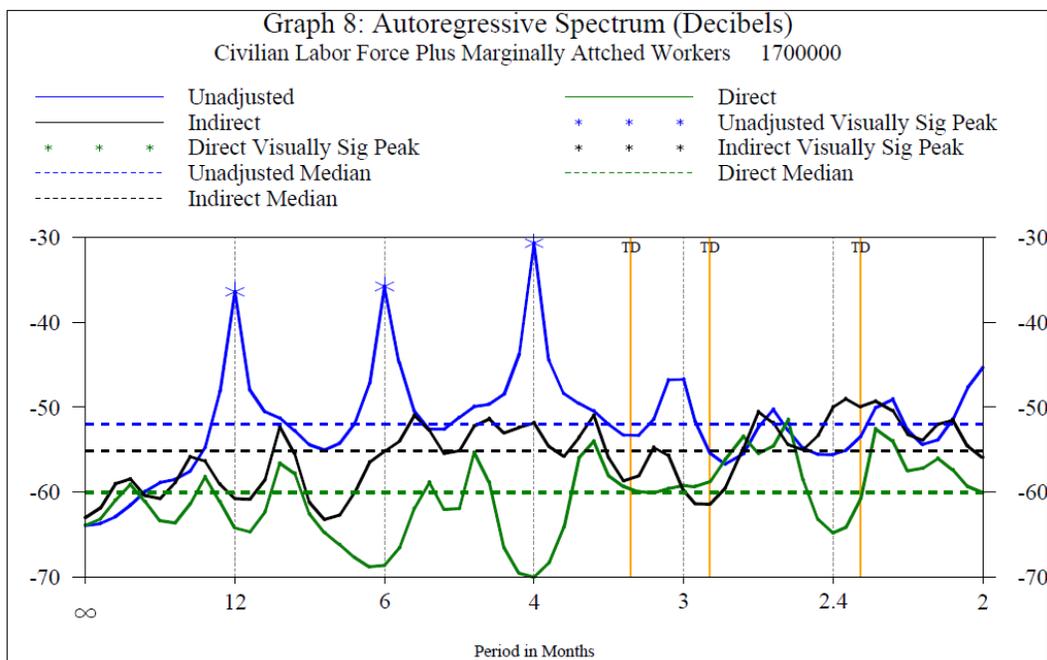
Another interesting issue is seen in Graph 7 below. The civilian labor force level for black males has unusual seasonal factors for the first quarter of 2000. The population control for black males, 20+, has outliers in the first quarter of 2000. This issue is well handled in the direct adjustments with additive outliers, but appears in the derived seasonal factors for any indirect adjustment that includes the population control for black adult males. Of course, this is only a "problem" since the outliers remain in the unadjusted series. The important point here is that all series used to create indirectly adjusted series must be examined and modeled if necessary. One cannot assume that even if a series is deemed nonseasonal, that the series is problem free.

Graph 7: Seasonal Monthly Sub-Plots (000s)
Civilian Labor Force Level - Black or African American Male   1000007
—— Direct —— Indirect —— Direct Means —— Indirect Means

The final plot in this section is Graph 8. The purpose in showing this plot is that it is typical of those seen in this study. First, the unadjusted series is strongly seasonal (blue line) with three pronounced seasonal peaks. Second, the level of the indirectly adjusted series is somewhat higher than that for the directly adjusted. Finally, the directly adjusted series tend to have troughs or dips at the seasonal frequencies, yet the indirectly series typically do not.

Why do the spectral plots in this study so often have basic similarities to that in Graph 8? I have no clear answer at this time. It is common for the spectrum of seasonally adjusted series to exhibit dips at seasonal frequencies, as it is an artifact of the optimal or minimum mean squared error linear seasonal adjustment and not necessarily a problem of overadjustment. (See Bell and Hillmer (1984) review the literature on this topic.) One might expect for the indirectly adjusted spectrum to have similar properties, but for these CPS series, they typically do not.

Another interesting issue is in the comparison of the spectral medians. The median is higher for the indirectly adjusted series than the unadjusted series for 17 series. Most of these can be explained by irregularities with the data or pop control issues. The direct median was only higher than the indirect median for just two series—but just barely. Regardless, one may conclude that the spectra for both types of adjustment are almost always satisfactory.

Graph 8: Autoregressive Spectrum (Decibels)
Civilian Labor Force Plus Marginally Attached Workers   1700000

7. Summary

Of the 392 CPS national series that are indirectly seasonally adjusted, only a few have either data or diagnostic issues as noted above in this article. In short, the indirect adjustments are pretty similar to those for the direct adjustments. There are no clear issues regarding outliers, etc. that are related to simply using indirect adjustment. Several of the indirectly series will be more closely examined due to data errors, formula errors, or from seasonality that is in one of the indirect series' components. In the future, indirectly adjusted series will be more thoroughly examined for adequacy during end-of-year annual processing along with the directly adjusted series.

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