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Revision of Seasonally Adjusted Labor Force Series

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The original data values for many economic time series are often substantially influenced by seasonality, reflecting recurring calendar-related effects caused by weather, holidays, the opening and closing of schools, and other such seasonal events. Seasonal adjustment is a process used to estimate and remove that seasonality. The reason for doing so is to make it easier to observe and analyze the nonseasonal movements in the series, particularly short-term movements associated with business cycles.

The seasonal adjustment process produces estimates of seasonality, called seasonal factors, for the period of observations used in the process and for some projected observations immediately following that period. For the labor force series, initial seasonal adjustment of current data is done using the projected seasonal factors, which are estimates of how much the original unadjusted values can be expected to deviate from underlying trend-cycle levels due to recurring behavior as projected from average seasonal patterns in the recent past.

Even though seasonality involves regularly recurring patterns, it does tend to change or at least evolve over time, creating a need for periodic reestimation of factors and revision of recently adjusted estimates. By including more recent data in the estimation process, the revision process can provide better estimates of how much the original, unadjusted estimates actually deviated from underlying trend-cycle levels during the recent period, thereby improving the historical seasonally adjusted data for that period. In addition, the new information is incorporated to produce the new projected factors to be used for current seasonal adjustment.

Therefore, at the end of each calendar year, the Bureau of Labor Statistics (BLS) reestimates the seasonality of the unemployment, employment, and other labor force series derived from the Current Population Survey (CPS) by including another full year of data in the estimation process. Based on this annual reestimation, BLS issues the projected factors for the first 6 months of the new year as well as revised estimates of historical seasonally adjusted data for the last 5 years. Each year's data are generally subject to five revision cycles before the values are considered final. The fifth and final revisions in the earliest of the 5 years are usually quite small, while the first-time revisions in the most recent year can be much more substantial, although even these rarely alter the essential trends observed in the initial major estimates. This year's revisions incorporate data through December 2001 and provide revised estimates for January 1997 through December 2001 for all previously seasonally adjusted labor force series.

Table 1 contains the new projected seasonal factors to be applied during the first 6 months of 2002 to the 12 component series used in the computation of the seasonally adjusted civilian labor force and unemployment rate. (See the section on aggregation procedures later in the article.) Projected factors for the last 6 months of 2002 will be published in the July issue of this publication.

Effect of revisions

One of the criteria used to evaluate alternative methods of seasonal adjustment is how close initial estimates are to subsequent revisions. Policymakers and analysts must make determinations based on current information, and so it is important that the initial estimates of current factors for the seasonal adjustment of major economic series produce estimates of level and change that are as close as possible to the improved estimates that will be made after more data have become available. Even though the revisions currently being released for the 2001 seasonally adjusted data are not final, the first revisions are usually more substantial than, and often indicate the direction of, any subsequent revisions. Therefore, it is appropriate to compare these first revisions with the initial estimates. Table 2 shows the civilian unemployment rates for 2001 as first computed and as revised, as well as the changes due to revision. Rounded to one decimal place as published, the rates were unchanged in 7 of the 12 months, and changed by ± 0.1 percentage point in the remaining 5 months. The effects of the revisions would be more evident if the rates were computed to more decimal places.

Adjustment methods and procedures

The official seasonal adjustment procedure for the labor force series is the X-11 ARIMA program, which was developed at Statistics Canada during the 1970s as an extension of and improvement to the widely used X-11 method developed at

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[1] The primary documentation for the X-11 ARIMA procedure is *The X-11 ARIMA Seasonal Adjustment Method*, by Estela Bee Dagum (Statistics Canada Catalogue No. 12-564E, January 1983). (ARIMA is an acronym for Auto-Regressive Integrated Moving Average.) The X-11 method is described in *The X-11 Variant of the Census Method II Seasonal Adjustment Program*, by Julius Shiskin, Alan Young, and John Musgrave (Technical Paper No. 15, Bureau of the Census, 1967).

Table 1. **Pre-1994 prior adjustment and January-June 2002 seasonal adjustment factors for the 12 major civilian labor force components**

Procedure and series	Prior adjustment factors	Seasonal adjustment factors					
		January	February	March	April	May	June
Multiplicative adjustment (Divide factor into original value)							
Agricultural employment:							
Men, 20 years and over	[1]	.895	.885	.924	1.005	1.052	1.076
Women, 20 years and over	.776	.935	.969	.979	1.026	1.057	1.046
Men, 16 to 19 years	.860	.607	.590	.695	.856	1.121	1.393
Women, 16 to 19 years	.853	.650	.653	.754	.787	1.229	1.627
Nonagricultural employment:							
Men, 20 years and over	[2].996, 1.003	.993	.994	.996	.999	.999	1.003
Women, 20 years and over	[3].996	1.000	1.003	1.007	1.003	1.001	.994
Unemployment:							
Men, 20 years and over	.938	1.202	1.201	1.147	.982	.936	.937
Women, 20 years and over	.976	1.093	1.030	1.018	.929	.957	1.036
Additive adjustment (Subtract factor from original value)							
Nonagricultural employment:							
Men, 16 to 19 years	-68	-302	-218	-162	-179	-94	432
Women, 16 to 19 years	-96	-190	-164	-200	-163	-135	365
Unemployment:							
Men, 16 to 19 years	-47	49	34	-35	-70	-72	208
Women, 16 to 19 years	[1]	-61	-27	-18	-67	-9	177

[1] No prior adjustment was done.

[2] For this series, the factors are pre-1997 and pre-1999. The first factor shows the adjustment of pre-1997 data relative to subsequent data, the second factor shows the adjustment of pre-1999 data relative to subsequent data. The actual net adjustment to pre-1997 data is the product of the two factors.

[3] For this series, the prior adjusted period was pre-1999 rather than pre-1994.

the U.S. Census Bureau in the 1960s.[1] The X-11 ARIMA method improves current estimates for most series by allowing recent observations, especially those of the last 6 months, to weigh more heavily in the estimates of current and recent seasonal factors than did the X-11 alone. The method provides this improvement through the use of ARIMA models to extend the data series by 12 months. The X-11 algorithm for seasonal adjustment is then applied to the extended series.

ARIMA models. ARIMA projections are based only on the past experience observed in a series itself. ARIMA models have proved to have good properties for short-term projection or extrapolation of a large class of time series, especially in a seasonal adjustment context, since the extrapolations tend to track intra-year movements quite well. The ARIMA models in the X-11 ARIMA program used to seasonally adjust the labor force series are of the Box-Jenkins type.[2] They can generally be described with the notation:

(p,d,q)(P,D,Q) TRANSFORMATION,

Where:

(1) p is the number of regular (nonseasonal) autoregressive parameters

(2) d is the number of regular differences

(3) q is the number of regular moving average parameters

(4) P is the number of seasonal autoregressive parameters

(5) D is the number of seasonal differences

(6) Q is the number of seasonal moving average parameters

(7) TRANSFORMATION may be NONE, LOG, or POWER(n).

While the lettered elements within the parentheses of the model specifications can theoretically take on many values, in practice, only small values are useful. (See table 3.)

For each labor force series which has been extended based on an ARIMA model, the model has been specifically

[2] For a more detailed discussion of ARIMA models, refer to previously cited Dagum (1983) and to G.E.P. Box and G.M. Jenkins, *Time Series Analysis, Forecasting and Control* (San Francisco, Holden Day, 1970); and C.W.J. Granger and P. Newbold, *Forecasting Economic Time Series* (New York, Academic Press, 1977).

Table 2. **Seasonally adjusted unemployment rates in 2001 and change due to revision**

Month	As first computed	As revised	Change
January	4.2	4.2	0
February	4.2	4.2	0
March	4.3	4.3	0
April	4.5	4.5	0
May	4.4	4.4	0
June	4.5	4.6	0.1
July	4.5	4.6	.1
August	4.9	4.9	0
September	4.9	5.0	.1
October	5.4	5.4	0
November	5.7	5.6	-.1
December	[1]5.9	5.8	-.1

[1] This rate reflects the use of seasonal factors projected for December 2001 as published in the July 2001 issue of *Employment and Earnings* and was subject to revision before regular publication of December data.

chosen as well suited to the particular series, based on a set of established criteria. The criteria essentially require a model to: (1) Fit the series well, (2) have low average forecasting errors in the last 3 years prior to the projected year, and (3) produce residuals (the differences between the observed values and the values forecast by the model for the observed period) which follow a random pattern. Acceptable ARIMA models have been identified and were used for 176 of the 182 labor force series which were directly adjusted at the end of 2001, including all 12 major civilian labor force components, whose ARIMA models are shown in table 3 and are unchanged from last year. The six remaining series for which acceptable models have not been identified were simply run through the X-11 part of the program without any ARIMA extrapolations.

X-11 procedures. The procedures used for this year's adjustment of the labor force series within the X-11 part of the process were different from the standard procedures of most previous years in one respect. Because of the changes introduced at the beginning of 1994, 1997, and 1999 in the survey and processing procedures on which the labor force series estimates are based, prior adjustment factors were used in these X-11 ARIMA runs to link the pre-1994, pre-1997, and/or pre-1999 data with the subsequent data for purposes of seasonal adjustment.[3] Without prior adjustment, those changes could have caused distortion in the seasonal decomposition. The prior adjustment factors used for all 12 major components are shown in table 1 alongside the seasonal factors. A 12-year time period, including data from January 1990 through December 2001, was used for the adjustment of all the labor force series except for the eight educational attainment series (which begin in 1992), and the one series for persons not in the labor force who currently want a job (which begins in 1994).

The X-11 method of seasonal adjustment contained in the X-11 ARIMA procedure assumes that the original series, including the 12 extrapolated observations if an ARIMA model has been applied, is either the product or the sum of three components—trend-cycle, seasonal, and irregular. The method uses either a ratio-to- or difference-from-moving-average approach to estimate the components, depending on whether the multiplicative or additive model is used. The seasonally adjusted series values are computed by dividing each month's original value by the corresponding seasonal factor if the multiplicative model is used, or by subtracting the factor if the additive model is used. Of the 12 major civilian labor force components, the 4 teenage unemployment and nonagricultural employment series were adjusted using the additive model, and the other 8 series with the multiplicative model. Of all the 182 directly adjusted series, 48 were adjusted with the additive model, including most teenage employment and unemployment series, for which the seasonal components were found to be fairly independent of the trend-cycle.

Moving-holiday adjustment. Two of the series directly adjusted with multiplicative models were seasonally adjusted using the moving-holiday extension of X-11 ARIMA which was developed at BLS. Both holiday-adjusted series—persons at work on part-time schedules for noneconomic reasons who usually work part time in all industries and nonagricultural industries—had tested as having significant and well-defined effects in their April data related to the timing of Easter. A detailed discussion of the nature of the Easter effect in these series and of the procedure used to con-

Table 3. **ARIMA models used in end-of-2001 seasonal adjustment for the 12 major civilian labor force components**

Series	Model	Transformation
Agricultural employment:		
Men, 20 years and over	(1,0,0)(0,1,1)	LOG
Women, 20 years and over	(0,1,1)(0,1,1)	LOG
Men, 16 to 19 years	(0,1,2)(0,1,1)	NONE
Women, 16 to 19 years	(2,1,2)(0,1,1)	NONE
Nonagricultural employment:		
Men, 20 years and over	(0,1,1)(0,1,1)	LOG
Women, 20 years and over	(0,1,4)(0,1,1)	LOG
Men, 16 to 19 years	(4,1,1)(0,1,1)	NONE
Women, l6 to 19 years	(2,1,0)(0,1,1)	NONE
Unemployment:		
Men, 20 years and over	(0,1,3)(0,1,1)	LOG
Women, 20 years and over	(0,1,1)(0,1,1)	LOG
Men, 16 to 19 years	(0,1,1)(0,1,1)	NONE
Women, 16 to 19 years	(2,1,2)(0,1,1)	NONE

[3] For further discussion of these prior adjustment factors and the changes that they control for, see the following articles in previous issues of this publication: "Revisions in the Current Population Survey Effective January 1994" in the February 1994 issue; "Revisions in Household Survey Data Effective February 1996" in the March 1996 issue; "Revisions in the Current Population Survey Effective January 1997" in the February 1997 issue; "Revision of Seasonally Adjusted Labor Force Series" in the January 1998 issue; "Revisions in the Current Population Survey Effective January 1999" in the February 1999 issue; and "New Seasonal Adjustment Factors for Household Data Series" in the July 1999 issue.

trol for it as part of the seasonal adjustment process was included in the January 1990 version of this article.

Six-month updates. The current official practice for the seasonal adjustment of the labor force series involves the running of all directly adjusted series through X-11 ARIMA twice each year. This is done after receipt of June and December data, with 6 months of projected factors drawn from each run and historical revisions drawn from the end-of-year run. This practice allows, among other things, the prior publication of seasonal factors, which historically has been regarded by the Bureau of Labor Statistics and other statistical agencies as an important way of ensuring the openness of their seasonal adjustment procedures, especially where very sensitive indicators such as the unemployment rate have been involved. A number of research studies, including a 1987 paper on the labor force series,[4] have indicated that the alternative practice of concurrent adjustment, where the seasonal adjustment procedure is run with all available data each month and factors cannot be published ahead of time, generally produces initial seasonally adjusted estimates requiring smaller revisions than those produced by adjustment using projected factors. The BLS is continuing to compute and evaluate concurrent adjustment for the labor force series.

Aggregation procedures

BLS maintains and publishes several hundred seasonally adjusted labor force series in addition to the 182 directly adjusted series discussed above. These additional series are produced by arithmetically combining or aggregating the directly adjusted series with each other or, in some cases, with series on population which are not seasonally adjusted because they are not considered to have any significant seasonal variation. For example, the seasonally adjusted levels of total unemployment, civilian employment, and civilian labor force, and the seasonally adjusted unemployment rate for all civilian workers, are all produced by aggregation of some or all of the seasonally adjusted results for the 12 major civilian labor force components. The seasonally adjusted level of total unemployment is the sum of the seasonally adjusted levels of unemployment for the four age-sex groups—men and women 16 to 19, and men and women 20 years and over. Seasonally adjusted civilian employment is the sum of the seasonally adjusted levels of employment for the eight employment components—the same four age-sex groups as noted above employed in nonagricultural and agricultural industries. The seasonally adjusted civilian labor force is the sum of all 12 components. The seasonally adjusted civilian unemployment rate is calculated by taking the total seasonally adjusted unemployment level as a percent of the total seasonally adjusted civilian labor force.

[4] G.R. Methee and R.J. McIntire, "An Evaluation of Concurrent Seasonal Adjustment for the Major Labor Force Series," in the 1987 *Proceedings of the Business and Economic Statistics Section,* American Statistical Association.

The principal reason for producing many of the major seasonally adjusted estimates for the labor force by aggregation rather than by direct adjustment is that this approach ensures that the major seasonally adjusted totals will be arithmetically consistent with at least one major set of components. If the totals were directly adjusted along with the components, such consistency would not, in all likelihood, occur, since the X-11 is not a sum-preserving procedure. That is, the sum of the result for two or more directly adjusted series will not generally be the same as the result of directly adjusting the sum of the unadjusted versions of the same series. Another factor is that it would generally be inappropriate to apply seasonal factors computed for an aggregate series to the components of the aggregate. The various labor force components tend to have significantly different patterns of seasonal variation; for example, teenage unemployment tends to peak in June, while unemployment of adult men tends to peak in the winter months of January and February. In order to estimate properly these varying seasonal patterns, it is necessary to adjust the components directly. Of course, one of the implications of producing seasonally adjusted estimates for many major series by aggregation is that exact factors cannot be projected for those series. However, implicit seasonal adjustment factors can be calculated after the fact by taking the ratio of the unadjusted aggregate to the seasonally adjusted aggregate, or, for additive implicit factors, the difference between those two aggregates.

Effects of September 11 on seasonal adjustment

The seasonally adjusted total unemployment rate jumped four-tenths of a percentage point in October and continued to increase through December 2001. This unusually large increase to a new level raises the issue as to whether there has been a sudden change in trend for unemployment and perhaps for other labor force categories. This would seem to be a real possibility because October is the month in which the initial impact of the September 11, 2001, terrorist attacks would be expected to be seen in the CPS data.

A specific event that causes a time series to deviate from its expected evolutionary pattern is often referred to as an intervention. Should such an event occur in the CPS and nothing is done to adjust for it, the projections of seasonal factors and revisions to the historical factors may be seriously distorted.

To test for the possibility that the terrorist attacks had important effects on the CPS series, each ARIMA model used for forecasting was modified to include an intervention variable. This variable is a dummy regressor or indicator variable, which flags October as the timing of the intervention and assumes the intervention is permanent. The coefficient for this variable provides an estimate of the direction and magnitude of the intervention effect.

Out of the 182 series that are directly seasonally adjusted, 2 series, unemployed job losers and unemployed private wage and salary workers in the transportation and public utilities

industry, were identified as having had substantial upward level shifts that seriously distorted their seasonal patterns. Before seasonally adjusting these two series, the estimated level shifts were removed in a process called prior adjustment. Prior adjustment factors that reflect 75 percent of the estimated intervention coefficients were actually used to guard against overadjustment. Estimation of the seasonal factors was then done on the adjusted series. These factors were then applied to the original series without prior adjustment to obtain the seasonally adjusted series.

While this assessment was made with the limited amount of data available following September 11, additional data will be available at midyear to reassess these effects. Moreover, the projected seasonal factors for the first part of 2002 were not much affected by the events of September 11. The seasonally adjusted total unemployment rate was not affected at all since none of the 12 series used to derive the rate appear to need intervention adjustment.

Availability of revised series

This issue of Employment and Earnings contains revised monthly and quarterly data for the most recent 13 months and calendar quarters for many seasonally adjusted labor force series. These revisions replace the seasonally adjusted estimates previously published for those periods. Revised historical seasonally adjusted labor force data also are available in various forms on the Internet (**www.bls.gov**), including ftp access (**ftp://ftp.bls.gov/pub/special.requests/lf/**) to all the revised data. The seasonally adjusted data last published for 1996 and earlier years were not further revised.

The January-June 2002 factors for any of the directly adjusted series beyond the 12 major components can be obtained from BLS upon request. Requests for the seasonal factors used for the labor force data should be addressed to the Division of Data Development and Publications, Office of Employment and Unemployment Statistics, Bureau of Labor Statistics, Washington, DC 20212.