

# Calculating Approximate Standard Errors and Confidence Intervals for Current Population Survey Estimates

Each month, at the time of the *Employment Situation* news release, BLS publishes a [statistical significance test online for selected labor force indicators](#). For those who wish to generate their own standard errors and confidence intervals, this document provides information about how to do this for estimates from the Current Population Survey (CPS).<sup>1</sup> See the accompanying [Standard error illustrations XLSX](#) file for calculations behind the illustrations in this document.

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## What is a confidence interval?

When a sample, rather than the entire population, is surveyed, estimates differ from the true population values that they represent. The component of this difference that occurs because samples differ by chance is known as sampling error, and its variability is measured by the standard error of the estimate. A sample estimate and its estimated standard error can be used to construct confidence intervals. A confidence interval is a range of values centered around the sample estimate that is likely to include the true population value with a degree of confidence. When sample estimates are unbiased, the statistical properties of confidence interval “coverage” are known.

The following are examples of confidence intervals:

- A 90% confidence interval is the range from 1.645 standard errors below the estimate to 1.645 standard errors above the estimate. The true population value is unknown, but there is an approximate 90% probability that the interval includes or “covers” the true population value.
- A 95% confidence interval is the range from 1.96 standard errors below the estimate to 1.96 standard errors above the estimate. The true population value is unknown, but there is an approximate 95% probability that the interval includes or “covers” the true population value.

Confidence interval statements like these are approximately true for the CPS, and this is especially so for rates and changes over time. For a more complete explanation of confidence interval coverage refer to a standard survey methodology text, such as chapter 1.7 in the 3<sup>rd</sup> edition of *Sampling Techniques* by William G Cochran (Wiley, 1977).

It is important to know if the difference between two estimates is statistically significant. The difference may be a comparison of the same characteristic in different time periods (like the employment-population ratio in May compared with June) or a comparison between different groups in the same time period (like the March unemployment rate for men compared with that for women). Given an unbiased estimate of the difference and an unbiased estimate of standard error for that difference, confidence intervals can be constructed and statements such as the following can be made:

- If zero lies outside of the 90% confidence interval, from 1.645 standard errors below the estimated difference to 1.645 standard errors above the estimated difference, the difference is statistically significant at a 90% confidence level. If zero lies within the interval, the difference is not statistically significant at a 90% confidence level.
- If zero lies outside of the 95% confidence interval from 1.96 standard errors below the estimated difference to 1.96 standard errors above the estimated difference, the difference is statistically significant at a 95% confidence level. If zero lies within the interval, the difference is not significantly different at a 95% confidence level.

## Calculating approximate standard errors and confidence intervals

### Parameter and factor tables PF-1 through PF-16

Approximate standard errors and confidence intervals for CPS estimates can be calculated using the following [instructions](#) and [parameter and factor tables](#) (PF-1 through PF-16) that are available online. (These tables mirror tables A-1 through A-16 of the monthly [Employment Situation news release](#).) The parameters and factors are used in formulas that are commonly called generalized variance functions. The parameter and factor tables allow users to calculate approximate standard errors for a wide range of estimated levels, rates, and percentages, and also changes over time.

These tables do not include parameters and factors for all possible estimates from the CPS; they only include parameters and factors for series that are published in the Employment Situation news release. The next section of this document provides [instructions on how to borrow parameters and factors](#) from the estimates covered in these tables to calculate an approximate standard error for estimates that are not covered.

Information presented here may be of use to researchers working with official BLS estimates as well as those computing estimates using the public use CPS microdata files, available from the [U.S. Census Bureau's website](#) or from Census's [Microdata Access Tool \(MDAT\)](#). Note that estimates generated using the public use microdata files, except for a few topside estimates, will not match official BLS estimates.<sup>2</sup>

[CPS parameters and factors tables](#) give  $\alpha$  and  $\beta$  parameters that can be used with formulas to calculate approximate monthly standard errors for a wide range of estimated levels, proportions, and rates. Factors are provided to convert monthly standard error measures into approximate standard errors of estimates for other periods and approximate standard errors for changes over time. Specifically, the tables show factors ( $f$ ) that are used in calculating standard errors for:

- Consecutive month-to-month changes
- Changes in monthly estimates 1 year apart
- Quarterly averages
- Changes in consecutive quarterly averages
- Yearly averages
- Changes in consecutive yearly averages

The standard errors for estimated changes in level estimates from one time period to the next (for example, one month to the next or one year to the next) depend more on the monthly levels than on the size of the changes. Likewise, the standard errors for changes in rates (or percentages), means, and medians depend more on the monthly figures than on the size of the changes. Accordingly, the factors presented in tables PF-1 through PF-16 are applied to the monthly standard error approximations for levels, percentages, or rates; the magnitudes of the changes do not come into play. Factors are not given for estimated changes between nonconsecutive months (except for changes of monthly estimates 1 year apart); however, the standard errors for changes

between nonconsecutive months are generally assumed to be larger than those for consecutive months.

**IMPORTANT:** CPS data are published as levels in thousands, so 4 million unemployed people would be displayed as 4,000 in a table. Similarly, an entry of 2,460 in a CPS table represents 2,460,000 people. When calculating standard errors and confidence intervals, you must use the actual level at full precision, not the data as published in thousands.

## Formulas to calculate standard errors

### 1. Standard errors of estimated levels

#### *Standard errors for estimated monthly levels*

The approximate standard error  $se(x)$  of  $x$ , an estimated monthly level, can be obtained using the formula below, where  $\alpha$  and  $\beta$  are the parameters from parameter and factor [tables PF-1 through PF-16](#) associated with a particular characteristic, and  $N$  is the total civilian noninstitutional population 16 years and over.

$$se(x; N) = \sqrt{(\alpha + \beta N) \left( x - \frac{x^2}{N} \right)}$$

Note that  $x$  is the monthly level (not in thousands).

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#### *Illustration 1.1 – calculating a standard error for a single-month level*

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In a given month, there are an estimated 4 million unemployed men, and the civilian noninstitutional population is 250 million. Obtain the appropriate  $\alpha$  and  $\beta$  parameters from table PF-1 (in row 22 for unemployed men, 16 years and over). Use the formula above for  $se(x; N)$  to compute an approximate standard error on the estimate of  $x = 4,000,000$  where  $N = 250,000,000$ .

$$\begin{aligned}\alpha &= -6127.75 \\ \beta &= 0.00003934\end{aligned}$$

$$\begin{aligned} &se(4,000,000; 250,000,000) \\ &= \sqrt{(-6127.75 + (0.00003934 * 250,000,000)) * (4,000,000 - \left(\frac{4,000,000^2}{250,000,000}\right))} \\ &= 120,796\end{aligned}$$

$$se(4,000,000; 250,000,000) \approx 121,000$$

*Standard errors for levels: Estimated quarterly averages, annual averages, and changes over time*

The approximate standard error  $se(x)$  of  $x$ , an estimated level that is a quarterly average, annual average, or change over time, can be obtained using the formula below, where  $\alpha$  and  $\beta$  are the parameters and  $f$  is the factor associated with a particular characteristic (from [tables PF-1 through PF-16](#)), and  $N$  is the total civilian noninstitutional population 16 years and over.

The  $f$  in the formula is frequently called an *adjustment factor* because it appears to adjust a monthly standard error  $se(x)$ . However, the  $x$  and  $N$  in the formula are not monthly levels, but averages of monthly levels (see examples listed below).

$$se(x; N; f) = f * se(x; N) = f * \sqrt{(\alpha + \beta N)\left(x - \frac{x^2}{N}\right)}$$

Step 1. If quarterly or annual averages are not available, you will need to calculate them from the monthly estimates. Average levels appropriately to obtain  $x$  and  $N$ . Levels for 3 months are averaged to calculate quarterly averages, and levels for 12 months are averaged to calculate annual averages. For changes in consecutive levels, average over the 2 months, 2 quarters, or 2 years involved. For changes in monthly estimates 1 year apart, average the 2 months involved.

Step 2. Calculate an approximate standard error  $se(x)$ , treating the average  $x$  from step 1 as if it were an estimated level for a single month. For a given characteristic, obtain parameters  $\alpha$  and  $\beta$  from the applicable PF table.

Step 3. Determine the standard error  $se(x; f)$  on the average level or on the change in level. Multiply the result from step 2 by the appropriate factor  $f$ . The  $\alpha$  and  $\beta$  parameters used in step 2 and the factor  $f$  used in this step come from the same line in the corresponding PF table.

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*Illustration 1.2 – calculating a standard error for a consecutive month change in level*

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Continuing from [illustration 1.1](#) above, suppose that in the next month the estimated number of unemployed men increases by 150,000, from 4,000,000 to 4,150,000. Also suppose the civilian noninstitutional population 16 years and over increases by 200,000, from 250,000,000 to 250,200,000.

Step 1. Average the two monthly levels for the estimate and the total population to obtain  $x = 4,075,000$  and  $N = 250,100,000$ .

Step 2. Apply the  $\alpha$  and  $\beta$  parameters from table PF-1 (in row 22 for unemployed men, 16 years and over) to the average  $x$  and  $N$ , treating them like an estimate and a population value for a single month.

$$\alpha = -6127.75$$

$$\beta = 0.00003934$$

$$se(4,075,000; 250,100,000)$$

$$= \sqrt{\left(-6127.75 + (0.00003934 * 250,100,000)\right) * \left(4,075,000 - \frac{4,075,000^2}{250,100,000}\right)}$$

$$= 121,970$$

$$se(4,075,000; 250,100,000) \approx 122,000$$

Step 3. Obtain  $f = 1.12$  from the same row of table PF-1 in the column “Consecutive month-to-month change,” and multiply the factor by the result from step 2 to calculate the standard error for the change between the 2 months.

$$se(150,000) = f * se(4,075,000; 250,100,000) = 1.12 * 121,970 = 136,606$$

$$se(150,000) \approx 137,000$$

For an approximate 90-percent confidence interval, compute  $1.645 * 136,606 = 224,717 \approx 225,000$ . Next, subtract the number from and add the number to 150,000 to obtain an interval of -75,000 to 375,000. This is an approximate 90-percent confidence interval for the true change, and since this interval includes zero, one cannot assert at this level of confidence that any real change has occurred in the unemployment level over the month. The result also can be expressed by saying that the apparent change of 150,000 is not statistically significant at a 90-percent confidence level.

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*Illustration 1.3 – calculating a standard error for a quarterly average level*

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Suppose that an approximate standard error is desired for a quarterly average of the Black or African American employment level. Suppose that the estimated employment levels for the 3 months making up the quarter are 14,900,000; 15,000,000; and 15,100,000, and the corresponding levels of the civilian noninstitutional population 16 years and over are 249,800,000; 250,000,000; and 250,200,000.

Step 1. The averages of the 3 monthly levels are  $x = 15,000,000$  and  $N = 250,000,000$ .

Step 2. Apply the  $\alpha$  and  $\beta$  parameters from table PF-2 (in row 40 for employed Black or African American people) to the average  $x$  and  $N$ , treating them like an estimate for a single month.

$$\begin{aligned}\alpha &= -1478.12 \\ \beta &= 0.00001191\end{aligned}$$

$$\begin{aligned}se(15,000,000; 250,000,000) \\ &= \sqrt{(-1478.12 + (0.00001191 * 250,000,000)) * (15,000,000 - \frac{15,000,000^2}{250,000,000})} \\ &= 145,400\end{aligned}$$

$$se(15,000,000; 250,000,000) \approx 145,000$$

Step 3. Obtain  $f = 0.85$  from the same row of table PF-2 in the column “Quarterly averages,” and multiply the factor by the result from step 2 to calculate the standard error of the quarterly average.

$$se(15,000,000) = 0.85 * 145,400 = 123,590$$

$$se(15,000,000) \approx 123,600$$

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*Illustration 1.4 – calculating a standard error for a consecutive quarter change in level*

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Continuing the example from [illustration 1.3](#), suppose that, in the next quarter, the estimated average employment level for Blacks is 15,400,000, based on monthly levels of 15,300,000; 15,400,000; and 15,500,000. This is an estimated increase of 400,000 over the previous quarter. Also suppose the average population level in the next quarter is 250,600,000, based on monthly levels of 250,400,000; 250,600,000; and 250,800,000.

Step 1. The average of the two quarterly levels (15,000,000 and 15,400,000) is  $x = 15,200,000$ . The average of the two quarterly population levels (250,000,000 and 250,600,000) is  $N = 250,300,000$ .

Step 2. Apply the  $\alpha$  and  $\beta$  parameters from table PF-2 (in row 40 for employed Black or African American people) to the average  $x$  and  $N$ , treating them like an estimate for a single month.

$$\alpha = -1478.12$$

$$\beta = 0.00001191$$

$$se(15,200,000; 250,300,000)$$

$$= \sqrt{(-1478.12 + (0.00001191 * 250,300,000)) * (15,200,000 - \frac{15,200,000^2}{250,300,000})}$$

$$= 146,484$$

$$se(15,200,000; 250,300,000) \approx 146,000$$

Step 3. Obtain  $f = 0.81$  from the same row of table PF-2 (row 40 for employed Black or African American people) in the column “Change in consecutive quarterly averages,” and multiply the factor by the result from step 2 to calculate the standard error of the change in quarterly averages.

$$se(400,000) = 0.81 * se(15,200,000) = 0.81 * 140,195 = 118,652$$

$$se(400,000) \approx 119,000$$

For an approximate 90-percent confidence interval, compute  $1.645 * 118,652 = 195,183 \approx 195,000$ . Subtract the number from and add the number to 400,000 to obtain an interval of 205,000 to 595,000. The interval excludes zero. Another way of stating this is to observe that the estimated change of 400,000 clearly exceeds 1.6 standard errors, or 195,000. One can conclude from these data that the change in quarterly averages is statistically significant at a 90-percent confidence level.

## 2. Standard errors of estimated rates, ratios, and percentages

### *Standard errors for estimated monthly rates, ratios, and percentages*

As shown in the formula below, the approximate standard error  $se(p;y)$  of an estimated rate or percentage  $p$  depends, in part, upon the number of people  $y$  in its base or denominator (which is the number of people represented by a particular estimate). The  $\alpha$  and  $\beta$  parameters are obtained from the parameter and factor (PF) tables.

For a rate, ratio, or percentage covered in the [PF tables](#), use the  $\alpha$  and  $\beta$  parameters for that estimate.

For a percentage that is not itself covered in the PF tables but that is calculated from two series that are **INCLUDED** in the PF tables, use the  $\alpha$  and  $\beta$  parameters from the PF table relevant to the numerator of the rate or percentage. For example, when calculating a standard error for the proportion of the of the labor force made up by women (two series that are **INCLUDED** in the PF tables), use the  $\alpha$  and  $\beta$  parameters associated with the number of women in the labor force (the numerator) rather than the total number of people in the labor force (the denominator).



For a rate or percentage calculated from two series that are *NOT INCLUDED* in the PF tables, see the [instructions on how to borrow parameters and factors](#) below.

$$se(p; y) = \sqrt{\frac{(\alpha + \beta y)}{y} p(100 - p)}$$

Note that  $y$  (not in thousands) is the base of percent  $p$ , and  $se(p; y)$  is in percent.

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*Illustration 2.1 – calculating a standard error for a single-month percent*

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For a given month, suppose  $y = 156,000,000$  employed people. Of this total, 27,000,000, or  $p = 17.3$  percent, are classified as part-time workers. Obtain the  $\alpha$  and  $\beta$  parameters from table PF-9 (in row 49 for part-time workers) that are relevant to the numerator of the percentage. Apply the formula to obtain:

$$\begin{aligned}\alpha &= -4841.52 \\ \beta &= 0.00003413\end{aligned}$$

$$\begin{aligned}se(17.3; 156,000,000) \\ &= \sqrt{\frac{(-4841.52 + (0.00003413 * 156,000,000))}{156,000,000} * 17.3 * (100 - 17.3)} \\ &= 0.067 \approx 0.1 \text{ percent}\end{aligned}$$

For an approximate 90-percent confidence interval, compute  $1.645 * 0.067 = 0.109$  percent  $\approx 0.1$  percent. Subtract this from and add this to the estimate of  $p = 17.3$  percent to obtain an approximate confidence interval of 17.2 percent to 17.4 percent.

*Standard errors for percentages: Estimated for quarterly averages, annual averages, and changes over time*

Factors from [tables PF-1 through PF-16](#) can be used to compute approximate standard errors on rates, ratios, and percentages for quarterly averages, annual averages, and for changes over time. As with levels, there are three steps in the procedure for applying the formula.

$$se(p; y; f) = f * se(p; y) = f * \sqrt{\frac{(\alpha + \beta y)}{y} p(100 - p)}$$

Note that  $p$  and  $y$  are averages for the designated period, and  $se(p; y; f)$  is a percent.

Step 1. If you need a quarterly or annual average that is not available, then you will need to calculate one by averaging the monthly level estimates for the numerator and denominator and dividing the average for the numerator by the average for the denominator to obtain  $p$ . The average for the denominator will be  $y$ . For changes in consecutive averages, average over the 2 months, 2 quarters, or 2 years involved. For changes in monthly estimates 1 year apart, average the 2 months involved.

Step 2. Calculate an approximate standard error  $se(p; y)$ , treating the averages  $p$  and  $y$  from step 1 as if they were estimates for a single month. Obtain the  $\alpha$  and  $\beta$  parameters from the [PF table](#) that correspond to the numerator of the rate or percentage.

Step 3. Determine the standard error  $se(p; y; f)$  for the average percentage or the change in percentage. Multiply the result from step 2 by the appropriate factor  $f$ . The  $\alpha$  and  $\beta$  parameters used in step 2 and the factor  $f$  used in this step will come from the same row in the appropriate PF table.

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*Illustration 2.2 – calculating a standard error for a consecutive month change in percentage*

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Continuing the example from [illustration 2.1](#), suppose that, in the next month, there are 156,600,000 employed people, and that 28,000,000, or 17.9 percent, are part-time workers.

Step 1. The month-to-month change is 0.6 percentage point—that is, the share of the employed who worked part time changed from 17.3 percent to 17.9 percent over the month. The average of the two monthly percentages of 17.3 percent and 17.9 percent is needed ( $p = 17.6$  percent), as is the average of the two bases of 156,000,000 and 156,600,000 ( $y = 156,300,000$ ).

Step 2. Apply the  $\alpha$  and  $\beta$  parameters from table PF-9 (in row 49 for part-time workers) to the averaged  $p$  and  $y$ , treating the averages like estimates for a single month.

$$\begin{aligned}\alpha &= 4841.52 \\ \beta &= 0.00003413\end{aligned}$$

$$\begin{aligned} & se(17.6; 156,300,000) \\ &= \sqrt{\frac{(-4841.52 + (0.00003413 * 156,300,000))}{156,300,000} * (17.6) * (100 - 17.6)} = 0.068 \\ &\approx 0.1 \text{ percent} \end{aligned}$$

Step 3. Obtain  $f = 1.00$  from the same row of table PF-9 in the column “Consecutive month-to-month change,” and multiply the factor by the result from step 2.

$$se(0.6 \text{ percent}) = 1.00 * 0.068 = 0.068 \text{ percent} \approx 0.1 \text{ percent}$$

For an approximate 90-percent confidence interval, compute  $1.645 * 0.068 = 0.111 \approx 0.1$  percent. Subtract this from and add this to the 0.6-percentage point estimate of change to obtain an interval of 0.5 percent to 0.7 percent. Because this interval does not include zero, it can be concluded that the over-the-month change is statistically significant at a 90-percent confidence level.

### 3. Standard errors of estimated mean duration of unemployment

#### *Standard errors for estimated single-month means*

The approximate standard error  $se(\bar{x}; y)$  of  $\bar{x}$ , the monthly estimate of mean duration of unemployment, can be obtained using the formula below, where  $\alpha$  and  $\beta$  are the parameters from parameter and factors table PF-12. The formula depends, in part, upon the total number of unemployed people  $y$  in its denominator.

$$se(\bar{x}; y) = \frac{\alpha + \beta \bar{x}}{\sqrt{y}}$$

Note that  $y$  is a monthly level (not in thousands).

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#### *Illustration 3.1 – calculating a standard error for a single-month mean*

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In a given month, suppose there are an estimated 7 million unemployed people, and the estimated mean duration of unemployment is 22.7 weeks. To estimate the standard error for the mean duration of unemployment, start by finding the appropriate  $\alpha$  and  $\beta$  parameters from table PF-12 (in row 12 for the average duration of unemployment in weeks). Use the formula  $se(\bar{x}; y)$  to compute an approximate standard error for the estimate of  $\bar{x} = 22.7$  where  $y = 7,000,000$ .

$$\begin{aligned}\alpha &= 521.77 \\ \beta &= 55.85768590\end{aligned}$$

$$se(22.7; 7,000,000) = \frac{521.77 + (55.85768590 * 22.7)}{\sqrt{7,000,000}} = 0.6765$$

$$se(22.7; 7,000,000) \approx 0.68 \text{ weeks}$$

*Standard errors for means: Estimated for quarterly averages, annual averages, and changes over time*

The approximate standard error  $se(\bar{x}; y; f)$  of  $\bar{x}$ , the average of monthly estimate of mean duration of unemployment over the designated period, can be obtained using the formula below. Table PF-12 provides factors that can be used to compute approximate standard errors of mean duration of unemployment for quarterly averages, annual averages, and changes over time. The formula depends, in part, upon the total number of unemployed people  $y$  in its denominator. As with levels and rates, there are 3 steps in the procedure for using the formula.

$$se(\bar{x}; y; f) = f * se(\bar{x}; y) = f * \left( \frac{\alpha + \beta \bar{x}}{\sqrt{y}} \right)$$

Note that  $\bar{x}$  is the mean duration of unemployment over the designated period,  $y$  is the average number of unemployed people over the designated period, and  $se(\bar{x}; y; f)$  is in weeks. If quarterly or annual averages are not available, you will need to calculate them by averaging the monthly estimates.

Step 1. Average monthly estimates appropriately to obtain  $\bar{x}$  and  $y$ . Means ( $\bar{x}$ ) and levels ( $y$ ) for 3 months are averaged for quarterly averages, and those for 12 months are averaged for yearly averages. For changes in consecutive mean estimates, average over the 2 months, 2 quarters, or 2 years involved. For changes in monthly estimates 1 year apart, average the 2 months involved.

Step 2. Calculate an approximate standard error  $se(\bar{x}; y)$ , treating the averages  $\bar{x}$  and  $y$  from step 1 as if they were estimated means and levels, respectively, for a single month. Obtain the appropriate  $\alpha$  and  $\beta$  parameters from table PF-12.

Step 3. Determine the standard error  $se(\bar{x}; y; f)$  on the average (average of multiple monthly mean estimates) or on the change in mean estimates. Multiply the result from step 2 by the appropriate factor  $f$ . The  $\alpha$  and  $\beta$  parameters used in step 2 and the factor  $f$  used in this step come from the same row of table PF-12.

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*Illustration 3.2 – calculating a standard error for a consecutive month change in mean duration of unemployment*

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Continuing the example from [illustration 3.1](#), suppose that in the next month the estimated number of unemployed people decreased by 200,000, from 7,000,000 to 6,800,000. Also, suppose the estimate of the mean duration of unemployment increased by 2.0 weeks, from 22.7 to 24.7 weeks.

Step 1. The averages of the two monthly means ( $\bar{x}$ ) and levels ( $y$ ) are  $\bar{x} = 23.7$  and  $y = 6,900,000$ .

Step 2. Apply the  $\alpha$  and  $\beta$  parameters from table PF-12 (Unemployed people by duration of unemployment) to the averages  $\bar{x}$  and  $y$ , treating them like estimates for a single month.

$$\begin{aligned}\alpha &= 521.77 \\ \beta &= 55.85768590\end{aligned}$$

$$se(23.7; 6,900,000) = \frac{521.77 + (55.85768590 * 23.7)}{\sqrt{6,900,000}} = 0.7026$$

$$se(23.7; 6,900,000) \approx 0.70 \text{ weeks}$$

Step 3. Obtain  $f = 1.11$  from the same row of table PF-12 (in row 12 for the average duration of unemployment in weeks) in the column “Consecutive month-to-month change,” and multiply the factor by the result from step 2 to calculate the approximate standard error for the change between the two months.

$$se(2.0) = f * se(23.7; 6,900,000) = 1.11 * 0.7026 = 0.7799$$

$$se(2.0) \approx 0.78 \text{ weeks}$$

For an approximate 90-percent confidence interval, compute  $1.645 * 0.7799 = 1.2829 \approx 1.3$  weeks. Next, subtract the number from and add the number to 2.0 weeks to obtain an interval of 0.7 to 3.3 weeks. Because this interval does not include zero, it can be concluded that the change in the mean duration of unemployment is statistically significant at a 90-percent confidence level.

#### 4. Standard errors of estimated median duration of unemployment

##### *Standard errors for estimated single-month medians*

The approximate standard error  $se(m; y)$  of  $m$ , the monthly estimate of median duration of unemployment, can be obtained using the formula below, where  $\alpha$  and  $\beta$  are the parameters from parameter and factors table PF-12. The formula depends upon both the estimates of mean weeks unemployed  $\bar{x}$  and the total number of unemployed people  $y$  but does not depend directly on the estimated median  $m$ .

$$se(m; \bar{x}; y) = \frac{\alpha + \beta(\bar{x}y)}{\sqrt{y}}$$

Note that  $y$  is a monthly level (not in thousands).

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*Illustration 4.1 – calculating a standard error for a single month median*

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Suppose that in a given month there are an estimated 7 million unemployed people, the mean duration of unemployment is 22.7 weeks, and the median duration of unemployment is 9.4 weeks. Obtain the appropriate  $\alpha$  and  $\beta$  parameters from table PF-12 (in row 13 for the median duration of unemployment in weeks). Use the formula  $se(m; \bar{x}; y)$  to compute an approximate standard error on the estimate of  $m = 9.4$ , where  $\bar{x} = 22.7$  and  $y = 7,000,000$ .

$$\begin{aligned}\alpha &= 274.00 \\ \beta &= 0.00000405\end{aligned}$$

$$se(9.4; 22.7; 7,000,000) = \frac{274.00 + 0.00000405 * (22.7 * 7,000,000)}{\sqrt{7,000,000}} = 0.3468$$

$$se(9.4; 22.7; 7,000,000) \approx 0.35 \text{ weeks}$$

*Standard errors for medians: Estimated quarterly, annually, and for changes over time*

The approximate standard error  $se(m; \bar{x}; y; f)$  of  $m$ , the quarterly or annual median duration of unemployment, or change over time in this measure, can be obtained using the formula below. Table PF-12 provides factors that can be used in the computation. The formula depends upon estimates of both the mean weeks unemployed  $\bar{x}$  and the total number of unemployed people  $y$ , but does not depend directly on the estimated median  $m$ . As with levels, rates, and means, there are 3 steps in the procedure for using the formula.

$$se(m; \bar{x}; y; f) = f * se(m; \bar{x}; y) = f * \left( \frac{\alpha + \beta(\bar{x}y)}{\sqrt{y}} \right)$$

Note that  $\bar{x}$  is the mean duration of unemployment over the designated period,  $y$  is the number of unemployed people, and  $se(m; \bar{x}; y; f)$  is in weeks.

Step 1. Average monthly estimates appropriately to obtain  $\bar{x}$  and  $y$ . Means ( $\bar{x}$ ) and levels ( $y$ ) for 3 months are averaged for quarterly averages, and those for 12 months are averaged for yearly averages. To calculate a standard error for changes in consecutive median estimates, average the medians ( $m$ ), means ( $\bar{x}$ ) and levels ( $y$ ) over the 2 months, 2 quarters, or 2 years involved. For changes in monthly estimates 1 year apart, average the 2 months involved.

Step 2. Calculate an approximate standard error  $se(m; \bar{x}; y)$ , treating the averages from step 1 as if they were estimates for a single month. Obtain the appropriate  $\alpha$  and  $\beta$  parameters from table PF-12.

Step 3. Determine the standard error  $se(m; \bar{x}; y; f)$  on the average median or on the change in median estimates. Multiply the result from step 2 by the appropriate factor  $f$ . The  $\alpha$  and  $\beta$  parameters used in step 2 and the factor  $f$  used in this step come from the same row of table PF-12.

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*Illustration 4.2 – calculating a standard error for a quarterly median duration of unemployment*

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Suppose the median duration of unemployment estimates for a quarter is 10.5 weeks. Also suppose the mean duration of unemployment estimates for 3 consecutive months are 22.7, 24.7, and 24.3 weeks, and the estimates of total unemployed people for 3 consecutive months are 7,000,000; 6,800,000; and 6,000,000.

Step 1. The averages of the means ( $\bar{x}$ ) and levels ( $y$ ) are  $\bar{x} = 23.9$  and  $y = 6,600,000$ .

Step 2. Apply the  $\alpha$  and  $\beta$  parameters from table PF-12 (in row 13 for the median duration of unemployment in weeks to the averages  $\bar{x}$  and  $y$ , treating them like estimates for a single month.

$$\alpha = 274.00$$

$$\beta = 0.00000405$$

$$se(10.5; 23.9; 6,600,000) = \frac{274.00 + 0.00000405 * (23.9 * 6,600,000)}{\sqrt{6,600,000}} = 0.3553$$

$$se(10.5; 23.9; 6,600,000) \approx 0.36 \text{ weeks}$$

Step 3. Obtain  $f = 0.69$  from the same row of table PF-12 in the column “Quarterly averages,” and multiply the factor by the result from step 2 to calculate the approximate standard error for the quarterly average of median duration of unemployment.

$$se(10.5) = f * se(10.5; 23.9; 6,600,000) = 0.69 * 0.3553 = 0.2452$$

$$se(10.5) \approx 0.25 \text{ weeks}$$

For an approximate 90-percent confidence interval, compute  $1.645 * 0.2452 = 0.4033 \approx 0.4$  weeks. Subtract the number from and add the number to 10.5 weeks to obtain a 95-percent confidence interval of 10.1 to 10.9 weeks.

## Borrowing $\alpha$ - $\beta$ parameters from another series

The  $\alpha$  and  $\beta$  parameters appearing on the PF tables (PF-1 through PF-16) can be used to generate standard errors for CPS estimates that do not appear on tables A1-A16. However, the terms in the standard error formulas need to be modified slightly.

When calculating standard errors for CPS estimates *NOT* appearing on tables A1-A16 of the Employment Situation, it is common to use  $\alpha$  and  $\beta$  parameters and factors from an available series that is conceptually similar. When borrowing  $\alpha$  and  $\beta$  parameters, the implicit assumption is that the design effects<sup>3</sup> of the lending series and the borrowing series are approximately equal.

There are two primary types of  $\alpha$  and  $\beta$  parameters: those for levels and those for rates.

When borrowing, or generalizing,  $\alpha$  and  $\beta$  parameters from a level series, it is important to use the total civilian noninstitutional population 16 years and over as  $N$ . When borrowing from a rate, ratio, or percentage series, it is important to use the base of that the rate, ratio, or percentage, which is referred to as  $y_{borrowed}$ , in the formula. Using the wrong population estimate or base is a common mistake that can result in inaccurate standard errors.

Note: Parameters for the mean and median duration of unemployment cannot be generalized to other means or medians. Additionally, the standard error formulas for the mean and median duration of unemployment cannot be used to generate approximate standard errors for other means or medians.

The formulas presented below demonstrate how to borrow  $\alpha$  and  $\beta$  parameters from one series and apply them to another.

### Guidelines for selecting an appropriate series to lend $\alpha$ and $\beta$ parameters:

- If possible,  $\alpha$  and  $\beta$  parameters should be borrowed from a series of the same type: level-to-level conversions and rate-to-rate conversions. However, sometimes a level-to-rate conversion may be necessary.
- For unemployment level or unemployment rate estimates,  $\alpha$  and  $\beta$  parameters should only be borrowed from an available series that also measures unemployment. Parameters for estimates of employed people, the civilian labor force, and people not in the labor force can be borrowed from one another, if necessary, as these types of estimates tend to have similar design effects.
- When considering multiple series to borrow from, using the  $\alpha$  and  $\beta$  parameters that generate the highest standard error is generally advised.

If borrowing factors for [changes over time](#), [means](#), or [medians](#), apply these modifications in the same way described below in the [formulas to calculate standard errors](#).



## Formulas to calculate standard errors when borrowing $\alpha$ and $\beta$ parameters and factors

### A. Borrowing parameters from one level for use by another level

If the  $\alpha$  and  $\beta$  parameters and factors are not available for a specific level from tables PF-1 through PF-16, the approximate standard error  $se(x)$  of  $x$  can be obtained by borrowing parameters and factors from a similar level series. The borrowed parameters and factors would be entered into the same formulas displayed above to calculate the [standard errors of estimated levels](#).

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*Illustration A – calculating a standard error for a level when borrowing parameters from one level for use by another level*

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Suppose that in a given month, there are 36 million people ages 25 to 34 in the labor force, and the civilian noninstitutional population is 250 million. This level estimate does not appear on tables A1–A16 of the Employment Situation news release, and thus [tables PF-1 through PF-16](#) do not list corresponding  $\alpha$  and  $\beta$  parameters. A standard error can be estimated by borrowing  $\alpha$  and  $\beta$  parameters from another level series and entering them into the standard error formula for a single-month level.

Step 1. [Choose a level series similar to](#) that for people ages 25 to 34 in the labor force that is included in tables PF-1 through PF-16, such as employed people ages 25 to 34 (in row 15 of table PF-9). Borrow the  $\alpha$  and  $\beta$  parameters from that series:

$$\begin{aligned}\alpha &= -1410.35 \\ \beta &= 0.00000900\end{aligned}$$

Step 2. Use the universe total  $N$ , which is the total civilian noninstitutional population 16 years and over.

$$N = 250,000,000$$

Step 3. Enter these values into the formula to calculate a [standard error for a single-month level](#):

$$SE_{GVF} = \sqrt{(\alpha + \beta N) \left( x - \frac{x^2}{N} \right)}$$

The approximate standard of  $x$  is then calculated as:

$$SE_{GVF} = \sqrt{(-1410.35 + (0.00000900 * 250,000,000)) \left( 36,000,000 - \frac{36,000,000^2}{250,000,000} \right)}$$

$$= 160,856$$

$$SE_{GVF} \approx 161,000$$

## B. Borrowing parameters from one rate for use by another rate

If the  $\alpha$  and  $\beta$  parameters and factors are not available for a specific rate or percent from [tables PF-1 through PF-16](#), the approximate standard error  $se(p)$  of  $p$  can be obtained by borrowing parameters and factors from a similar rate or percent series. The borrowed parameters and factors would then be entered into the same formulas displayed above to calculate the [standard errors of rates, ratios, and percents](#).

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*Illustration B – calculating a standard error for a rate or percent when borrowing parameters from one rate for use by another rate*

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Suppose that in a given month, there are 18 million people ages 25 to 29 in the labor force, there are 36 million people ages 25 to 34 in the labor force, and the unemployment rate for people ages 25 to 29 is 3.7 percent. This rate estimate does not appear on tables A1–A16 of the Employment Situation news release, and thus [tables PF-1 through PF-16](#) do not list corresponding  $\alpha$  and  $\beta$  parameters. A standard error can be estimated by borrowing  $\alpha$  and  $\beta$  parameters from another rate series and entering them into the standard error formula for a single-month rate, ratio, or percent.

Step 1. [Choose a rate series similar to](#) the unemployment rate for people ages 25 to 29 that is included in [tables PF-1 through PF-16](#), such as the unemployment rate for people ages 25 to 34 (in row 62 of table PF-10). Borrow the  $\alpha$  and  $\beta$  parameters from that series:

$$\alpha = -8511.91$$

$$\beta = 0.00035280$$

Step 2. Determine the base or denominator,  $y_{borrowed}$ , of the series the parameters are borrowed from—in this example, the base for the unemployment rate of people ages 25 to 34. The base of this unemployment rate is the number of people ages 25 to 34 in the labor force, in this case 36 million. This term,  $y_{borrowed}$ , is used with the borrowed parameters in the numerator of the standard error calculation.

$$y_{borrowed} = 36,000,000$$

Step 3. Determine the base or denominator,  $y$ , of the series being analyzed—the unemployment rate for people ages 25 to 29. The base of the unemployment rate is the number of people ages 25 to 29 in the labor force, in this case 18 million.

$$y = 18,000,000$$

Step 4. Enter these values into the formula to calculate a [standard errors of rates, ratios, and percents](#) modified as follows:

$$SE_{GVF} = \sqrt{\frac{(\alpha + \beta y_{borrowed})}{y} p(100 - p)}$$

Where  $y_{borrowed}$  = base of the series that the parameters are borrowed from

The approximate standard of  $p$  is then calculated as:

$$SE_{GVF} = \sqrt{\frac{(-8511.91 + (0.00035280 * 36,000,000))}{18,000,000} * 3.7 * (100 - 3.7)}$$

$$= 0.288 \approx 0.3 \text{ percent}$$

### C. Borrowing parameters from a level for use by a rate

If the  $\alpha$  and  $\beta$  parameters and factors are not available for a specific rate or percent from tables [PF-1 through PF-16](#), and there is not a similar rate or percent series available in the tables, the approximate standard error  $se(x)$  of  $x$  can be obtained by borrowing parameters and factors from a related level series. The borrowed parameters and factors would then be entered into the same formulas displayed above to calculate the [standard errors of rates, ratios, and percents](#).

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*Illustration C – calculating a standard error for a rate or percent when borrowing parameters from a level*

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Suppose that in a given month, the labor force participation rate for people ages 25 to 29 is 81.5 percent, the civilian noninstitutional population age 16 and over numbers 250 million, and there are 22 million people ages 25 to 29 in the population. The labor force participation rate for people ages 25 to 29 does not appear on tables A1–A16 of the Employment Situation news release, and thus [tables PF-1 through PF-16](#) do not list corresponding  $\alpha$  and  $\beta$  parameters. Nor is there a similar rate series, such as the employment-population ratio for this age group, in [tables PF-1 through PF-16](#). A standard error can be estimated by borrowing  $\alpha$  and  $\beta$  parameters from

another level and entering them into the standard error formula for a single-month rate, ratio, or percent.

Step 1. [Choose a level series related to](#) labor force participation rate for people ages 25 to 29 that is included in [tables PF-1 through PF-16](#), such as the number of employed people ages 25 to 34 (in row 15 of table PF-9). Borrow the  $\alpha$  and  $\beta$  parameters from that series:

$$\begin{aligned}\alpha &= -1410.35 \\ \beta &= 0.00000900\end{aligned}$$

Step 2: Because the series being borrowed from is a level series and does not have a base or denominator, use the universe total N, which is the total civilian noninstitutional population 16 years and over.

$$N = 250,000,000$$

Step 3. Determine the base or denominator, y, of the series being analyzed—the labor force participation rate for people ages 25 to 29. The base of the labor force participation rate is the population, in this case the 22 million people ages 25 to 29 in the population.

$$y = 22,000,000$$

Step 4. Enter these values into the formula to calculate a [standard errors of rates, ratios, and percents](#) modified as follows:

$$SE_{GVF} = \sqrt{\frac{(\alpha + \beta N)}{y} p(100 - p)}$$

Where N = the civilian noninstitutional population 16 years and over

The approximate standard of p is then calculated as:

$$\begin{aligned}SE_{GVF} &= \sqrt{\frac{(-1410.35 + (0.00000900 * 250,000,000))}{22,000,000} * 81.5 * (100 - 81.5)} \\ &= 0.240 \approx 0.2 \text{ percent}\end{aligned}$$

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<sup>1</sup> A June 2022 update of this document introduces information on calculating standard errors for mean and median duration of unemployment and slightly revises the parameter and factor values based on standard error models that were updated with the release of January 2019 data. A November 2018 update of this document introduced the  $\alpha$  and  $\beta$  parameters and a slightly different methodology for calculating standard errors.

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<sup>2</sup> Beginning with data for January 2011, the Census Bureau incorporated additional safeguards in the CPS public use microdata files to ensure that respondent identifying information is not disclosed. In general, respondents' ages were altered, or "perturbed," in the public use microdata files to further protect the confidentiality of survey respondents and the data they supply. One result of the measures taken to enhance data confidentiality is that labor force and other estimates from the public use microdata files will no longer exactly match most estimates published by BLS, which are based on internal, nonpublic-use files. Although certain topside labor force estimates for all persons will continue to match published data—such as the overall levels of employed, unemployed, and not in the labor force—estimates below the topside level (such as employment status by age, sex, race, and Hispanic or Latino ethnicity) all have the chance of differing slightly from the published data. In addition, estimates calculated using characteristics such as industry, occupation, hours worked, duration of unemployment, along with all other characteristics not expressly listed above, are subject to such differences. All such differences should fall well within the sampling variability associated with CPS estimates.

<sup>3</sup> A design effect is a survey methods concept relating the variance of a statistic from a complex survey design (such as that used by the CPS) relative to a simple random sample design. CPS does not publish design effects, but the  $\alpha$ - $\beta$  parameters account for them.