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SAMPLING AND ESTIMATION METHODOLOGIES

The estimates in this 2012 data release were based on two distinct samples, each further grouped (stratified) and chosen by simple random samples of enterprises within those groups. The first sample consisted of 45,119 enterprises with paid employees having nonzero payroll in the previous year, 2011. These enterprises received the ACE-1 form. The second sample, which received the ACE-2 form, consisted of 29,987 enterprises without paid employees in the previous year, 2011. Survey Forms and Instructions has examples of each type of survey form.

The survey's scope includes all private, nonfarm, domestic enterprises. Major exclusions from the frame are government-owned operations, including the U.S. Postal Service; foreign-owned operations of domestic enterprises; establishments located in U.S. territories; establishments engaged in agricultural production (agricultural services are not excluded); and private households.

The 2012 ACE-1 sampling frame was developed using 2011 administrative data in the Census Bureau's establishment-based database, the Business Register (BR). The 2011 BR contained records for each physical business entity, the establishment, located within the United States, enterprise ownership information, and administrative data such as with 2011 payroll.

In creating the 2012 ACE-1 sampling frame from 2011 administrative data, enterprise level records were created for enterprises that had more than a single establishment, called multi-unit or multi-establishment enterprises, by consolidating their establishment level data. Enterprises comprised of only a single establishment are called single unit or single establishment enterprises. Collectively, the multi-establishment and single establishment enterprises resulted in a 2012 sampling frame of 5.6 million enterprises with paid employees based on 2011 administrative data.

For single establishment enterprises, the business activity classification is the classification already assigned to its establishment in the BR. For multi-establishment enterprises, business activity classification was assigned based on an examination of its constituent establishments. The employment and payroll data for each of these establishments were gathered using that

establishment's assigned 2007 six-digit North American Industry Classification System[1] (NAICS) industry in the BR. The multi-establishment enterprise was then assigned to the economic sector in which it had an active establishment with the most payroll (e.g., manufacturing, construction, etc.). Following that, subsector within that sector, industry group within that subsector, and industry within that industry group were subsequently determined in the same fashion. Each enterprise, multi-establishment and single establishment, once having a 2007 NAICS industry code, was recoded to an Annual Capital Expenditures Survey (ACES) industry code.

The 5.6 million enterprises in the 2012 ACE-1 sampling frame were partitioned into two major portions: the certainties and noncertainties. The certainty portion was a group of 17,171 enterprises that had 500 or more employees based on 2011 administrative data. These enterprises
were considered large enough for automatic, or certain, inclusion in the sample. The remaining enterprises in the 2012 ACE-1 sampling frame, or noncertainty portion, had between 1 and 499 employees based on 2011 administrative data and were stratified into one of the ACES industry codes. Each of these ACES industry codes were further divided into four substrata based on 2011 administrative payroll. The exact payroll values of the substrata were determined by minimizing the overall sample size needed to achieve a desired level of reliability based on sample estimation of the known frame value of administrative payroll. Samples were chosen from each of these ACES industry codes and their four substrata from the noncertainty part of the ACE-1 sampling frame. In the 2012 ACES, this resulted in an additional 27,948 enterprises selected.

The 2012 ACE-2 sampling frame was a composite frame of four categories of small businesses, each treated as an independent stratum. The first two categories came from the same 2011 BR used in creating the ACE-1 frame. The first category consisted of enterprises having neither payroll at any point in 2011 nor employment in the first quarter of 2011. These enterprises may have had paid employees in years before 2011, as well as some IRS activity in the last 5 years. The second category consisted of enterprises that had applied for an employer identification number (EIN) from the IRS within the last 2 years. These enterprises did not report payroll at any point in 2011 or employment in the first quarter of 2011. The last two categories comprising the ACE-2 sampling frame came from a separate 2011 nonemployer database. The majority of these enterprises were sole proprietorships without employees, and had receipts of $1,000 or more in 2011. The remaining enterprises were nonemployer corporations and partnerships. Collectively, these four categories accounted for 30.3 million records. Simple random samples taken from the four categories resulted in an ACE-2 sample of 29,987 selected enterprises.

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The unit response rate (URR) is a quality measure defined as the percentage of all eligible enterprises that responded to the survey. The measure treats all enterprises equally. For the 2012 ACES, the URR was 70.7%.

$$URR = \frac{R}{S} * 100$$

URR: Unit Response Rate

R : total number of enterprises that responded to the survey

S : total number of enterprises sampled

An enterprise's impact on the estimates varies with their sampling weight and their reported data. Each sampled enterprise has a sample weight reflecting other unselected enterprises in the population. Sampled enterprises in the same substratum have identical weights, which range from one, so that enterprise represents only itself, to several thousand. Respondents' weights are further increased to widen their representation to account for enterprises that did not respond to the survey. Final estimates use these increased weights. The proportion of the published estimates coming from respondent data using only their original unadjusted-for-nonresponse sampling weights is the total quantity response rate. In 2012, this value was 89.9%.

$$TQRR = \frac{\sum_{h=1}^{k} \sum_{i \in h} (W_h * X_{i,h})}{\hat{X}_{tot}}$$

TQRR : total quantity response rate

W_h : substratum sampling weight of the h^{th} substratum

$X_{i,h}$: total capital expenditures value attributed to the i^{th} responding enterprise of substratum h.

$\hat{X}_{tot}$: published estimate for total capital expenditures for all enterprises

A third measure used during processing as a measure of capital expenditures as yet unreported by enterprises with paid employees is the coverage rate. This is the percentage of payroll in the sample accounted for by the respondents. The coverage rate for the 2012 ACES was 93.7%.

Sampling Weights and Weight Adjustment for Nonresponse

As discussed above, each sampled enterprise has an initial sampling weight which may then be adjusted based on characteristics such as activity status, response status, and employment status.

Each sampled enterprise becomes a respondent, a nonrespondent, out-of–scope (if it is found to have been out of business prior to the survey year), or a duplicate to another record. Enterprises that went out of business during the survey year are still in-scope, and efforts are made to collect data for the period the enterprise was active.

An enterprise that receives the ACE-1 form is considered a respondent if they return a form in which they report some value of capital expenditures in item 1A, row11 (total Capital Expenditures), or they report data for some rows in item 2 (more detailed Capital Expenditures). An enterprise that receives the ACE-2 form is considered a respondent if they report data for some rows in item 1 (Capital Expenditures).

To account for non-response, the sampling weights of respondents were raised to better represent the entire in-scope population. The adjustment for ACE-1 respondents is based on the outstanding payroll of nonrespondents by ACES industry by substrata. The adjustment for ACE-2 respondents is based solely on the percentage of enterprises not reporting, regardless of size. In addition, enterprises who are deemed 'extreme outliers' may have their weights further adjusted to minimize the mean squared error of the estimates.

ACE-1 segment. The following discussion assumes 660 substrata (substrata designation h = 1, 2, . . ., 660) which are based on the 132 ACES industries, each containing five strata (four noncertainty strata and the certainty stratum). All substratum sampling weights, W_h, are the same within each substratum h, equaling the ratio of the substratum population size, N_h, to its sample size, n_h. The ACE-1 respondent sampling weights are then adjusted for nonresponse based on payroll in the following way:

$$W_{h(adj)} = W_h * \frac{P_{hr} + P_{hn}}{P_{hr}}$$

where,

$W_{h(adj)}$: adjusted substratum weight of the h^{th} substratum

W_h : substratum sampling weight of the h^{th} substratum

P_{hr} : sum of total enterprise payroll for respondents in substratum h

P_{hn} : sum of total enterprise payroll for nonrespondents in substratum h

ACE-2 segment. The ACE-2 segment initially was stratified into four strata based on the four small business categories discussed above. Two of these strata are poststratified after survey data collection based on updated administrative record data showing the presence of payroll. The stratum consisting of ''enterprises without payroll in the prior year or employment on March 12^{th} of the prior year, but had paid employees in the past and some IRS activity in the last 5

years'' was poststratified into two strata. The stratum ''enterprises that applied for an EIN in the last 2 years, but still have no payroll, employment, or receipts'' was poststratified into two strata. This method resulted in six ACE-2 strata (strata designation h = 1, 2,…6). The stratum population sizes, sample sizes, response counts, and stratum weights for the four new strata resulting from the poststratification were modified accordingly, while the other two strata retained their original weights.

The ACE-2 stratum weights (W_h) were also adjusted to compensate for nonresponse based on number of respondents:

$$W_{h(adj)} = W_h\left(\frac{n_h}{r_h}\right) = \frac{N_h}{r_h}$$

where,

$W_{h(adj)}$: adjusted stratum weight of the h^{th} stratum

W_h : stratum weight of the h^{th} stratum

N_h : population size of the h^{th} stratum

n_h : sample size of the h^{th} stratum

r_h : number of respondents in the h^{th} stratum

Publication Estimation

Publication cell estimates were computed by obtaining a weighted sum of reported values for in-scope respondents.

ACE-1 Estimation: The ACE-1 estimates, $\hat{X}_j$, are (where substrata h = 1 to k, and k=660) calculated as:

$$\hat{X}_j = \sum_{h=1}^{k}\sum_{i\in h}(W_{h(adj)} * X_{(j),i,h})$$

where,

$W_{h(adj)}$: adjusted weight of the h^{th} substratum

$X_{(j),i,h}$: value attributed to the i^{th} enterprise of substratum h, where j is the publication cell of interest.

Note: Although an enterprise is assigned to and sampled from a single ACES industry, it can report capital expenditures in several ACES industries. Reported data for all industries are inflated by the weight in the sample industry of the respondent.

ACE-2 Estimation: The ACE-2 estimates, $\hat{X}_j$, are (with k=7) are calculated as:

$$\hat{X}_j = \sum_{h=1}^{k} \sum_{i \in h} (W_{h(adj)} * X_{(j),i,h})$$

where,

$W_{h\,(adj)}$: adjusted weight of the h^{th} stratum

$X_{(j),i,h}$: value attributed to the i^{th} enterprise in stratum h, where j is the publication cell of interest

Note that there are no industry level estimates from the ACE-2 enterprises. Therefore, j becomes a constant and the estimate will always represent a national-level estimate.

RELIABILITY OF THE ESTIMATES

The published estimates are derived from sample data, and will differ from results derived from data from other samples or from a complete census of the population. A sample and a census will both experience errors classified as nonsampling errors, which often introduce systematic bias into the results. Bias is the difference, averaged over all possible samples of the same design and size, between the estimate and the true value being estimated. These types of errors are not explicitly measured. Only samples have sampling errors, the error from only observing a subset of the population. With a probability sample, this type of error can be explicitly measured. For any particular estimate though, the total error from sampling and nonsampling error may considerably exceed the measured error.

Sampling Variability

The sample selected is only one of the many possible samples that could have been selected with that same design and size, with each possible sample producing possibly different results. The relative standard error (RSE) is a measure of the sampling variability among all these possible estimates from all these possible samples, relative to the estimates. These are calculated using a delete-a-group jackknife replicate variance estimator. The RSEs in the tables can be used to derive the standard error (SE), which can then be used to create interval estimates with prescribed levels of confidence, called confidence intervals (CI).

The SE of the estimate is calculated by multiplying the RSE by its corresponding estimate. Note that the RSE is the measure of variability presented for all estimates in this publication except for the estimates of percent change. RSEs are also given as a percentage, and need to be divided by 100 before being used to calculate the SE.

In general, intervals defined by 1.645 standard errors above and below the sample estimate will contain the true population value about 90 percent of the time. Intervals defined by 2 standard errors above and below the sample estimate will contain the true population value about 95 percent of the time. Note that the SE is in the same units as the estimate, while the RSE is a unit-less number.

Examples of Calculating a Confidence Interval (CI)

a. Calculating a confidence interval for a specific estimate within a single survey year: using ACES 2012 estimates from table 4a and RSEs from table 4c, the SE for the mining sector's total capital expenditures would be calculated as follows

$$\hat{\sigma}(\hat{X}_j) = \left(\frac{RSE(\hat{X}_j)}{100}\right) * \hat{X}_j$$

$$= \left(\frac{3.7}{100}\right) * \$193{,}613\ million = \$7{,}164\ million$$

The 90-percent confidence interval can be constructed by multiplying this SE by 1.645 to create the margin of error (MOE), and adding and subtracting the MOE to the estimate. The value of 1.645 corresponds to using the Census Bureau standard of 90% confidence intervals. The 90-percent confidence interval for the estimate of mining's total capital expenditures is:

$$\hat{X}_j \pm (1.645 * \hat{\sigma}(\hat{X}_j))$$

$$= \$193{,}613\ million\ \pm (1.645 * \$7{,}164\ million = \$193{,}613 \pm \$11{,}784\ million$$

$$= (\$193{,}613 - \$11{,}784\ million) to\ (\$193{,}613 + \$11{,}784\ million)$$

Which gives a 90 percent confidence interval of $181,829 million to $205,397 million.

So there is 90% confidence that the interval from $181,829 million to $205,397 million contains the actual true value for capital expenditures in the mining sector by enterprises with paid employees in 2012.

b. Calculating a confidence interval for a percent change of an estimate between two survey years: using estimates from Tables 2a and SEs from table 2b, the 90-percent confidence interval

can be constructed by multiplying 1.645 by the SE of the percent change to create the MOE, and then adding and subtracting the MOE to the estimate. For example, from Table 2a, the mining total capital expenditures estimated percent change from 2011 to 2012 is a positive 16.9 percent and from Table 2b, the standard error of this estimate is 10.1 percent.

$$16.9\% \pm (1.645 * 10.1\%) = 16.9\% \pm 16.6\%$$

$$= (16.9\% - 16.6\%) to\ (16.9\% - 16.6\%)$$

Which gives a CI of 0.3% to 33.5%.

By probability theory, 90-percent of all samples should produce an estimate of the percent change in this sector that contains the true unknown percent change. In this one observed sample, the estimate creates the interval of positive 0.3 percent to positive 33.5 percent. Since this confidence interval does *not* contain zero, there is sufficient evidence at the 90-percent confidence level to conclude that the estimated percent change was statistically different from 0, and that the change is positive. In other words, this sector showed a statistically significant increase in the amount of capital expenditures. The interval is quite large however, and had the estimate been only slightly smaller, or the standard error only slightly larger, the confidence interval would likely have contained zero and no significant difference would have noted at the 90% confidence level. Confidence intervals also do not consider any additional issues due to nonsampling errors, e.g., measurement errors or nonresponse biases.

Examples of Calculating Differences and Percent Changes

Data for the current year along with revised data for the prior year are presented in this publication. Data users can calculate a difference, $\hat{d}_j$, and a percent change, $\widehat{PC}_j$, between the current year and prior year estimates along with corresponding confidence intervals using data on tables where the difference and percent change are not expressly given, using the following formulae.

The difference is calculated as:

$$\hat{d}_j = \left(\hat{X}_t - \hat{X}_{t-1}\right)$$

where,

$\hat{X}_t$: current year estimate of interest.

$\hat{X}_{t-1}$: prior year estimate of interest.

The MOE for a 90-percent confidence interval on this difference is approximately:

$$MOE(\hat{d}_j) = 1.645 * \sqrt{\sigma^2(\hat{X}_t) + \sigma^2(\hat{X}_{t-1})}$$

As an example, for NAICS 2111, oil and gas extraction within mining, from table 4a, the total expenditures estimate for 2012 is $156,270 million with an RSE, found in Table 4c, of 4.1%. The revised 2011 estimate from Table 4b is $129,924 million with an RSE, found in Table 4d, of 9.5%. The difference is estimated as:

$$\$156{,}270\ million - \$129{,}924\ million = \$26{,}346\ million$$

The MOE for the 90-percent confidence interval of the year-to-year change is estimated as follows, including translating the RSEs into variances by dividing the RSE by 100 and multiplying by the estimate, and squaring:

$$= 1.645 * \sqrt{\left[\left(\left(\frac{4.1}{100}\right) * \$156{,}270\ million\right)^2 + \left(\left(\frac{9.5}{100}\right) * \$129{,}924\ million\right)^2\right]}$$

$$= 1.645 * \sqrt{\left[\left((0.041) * \$156{,}429\ million\right)^2 + \left((0.095) * \$129{,}924\ million\right)^2\right]}$$

$$= 1.645 * \sqrt{\$41{,}050{,}546 + \$152{,}344{,}218\ million}$$

$$= 1.645 * \sqrt{\$193{,}394{,}764\ million}$$

$$= 1.645 * \$13{,}907\ million$$

$$= \$22{,}876\ million$$

The 90-percent confidence interval for the difference between the two years is:

$$\$26{,}346\ million \pm \$22{,}876\ million$$

$$(\$26{,}346 - \$22{,}876\ million)\ to\ (\$26{,}346 + \$22{,}876\ million)$$

Which gives a CI of $3,470 million to $49,222 million.

So we are 90-percent confident that the difference between the 2011 estimate and the 2012 estimate is an increase between $3,470 million and $49,222 million.

The percent change is calculated as 100 multiplied by the ratio of the difference divided by the prior estimate.

Continuing with the example from above,

$$\widehat{PC_j} = 100 * \left(\frac{\hat{d}_j}{\hat{X}_{t-1}}\right)$$

$$= 100 * \frac{\$26{,}346\ million}{\$129{,}924\ million}$$

$$= 20.3\%$$

The MOE for a 90-percent confidence interval on this percent change is estimated as:

$$MOE\left(\widehat{PC_j}\right) = 1.645 * \left(\frac{\hat{X}_t}{\hat{X}_{t-1}}\right) * \sqrt{\left(\frac{RSE_{\hat{X}_t}}{100}\right)^2 + \left(\frac{RSE_{\hat{X}_{t-1}}}{100}\right)^2}$$

$$= 1.645 * \frac{\$156{,}270\ million}{\$129{,}924\ million} * \sqrt{\left[\left(\frac{4.1}{100}\right)^2 + \left(\frac{9.5}{100}\right)^2\right]}$$

$$= 1.645 * (1.2028) * \sqrt{0.041^2 + 0.095^2}$$

$$= 1.645 * (1.2028) * \sqrt{0.0107}$$

$$= 1.645 * (1.2028) * (0.1035)$$

$$= 1.645 * 0.1245$$

$$= 0.2048$$

$$= 20.5\%$$

The 90-percent confidence interval for the percent change between the two years is:

$20.3\% \pm 20.5\%$

$(20.3\% - 20.5\%)\ to\ (20.3\% + 20.5\%)$

Which gives a CI of -0.2% to 40.8%.

The 90-percent confidence interval of the true value of the percent change is between -0.2% percent and 40.8% percent. Since this interval does contain zero (0), we *cannot* conclude that the percentage change from 2011 to 2012 is a statistically significant increase at the 90-percent confidence level.

Nonsampling Error

All surveys and censuses are subject to nonsampling errors. Nonsampling errors can be attributed to many sources, including: inability to obtain information about all enterprises in the sample; inability or unwillingness on the part of respondents to provide correct information; difficulties in defining concepts; differences in the interpretation of questions; mistakes in recording or coding the data; and other errors of collection, response, coverage, and estimation for nonresponse.

Explicit measures of the effects of these nonsampling errors are not available. However, to minimize total nonsampling error, all reports were reviewed for reasonableness and consistency, and every effort was made to obtain accurate responses from all survey participants. Coverage errors, meaning errors from not including enterprises that are in-scope of the survey or mistakenly including those that are out-of-scope as eligible, may have a significant effect on the accuracy of estimates for this survey. The Business Register, a subset of which forms the sampling frame, may not contain all in-scope businesses, or have incorrect values of payroll that then affect how they are sampled and the impact of their responses through their sampling weights.

A more detailed profile on the quality of the Annual Capital Expenditures Survey is available on request. Please contact the Business Investment Branch of the Company Statistics Division at 301-763-3324.

[1]*North American Industry Classification System (NAICS) – United States, 2007*. For sale by National Technical Information Service (NTIS), Springfield, VA 22161. Call NTIS at 1-800-553-6847 or go to <www.census.gov/epcd/www/naics.html>.