National Sample Reallocation for the Occupational Employment Statistics Survey

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Abstract
The Occupational Employment Statistics (OES) survey provides detailed occupational employment and wage estimates for all metropolitan and balance of state (MSA/BOS) areas in the U.S. To provide consistency in annual state budgets and workloads, the OES state sample sizes have been fixed since 1995. As a result the reliability among areas across states has been inconsistent, especially since some states' economies have grown over time and become more industrially diverse. This paper describes a methodology to remove the fixed state allocation and change to a national allocation among MSA/BOS areas. This will result in a more robust design that will treat all MSA/BOS areas consistently, taking into consideration the industrial diversity and employment in each area compared to the other areas in the U.S and will provide more consistent reliability among area estimates throughout the U.S.

Key Words: Establishment survey, sample, Occupational Employment Statistics, power allocation

1. Introduction

The Occupational Employment Statistics (OES) survey is a Federal/State Cooperative program, conducted by the U.S. Bureau of Labor Statistics[1] (BLS) in partnership with the 50 States, the District of Columbia, and three territories (Guam, Puerto Rico, and the Virgin Islands). For simplicity, we will refer to these 54 geographies as simply "states" in the remainder of the paper. The OES survey produces cross-industry employment and wage estimates for over 800 detailed occupations by area, specifically metropolitan statistical areas (MSA) along with the residual areas within the states called balance of state (BOS) areas. OES also produces national employment and wage estimates for detailed occupations by industry. OES uses a stratified sample design, stratifying its frame by state, MSA/BOS area, and industry. Industries are classified by the North American Industry Classification System (NAICS). There are approximately 174,000 non-empty strata. The OES samples business establishments within these strata.

The sample is currently allocated among strata using a power Neyman allocation for each state. Bankier (1988)[2] explains how power allocations are valuable when estimating sub-national areas that vary in size or importance. The power Neyman allocation depends directly on the occupational variability in each industry and the total employment[3] for each stratum. That is, strata with higher occupational variability and larger employment will be allocated more sample than strata with lower occupational variability and smaller employment.

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[1] Views expressed in this paper are those of the authors and do not necessarily reflect the views or policies of the Bureau of Labor Statistics.

[2] From the paper *Power Allocations: Determining Sample Sizes for Subnational Areas*.

[3] OES uses the maximum employment which is determined for each establishment and is the maximum value of the 12 monthly employment counts for the establishment. Maximum employment eliminates having to make seasonality adjustments and minimizes sample weights.

Beginning in 1995, OES assigned fixed state sample sizes to the states based on the employment population and historical occupational variability. BLS has not changed the state sample sizes since 1995 in order to maintain consistency in annual state budgets and workloads. As a consequence the reliability among areas across states has been inconsistent, since some states' economies have grown over time causing them to become more industrially diverse, while others have remained the same or even contracted.

2. Frame Construction

The majority of the OES frame is constructed from the BLS Longitudinal Database (LDB). This comes from each State's Unemployment Insurance (UI) program, where business establishments report data such as business name and address, employment from each of the last12 months, ownership, county, township, and NAICS codes. The LDB has approximately 6.9 million in scope business establishments and is a near census of all US establishments. BLS's *Handbook of Methods* further explains the Longitudinal Database.

Business establishments in the crop/animal production, fishing/hunting/trapping, and private household industries are out-of-scope and removed from our frame. Establishments in foreign physical locations or small (employment less than 50) establishments with unidentified county codes are also out-of-scope and deleted off our frame. We receive a census of Federal government employment and wages, including the U.S. Postal Service yearly; thus these units are also excluded from our frame.

Establishments in Guam and the railroad industry do not participate in the UI program. The territory of Guam and the Occupational Safety and Health program (OSH) supplies OES with supplemental Guam and railroad frames, respectively. The LDB files along with the two supplemental frames are concatenated to create the official OES frame, containing about 6.9 million business establishments.

3. Current Allocation Methodology

3.1 Strata Definition

Once the OES frame is created, it is stratified by State and MSA/BOS area. If an MSA crosses a state boundary, the pieces that are in each state are treated as if they are separate areas. For example, the St. Louis metropolitan statistical area is found in both Illinois and Missouri. The part of this MSA that is in Illinois will be treated as a one area, and the part in Missouri will be treated as another distinct area. Within each state, areas that are not included in an MSA are put into one of the state's BOS areas. States typically have four BOS areas, and control which counties (or townships for New England states) in their state fall into which BOS. There are about 690 of these State / MSA-BOS areas.

The frame is then further stratified by industry. OES uses the NAICS code at the 4-digit level of detail for the majority of the industries. We break some industries out to the 5-digit level, where more detail is necessary for measuring specific occupations. There are about 340 of these 4/5-digit NAICS industry groups.

Strata within the education industry are further stratified by ownership. An establishment could either be privately owned or publicly owned by a state or local government. A typical frame will have about 174,000 non-empty strata. We allocate approximately 1.2 million sample units to these non-empty strata.

3.2 Fixed State Sample Sizes

In 1995, OES set fixed sample sizes for the states. These sample sizes were determined by first allocating a minimum of two units per State / MSA-BOS / Industry / Size Class[4] stratum. Then sample was allocated by equalizing a target relative error (TRE) for employment estimates across all MSA-BOS / Industry strata, using stratum employment and typical historical variability of typical occupations associated with each industry. The maximum of these two allocated were used as the sample size, for each state. BOS areas were over-sampled by 20 percent.

3.3 Certainty Units

Business establishments on the OES frame are classified as either certainty units or non-certainty units. Certainty units are units that OES designate to be selected into the sample with a probability of one. These units are establishments either found in distinct industries or are considered to be “large” establishments. Currently OES uses three different certainty cutoffs for different groups of states. Certainty units make up about 7 percent of the total sample.

It is important to mention, that some non-certainty units can also be selected into the sample with a probability of one. This occurs most often if they are found in small strata, or are relatively large units compared to other units within a stratum. Please note that these units are still considered non-certainty units.

The OES allocation algorithm excludes certainty units since they are selected into the sample with a probability of one. Certainty establishments are subtracted from each State’s fixed sample size, leaving what we call the state’s target sample size. The target sample size is the amount of sample left to allocate, after the certainty units are selected. OES excludes all certainty units from the frame during the allocation algorithm.

3.4 Minimum Allocation

Once the certainty establishments are removed, we allocate a minimum number of sample units to all non-empty strata. Currently OES has two sets of minimum allocation criteria:

3.4.1 The Normal Minimum Allocation Criteria

If a stratum contains 1, 2, or 3 non-certainty units, then allocate all units to the sample
If a stratum contains 4-12 non-certainty units, then allocate at least 3 units to the sample
If a stratum contains 13 or more non-certainty units, then allocate at least 6 units to the sample

3.4.2 The Relaxed Minimum Allocation Criteria

If a stratum contains 1, 2, or 3 non-certainty units, then allocate all units to the sample
If a stratum contains 4-18 non-certainty units, then allocate at least 3 units to the sample
If a stratum contains 18 or more non-certainty units, then allocate at least 6 units to the sample

[4] OES assigns establishments to size classes based on the following criteria: Size Class 1 = 1 to 4 employees; Size Class 2 = 5 to 9 employees; Size Class 3 = 10 to 19 employees; Size Class 4 = 20 to 49 employees; Size Class 5 = 50 to 99 employees; Size Class 6 = 100 to 249 employees; Size Class 7 = 250+ employees

All states except Idaho, Montana, Wyoming and Guam have the normal minimum allocation. The minimum allocation requirement makes up about 50 percent of the total sample.

3.5 Power Neyman Allocation

We also allocate sample using the power Neyman allocation which uses both stratum employment and occupational variability. Current procedure involves 54 independent allocations, one for each state and territory, using respective target sample sizes. We allocate each state's sample using the formula:

3.5.1 The Power Neyman Allocation Formula

$$n_h = n \bullet \frac{\sqrt{X_h} \cdot S_h}{\sum_{h=1}^{H}\left(\sqrt{X_h} \cdot S_h\right)} \qquad (3.1)$$

Where,

- h = the stratum defined as {State / MSA-BOS area / 4/5-digit NAICS industry group}. There are H total strata in the state
- n_h = sample allocated by the power Neyman allocation to stratum h
- n = target state sample size (fixed sample size minus the number of certainties)
- X_h = stratum h non-certainty employment (from the non-certainty frame)
- S_h = average occupational employment variability within stratum h

3.5.2 Determining Occupational Variability (S_h)

OES calculates the occupational variability for each 4/5-digit level industry and applies these to all areas in the nation. Using the most recent estimation file, we first find the employment ratio estimate of each occupation within an industry.

$$R_{w(j,z)} = \frac{\sum_i \left(w_{i,z} \cdot y_{i,j,z}\right)}{\sum_i \left(w_{i,z} \cdot x_{i,z}\right)} \qquad (3.2)$$

Where,

- $R_{w(j,z)}$ = the weighted ratio estimate of occupation *j*'s employment within industry *z*, to industry z's total employment
- $w_{i,z}$ = weight assigned to establishment *i*, where establishment *i* is within industry *z*
- $y_{i,j,z}$ = occupation *j*'s employment, from establishment *i*, where establishment *i* is within industry *z*
- $x_{i,z}$ = establishment *i*'s total employment, where establishment *i* is within industry *z*

Next we find the Coefficient of Variation (CV) for each one of these ratio estimates. This can be approximated by:

$$CV_{R(j,z)} \approx \frac{\frac{1}{\bar{x}_{wz}} \cdot \sqrt{\frac{\sum_i \left[w_{i,z} \cdot y_{i,j,z} - R_{w(j,z)} \cdot w_{i,z} \cdot x_{i,z}\right]^2}{\sum_i w_{i,z} - 1}}}{R_{w(j,z)}} \qquad (3.3)$$

Where,

$CV_{R(j,z)}$ = the CV value for the weighted ratio estimate of occupation *j*'s employment within industry *z*, to industry z's total employment

$\bar{x}_{wz}$ = the weighted mean employment in industry *z*

Lastly, to get a single measure for occupational variability we calculate a weighted CV mean using the 90th percentile of the CVs of the occupational employment estimates within each industry. This weighted mean is used as the S_h value for each 4/5 NAICS industry group. This is the average occupational variability we use in the power Neyman allocation. We only use the 90th percentile of the occupations to exclude any outliers within each industry. To learn more about this please reference *Alternative Allocation Designs for a Highly Stratified Establishment Survey* by Lawley, et.al.

To get the allocated value for each stratum we take the maximum value between the minimum and power Neyman allocation. Each state's allocated sample will exceed their target sample sizes substantially, because of strata that are using the minimum allocation. We use an iterative process, where *n* in formula 3.1 is adjusted until each state's allocated sample to be within 0.5 percent of their target sample sizes.

3.6 Issues and Temporary Solutions

The amount of the OES sample that is used to meet the minimum allocation and to cover the certainty units is about 57 percent of the sample size, nationwide. That leaves about 43 percent of the sample to be allocated using the power Neyman allocation. Since each state's sample is bounded by their fixed state sample size, these percentages are different among the states. The amount of sample needed to cover the minimum allocation and certainty units varies from 34.5 percent in Rhode Island to 93.7 percent in Montana. This means that Rhode Island can allocate 65.5 percent of its sample using the power Neyman allocation, where Montana can only allocate 6.3 percent using power Neyman. Table 4, at the end of this document, shows the break-out for all the states in November of 2007. These large differences create inconsistency in the reliability among areas across states. States that have a high percentage of their sample going to cover the certainty plus minimums are loosing the benefits the power Neyman allocation offers for their estimates. Rather than their sample being allocated to strata that has the most uncertainty, it is being allocated to meet the state's minimum allocation criteria.

To counter this problem, OES relaxed four states' minimum criteria to free up some sample for the power Neyman allocation. However this could only temporarily alleviate this problem, since state's economies continue to change over time. Some states' sample sizes are just too small to properly represent their workforce population. Other some states are receiving more sample than they need to properly produce estimates of similar reliability.

In November of 2008, OES shifted sample from four states that had a low percentage of their sample being used for minimums and certainties, to four states that were in need of more sample. We did this in such a way that every state would allocate at least 15% of their sample using the power Neyman allocation. This too would only be a temporary solution, since states economies will continue to change.

4. National Reallocation Solution

A permanent solution would be to allocate using a single power Neyman allocation for the whole nation rather than 54 independent allocations. This would allow all areas of the nation to be compared against each other equally and for sample to be allocated where it is most needed to create estimates of comparable reliability across areas. We looked into two options that would replace our current allocation method.

4.1 "MSA" Allocation

The "MSA" allocation option would allocate sample to each MSA-BOS area / industry stratum using a national fixed sample size, instead of fixed state sample sizes. This allocation will benefit our area (MSA-BOS) estimates the most by treating every area nation-wide the same. As you will see in section 4.2 the "State/MSA" allocation will benefit our state estimates the most, by allocating more sample to areas that are in more than one state (cross-state areas).

One national power Neyman allocation will replace our 54 state allocates we currently have. Since we are now only concerned with one allocation, we tightened up the tolerance that the allocated sample must be within the target sample size, to be 0.1 percent instead of 0.5.

All states will have the same certainty cutoffs and use the "normal" minimum allocation criteria. Sample will go to the areas where sample is most needed, and will be "self-adjusting" each time we allocate our sample. This means over time States that need more sample will be allocated more sample, and vice versa.

We will ignore state boundaries when defining our strata, meaning that each MSA would now be considered a complete geographical area, instead of each State / MSA area. For MSAs that are in more than one state, we will do a second-stage allocation that allocates sample proportional to employment for each State/MSA piece. This second-stage allocation will help assure enough sample for state-wide estimates.

During this second-stage allocation it is possible for more sample units to be allocated to strata than there are establishments. To compensate for this, we devised a special algorithm.

4.1.1 Special Algorithm Illustration

Let us consider a situation where an MSA, named MSA 1, is found in three different states, named State A, State B and State C:

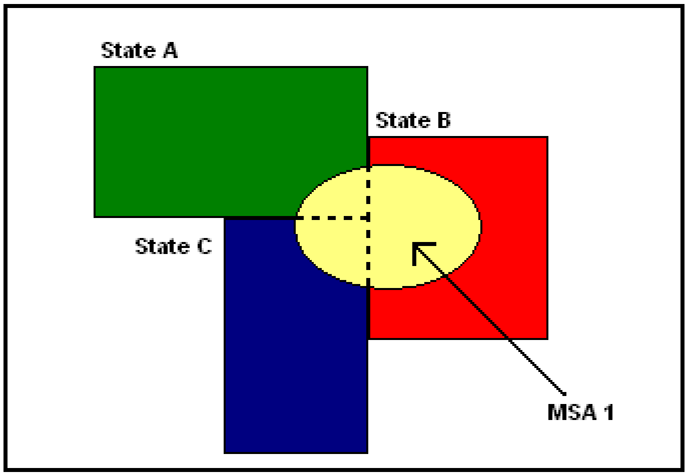

Figure 1: Visual representation of an interstate MSA

For this example, there exists an Industry I within MSA 1 that appears in all three states. The stratum {MSA 1 / Industry I} has the following "MSA" allocation information:

Table 1: Stratum {MSA 1 / Industry I} "MSA" allocation information

MSA	Industry	Non-Certainty Units	Non-Certainty Employment	Minimum Allocation	Power Neyman Allocation
MSA 1	Industry I	5	256	3	4

Since the power Neyman allocation is larger than the minimum allocation, we use the power Neyman allocation. So stratum {MSA 1 / Industry I} is allocated 4 sample units. Since this stratum is stretched across three states we need to allocate these 4 units to each state's stratum piece, proportional to employment:

Table 2: Proportional second-state allocation results

State	MSA	Industry	Non-Certainty Units	Non-Certainty Empl	Proportional Allocation	After Random Rounding
State A	MSA 1	Industry I	1	249	3.89	4
State B	MSA 1	Industry I	3	5	0.08	0
State C	MSA 1	Industry I	1	2	0.03	0

As you can see, all 4 sample units are being allocated to the stratum {State A / MSA 1 / Industry I}, but there is only one non-certainty unit in this stratum. So we must now allocated 3 units out of stratum {State A / MSA 1 / Industry I}, into the other two. We allocate each unit to the stratum that has the highest difference between the number of non-certainty units in the stratum, to the number of units already allocated, recalculating this difference after allocating each unit. So from our example, we will allocate the first unit to stratum {State B / MSA 1 / Industry I} because it can be allocated 3 units, whereas stratum {State C / MSA 1 / Industry I} can only be allocated 1. The next unit will also go to stratum {State B / MSA 1 / Industry I}, because it still has more units left to allocate. The last unit has an equal chance of being allocated to stratum {State B / MSA 1 / Industry I} or {State C / MSA 1 / Industry I}, since they both can only allocated 1 unit. We will assume it is allocated to stratum {State C / MSA 1 / Industry I}. **Note:** This algorithm was created to put sample units in {State/MSA} pieces with the most establishments. Further research could look into using a standard method like the one outlined in Cochran (1977)[5] or the method outlined in Ernst's paper (2002)[6].

Table 3: Final Allocation

State	MSA	Industry	Non-Certainty Units	Non-Certainty Employment	Final Allocation
State A	MSA 1	Industry I	1	249	1
State B	MSA 1	Industry I	3	5	2
State C	MSA 1	Industry I	1	2	1

Besides the changes mentioned above, the allocation methodology will stay the same. That means, we will still remove the certainty units before allocation, allocated a minimum number of sample units, and then use the power Neyman allocation, now nationally, to allocate the remaining sample units.

4.2 "State/MSA" Allocation

The "State/MSA" allocation and "MSA" allocation are similar, except for the way we define the strata in each. The "State/MSA" allocation uses the same stratum definitions as the current method; State / MSA-BOS area / industry. That means we consider each State / MSA area as a complete geographical area when stratifying our frame. This benefits OES's state estimates, since we are further stratifying our cross-state areas.

We also replace the fixed state sample sizes with one national fixed sample size, and perform only one power Neyman allocation instead of 54. There is no need to have a second-stage allocation, since sample has already been allocated to the State / MSA pieces.

4.3 Simulation Results

To test these two proposed methods, we simulated both allocations over 5 and a half years using historic frames, and sampling inputs. These simulations allowed us to compare among the current methodology and each of the proposed methods.

We were particularly interested in the variation of the sample totals allocated to each state over time. These values directly contribute to state funding and workloads, so stability is desirable from year-to-year. Since both proposed allocations were bounded by a national fixed sample size instead of 54 state/territory fixed sample sizes, sample could flow in and out of states over time. The simulations showed us the state totals, in both allocations, stayed stable over time except when the MSA definitions changed in 2005. This was not surprising, since the changes to the MSA definition directly affect our strata definitions, causing sample to shift areas nation-wide.

The simulations also showed that, compared to our current methodology, both methods shifted sample from larger areas (over 500,000 employees) to medium and smaller areas (between 25,000 and 500,000 employees). The smallest areas (between 25,000 and 50,000 employees) saw the biggest increase from the "State/MSA" allocation.

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[5] *Sampling Techniques* (Section 5.8)

[6] The paper's title is *Allocating Sample to Strata Proportional to Aggregated Measure of Size with Both Upper and Lower Bounds on the Number of Units in Each Stratum* from the 2002 Joint Statistical Meetings.

The “State/MSA” method, allocated about 31,000 more sample units to the cross-state MSAs compared to the “MSA” method. This is because we are further stratifying by state boundaries in the “State/MSA” method. This makes up about 2.5% of the total 1.2 million sample units. The “MSA” allocation treats all MSA and BOS areas the same, where the “State/MSA” allocation over-sample the cross-state MSAs.

The simulations also showed that, using the “MSA” allocation, some state boundaries would need to be kept in states that had a large proportion of their employment in cross-state MSAs. The reason is that the second-stage allocation had the potential to shift sample out of these states, causing problems with the state-wide estimates. One example of this would be the District of Columbia, since 100% of its employment is in a cross-state MSA that is also in Maryland, Virginia and West Virginia. There are no clear criteria for states that would need to still stratify by their boundaries.

5. Final Changes to the OES Allocation

Initially, when we began our research the “MSA” allocation appeared to be the better option. The main goal of the OES survey is to produce area estimates, so it seemed beneficial to use the “MSA” allocation since all MSA and BOS areas are treated the same, meaning they are allocated sample using the same criteria and procedures. As mentioned above, the “State/MSA” allocation further stratifies cross-state MSAs, causing more sample units to be allocated to these areas.

After the simulations, the original arguments for choosing the “MSA” were still there, but the results showed the “State/MSA” allocation would be the better option to implement. We didn’t think that the efficiency of shifting 2.5% of our sample out of the cross-state MSAs to the other areas would outweigh the operational risks associated with the “MSA” allocation. The second-stage allocation in the “MSA” option would complicate our methodology making it harder to implement and maintain. Also, we would need to make case-by-case judgments when dealing with the special states that would keep their boundaries, making this option no longer entirely robust or transparent. Another argument for keeping the state boundaries in our stratification is that state’s wages and staffing patterns may be heterogeneous across state lines. Examples of this would be states having different minimum wage, or a states having different laws causing higher employment in particular occupations.

After analyzing the results from our simulation we decided to implement the “State/MSA” allocation. This option had less risks and complications associated to it. The first sample that will be allocated using this new method will be in November of 2009.

6. Conclusions and Further Research

The OES survey, like many complex surveys, changes a lot over time to address specific issues to improve the overall quality of the estimates. The issues associated with using out-dated fixed sample sizes, became more evident as time went by. Looking into two national allocation solutions, we relied heavily on empirical research that led us to the “State/MSA” allocation. This option was favored over the “MSA” allocation because of operational risks and complexities that the “MSA” option would introduce to our allocation methodology and because of the desire for BLS to maintain transparency and consistency in how it treats the state allocation.

Future research might include looking into the power we use in the power Neyman allocation. We currently use 1/2, but there may be benefits to using some other value between 0 and 1. Also if we ever revisit an “MSA” allocation, it would be beneficial to research different ways to allocate sample to the {State/MSA} pieces within the cross-state MSAs.

Table 4: Certainty plus Minimum coverage percentages, by State (**November 2007**)

State	State Fixed Sample Size	Certainty Units	Minimum Sample Size	Certainty plus Minimum	% Certainty plus minimum
Alabama	24,090	1,083	14,258	15,341	63.7%
Alaska	4,620	547	3,190	3,737	80.9%
Arizona	16,620	1,660	7,628	9,288	55.9%
Arkansas	15,180	2,025	10,110	12,135	79.9%
California	106,350	8,804	37,673	46,477	43.7%
Colorado	22,740	3,711	11,626	15,337	67.4%
Connecticut	20,670	844	9,311	10,155	49.1%
DC	3,240	306	1,181	1,487	45.9%
Delaware	5,490	734	2,712	3,446	62.8%
Florida	64,020	4,021	29,558	33,579	52.5%
Georgia	28,770	2,273	16,503	18,776	65.3%
Guam	1,800	182	553	735	40.8%
Hawaii	6,210	676	2,506	3,182	51.2%
Idaho	8,160	331	7,208	7,539	92.4%
Illinois	36,840	3,365	16,811	20,176	54.8%
Indiana	31,830	1,763	17,486	19,249	60.5%
Iowa	18,690	854	12,621	13,475	72.1%
Kansas	14,970	850	6,096	6,946	46.4%
Kentucky	19,410	1,070	11,781	12,851	66.2%
Louisiana	22,830	1,145	12,184	13,329	58.4%
Maine	9,240	301	5,337	5,638	61.0%
Maryland	19,830	1,169	8,922	10,091	50.9%
Massachusetts	30,360	1,780	16,690	18,470	60.8%
Michigan	35,550	2,575	19,721	22,296	62.7%
Minnesota	23,190	1,599	9,944	11,543	49.8%
Mississippi	12,480	684	8,569	9,253	74.1%
Missouri	27,000	1,394	12,525	13,919	51.6%
Montana	6,810	615	5,764	6,379	**93.7%**
Nebraska	10,650	541	6,493	7,034	66.0%
Nevada	10,080	693	4,828	5,521	54.8%
New Hampshire	10,950	335	8,154	8,489	77.5%
New Jersey	35,490	2,289	11,267	13,556	38.2%
New Mexico	9,840	432	6,392	6,824	69.3%
New York	56,880	4,424	19,850	24,274	42.7%
North Carolina	36,780	2,055	20,223	22,278	60.6%
North Dakota	6,330	580	4,907	5,487	86.7%
Ohio	50,820	2,851	21,007	23,858	46.9%
Oklahoma	15,690	965	8,268	9,233	58.8%

State	State Fixed Sample Size	Certainty Units	Minimum Sample Size	Certainty plus Minimum	% Certainty plus minimum
Oregon	19,290	2,666	10,440	13,106	67.9%
Pennsylvania	51,030	2,913	22,398	25,311	49.6%
Puerto Rico	9,810	706	4,677	5,383	54.9%
Rhode Island	6,390	223	1,984	2,207	**34.5%**
South Carolina	19,920	1,067	13,220	14,287	71.7%
South Dakota	6,240	638	4,538	5,176	82.9%
Tennessee	25,200	1,700	14,172	15,872	63.0%
Texas	76,560	5,905	34,291	40,196	52.5%
Utah	11,430	1,943	7,716	9,659	84.5%
Vermont	5,340	487	3,302	3,789	71.0%
Virgin Islands	1,440	135	609	744	51.7%
Virginia	30,330	1,872	14,719	16,591	54.7%
Washington	25,800	1,380	15,904	17,284	67.0%
West Virginia	11,280	1,126	7,529	8,655	76.7%
Wisconsin	29,760	1,580	18,272	19,852	66.7%
Wyoming	5,040	409	4,238	4,647	92.2%
Totals:	1,215,360	86,276	607,866	694,142	57.1%

Acknowledgements
George D. Stamas, Bureau of Labor Statistics
Shail J. Butani, Bureau of Labor Statistics
Ernest Lawley, Bureau of the Census
Teresa Hesley, Bureau of Labor Statistics
Martha A. Duff, Bureau of Labor Statistics
Laura Train, Bureau of Labor Statistics

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