Update on Use of Administrative Data to Explore Effect of Establishment Non-response Adjustment on the National Compensation Survey Estimates

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Abstract
Nearly all establishment surveys are prone to some level of non-response. Non-response may lead to biases in survey estimates and an increase in survey sampling variance. Survey practitioners use various techniques to reduce bias due to non-response. The most common technique is to adjust the sampling weights of responding units to account for non-responding units within a specified set of weighting classes or cells. In the National Compensation Survey (NCS), which is an establishment survey conducted by the Bureau of Labor Statistics, the weighting cells are formed using available auxiliary information: ownership, industry, and establishment employment size. At JSM 2006, we presented a paper in which we explored how effective the formed cells are in reducing potential bias in the NCS estimates and presented results for one NCS area. Since 2006, NCS has expanded the study of potential bias due to non-response to several additional survey areas and time periods. In this paper, we present results from this additional research. We include localities of different size and with different levels of non-response. Also we compare the direction and magnitude of bias across time and across areas.

Key Words: Unit non-response, bias, weighting cells

1. Introduction

The non-response rates are increasing in many establishment surveys. As a result of increasing non-response rates there is a greater emphasis put on non-response bias studies. In fact, the non-response bias studies are called for by recent OMB standards and guidelines for all U.S. federal government funded statistical surveys when the expected unit response rate is below 80 percent. In the National Compensation Survey (NCS) Program, unit response rate has dipped below 80 percent for the private industry samples. Unit non-response occurs because of refusal or inability of a sample establishment to participate in the survey. In addition non-response may occur because of inability of an interviewer to make contact with a sample establishment within a specified survey data collection cycle. Since non-responding sample establishments' data on employee earnings may be systematically different, that is, larger or smaller on average from responding establishments, there may be bias in the survey estimates due to non-response. Non-response also causes an increase in the variance of survey estimates because the effective sample size is reduced. However, bias is usually considered to be a bigger concern because, in the presence of a significant bias, a calculated confidence interval will be centered on the wrong value and thus will be misleading.

The goal of non-response bias studies is to provide data users with assessment of bias that may exist in key survey estimates. Over the years, a number of methods have been presented in statistical literature for assessing non-response bias (Brick et al. 2003; Curtin, Presser, and Singer 2000, 2005; Lin and Schaeffer 1995; Potthoff, Manton, and Woodbury 1993; Groves and Couper 1998; Groves 2006). Groves describes several methods and their properties, including their strengths and their weaknesses. Perhaps the most common approach for non-response bias analysis is comparing survey estimates based on useable sample responses to estimates based on administrative data for all sample units. This is the approach used in our assessment of non-response bias in the NCS estimates.

In the 2006 paper (Ponikowski and McNulty 2006), we explored the effect of establishment non-response adjustment procedures on the NCS estimates. Using data from one NCS area survey, we calculated and compared response rates for the auxiliary variables that are used in forming weighting adjustment cells. We found that response rates vary by industry group and establishment employment size class, the auxiliary variables. We used administrative data to determine whether non-response might be biasing survey estimates. We noted that the NCS weighting adjustment helps reduce the bias due to non-response. Also as a part of our study we selected 100 samples from the original frame

and then calculated the ratio of the bias to the standard deviation to assess the effect of bias on the accuracy of average monthly earnings estimates. We found that the effect of non-response bias on the accuracy of estimates is usually negligible. However the study was limited to one NCS sample area and time period.

In this paper we explore further the effect of non-response adjustment on estimates in the NCS. We examine data from other survey areas and time periods. We include three more areas of different size and with different levels of non-response. We compare the direction and magnitude of bias across time and across the four areas. We provide a brief description of the NCS in Section 2; present empirical analysis and results in Section 3; and state our conclusion and propose issues for further research in Section 4.

2. Description of the National Compensation Survey

The NCS is an establishment survey of wages and salaries and employer-provided benefits conducted by the Bureau of Labor Statistics (BLS). It is used to produce three general types of survey outputs: employment cost data, employee benefits data, and wage data. The employment cost data includes the Employment Cost Index (ECI), a series of indexes that track quarterly and annual changes in wages and benefit costs, and quarterly cost level information on the cost per hour worked of each component of pay and benefits. The employee benefits data includes the incidence and provisions of selected employee benefits plans and are published once a year. The wage data include annual publication of occupational wages for a sample of localities, census divisions, and for the nation as a whole. All state and local governments and private sector industries, except for farms and private households, are covered in the survey. All employees are covered except the self-employed.

The BLS Quarterly Census of Employment and Wages (QCEW) serves as the sampling frame for the NCS survey and was used as the administrative data for this study. The QCEW is created from State Unemployment Insurance (UI) files of establishments, which are obtained through the cooperation of the individual state agencies.

The NCS private industry sample consists of five rotating replacement sample panels. Each of the five private industry sample panels will be in sample for five years before being replaced by a new panel selected annually from the most current frame. The NCS sample is selected using a three-stage stratified design with probability proportionate to employment sampling at each stage. The first stage of sample selection is a probability sample of areas; the second stage is a probability sample of establishments within sampled areas; and the third stage is a probability sample of occupations within sampled areas and establishments.

The samples used in this analysis were selected from an NCS sample of 152 areas based on the Office of Management and Budget (OMB) 1994 area definitions. In 2003 OMB released a new set of area definitions. The new area definitions define a set of Core Based Statistical Areas (CBSA) and designate the remaining geographical areas as outside CBSA counties. The outside CBSA areas for NCS sampling purposes are usually clusters of adjacent counties, not single counties. The NCS has selected a new sample of areas using the 2003 OMB definitions and is in the process of replacing the current set of primary sampling units (PSUs) over the next few years. A more detailed description of the NCS sample design is provided in Chapter 8 of Handbook of Methods available from the BLS website: www.bls.gov.

The NCS wage program collects wage data for a sample of jobs which are then classified into occupations within sampled establishments. During the initial interview or update interview, some sample establishments refuse to provide or are unable to provide wage data. This results in establishment or unit non-response. Ignoring the establishment non-response could result in substantial bias in estimates and incorrect variance estimates.

In our study, we used the administrative and NCS private industry sample data from the Chicago Consolidated Metropolitan Statistical Area and the Orlando, San Antonio, and San Diego Metropolitan Areas from 2001 to 2005. The definitions of these areas are provided in the 1997 BLS Handbook of Methods. The administrative data provided us with auxiliary variables as well as data on establishment earnings and employment. The administrative data are available approximately nine months after the reference date for the quarterly data collection. The NCS data provided the sample size allocated to private industry in the Chicago, Orlando, San Antonio, and San Diego areas and the distribution of NCS non-respondents among industries and establishment size classes within these areas. The non-respondents in the NCS are establishments that do not provide any earnings data. The useable establishments are

establishments with earnings data for at least one sampled occupation. The in-scope sample sizes for each area and time period studied are shown in Table 1, below. The sample sizes include both usable and refusal units, but exclude establishments that could not be matched with current administrative data.

Table 1. In-scope Sample Sizes

Area	Year	Units	Area	Year	Units
Chicago	2001	665	San Antonio	2001	189
	2002	737		2002	197
	2003	807		2003	209
	2004	812		2004	204
	2005	916		2005	221
Orlando	2001	216	San Diego	2001	415
	2002	211		2002	409
	2003	246		2003	479
	2004	248		2004	536
	2005	206		2005	458

3. Empirical Analysis and Results

To investigate the effect of establishment non-response adjustment on NCS estimates, we studied data from four NCS areas – Chicago, Orlando, San Antonio, and San Diego – between 2001 and 2005. For each of the twenty area-year samples, we used administrative data to calculate average earnings for the entire NCS sample, for useable establishments, and for non-responding establishments. We also conducted a simulation study for each area and time period using the administrative data.

We first assessed how well NCS adjustments for non-response compensate for data lost to establishment non-response. We matched the NCS sample establishments with units on the administrative data file and extracted their earnings and employment information from the file. The earnings data on the administrative file are available at the establishment level only. We calculated average monthly earnings for the respondents, the non-respondents, and the total sample. The initial sample weights were used in the calculations of estimates. The total sample estimates simulate estimates that might be produced if NCS had no non-response; the average earnings for respondents simulate estimates that might be obtained if no non-response adjustment is done to account for the non-respondents. In addition, we calculated average earnings for respondents using initial sample weights that were adjusted for non-respondents using current weighting adjustment cells and procedures. Collapsing of cells was done using the NCS collapse pattern when adjustment factor was greater than 4.0 within a cell. These estimates simulate published estimates. The area-wide results are presented in Table 2, attached at the end of paper.

The Total Sample estimate was less than the estimate for the Responding Sample without Weights Adjusted for Non-response in fourteen of the twenty samples (see Table 2), reflecting lower average wages for nonrespondents in these samples. After non-response adjustment, the Total Sample estimate was less than the estimate for the Responding Sample with Weights Adjusted for Non-response in fifteen of the twenty samples. In most samples, non-response adjustment did not mask the effect of the non-respondents; the difference between the Total and Responding Sample estimates remained negative (or positive) in all but three of the twenty samples. In all five Orlando samples, Responding Sample estimates were greater than the Total Sample estimate both before and after nonresponse adjustment. Other areas had mixed results.

The difference between the Total and Responding Sample estimates after non-response was smaller than the difference between the Total and Responding Sample estimates before non-response in thirteen of the twenty samples. This shows that non-response adjustment improved the Responding Sample estimate in these samples. For example, in Chicago-2002, the Total Sample estimate of $3,948.62 was larger than the Responding Sample by $284.47 (7.2% of full-sample estimate) when estimates were calculated using unadjusted respondent data, but the difference decreased to $207.37 (5.3% of full-sample estimate) after the weights were adjusted for nonresponse.

The difference between the Total and Responding Sample estimates were usually less than 10% of the Total Sample estimate. The largest difference as a percentage of the Total Sample estimate before non-response adjustment was 11.5% in Orlando-2001, where the Responding Sample estimate of $2,867.14 was $295.72 greater than the Total Sample estimate. After non-response adjustment, the largest difference was 9.9% in Orlando-2003, where the Responding Sample estimate was $284.01 greater than the Total Sample estimate of $2,871.32.

The results show that non-response error in NCS samples varies in magnitude and direction. It is also largely affected by area; Orlando showed more non-response error than the other three areas. Sample size also seems to be related to the amount of error, since the areas with larger samples (Chicago and San Diego, see Table 1) in general had less bias than the areas with smaller samples (Orlando and San Antonio). Adjusting weights for nonresponse does not always bring estimates closer to the full-sample estimates, though it did bring (or keep) error below 10% of the full-sample estimate in all samples.

The amount of bias in estimated average earnings for each area and time period cannot be determined from a single sample. To measure the amount of bias in the average earnings estimates of an area-year NCS sample, we drew a total of 100 samples of the same size and same industry composition as the NCS sample. These samples were taken from the frame corresponding to the same area and year as the NCS sample; this frame is also the administrative source of the wages and employment figures summarized in Table 2. For each sample, a response set was obtained by using the current NCS sample response rates within each non-response adjustment cell. The non-respondents within each non-response adjustment cell were assigned at random. Under missing at random assumption the bias is expected to be negligible. However, in our study the random assignments did not assure negligible bias because non-response cells were collapsed when the non-response adjustment factor exceeded the maximum factor of 4.0.

We generated two sets of estimates using the respondent data. In the first set we used the initial sample establishment weight, and in the second set we used the initial sample establishment weight adjusted for non-response. The sample weight adjustment was done using the current NCS weight adjustment procedures and cells that have five size classes. When the adjustment factor exceeded 4.0 within a cell, the collapsing of cells was done using the NCS collapse pattern.

The variances for each sample were computed using balanced repeated replication (BRR) methodology. For a detailed description of the BRR methodology see Wolter (1985). Re-weighting for nonresponse was not re-done for each replicate, following NCS procedures.

The formulas used to calculate the amount of bias in average earnings and ratios of bias to standard deviation are as follows:

$$B_d = E(\bar{y}_{dr}) - E(\bar{y}_d) = \bar{Y}_{dr} - \bar{Y}_d$$

$$r_d = |B_d| / \sigma_d$$

where,

B_d is the bias in average earnings for domain d

$E(\bar{y}_{dr})$ is the expected value of average earnings of respondents in domain d over the 100 samples

$E(\bar{y}_d)$ is the expected value of average earnings of the total sample in domain d over the 100 samples

$\bar{Y}_{dr}$ is the average earnings of respondents in domain d

$\bar{Y}_d$ is the average earnings in domain d

r_d is the ratio of the bias to standard deviation in domain d

σ_d is the standard deviation for the average earnings in domain d

The results, averaged over the 100 samples for each area-year survey, are displayed in Table 3 (attached at the end of paper).

The results show that, as with the NCS sample, the amount of absolute bias varies in magnitude and direction, but survey area is the source of the most notable pattern. The absolute bias of the Responding Sample without Weights Adjusted for Non-response was greater than the absolute bias of Responding Sample with Weights Adjusted for Non-response for ten of the twenty samples (see Table 3). However, the absolute bias increased in four of the five Chicago time periods and four of the five Orlando time periods, indicating that non-response adjustment was less effective in these areas. The survey area seems to have an effect on the amount of bias that remains after weights are adjusted for non-response.

To determine the effect of absolute bias on the accuracy of estimates, we calculated the ratio, r_d, defined above, for each industry group estimate. Cochran (1953) points out that the effect of bias on accuracy of an estimate is negligible if the bias is less than one tenth of the standard deviation of the estimate. A ratio between 0.1 and 0.2 is considered to have a modest impact on accuracy of an estimate. The calculated ratios are presented in Table 4.

Table 4. Ratio of the Absolute Bias to the Standard Deviation by Area and Year in Adjustment for Non-response

Area	Year	r_d	Area	Year	r_d
Chicago	2001	0.02	**San Antonio**	2001	0.02
	2002	0.21		2002	0.06
	2003	0.34		2003	0.06
	2004	0.51		2004	0.10
	2005	0.23		2005	0.07
Orlando	2001	0.26	**San Diego**	2001	0.14
	2002	0.26		2002	0.04
	2003	0.06		2003	0.09
	2004	0.28		2004	0.04
	2005	0.75		2005	0.08

The ratios are above 0.2 in four of the five Chicago time periods and four of the five Orlando time periods. The ratios are under 0.1 in four of the five San Antonio time periods and four of the five San Diego time periods, and those not less than 0.1 are less than 0.2. The survey area seems to have a large effect on the impact of the observed bias.

4. Conclusion and Issues for Further Research

In this study, we have explored whether establishment non-response might be biasing the NCS survey estimates. We used administrative data from the Chicago, Orlando, San Antonio, and San Diego survey areas to calculate average earnings for responding units, non-responding units, and the entire NCS sample in those areas. We noted that the NCS weighting adjustment usually helps reduce the bias due to non-response; the industry and employment size class are powerful auxiliary variables in treating non-response.

We selected 100 samples from the original frame and then calculated the ratio of the bias to the standard deviation to assess the effect of bias on the accuracy of average monthly earnings estimates. We noted that the effect of bias on the accuracy of estimates is usually negligible.

In our further research we would like to explore using other methods for assessing potential non-response bias in our earnings estimates. In particular we would like to use response rate comparisons across industry and establishment size, comparisons to similar estimates from other sources, and comparisons of respondent estimates from early co-operators with those from final respondent data set.

We would like to continue to extend this study to other survey areas and time periods. We plan to continue to include localities of different size and with different levels of non-response. We plan to continue to compare the direction and

magnitude of the bias across time and across areas. If it turns out that there are some more consistent trends, then there may be justification for making a non-response bias adjustment. We would still like to perform some evaluation of coverage of confidence intervals. We would also like to investigate whether there are any other auxiliary variables that may be useful in reducing bias due to non-response. In particular, we would like to explore whether using average monthly wage as an auxiliary variable would lend strength to re-weighting procedures. In addition, we would like to investigate the current criteria used for collapsing weighting adjustment cells. As part of this work we would like to determine whether requiring a minimum number of responding establishments within weighting adjustment cells has an impact on bias and variance of estimates. Also, we would like to explore using both the magnitude of the weight adjustment factor and number of responding units in the criteria for collapsing weighting adjustment cells.

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Table 2. Average Monthly Earnings Estimates for NCS Responding, Non-responding, and Total Sample by Selected Area and Time Period, Based on 100 Samples

Area	Time Period	Total Sample	Responding Sample Without Weights Adjusted for Non-response	Non-responding Sample	Responding Sample with Weights Adjusted for Non-response
Chicago	2001	$3,763.48	$3,721.62	$3,847.42	$3,815.92
	2002	$3,948.62	$3,664.15	$4,584.01	$3,741.25
	2003	$3,961.06	$3,909.15	$4,074.09	$3,921.84
	2004	$4,598.48	$4,702.42	$4,350.24	$4,761.39
	2005	$4,509.53	$4,588.02	$4,304.58	$4,583.14
Orlando	2001	$2,571.42	$2,867.14	$2,103.82	$2,749.11
	2002	$2,662.63	$2,941.94	$2,113.66	$2,922.70
	2003	$2,871.32	$3,127.75	$2,166.06	$3,155.33
	2004	$2,787.26	$2,846.79	$2,539.36	$2,903.39
	2005	$2,684.78	$2,742.34	$2,453.74	$2,769.60
San Antonio	2001	$2,800.59	$3,017.42	$2,248.29	$3,056.68
	2002	$3,028.62	$3,251.65	$2,378.95	$3,169.84
	2003	$3,140.19	$3,268.18	$2,685.05	$3,239.38
	2004	$3,467.81	$3,652.92	$2,853.17	$3,648.53
	2005	$2,449.77	$2,357.73	$3,255.45	$2,414.85
San Diego	2001	$3,186.65	$3,218.49	$3,124.95	$3,209.05
	2002	$3,367.90	$3,479.64	$3,166.55	$3,356.75
	2003	$3,543.45	$3,606.67	$3,418.39	$3,644.03
	2004	$3,407.08	$3,331.62	$3,583.40	$3,391.71
	2005	$3,492.18	$3,454.20	$3,577.85	$3,515.32

Table 3. Estimates of Bias and Variance Based on 100 Samples by Area and Survey Year

Area	Time Period	Total Sample	Responding Sample Without Weights Adjusted for Non-response	Non-responding Sample	Responding Sample with Weights Adjusted for Non-response
Chicago	2001	$3,697.06	$3,658.12	$3,735.00	$3,702.46
	2002	$3,721.55	$3,693.32	$3,762.65	$3,785.67
	2003	$3,878.60	$3,928.50	$3,798.58	$3,943.41
	2004	$3,958.56	$4,058.37	$3,810.86	$4,080.14
	2005	$4,270.98	$4,337.33	$4,163.70	$4,338.32
Orlando	2001	$2,538.83	$2,600.91	$2,481.15	$2,590.50
	2002	$2,626.75	$2,651.22	$2,594.80	$2,675.50
	2003	$2,709.50	$2,711.80	$2,706.83	$2,721.20
	2004	$2,824.75	$2,860.08	$2,766.62	$2,885.87
	2005	$3,041.84	$3,096.87	$2,956.05	$3,247.91
San Antonio	2001	$2,631.37	$2,655.10	$2,592.59	$2,636.43
	2002	$2,668.28	$2,647.88	$2,713.80	$2,648.81
	2003	$2,812.52	$2,814.78	$2,803.46	$2,827.63
	2004	$3,032.19	$3,066.74	$2,941.52	$3,062.52
	2005	$3,113.19	$3,200.53	$2,893.03	$3,140.05
San Diego	2001	$3,075.97	$3,162.67	$3,002.97	$3,111.03
	2002	$3,194.89	$3,243.58	$3,152.93	$3,183.35
	2003	$3,238.84	$3,237.08	$3,241.44	$3,254.82
	2004	$3,349.21	$3,339.92	$3,364.25	$3,341.73
	2005	$3,494.62	$3,456.15	$3,567.75	$3,479.63

Table 3. Estimates of Bias and Variance Based on 100 Samples by Area and Survey Year (Continued)

Area	Survey Year	Bias of Responding Sample Without Weights Adjusted for Non-response	Variance of Responding Sample	Bias of Responding Sample With Weights Adjusted for Non-response	Variance of Responding Sample With Weights Adjusted for Non-response
Chicago	2001	$38.94	70,406	-$5.40	87,352
	2002	$28.23	65,256	-$64.12	91,357
	2003	-$49.89	34,098	-$64.81	36,495
	2004	-$99.81	55,531	-$121.58	57,732
	2005	-$66.35	62,109	-$67.33	86,336
Orlando	2001	-$62.08	39,546	-$51.67	40,932
	2002	-$24.48	32,364	-$48.76	35,542
	2003	-$2.31	31,979	-$11.71	37,830
	2004	-$35.33	41,401	-$61.11	47,616
	2005	-$55.02	85,162	-$206.07	75,445
San Antonio	2001	-$23.73	79,853	-$5.05	82,507
	2002	$20.40	116,214	$19.46	108,526
	2003	-$2.26	58,036	-$15.11	56,912
	2004	-$34.55	101,097	-$30.34	101,621
	2005	-$87.34	175,077	-$26.86	158,491
San Diego	2001	-$86.70	60,753	-$35.07	65,203
	2002	-$48.69	50,798	$11.55	69,136
	2003	$1.76	28,152	-$15.98	29,865
	2004	$9.29	30,274	$7.48	30,216
	2005	$38.47	30,190	$14.99	36,558