Quarterly Financial Report Nonresponse Bias Analysis

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Abstract

The Office of Management and Budget (OMB) Standards and Guidelines for Statistical Surveys (2006) require that a nonresponse bias analysis be conducted for a federal statistical survey if the expected unit response rate is less than 80 percent. For the Quarterly Financial Report (QFR), the overall unit response rate has fallen below 80 percent; hence, this nonresponse bias analysis is performed to comply with the OMB standards. First, unit response rates and total quantity response rates are reviewed. Next, the correlation study between sample frame assets and survey assets is presented. Finally, the relative nonresponse bias between respondents and nonrespondents for certainty corporations is presented along with the equivalence of means test for non-certainty corporations. This comprehensive analysis determines nonresponse bias and its magnitude.

1. Background

1.1 Overview of Quarterly Financial Report (QFR) Survey

The Quarterly Financial Report publishes up-to-date aggregate statistics on the financial results and position of U.S. corporations. This principal economic indicator provides comprehensive and timely financial data, essential to calculation of key U.S. Government measures of national economic performance. Based upon a sample survey, the QFR presents estimated statements of income and retained earnings, balance sheets, and related financial and operating ratios for manufacturing corporations with assets of $250,000 and over, and corporations in mining, wholesale trade, retail trade, and selected service industries with assets of $50 million and over or above industry specific receipt cut-off values. The report presents the statistical data by industry and asset size.

QFR assigns each corporation to a recoded version of the three-digit 2012 North American Industry Classification System (NAICS) code. Recodes have a one-to-one correspondence with the 2012 NAICS except for recodes 371-386. These recodes are defined in table 1.1 below.

TABLE 1.1: QFR RECODES AND NAICS

Recodes	NAICS	Definitions
371	3311, 3312	Iron, Steel, and Ferroalloys
374	3341	Computer and Peripheral Equipment
375	3251, 3252	Basic Chemicals, Resins, and Synthetics
376	3361-3363	Motor Vehicles and Parts
381	3313, 3314	Nonferrous Metal
384	3342	Communications Equipment
385	3254	Pharmaceuticals and Medicines
386	3364	Aerospace Products and Parts

Each year, QFR builds a sampling frame using corporate income tax returns stratified by industry classification, size of total assets, and gross receipts prior to sampling. The sample identifies in-scope corporations with total assets of $250 million and over as certainty units with the sampling weight of one. QFR selects simple random samples from eligible non-certainty units in the remaining industry-by-size strata and systematically divides the sample in each cell into four panels that are introduced over the next year. Each non-certainty panel is in the survey for eight successive quarters. Each quarter, one non-certainty panel rotates out and a new panel rotates into the sample. This means that the non-certainty sample for adjacent quarters is seven-eighths identical, and is one half identical for quarters ending one year apart. This panel rotation scheme also means that panels from up to three different sample frames could be active. QFR introduces panels from the most recent sample starting in the fourth quarter, with the remaining three panels introduced, one at a time, into the sample in each succeeding quarter (i.e., quarters one, two, and three). Then this process starts over again with the new sample selected in the following year. The estimates from non-certainty samples contain sampling variation as simple random sampling is applied during the sample selection with panel rotation scheme explained above.

 As a result of the Paperwork Reduction Act of 1995, QFR sample units are subject to time-in / time-out constraints. If a sampled corporation has less than $50 million in total assets and has been in the survey for eight quarters, that corporation is not eligible for selection again for the next ten years. If a corporation has total assets between $50 million and $250 million and has been in the survey for eight quarters, it is not eligible for selection again for the next two years. Because of the time-in / time-out constraints, it is necessary to evaluate the frame to ensure there are enough eligible units for the four panels of the current sample, and there remain enough units on the frame that will be eligible for selection in subsequent years. If there are too few units, the optimal sample size for the current year is reduced to allow enough units for future years' selections. This adjustment to the optimal sample size results in increased variance for these strata.

Data are imputed for corporations that do not respond to the survey, via statistical procedures that utilize previously reported data (if available) and data from current respondents of similar asset size and industry classification. The entire report is imputed and the unit treated as a nonresponse for corporations who report insufficient or inadequate data. For more information, see the "How the Data are Collected" section of the QFR website https://www.census.gov/econ/qfr/collection.html. Section 2.3 discusses imputation, as it relates to nonresponse bias.

After an initial screening, if the corporation is found to be within the scope of the program, filing of the QFR report form is mandatory. QFR mails a set of report forms during the last month of the quarter. Upon expiration of the 25-day filing requirement, a letter advising the corporation of its delinquency is mailed with a form. In the event of continued noncompliance, corporations are contacted by telephone at least once and advised of the report's mandatory nature. Very large certainty delinquents may be contacted up to three times. QFR also conducts courtesy calls to corporations sampled for the first time informing them that they will begin receiving the QFR survey. Data are collected by mail, web, facsimile, or telephone. Administrative data from Securities and Exchange Commission (SEC) reports are also treated as reported data. For instance, in 2017Q4, approximately 12% of reports were received by mail; 79% received via the web; 4% by fax; less than 1% by telephone; and 5% keyed from SEC reports.

1.2 Purpose

Guideline 3.2.9 of the Office of Management and Budget (OMB) Standards and Guidelines for Statistical Surveys (2006) prescribes that "Given a survey with an overall unit response rate of less than 80 percent, conduct an analysis of nonresponse bias…" A study of this kind was last completed in 2014 (Cepluch and Knutson, 2014). Since the unit response rate of the QFR survey is consistently below 80 percent threshold, a similar analysis should be done regularly. The primary purpose of this study is to compare the QFR respondents and nonrespondents based on survey and frame characteristics. The study also researches the potential biases due to nonresponse in the survey.

The unit nonresponse, henceforth called nonresponse, occurs if a sample survey unit fails to summit a response or responds with insufficient data. The effects of nonresponse on a survey are of interest because they have the potential to add errors to the estimates. A substantial amount of nonresponse could create substantial nonresponse bias in the estimates, if the characteristics being measured for nonresponding units differ from the characteristics for responding units. Nonresponse bias is defined as the product of nonresponse rate and the difference between the respondent and nonrespondent means. Mathematically, this can be expressed as:

$$\bar{y}_r - \bar{y}_s = \frac{nr_s}{n_s}\left(\bar{y}_r - \bar{y}_{nr}\right)$$

where $\bar{y}_s$ is the mean of entire sample, $\bar{y}_r$ is the mean of respondents within the sample, $\bar{y}_{nr}$ is the mean of non-respondents within the sample, n_s is the total number of sampled units in the sample, and nr_s is the number of non-respondents in the sample. This suggests that a high rate of nonresponse does not necessarily imply a large bias, nor does a low rate of nonresponse necessarily imply a small bias. The nonresponse rate is easy to calculate, while its impact is not, without rigorous efforts to contact the non-respondents to collect their survey data. A high response rate may only decrease the risk of nonresponse bias. Investigating or estimating bias must be done in an indirect manner.

2. Analysis

The research explained in this section is based on QFR survey data as well as frame data. First, we review the unit response rates (URR) and total quantity response rates (TQRR). Next, we study the correlation between QFR sample frame assets and survey assets. Finally, we present the relative nonresponse bias between respondents and nonrespondents of sample frame assets for certainty corporations along with the equivalence of means test for non-certainty corporations.

2.1 Unit Response Rate Analysis

URR is defined as the ratio between the number of respondents in a sample (numerator) and total eligible units in sample (denominator), expressed as percentage. URRs are indicators of the performance of data collection for obtaining usable responses. Corporations need to provide sufficient data information in order to be defined as respondents. According to the guidelines provided by the Office of Management and Budget (OMB), the URR is a required metric and a nonresponse bias analysis needs to be conducted if the expected URR of a survey falls below 80%. The standards caution that serious data quality issues related to non-sampling occur when the URR falls below 60%.

In this section, we review unweighted URRs, weighted URRs, and revised URRs. For each, we first present the response rates by sector and then drill down to the three-digit

North American Industry Classification System (NAICS) level in order to identify low response rates.

2.1.1 Unweighted Unit Response Rates

The unweighted URR is calculated as:

$$\hat{p} = \frac{Number\ of\ inscope\ respondents}{Total\ inscope\ sample\ size}$$

The equation above has neither sampling weights, nor any measure of size components, so this rate treats all units as equal. This is easy to implement and provides an indicator of performance of data collection, but ignores sources of information about corporations that could be valuable.

The table and graphs below present the unweighted URR by sector and certainty status (asset class).

Table 2.1.1 shows the unweighted URR for mining, manufacturing, wholesale trade, selected service industries (MMWS), and retail trade by sector for eight quarters, 4th quarter 2015 (2015Q4) through 3rd quarter 2017 (2017Q3) . Table 2.1.1 reveals that the sector retail trade has the lowest eight quarter average unweighted URR below 60%. These are the initial response rates at the time of the initial release and do not include any revisions to the data. Section 2.1.3 addresses the revised response rates.

TABLE 2.1.1: UNWEIGHTED URR BY SECTOR

SECTOR	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4	2017Q1	2017Q2	2017Q3	MEAN
All	59.5	62.4	63.0	60.8	59.9	62.0	62.0	60.7	61.3
INF	61.9	65.2	66.5	66.3	63.3	67.6	67.5	63.6	65.2
MFG	59.6	61.8	62.4	60.5	59.8	61.6	61.5	60.4	61.0
MIN	63.8	67.3	66.8	69.0	65.9	70.3	67.6	69.6	67.5
PTS	59.9	65.7	65.9	62.8	61.1	64.4	65.0	66.4	63.9
RET	56.4	59.8	60.0	54.3	56.4	54.5	58.1	51.8	56.4
WHS	58.3	62.9	63.7	60.6	58.9	62.3	61.7	60.2	61.1

Unweighted URR by sector are published quarterly in the QFR press release at http://www.census.gov/econ/qfr. Sectors are defined as follows: INF = All information (NAICS 511 – 519); MFG = All Manufacturing (NAICS 311 – 339); MIN = All Mining (NAICS 211 – 213); PTS = All Professional and Technical Services, except Legal Services (NAICS 545 – 549); RET = All Retail Trade (NAICS 441 – 450); WHS = All Wholesale Trade (NAICS 421 – 422).

Figure 2.1.1.1 displays the unweighted URRs by asset size for retail trade for the historical five-year period from 2013Q1 to 2017Q4 updated every fourth quarter as available in the QFR website at https://www.census.gov/econ/qfr/collection.html. Non-certainty strata with assets less than $250 million are displayed in red (square data points). The certainty stratum with assets over $250 million is portrayed in green (round data points). The combined 'all assets' is presented in blue. Because eligible certainty corporations never leave the sample, these corporations are well trained in reporting. Certainties may have government reporting offices and accounting departments. Non-certainty corporations may rotate out of sample for two or ten years, depending on size and whether they are selected. Although the overall URR is generally above 60%, the

URR for non-certainties is often well below 60%. A prolonged dip in retail URR shown in Figure 2.1.1.1 for both certainties and non-certainties begins with 2015Q4 and continues to the end of the graph. We observe a typical fourth quarter dip in response rates in 2015Q4 with a smaller recovery and continued overall pattern of decline from 2015Q4 and forward. The fourth quarter response rate is lower due to additional corporation workload for end-of-year annual reporting. In 2016Q1, QFR began publishing retail one week early to coincide with the release of MMWS. An earlier release date streamlined survey processing and allowed the current quarter retail estimates to be included in the publication (previously, the retail estimates were one quarter delayed). Releasing retail one week earlier is a likely contributor to the lower response rate.

**Figure 2.1.1.1 UNWEIGHTED RETAIL TRADE URR BY ASSET CLASS**
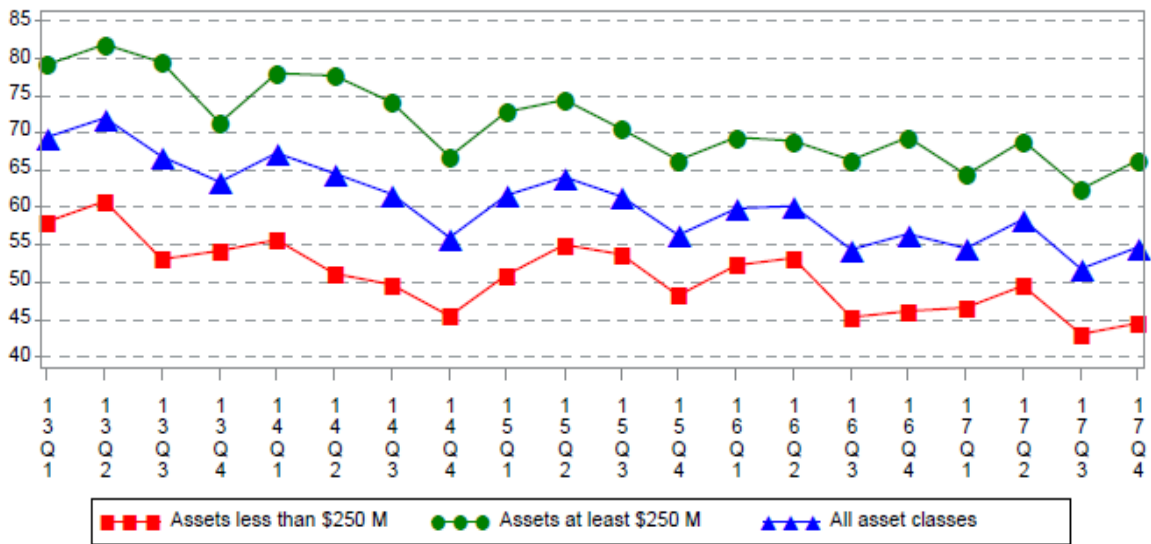
Assets less than $250 million represent the non-certainty strata corporations. Assets at least $250M represent the corporations in the certainty stratum. The graphs shown are available on the QFR website at https://www.census.gov/econ/qfr/collection.html. The graph is updated for a new five year span every 4th quarter.

Figure 2.1.1.2 presents the unweighted URRs for the historical five-year period from 2013Q1 to 2017Q4 by sector for MMWS. The highest response rates are observed in the mining (MIN) and information (INF) sectors whereas the lowest rates are observed in the manufacturing (MFG) and wholesale (WHS) sectors.

Similarly, Figure 2.1.1.3 presents the unweighted historical URRs by asset size for manufacturing, mining, wholesale trade, and selected service industries (MMWS). Non-certainty strata with assets less than $250 million are displayed in red (square data points). URRs for the certainty stratum with assets over $250 million is portrayed in green (round data points). The combined 'all assets' is presented in blue. This graph reveals that certainty corporations are much more likely to respond than non-certainty corporations sampled in QFR survey. Although the overall URR is generally above 60%, the URR for non-certainties is below 60%. Because the certainty eligible corporations never leave the sample, these corporations are well trained in reporting. Non-certainty corporations may rotate out of sample for two or 10 years, depending on their size and whether they are selected.

Figure 2.1.1.2 UNWEIGHTED MMWS URR BY SECTOR
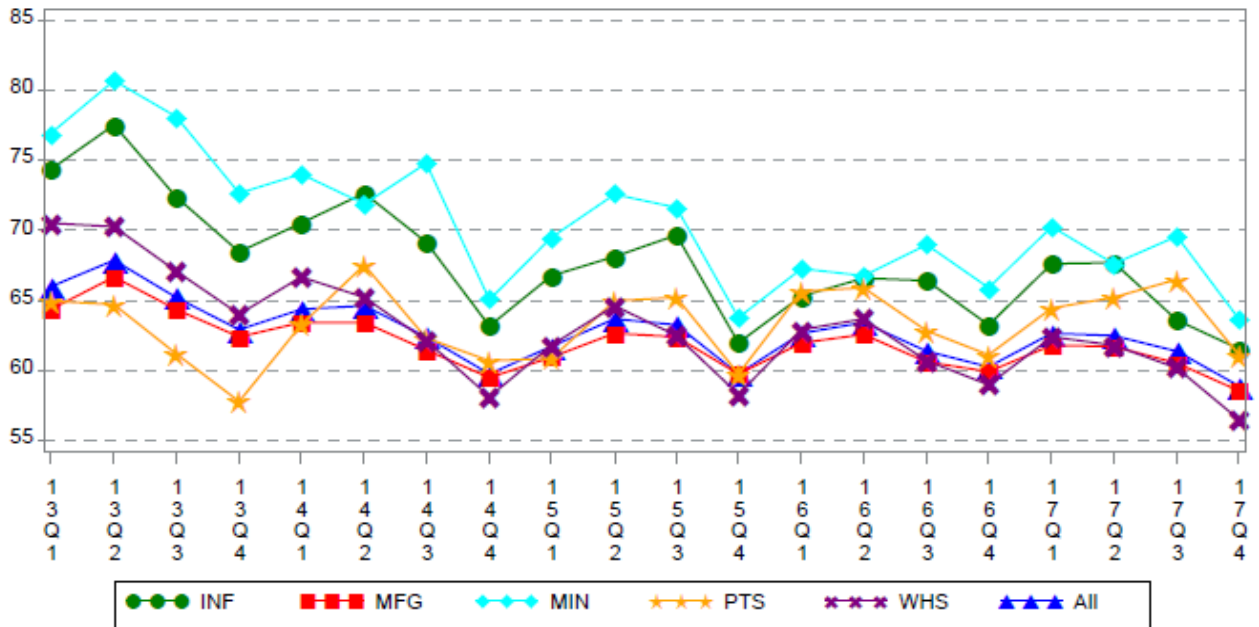
The graph is available on the QFR website at https://www.census.gov/econ/qfr/collection.html. The graph is updated for a new five-year span every 4th quarter.

FIGURE 2.1.1.3: UNWEIGHTED MMWS URR BY ASSET CLASS
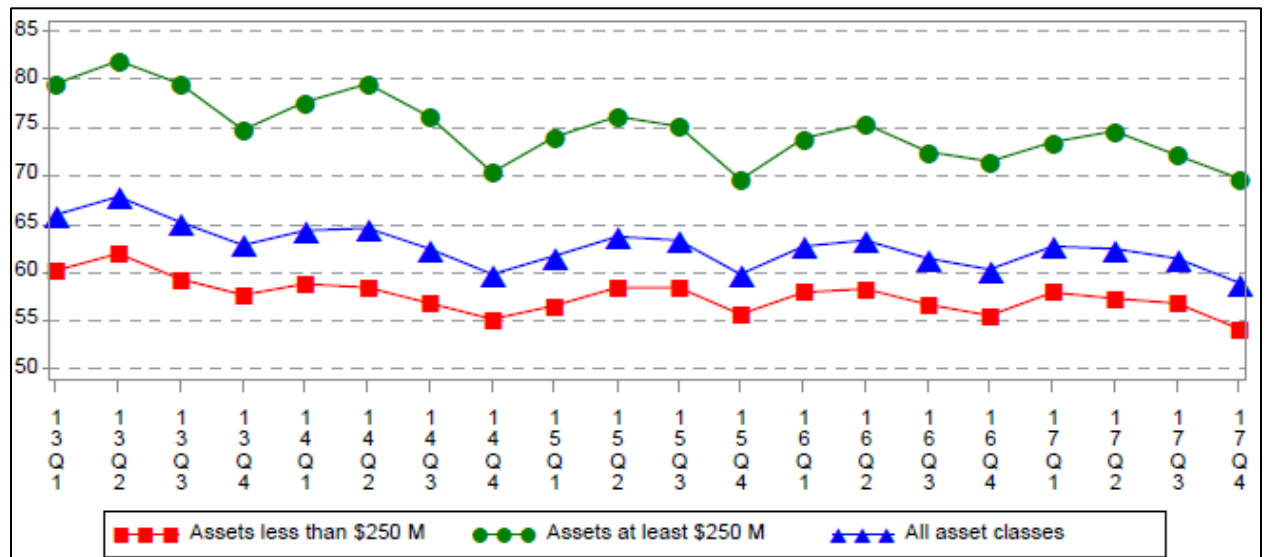
This graph is available on the QFR website at https://www.census.gov/econ/qfr/collection.html. The graph is updated for a new five-year span every 4th quarter.

We also drilled down to the three-digit NAICS level to reveal that 16 out of 46 NAICS (around 35%) have mean unweighted URR less than 60%. We also observed that NAICS 441 (motor vehicles and parts dealers; gasoline stations), NAICS 448 (clothing and general merchandise stores), and NAICS 450 (all other retail trade) have a lower unweighted URR among the retail trade corporations.

The significance test on the differences between URR of certainty and non-certainty corporations reveal that the URR of certainty corporations is significantly different from

the URR of non-certainty corporations at 95% confidence level. Overall, the certainty corporations are much more likely to respond. Unweighted URR varies by industry sectors.

2.1.2 Weighted Unit Response Rates
The weighted URR is calculated as:

$$\hat{p} = \frac{\sum_r smpwgt}{\sum_s smpwgt} \ ,$$

where $smpwgt$ is the initial weight assigned to a case during sample selection, also called sampling weight, which is equal to the inverse of the probability of selection, r is in-scope respondents and s is the in-scope survey corporations . This rate assumes that all units in a cell are essentially equivalent. Therefore, it is slightly more complex than the unweighted URR, using sampling weight as a proxy for the population size.

Table 2.1.2 shows the weighted URR for MMWS and retail trade by sector for eight quarters 2015Q4 through 2017Q3.

TABLE 2.1.2: WEIGHTED URR BY SECTOR

SECTOR	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4	2017Q1	2017Q2	2017Q3	MEAN
ALL	53.2	54.0	54.4	53.3	53.9	54.6	53.6	53.4	53.8
INF	58.1	59.4	59.6	59.7	59.6	63.5	62.4	58.5	60.1
MFG	53.1	53.7	54.2	53.0	53.8	54.4	53.3	53.2	53.6
MIN	59.7	61.5	61.0	64.5	61.8	65.9	62.7	63.4	62.6
PTS	55.4	62.2	62.4	59.6	57.7	62.7	62.5	66.3	61.1
RET	50.7	54.6	55.3	48.1	49.4	49.0	52.3	46.0	50.7
WHS	55.1	60.0	60.9	58.1	55.4	59.4	57.7	56.4	57.9

Data based on sampled QFR survey: https://www.census.gov/econ/qfr/

Studying weighted URR by assets size stratum shows that the certainty stratum has a higher response rate with eight quarter average around 72.3% than the non-certainty strata with average being around 55%.

We also look at the weighted unit response rate at three-digit NAICS level which show that 37 out of 46 (80%) of NAICS have an eight quarter (2015Q4 through 2017Q3) average weighted URR less than 60%.

The weighted URR for certainty industries is the same as the unweighted URR as we know that the weight is one for certainty corporations. In general, the weighted URR is lower than the corresponding unweighted URR for a given industry category. This is the evidence that smaller corporations have a larger tendency towards nonresponse.

2.1.3 Revised Unweighted Unit Response Rates
Response rates presented in sections 2.1.1 and 2.1.2 discussed *unrevised* initial response rates. However, we also monitor *revised* unweighted URR. Revised estimates include responses received after the deadline for the initial release plus revised data for corporations that responded and were included in the initial release. QFR publishes an initial (r = 0) unrevised estimate in the current quarter followed by a revision each quarter for a year following the initial release (r = 1, 2, 3, and 4). For example, estimates for

2016Q4 are restated in 2017Q1 (r = 1), 2017Q2 (r = 2), 2017Q3 (r = 3), and 2017Q4 (r = 4). Receipt of delinquent reports improves unweighted URR between the initial (r = 0) and final (r = 4) by approximately 7 percentage points. Receipt of these additional reports boosts unweighted URR above 60%. Table 2.1.3 demonstrates this improvement in unweighted URR. The biggest gains are observed in mining (14.0 percentage points) and retail (9.6 percentage points). The improvement in retail trade is especially welcome given the compressed reporting cycle described in section 2.1.1.

TABLE 2.1.3 REVISED UNWEIGHTED URR FROM 2016Q4 to 2017Q4

SECTOR	Published URR 2016Q4 r = 0	Revised URR 2017Q1 r = 1	Revised URR 2017Q2 r=2	Revised URR 2017Q3 r=3	Revised URR 2017Q4 r=4	Difference Between r = 0 and r = 4
MFG	59.8	63.4	65.2	65.8	66.1	6.3
MIN	65.9	74.4	77.1	78.3	79.9	14.0
WHS	58.9	62.5	65.1	65.7	65.8	6.9
INF	63.3	68.2	71.3	71.5	72.2	8.9
PTS	61.1	65.0	67.8	68.6	68.9	7.8
RET	56.4	62.9	64.9	65.7	66.0	9.6
ALL	59.9	64.0	66.0	66.7	67.0	**7.0**

Data based on sampled QFR survey: https://www.census.gov/econ/qfr/

2.2 Total Quantity Response Rate Analysis

The Total Quantity Response Rate (TQRR) is defined as the proportion of the estimated (weighted) total of a key item reported by tabulation units, or sources determined to be of equivalent quality to survey-reported data. This is the item-level indicator of response quality of each estimate, and is expressed as a percentage. TQRR takes the size of the tabulation unit into account, as well as the associated sample parameters, and is a coverage rate that informs us how much of the estimate comes from respondents. This rate is also referred as the weighted dollar-volume response rate.

Unlike the URR, TQRR is calculated for individual data items, so that a survey may produce many TQRRs per statistical period as data quality indicators. Total quantity response rate is calculated as:

$$\hat{p} = \frac{\sum_r wgt * item}{\sum_s wgt * item} \ ,$$

where wgt is the final estimation weight, r is in-scope respondents and s is in-scope survey corporations, $item$ refers to the key items. For QFR, wgt is a variable weight estimator that takes into account the rotating eight panel sampling scheme, and TQRRs are calculated for Sales, Depreciation, |NIBT|, and Assets. The absolute value is applied to real-valued data NIBT (|NIBT|) prior to calculating the TQRR. In-scope respondents are the corporations providing sufficient data information to the survey. It is necessary to determine the source of the final tabulated value of an associated data item for each tabulation unit in order to compute TQRR for a particular estimate. This value could be directly obtained from respondent data, indirectly obtained from other equivalent quality data sources such as the Security and Exchange Commission, or imputed. For QFR, imputed data are treated as a nonresponse whereas reported or equivalent source data are treated as a response. The QFR population and sample are skewed, with large corporations making a greater contribution to the individual item estimates. One hundred percent minus TQRR (100% - TQRR) is the imputation rate.

Table 2.2 shows the TQRR by industry sector for item assets. This reveals that the sector wholesale has the lowest TQRR among the industry sectors. We took a closer look at the TQRR shown in the Table 2.2 by drilling down to three-digit NAICS level which showed that there are 11 out of 46 NAICS (24%) with TQRR less than 80% for the item assets. We discovered that NAICS 421 (Durable Goods) has the lowest TQRR of 69.0% among the sector wholesale trade for the item assets. This led us to find chronic nonrespondents for all eight quarters (2015Q4 through 2017Q3) for this NAICS. In order for this NAICS to perform better, it will be necessary to garner a response from some of the chronic nonrespondents. Similarly, TQRR for other key items sales, depreciation, and |NIBT| showed similar patterns as assets.

TABLE 2.2: TQRR OF ASSETS BY SECTOR

SECTOR	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4	2017Q1	2017Q2	2017Q3	MEAN
INF	93.1	94.7	92.8	94.6	92.4	94.4	95.2	94.9	94.0
MFG	88.2	88.3	90.9	88.2	90.0	88.4	89.3	88.0	88.9
MIN	90.0	92.4	93.1	90.4	91.4	92.3	90.3	90.5	91.3
PTS	82.7	88.0	86.5	83.4	81.9	80.4	84.7	85.7	84.2
RET	86.2	84.4	85.7	82.9	87.3	82.6	85.2	81.9	84.5
WHS	76.3	76.1	76.6	76.8	77.2	76.4	78.3	75.8	76.7

TQRR by sector are published quarterly in the QFR press release at http://www.census.gov/econ/qfr.

2.2.1 Revised Total Quantity Response Rates

Response rates discussed in section 2.2 represent *unrevised* initial TQRR. However, we also monitor *revised* TQRR. As mentioned in section 2.1.3, QFR publishes an initial (r = 0) unrevised estimate in the current quarter followed by a revision each quarter (r = 1, 2, 3, and 4). Receipt of delinquent reports improves the TQRR between the initial (r = 0) and final (r = 4) by approximately 5.5 percentage points. Receipt of these additional reports moves the TQRR well above the 80% OMB threshold. Table 2.2.1 shows the revised TQRR of assets from 2016Q4 to 2017Q4 by sector. Similar improvements in revised TQRR are noted for other key items sales, depreciation, and |NIBT|.

TABLE 2.2.1: REVISED TQRR OF ASSETS BY SECTOR

SECTOR	Published TQRR 2016Q4 r = 0	Revised TQRR 2017Q1 r = 1	Revised TQRR 2017Q2 r=2	Revised TQRR 2017Q3 r=3	Revised TQRR 2017Q4 r=4	Difference Between r = 0 and r = 4
MFG	90.0	92.0	93.0	93.6	94.0	4.0
MIN	91.4	95.3	95.8	96.0	96.9	5.5
WHS	77.2	79.4	81.4	82.3	82.7	5.5
INF	92.4	93.7	96.3	96.9	97.6	5.2
PTS	81.9	83.5	86.8	87.2	87.2	5.3
RET	87.3	92.6	93.1	93.9	94.1	6.8

Data based on sampled QFR survey: https://www.census.gov/econ/qfr/

2.3 Study of Correlated Frame Data

This section attempts to determine the severity of nonresponse bias within each imputation cell. The QFR imputation process assigns each corporation in the sample to

one of many imputation cells based upon its three-digit NAICS code and strata. A corporation will fall into either certainty or non-certainty strata based upon sample frame assets as discussed in section 1.1 above. Based on quartile boundaries, the non-certainty stratum with assets between 50 million and 250 million is further subdivided into two subgroups and the certainty stratum is further subdivided into four subgroups. Because too few respondent cases may reside in an imputation cell, two sets, or levels of imputation cells are used. If fewer than 8 respondent corporations reside in a level 1 imputation cell, then a 'collapsed' larger level 2 cell will be used for imputation.

The effective selection of imputation cells can be used to reduce nonresponse bias. An imputation cell should be relatively homogenous with respect to the items being imputed. Furthermore, for imputation to be a useful means of reducing nonresponse bias, respondents must be similar to the nonrespondents with respect to the items that are being imputed in a given cell. Level 2 cells are somewhat less homogenous and therefore less desirable. Finally, imputation is conducted by multiplying a prior quarter value for a corporation by an industry average for the imputation cell based upon the current or prior quarter. When no prior quarter data are available, a weighted means method is used to impute. The sample frame assets variable obtained from corporate income tax returns is available for respondents and nonrespondents alike, and is highly correlated to the survey assets value, and hence is used for nonresponse bias study.

2.3.1 Correlation Analysis of Frame and Survey Assets

The correlation analysis determined that the correlation between frame and reported survey assets for certainty and non-certainty cases are both strong. The correlation for respondents and nonrespondents is similarly strong as shown in the highlights Table 2.3.1 for most industries, but is much weaker for nonrespondents in industries 212 (mining: oil and gas extraction), 213 (mining: support activities), 517 (telecommunications) and 519 (all other information). The *Nonrespondents* column contains the correlation between frame and imputed survey assets. The *All* column contains the correlation between frame assets and the combination of both reported and imputed survey assets. The weaker correlations (<.6) are highlighted in yellow. Weak correlations advise us of potential anomalous imputes for these industries. Anomalous imputes may be caused by too few respondent cases in an imputation cell forcing imputation via a less homogenous cell. Poor imputes may also be caused by a less than ideal imputation method. Finally, imputes may be affected by volatility. During the period of study, mining experienced price drops and telecommunications experienced new activity resulting in market volatility. Conversely, we observed stronger nonrespondent correlation between frame and survey assets for industry 312 (Beverage and Tobacco Products) and QFR recode industry 381 (Nonferrous Metals). Overall, the sampling frame asset value is adequately correlated to item 223 (survey asset) to study the effect of nonresponse bias on item 223. Three-digit NAICS not shown in the table also demonstrated strong correlations for both respondents and nonrespondents.

TABLE 2.3.1: SOME HIGHLIGHTS OF CORRELATION COEFFICIENTS BETWEEN FRAME AND SURVEY ASSETS (2015Q4 – 2017Q3)

NAICS	All	Respondents	Nonrespondents
211	0.90	0.90	0.76
212	0.88	0.91	0.59
213	0.86	0.88	0.57
311	0.78	0.75	0.98
312	0.55	0.54	0.91
381	0.53	0.52	0.92
421	0.88	0.88	0.88
422	0.81	0.81	0.79
441	0.94	0.95	0.97
445	0.96	0.98	0.99
517	0.96	0.96	0.44
519	0.91	0.91	0.51

Data based on sampled QFR survey: https://www.census.gov/econ/qfr/

2.3.2 Relative Bias for Certainty Corporations on Frame Assets

We may compute a measure of the nonresponse bias for certainty corporations without having to perform any statistical testing since there is no association of sampling variance (Cepluch and Knutson, 2014). The nonresponse bias is calculated as:

$$bias = \bar{Y}_{resp} - \left[\frac{N_{resp}}{N}\left(\bar{Y}_{resp}\right) + \frac{N_{nonresp}}{N}\left(\bar{Y}_{nonresp}\right)\right]$$
$$= \left(\frac{N - N_{resp}}{N}\right)\left(\bar{Y}_{resp} - \bar{Y}_{nonresp}\right)$$

Relative bias is calculated as:

$$relative\ bias = \frac{100(\bar{Y}_{resp} - \bar{Y})}{\bar{Y}},$$

where, $\bar{Y}$ is the mean of frame assets and N is the sample size.

Out of all 46 unique certainty three-digit NAICS covered in this study, Table 2.3.2 summarizes the relative bias observed for those three-digit NAICS that exhibit a relative bias of at least 20 percent in at least one quarter.

TABLE 2.3.2: RELATIVE BIAS BETWEEN RESPONDENTS AND NONRESPONDENTS OF FRAME ASSETS FOR CERTAINTY INDUSTRIES WHERE RELATIVE BIAS IS GREATER THAN 20 PERCENT AT LEAST IN ONE QUARTER.

NAICS	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4	2017Q1	2017Q2	2017Q3	MEAN
211	27.36	26.33	30.28	21.36	29.96	22.91	23.98	16.82	**24.88**
212	30.68	18.26	19.06	16.67	19.01	17.09	23.42	19.21	20.43
213	23.66	22.36	23.79	24.38	24.68	16.20	21.96	28.04	**23.13**
312	42.18	40.92	25.58	29.29	27.02	31.48	36.80	39.49	**34.10**
313	28.36	8.51	18.23	23.37	28.90	22.04	13.45	13.45	19.54
315	14.34	23.57	12.89	9.46	15.27	10.49	8.99	29.31	15.54
316	72.59	16.31	18.97	18.97	96.88	49.03	49.03	49.03	**46.35**
321	10.81	23.52	27.02	12.63	10.58	11.79	14.05	9.22	14.95
322	15.92	16.60	11.27	19.02	22.92	14.35	16.69	21.22	17.25
324	36.47	23.05	28.96	34.43	24.12	26.83	27.95	27.29	**28.64**
325	29.04	22.40	16.26	17.63	19.87	16.68	20.41	18.65	20.12
326	17.73	12.99	21.17	21.81	18.33	17.89	8.15	19.56	17.20
331	-70.02	53.02	29.35	29.62	48.49	22.68	19.71	17.45	**36.29**
333	22.35	19.72	10.30	14.91	12.83	12.72	11.51	24.55	16.11
336	32.37	16.55	11.91	16.23	17.78	18.76	14.14	14.14	17.74
374	26.93	13.55	13.46	21.87	34.28	17.72	22.57	26.82	**22.15**
381	14.21	20.90	20.06	19.52	17.93	15.04	8.31	22.55	17.32
385	17.72	7.35	18.32	8.72	23.21	-1.56	19.36	6.85	12.89
386	29.32	30.72	29.05	26.23	32.53	52.09	41.63	34.99	**34.57**
448	24.99	14.35	21.91	20.78	25.09	21.05	32.51	30.51	**23.90**
450	15.79	22.51	23.96	20.72	17.86	15.05	8.99	5.27	16.27
511	19.79	13.44	8.44	14.44	20.03	15.78	8.77	21.64	15.29
512	47.38	33.84	23.13	7.81	44.25	21.02	43.34	8.70	**28.68**
517	36.33	44.81	30.53	18.25	31.93	30.91	31.34	39.24	**32.92**
519	21.24	32.24	27.76	12.66	21.04	26.52	19.03	20.21	**22.59**
545	12.21	23.31	20.20	22.18	19.93	16.56	19.97	23.68	19.76
546	16.83	17.11	8.09	23.15	10.63	14.17	7.15	10.06	13.40
549	15.97	6.51	21.38	13.46	17.70	23.56	22.44	32.94	19.25

Data based on sampled QFR survey: https://www.census.gov/econ/qfr/

Overall, certainty respondents are not very different from nonrespondents within the imputation cell, with respect to frame assets. There are few three-digit NAICS that frequently display higher relative bias and have mean relative bias greater than 30% over the eight quarters under study: 312 (beverage and tobacco product), 316 (leather and allied product manufacturing), 331 (foundries), QFR recode 386 (aerospace products and parts), and 517 (telecommunications). Approximately 26% of all NAICS (12 out of 46) have a relative bias that is on average greater than 20%.

The previous Nonresponse Bias Analysis (Cepluch and Knutson, 2014) studied 42 unique three-digit NAICS (excluding retail trade) and found out that 12 NAICS had relative bias between respondents and nonrespondent assets greater than 20% for at least in one quarter (2012Q2 through 2014Q1). For the current report, we included the retail trade sector and found 28 out of 46 unique three-digit NAICS with a relative bias greater than 20% for at least one quarter. However, there are only a few three-digit NAICS with an average relative bias greater than 30% in either analysis. QFR recode 386 (aerospace products and parts) and 517 (telecommunications) have an average relative bias of greater than 30% in *both* the studies. NAICS 335 (electrical equipment) and 512 (motion picture and recording industries) had an average relative bias greater than 30% in the Nonresponse Bias Study of 2014. As mentioned in the previous paragraph, NAICS 312, 316, and 331 have an average relative bias greater than 30% in the current study. Since the recode 386 and NAICS 517 showed up with a larger relative bias in *both* the studies, we determined chronic nonrespondents of eight quarters (2015Q4 through 2017Q3) for these NAICS for more aggressive follow up.

2.3.3 Equivalence of Means Test for Non-certainty Corporations on Frame Assets

The equivalence of means test is used to judge whether there is a difference between respondent and non-respondent frame assets within a NAICS and stratum. Although this test will not measure the severity of any difference that may exist between respondents and non-respondents within a NAICS, it does give us the evidence of whether a difference exists. The method used in the test is same as the one used in Nonresponse Bias Analysis for the Quarterly Financial Report (Cepluch and Knutson, 2014).

Table 2.3.3 summarizes these results by stratum. We provide the total number of imputation cells (NAICS) used, the quarter and the total number of cells containing statistically different means for respondents and non-respondents within the same imputation cell. A 90% confidence level is used in producing these results. While Table 2.3.3 results do give some indication that there are a few industries where respondent assets differ from non-respondent assets, some caution must be exercised in its interpretation, as this data is presented without consideration of any variance.

TABLE 2.3.3: NUMBER OF NAICS WITH AVERAGE NONRESPONDENT FRAME ASSETS DIFFERENT FROM AVERAGE RESPONDENT FRAME ASSETS FOR NON-CERTAINTY STRATA

STRATUM	TOTAL NAICS	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4	2017Q1	2017Q2	2017Q3	Mean
03	27	2	5	3	4	0	4	2	1	2.63
07	27	3	4	3	2	2	5	6	4	3.63
08	27	4	2	1	5	3	3	5	3	3.25
14	27	3	2	4	1	1	1	2	1	1.88
16	45	7	9	10	9	4	7	10	9	8.13

Data based on sampled QFR survey: https://www.census.gov/econ/qfr/

Strata are defined as follows: 03 = \$250,000 ≤ Assets < \$1,000,000; 07 = \$1,000,000 ≤ Assets < \$5,000,000; 08 = \$5,000,000 ≤ Assets < \$10,000,000; 14 = \$10,000,000 ≤ Assets < \$50,000,000; 16 = \$50,000,000 ≤ Assets < \$250,000,000; 18 = Assets ≥ \$250,000,000. Strata 03 through 16 are called non-certainty and the stratum 18 is called certainty. Strata 03 through 14 are sampled only for manufacturing corporations.

With the exception of stratum 07 in the second quarter of 2017 (22%), the proportion of NAICS with average non-respondent assets differing from average respondent assets remains below 20% for strata 03 and 07; however, approximately 20% of stratum 16 non-respondent frame assets are different from respondent frame assets. This shows that non-respondent frame assets are not very different from the respondent frame assets for non-certainty industries at 90% confidence level.

For each stratum, we investigated NAICS where average nonrespondent frame assets differed from average respondent frame assets for at least two quarters. Stratum 16 NAICS 517 (telecommunications) has evidence of all eight quarters having average nonrespondent frame assets different from average respondent frame assets. Similarly, stratum 07 recode 381 (nonferrous metals) has five out of eight quarters where the averages are different between respondents and non-respondents. Therefore, it will be beneficial to increase responses for corporations in these two categories, especially for stratum 16 since this is the larger non-certainty stratum. All the other non-certainty strata and three digit NAICS show evidences of differences in four or less quarters.

3. Conclusions

Response rate analyses found that there are different reporting patterns observed from the certainty units and non-certainty units. URRs for non-certainty corporations are significantly lower than URRs for certainty corporations. There is a concern that lower response rate for non-certainties increases the potential for nonresponse bias. This finding is the same as that from a previous QFR non-response bias study in 2014 using older samples (Cepluch and Knutson, 2014). Retail trade and wholesale trade have the lowest and second lowest eight quarter average URR respectively among the industry sectors. With each data revision, URR improves from the initial data release. Wholesale trade has the lowest eight quarter average TQRR of all the items under study, except for the item sales where the sector Professional and Technical Services has the lowest average TQRR. Like URRs, TQRRs for non-certainty corporations are lower than those of certainty corporations.

Analyses on nonresponse bias found evidence of the existence of bias for QFR estimates for both certainty and non-certainty corporations. Among the certainty corporations, the bias by three-digit NAICS is mostly below 30% except in five out of 46 (11%) NAICS. On the other hand, non-certainty corporations have also shown the evidence of minimal biases due to nonresponse.

Industries Aerospace Products and Parts (Recode: 386) and Telecommunications (517) suffered from a large relative bias in both the 2014 and 2018 nonresponse bias studies. Identification of chronic certainty nonrespondents for more aggressive follow-up in those industries as well as wholesale trade could have the potential to boost URR, TQRR, and decrease relative bias.

Our analysis revealed a relationship between data quality and response rates such that we can utilize response rates to monitor data quality for problematic three-digit NAICS identified by this study.

REFERENCES

Bethlehem, Cobben, and Barry Schouten. *Handbook of Nonresponse in Household Surveys*. A John Wiley & Sons, INC., Publication, Hoboken, New Jersey, 2011. Print.

Cepluch and Knutson. Nonresponse Bias Analysis for the Quarterly Financial Report (2014). Internal Census Bureau Memorandum, available upon request.

Fan and Shieh (2016), Advance Monthly Retail Trade Survey Nonresponse Bias Analysis Report. Internal Census Bureau Memorandum, available upon request.

Federal Register Notice (2006). Office of Management and Budget: Standards and Guidelines for Statistical Surveys, September 2006, Section 3.2, p ii https://collab.ecm.census.gov/dir/adep/intranet/QualityAudit/Documents/standards_stat_surveys.pdf

Harvey and Pennington. Correlation Study of Items IRS2N and 223. (2018). Internal Census Bureau Memorandum, available upon request.

Khatiwoda. Significance Test on Difference Between Certainty and Non-certainty URR. (2019). Internal Census Bureau Memorandum, available upon request.

Khatiwoda and Pennington. Nonresponse Bias Analysis for the Quarterly Financial Report (Full Report, 2018). Internal Census Bureau Memorandum, available upon request.

Nonresponse Bias Study for the Annual Capital Expenditures Survey Executive Summary. Internal Census Bureau Memorandum, available upon request.

U.S. Census Bureau, Quarterly Financial Report, How the QFR Data are Collected, Historical Response Rates (Updated annually in the Fourth Quarter), https://www.census.gov/econ/qfr/documents/hist_mmw_resp_rates.pdf,

https://www.census.gov/econ/qfr/documents/hist_ret_resp_rates.pdf.

U.S. Census Bureau, Quarterly Financial Report, How the QFR Data are Collected, QFR Data Collection Methodology, http://www.census.gov/econ/qfr/documents/QFR_Methodology.pdf