Measures of Nonresponse Bias for the Quarterly Financial Report

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Abstract

Studies have shown that there is not a direct link between nonresponse and nonresponse bias, which motivates the search for new ways to measure survey bias. This study looks at traditional measures of nonresponse bias like unit response rate (URR) and total quantity response rate (TQRR) and additional bias measures such as the Mann-Whitney U Test and R-Indicator. These methods are applied to the Quarterly Financial Report.

Key Words: bias, nonresponse, R-Indicator, model, total quality response rate, unit response rate

1. Background

1.1 Overview of Quarterly Financial Report (QFR) Survey

The Quarterly Financial Report (QFR) is a quarterly survey that publishes up-to-date aggregate statistics on the financial conditions of U.S. corporations. It is a principal economic indicator that provides comprehensive and timely financial data essential to the 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. Asset class sizes and industry-specific receipt cutoffs stratify the statistical data. Please note that beginning in the fourth quarter of 2019 (2019q4), the asset cutoff for Manufacturing corporations increased to $5 million from $250,000 as part of the sample improvement project.

Each year, the QFR sampling frame is built from an annual Internal Revenue Service (IRS) file of all corporate entities that elect to file Form 1120 with the IRS. During sample selection, the IRS file does not contain those corporate entities whose first income tax return has not been processed. In addition, several months elapse between the selection of this sample and its introduction into the QFR Program. To keep the QFR sample up-to-date, staff reviews current corporate news releases and public records to identify any

potential large changes to the target population. Corporations thus identified and thought to meet QFR in-scope criteria are contacted to verify their in-scope status. If determined to be in-scope, the corporation will automatically be included in the survey for the remainder of the sample year.

Corporations whose operations are within scope of the QFR and have total assets of $250 million and over may be included in the sample with certainty, based on industry-specific asset and receipt cutoffs. A simple random sample is selected from the eligible non-certainty units in the remaining industry-by-size strata. The noncertainty sample is divided systematically into four panels that are introduced over the next year. Each noncertainty panel is in the survey for eight successive quarters. Each quarter, one noncertainty panel is rotated out and a new panel is rotated into the sample. This means that the noncertainty sample is seven-eighths identical for adjacent quarters and is one half identical for quarters ending one year apart. Using this rotation scheme, panels from up to three different sample frames could be active in the QFR survey.

Panels from the most recent sample are introduced into the QFR survey starting in the fourth quarter, with the remaining three panels being 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. Beginning 2019q4, the certainty cutoff will be dynamically determined using the Glasser cutoff; and the Glasser cutoff will be at least $250 million (Glasser, 1962).

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. If a company has total assets between $250 million and the industry-specific cutoffs and has been in the survey for eight quarters, it is not eligible for selection again for the next year. Because of the time-in / time-out constraints, the frame must be evaluated to ensure there are enough eligible units for the four panels of the current sample to be selected, and enough units remain in 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, which results in increased variance for these strata.

When a corporation does not respond to the survey, data are imputed 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.

After an initial screening, if the corporation is found to be within scope, filing of the QFR report form is mandatory. A set of QFR report forms is mailed during the last month of each financial 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 two times, once prior to the due date and once after the due date. 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, or facsimile. For instance, in the third quarter of 2019 (2019q3), approximately 9% of reports were received by mail, 2% by fax, 86% via the web, and 3% keyed from Securities and Exchange Commission (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, this should motivate conducting an analysis of nonresponse bias." Nonresponse bias is the bias that occurs when the survey respondents differ significantly from those who do not respond to the survey. Studies of this kind were done for QFR in 2014 (Cepluch, 2014) and 2018 (Khatiwoda and Pennington, 2018). Since the recent (2017 to 2019) unit response rates of the QFR survey is below the 80% threshold as shown in Figure 2.1.1 (averaging 60% in 2019q3), a similar nonresponse bias analysis should be done regularly. The primary purpose of this study is to determine the differences between the QFR respondents and nonrespondents for both survey and frame variables/items. The study also researches the potential biases due to nonresponse in the survey covering nonresponse bias for 2017q4 to 2019q3.

Unit nonresponse, henceforth called nonresponse, occurs when no response or insufficient data was received for a sampled survey unit. 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 for a mean, which indicates the difference between the sample mean for a given variable and the mean of respondents within the sample is measured as the product of the nonresponse rate for a survey and the difference between the means of respondents and nonrespondents to the survey. Mathematically this can be expressed as (McMillen, Harris-Kojetin, Miller, & Ware-Martin, 2001):

$$B(\overline{y}_r) = \overline{y}_r - \overline{y}_t = (\frac{n_{nr}}{n})(\overline{y}_r - \overline{y}_{nr})$$

where:

- $\overline{y}_t$ = the mean based on all sample cases
- $\overline{y}_r$ = the mean based only on respondent cases
- $\overline{y}_{nr}$ = the mean based only on nonrespondent cases
- n = the number of cases in the sample
- n_{nr} = the number of nonrespondent cases

The formula 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 because that would require rigorous efforts to contact the non-respondents to collect their survey data. Estimating nonresponse-bias must therefore be done in an indirect manner.

2. Analysis

This study explores six indicators of nonresponse bias, including:

- Unit Response Rate (URR)
- Total Quantity Response Rate (TQRR)
- Correlation
- Relative Nonresponse Bias
- Mann-Whitney U Test
- R-Indicator

2.1 Unit Response Rate (URR)

The Unit Response Rate (URR) is an indicator of data collection performance for obtaining usable responses. It is defined as the ratio between the number of respondents in a sample (numerator) and total sample size (denominator), expressed as a percentage. Note that the URR is not a direct measure of nonresponse bias. The URR formula can be shown as:

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

According to the guidelines provided by the Office of Management and Budget (OMB), the URR is a required metric, and a nonresponse bias analysis must be conducted if the expected URR of a survey falls below 80%. Further, the standards caution that serious data quality issues related to non-sampling error may occur when the URR falls below 60%.

2.1.1 Initial Unit Response Rate Results

Figure 2.1.1 shows the URR by industry sector for each quarter from 2017q4 to 2019q3. None of the URRs from Figure 2.1.1 for any given quarter meet the 80% standard set by OMB. The yellow highlights mark the instances where the URR falls below 60%. Manufacturing and Retail industries are of particular concern due to their higher number of instances with less than a 60% URR.

The Retail industry has URRs consistently below 60%. Retail typically has a low 4th quarter URR compared to other industries like Manufacturing because months November, December, and January are reported for Retail instead of the traditional October, November, and December of other industries to capture the earnings in the holiday season. The corporations then need to report their financials by late February for their responses to be registered to QFR, and the limited time frame makes a timely response less likely.

Figure 2.1.1: Unit Response Rate (URR) from 2017q4 through 2019q3

Industry Sector	2017 q4	2018q1	2018q2	2018q3	2018q4	2019q1	2019q2	2019q3	Avg
MFG	58.5	59.6	59.9	59.0	56.5	58.5	60.3	57.9	58.8
MIN	63.7	69.1	73.0	69.0	63.1	70.7	70.8	69.1	68.6
WHS	56.5	60.4	60.2	60.0	56.9	59.3	60.5	59.9	59.2
INF	61.6	64.2	66.8	67.5	62.2	64.2	66.4	64.7	64.7
PTS	61.0	64.9	66.1	66.0	59.3	64.5	64.9	55.6	62.8
RET	54.6	56.4	55.5	54.2	54.9	57.7	56.9	56.6	55.9
ALL	58.5	60.4	60.8	60.0	57.1	59.5	61.0	58.6	59.5

Source: QFR survey 2017q4 - 2019q3 https://www.census.gov/econ/qfr/
The yellow highlights indicate that the response rates are below 60%.
MFG = Manufacturing ; MIN = Mining; WHS = Wholesale Trade; INF = Information; PTS = Professional and Technical Services (Except Legal Services); RET = Retail Trade, ALL = All QFR Industries; Avg = Average

2.1.2 Revised Unit Response Rate Results

Response rates discussed in Section 2.1.1 represent *unrevised* initial response rates. This section of the analysis reports URR based on *revised* numbers. QFR publishes an initial unrevised estimate in the current collected quarter, followed by a revision of data for this quarter when each of the next four quarters are published, as additional reporting data for this quarter is also obtained. Receipt of these additional reports after initial publication boosts the URR well above the 60% URR for all industry sectors, although it still remains below the 80% URR OMB threshold. Figure 2.1.2 shows the initial published URR in 2017q4 plus the revised URRs for each of the following four quarters. On average, receipt of delinquent reports improves the overall URR between the initial and final reports by approximately 7%. The biggest gains are observed in Mining (13.0%) and Retail (10.9%). The improvement in Retail Trade is especially welcome given the compressed reporting cycle. Though three industries are below the OMB threshold of 60% response rate in the initial publication (Manufacturing, Wholesale Trade, and Retail Trade); the first revision in 2018q1, shows every sector has received sufficient additional responses for a URR above the more concerning 60% URR OMB cautions can cause serious data quality issues.

Figure 2.1.2: Published and Revised URR from 2017q4 to 2018q4

Industry Sector	Published URR	Revised URRs for 2017q4 in Later Publications				Increase Between Published 2017q4 and Revised 2018q4
	2017q4	2018q1	2018q2	2018q3	2018q4	
MFG	58.5	61.6	63.8	64.4	64.7	6.2%
MIN	63.7	72.1	74.6	75.8	76.7	13.0%
WHS	56.5	60.0	61.8	62.1	62.1	5.6%
INF	61.6	66.4	68.1	68.8	69.1	7.5%
PTS	61.0	66.4	69.0	69.1	69.3	8.3%
RET	54.6	62.1	64.8	65.2	65.5	10.9%
ALL	58.5	62.3	64.5	65.1	65.3	6.8%

Source: QFR survey 2017q4 - 2019q3 https://www.census.gov/econ/qfr/

2.2 Total Quantity Response Rate (TQRR)

The Total Quantity Response Rate (TQRR) is a measure of quality at the item level, and for this analysis, the item in question is assets. Like the URR, it is not a direct measure of nonresponse bias. TQRR is defined as the percentage of the estimated (weighted) total of a key item that is reported directly from respondents or is obtained from a source determined to be of equivalent quality. The TQRR formula can be shown as follows:

$$\hat{p}_{TQRR} = \frac{\sum wgt \times item_{inscoperespondents}}{\sum wgt \times item_{inscopesurvey}}$$

The denominator of the TQRR equation uses both reported and imputed data to calculate the total weighted value of the item. Unlike the URR, these weighted response rates are calculated for individual data items, such as assets, sales, depreciation, etc., so a survey may produce TQRRs for multiple data items for each statistical period. To compute a TQRR for an estimate, the source of the final tabulated value must be determined for each unit and data item combination. This value could be directly obtained from respondent data, indirectly obtained from other equivalent quality data sources, or imputed. For each individual item in the survey, imputed data is treated as a nonresponse whereas reported or equivalent source data is treated as a response. When calculating TQRR for items that could contain a negative value, such as a loss with Net Income Before Taxes (NIBT), the absolute value is applied to the data prior to calculating the weighted estimated total.

2.2.1 Initial Total Quantity Response Rates Results

Figure 2.2.1 shows the TQRR for assets for each quarter from 2017q4 through 2019q3. Overall, the average TQRRs for QFR are greater than 80% except in Wholesale Trade. The Wholesale Trade industry has an average TQRR of 76.6%.

Figure 2.2.1: Initial TQRR for Assets at the Industry Sector Level from 2017q4 through 2019q3

Industry Sector	2017q4	2018q1	2018q2	2018q3	2018q4	2019q1	2019q2	2019q3	Avg
MFG	87.2	87.5	87.1	86.8	86.8	83.5	85.4	85.1	86.2
MIN	91.7	93.1	95.4	93.9	90.7	93.7	91.0	91.1	92.6
WHS	76.9	77.4	79.6	77.7	70.9	74.9	79.8	75.4	76.6
INF	94.9	95.2	96.4	96.7	92.6	92.3	96.3	94.1	94.8
PTS	82.8	84.4	83.9	85.5	79.2	82.4	85.9	77.4	82.7
RET	84.7	79.5	80.1	79.7	83.3	81.6	80.0	79.7	81.1

Source: QFR survey 2017q4 - 2019q3 https://www.census.gov/econ/qfr/

2.2.2 Revised Total Quantity Response Rates Results

Response rates discussed in Section 2.2.1 above represent unrevised initial TQRRs. The analysis also reports *revised* TQRRs. As described above, QFR publishes an initial unrevised estimate in the current quarter followed by a revision in each of the next four quarters. Receipt of delinquent late reports improves the TQRR between the initial and final reports by approximately 5%. Receipt of these additional reports improves the TQRR, boosting it well above the 80% OMB threshold. Figure 2.2.2 shows the revised TQRR for the key item, assets. Only Wholesale Trade had a TQRR below 80% for 2017q4, but every subsequent revision shows improvement for each sector.

Figure 2.2.2: Unrevised and Revised TQRR for Assets from 2017q4 to 2018q3 by Industry Sector

Industry Sector	Published Unrevised TQRR	Revised TQRRs for 2017q4 in Later Publications				Increase Between Published 2017q4 and Revised 2018q4
	2017q4	2018q1	2018q2	2018q3	2018q4	
MFG	87.2	88.5	90.6	91.7	91.8	4.6%
MIN	91.7	95.0	95.7	96.4	96.5	4.8%
WHS	76.9	80.8	82.1	82.4	82.4	5.5%
INF	94.9	97.4	97.4	97.5	97.8	2.9%
PTS	82.8	85.2	88.5	88.5	88.7	5.9%
RET	84.7	91.3	91.7	91.8	91.8	7.1%

Source: QFR survey 2017q4 - 2019q3 https://www.census.gov/econ/qfr/

2.3 Correlation Between QFR Survey and IRS Frame

This analysis compares the assets derived from the frame file provided by the IRS to assets as measured in the QFR survey. The survey assets for both respondents and nonrespondents are compared to the frame assets at the industry level. Nonrespondent values are imputed utilizing previously reported data (if available) and data from current respondents of similar asset size and industry classification (US Census Bureau, 2021). Note, the frame and QFR data are not identical due to timing differences; the frame asset values can be up to three years older than survey assets. A high correlation would suggest that frame and survey assets are analogous and that the nonresponse bias is low.

Because correlation is so sensitive to outliers, the analysis adjusts for them. Any cases where the ratio of QFR reported assets to IRS frame assets is not in the range of 0.2 to 5.0 are labeled as outliers and removed from the analysis (Khatiwoda & Pennington, 2018). Appendix Figure A shows the average Pearson's correlation coefficients based on outlier-adjusted assets for different industries. The industries are labeled with 3-digit North American Industry Classification System (NAICS) codes. Low correlations with coefficients less than 0.6 are highlighted in yellow.

For certainty corporations, only one respondent industry, 323-Printing and Related Support, has a correlation below 0.60. For noncertainty corporations, a small number of industries are below 0.60, but many of these are above 0.50. Noncertainty nonrespondent industries with correlation less than 0.60, but greater than 0.50 include:

- 450-All Other Retail (correlation 0.597)
- 421-Wholesale Durable Goods (correlation 0.576)
- 547-Scientific Research and Development Services (correlation 0.542)
- 448-Clothing and General Merchandise Stores (correlation 0.529)
- 517-Telecommunications (correlation 0.529)
- 545-Computer Systems Design (correlation 0.521)
  512-Motion Picture and Sound Recording Industries (correlation 0.513)

Noncertainty nonrespondent industries with correlation less than 0.50 include:

- 511-Publishing Industries (except Internet) (correlation 0.477)
- 519-All Other Information Services (correlation 0.477)
- 441-Motor Vehicle and Parts Dealers (correlation 0.356)
- 546-Management, Scientific, and Technical Consulting Services (correlation 0.178)
- 515-Broadcasting (except Internet) (correlation 0.070)

The correlation coefficients between the frame assets and the survey assets are greater than 0.6 for most industries which indicates that the QFR survey asset estimates are reflective of the IRS assets. Among certainty industries, only Printing and Related Support Activities (NAICS 323) has a correlation coefficient smaller than 0.6. Based on these results, the certainties appear to have a high correlation between the frame and survey assets, which is expected because certainties are much more likely to respond to the survey due to higher budget and staff who specialize in reporting corporation finances (Khatiwoda & Pennington, 2018). Similarly, noncertainty corporations are much less likely to have the resources to consistently respond to the QFR surveys. Overall, the correlation values for most industries for both certainties and noncertainties are high enough to conclude that QFR survey data and frame data are analogous based on assets.

2.4 Relative Nonresponse Bias

Nonresponse bias is a systematic difference between respondents and nonrespondents. Bias is high if the means of the item in question are very different between the respondents and nonrespondents. Bias is low if the means are approximately equivalent or if the proportion of nonrespondents is low. The bias equation is shown in Section 1.2.

The relative bias is the ratio between the bias and the mean based only on respondent cases. It provides the magnitude of the bias relative to the respondent mean (Seastrom, Kaufman, & Lee, n.d.):

$$Rel\ B(\bar{y}_r) = \frac{B(\bar{y}_r)}{\bar{y}_r}$$

For this analysis, relative biases were calculated for certainty corporations only to avoid potential issues with sampling errors with noncertainty corporations. Smaller noncertainty strata also tend to have lower response rates (Khatiwoda & Pennington, 2018). Relative biases were calculated using QFR survey data. Nonrespondent data were obtained via the QFR imputation methodology, based on data from corporations of similar asset size and industry (US Census Bureau, 2021).

2.4.1 Relative Nonresponse Bias Results

For certainty companies and QFR survey data, relative bias averages greater than 20% were flagged in Appendix Figure B. Please note that while the bias can be negative, the absolute values were taken when calculating the mean to emphasize the magnitude of the bias.
Figure B shows the relative bias of certainty corporations by three-digits NAICS for the key QFR item, assets (item 223). The results from Figure B also indicate that 29 out of 45 (64%) industries have average relative bias greater than 20%. Among these 29 industries, only 10 of them have average relative bias greater than 30%. Industries with average relative bias greater than 30%:

- 448-Clothing and General Merchandise Stores (relative bias 55.29%)
- 512-Motion Picture and Sound Recording Industry (relative bias 47.78%)
- 331-Foundries (relative bias 46.64%)
- 386-Aerospace Products (relative bias 44.04%)
- 545-Computer System Design (relative bias 39.96%)
- 313-Textile Mills and Products (relative bias 34.60%)
- 312-Beverage and Tobacco Products (relative bias 33.72%)
- 519-All Other Information Services (relative bias 33.19%)
- 517-Telecommunications (relative bias 32.72%)
- 450-All Other Retail (relative bias 32.05%)

One might expect industries 448-General Merchandise Stores and 450-All Other Retail, the components of Retail Trade industry, to have higher bias because the Retail Trade Sector has the lowest response rate (URR) among all the other industry sectors. For the other 8 industries with larger bias, it would be worthwhile to examine their imputation methods to confirm that imputed values are neither too large nor too small.

The relative nonresponse bias analysis for certainty corporations shows that most industries do not have a relative bias greater than 30%. With a threshold of 20%, a higher number of industries are listed as having high relative bias. Due to this, industries with relative bias greater than 30% are examined from both the last study (Khatiwoda & Pennington, 2018) and the current study.

2.4.2 Comparison of Relative Bias Between 2018 and 2020

To determine whether industries with high relative bias are consistent over time, the analysis compared the results of the current 2020 nonresponse bias study to the results from the 2018 study. In the 2018 study, 26 out of 46 (57%) industries were found to have relative bias greater than 20% (Khatiwoda & Pennington, 2018). Note that the 2018 study had one additional industry because 316-Leather was included in that study. The Leather industry

was removed from the current 2020 study because it has a small number of certainty corporations.

Figure 2.4.2 shows the industries that had relative bias greater than 30% in 2018 and 2020. When comparing the industries from both studies, the analysis shows that most industries with relative bias greater than 30% are the same in both years. Two new industries had average relative bias over 30% in 2020, but under 30% in 2018. These industries are highlighted in yellow and include 313-Textile Mills and 336-All Other Transportation.

Figure 2.4.2: Industries with Average Relative Bias Greater than 30% in 2018 and 2020

		Relative Bias Greater than 30%	
NAICS	**Description**	**In 2018 Study**	**In 2020 Study**
312	Beverage and Tobacco Products	Yes	Yes
313	Textile Mills and Products	No	Yes
331	Foundries	Yes	Yes
336	All Other Transportation	No	Yes
386	Aerospace Products	Yes	Yes
448	Clothing and General Merchandise Stores	Yes	Yes
450	All Other Retail	Yes	Yes
512	Motion Picture and Sound Recording Industries	Yes	Yes
517	Telecommunications	Yes	Yes
519	All Other Information Services	Yes	Yes
545	Computer Systems Design	Yes	Yes

Source: QFR survey 2015q4 - 2019q3 https://www.census.gov/econ/qfr/
Industries that were flagged in 2020, but not in 2018 are highlighted yellow.

2.5 Mann-Whitney U Test

The Mann-Whitney U Test is used to find a significant difference in population distributions between respondents and nonrespondents for each industry. Since QFR data are not normally distributed, a comparison of distributions requires a nonparametric test like the Mann-Whitney U Test. The test looks for a significant difference in the ranks of two independent samples, or between respondents and nonrespondents when applied to our study. We use weighted assets only for the noncertainty corporations. The test is performed on all the industries for certainty and noncertainty corporations' assets separately (Black, 2013). The Mann-Whitney U formulas are shown below:

$$U_R = n_R n_{NR} + \frac{n_R(n_R+1)}{2} - R_R$$

$$U_{NR} = n_R n_{NR} + \frac{n_R(n_R+1)}{2} - R_{NR}$$

where:

- R_R and R_{NR} = the sums of independent sample ranks, based on assets, for respondents and nonrespondents, respectively
- n_R and n_{NR} = the sample sizes for respondents and nonrespondents, respectively
- U_R and U_{NR} = the test statistics of respondents and nonrespondents, respectively, for the Mann-Whitney U Test

The corporation with largest value of assets among certainties in each industry is rank 1, the second is rank 2, etc. These ranks are summed to get R_R and R_{NR}. The same procedure is followed for noncertainties. The U value that is the smaller of the two is used as the statistic for the test. Generally, the closer the U value is to 0, the less likely it is for the two samples to have a significant difference in distribution. The null and alternative hypotheses for this test are as follows (Gravetter & Wallnau, 2009):

- H_0: There is no difference between the respondents and nonrespondents. There is no tendency for the ranks in respondents to be systematically higher or lower than the ranks in the nonrespondents.
- H_1: There is a difference between the rankings of respondents and nonrespondents.

The results for the Mann-Whitney U Test can be found in Appendix Figures C and D. Most industries have 4 or fewer significant quarters for certainties (64.4%) and noncertainties (73.3%). This study looks at industries with 7 or 8 quarters in which the Mann-Whitney U Test has a significant difference between respondents and nonrespondent. For certainty corporations, industries with 7 or 8 significant quarters on the Mann-Whitney U Test are:

- 211-Oil and Gas Extraction
- 322-Paper
- 333-Machinery
- 386-Aerospace Products
- 421-Wholesale Durable Goods
- 511-Publishing Industry (except Internet)
- 515-Broadcasting (except Internet)
- 545-Computer Systems Design

For noncertainty corporations, industries with 7 or 8 significant quarters on the Mann-Whitney U Test are:

- 421-Wholesale Durable Goods
- 422-Wholesale Nondurable Goods
- 441-Motor Vehicle and Parts Dealers
- 450-All Other Retail
- 511-Publishing Industry (except Internet)
- 517-Telecommunications
- 519-All Other Information Services
- 545-Computer Systems Design
- 549-All Other Professional Services and Technical Services (except Legal Services)

As mentioned in Section 2.4.1, certainty industries 448 and 450, the components of Retail Trade, were expected to show higher bias. Finding that these two certainty industries have significantly different distributions between respondents and nonrespondents would have been expected due to their high relative bias. However, the Mann-Whitney U test does not identify these two certainty industries as having significantly different distributions.

Noncertainty industries 421 and 422, the Wholesale Trade industries, have p-values very close to 0 for all 8 quarters, which is highly unusual. Consistently lower response rates may be a contributing reason for lower p-values. Using 2019q3 as an example, the response rates for industries 421 and 422 are 54.73% and 55.48%, respectively. In other prior

quarters, the response rates remained consistent. For certainty corporations, only industry 421 at 2018q4 has a p-value close to 0. This is because industry 421 has many chronic certainty nonrespondents as explained in the 2018 Nonresponse Bias Study (Khatiwoda & Pennington, 2018).

2.6 R-Indicator

The Representativeness Indicator, or R-Indicator, measures the degree of similarity between the set of respondents and the complete sample (Tourangeau, 2017). The calculation of the R-Indicator depends on the propensity of a unit to respond to the survey. These response propensities are estimated for individual units using predictive models based on auxiliary variables (predictors) available for both respondents and nonrespondents at the time of the survey. Different auxiliary variables may lead to different propensity estimates for the same corporation, so the auxiliary variables must be selected carefully. The R-Indicator is defined by the following formula (Schouten, 2009):

$$\hat{R}(p) = 1 - 2\sqrt{\frac{\sum_{i=1}^{N} \frac{s_i}{\pi_i}(\hat{p}_i - \hat{\bar{p}})^2}{N-1}} \approx 1 - 2 * sd(\hat{p})$$

where:

- $\hat{R}(p)$ → Point Estimate of R-Indicator
- $\hat{\bar{p}}$ → Estimated Average Response Propensity
- $\hat{p}_i$ → Estimated Response Propensity for the i^{th} Corporation in the Population
- N → Population Size
- $\frac{s_i}{\pi_i}$ → Inclusion Weights
- $sd(\hat{p})$ → Estimated Sample Response Propensity Standard Deviation

The R-Indicator ranges from 0 to 1, with 0 being least representative and 1 being most representative of the respondents compared to the complete sample. The indicator measures diversity among individual response probabilities based on the standard deviation of the response propensities. The larger the standard deviation, the lower the R-Indicator and vice versa.

2.6.1 Response Propensity Models

A model to predict response propensities is needed to calculate an accurate R-Indicator. To predict response, four longitudinal predictive models were created with the most recent response being the target variable and prior quarter data used as predictors. This same method could be used to determine the R-Indicator for future quarters as well.

Although the QFR sample contains both certainty and noncertainty corporations, only certainties were included in this research. TQRR values show that the largest weights are derived from the largest corporations.

In addition, multiple quarter timespans were used for this research. The four models built for this study predicted response for a different quarter based on different prior quarter timespans for the training datasets, as shown in Figure 2.6.1. Since the QFR introduces a new sampling frame in the fourth quarter of every year, these models used two different sampling frames: one introduced in 2017q4 (frame 1) and the other introduced in 2018q4 (frame 2). Model 1 predicts response in 2018q1 using prior quarter response (2017q4) and sampling frame 1. Model 2 predicts response in 2018q2 using two prior quarters of response data (2017q4-2018q1) and sampling frame 1. Likewise, Model 3 continues the

same pattern, predicting response for 2018q3 using three prior quarters of response data (2017q4-2018q2) and sampling frame 1. Model 4 predicts response for 2018q4 using four quarters of prior response (2017q4-2018q3.) Due to the timing of the study, Model 4 uses both sampling frame 1 and sampling frame 2.

Figure 2.6.1: Quarters Included in Response Propensity Models

		Quarters for QFR Response				
Model	**Description**	**2017q4**	**2018q1**	**2018q2**	**2018q3**	**2018q4**
Model 1	1-Quarter Prediction	Train	Test			
Model 2	2-Quarter Prediction	Train	Train	Test		
Model 3	3-Quarter Prediction	Train	Train	Train	Test	
Model 4	4-Quarter Prediction	Train	Train	Train	Train	Test

The response rates for these quarters, from 2017q4 through 2018q4, are shown in Figure E. Six auxiliary variables were used to predict response, including:

- State – State listed on the sampling frame.
- Industry – One of six industry sectors, including manufacturing, mining, retail trade, wholesale trade, professional and technical services, and information services. Figure F shows the distribution of the sample by industry.
- Frame receipts –Receipts as shown on the sampling frame.
- Frame assets – Corporate assets as shown on the sampling frame.
- Prior quarter reported assets – Corporate assets reported in the QFR in one of the prior quarter(s). Each of the four models built for this research relied on a different prior quarter response time span, as described in Figure 2.6.1
- Prior response – An indicator showing whether the corporation responded in each of the prior quarters

Initial exploratory analysis revealed that higher frame assets correlated to a higher response (Khatiwoda & Pennington, 2018). This relationship is likely due to larger corporations having more resources and staffing to complete the QFR survey. The values of frame assets were logarithm transformed due to the nature of corporations being right skewed, where there were fewer larger corporations. This data was also normalized between 0 and 1. After these transformations, the frame assets variable was approximately normally distributed. Prior reported assets were more highly correlated to response than frame assets. The transformed variables approximated a normal distribution. Frame receipts were generally correlated to assets, although some businesses had larger receipts than assets. The values of the frame receipts were also log normalized and approximated a normal distribution after transformation.

When frame assets and receipts were not available, missing values were imputed based on known data. Figure G-1 and G-2 show the incidence of missing data within the two sampling frames involved in the research. For this study, Fully Conditional Imputation (FCS) was used, which assumes that data is missing at random. This method is a type of multiple imputation that uses a sequential regression algorithm based on the data available and is useful for combining categorical and continuous data as factors for the model (Liu, 2015). The variables available for predicting missing values included the corporation's state, industry, frame assets, and frame receipts.

For each of the four models, four different algorithms were developed and compared to one another. The first algorithm is a basic logistic regression which predicts a binary variable of response versus nonresponse using the other auxiliary variables. The second algorithm is Bernoulli, which implements a naive Bayes algorithm that is designed to predict a binary outcome, such as response. The third algorithm is Gaussian, which uses a probability distribution of possible functions to predict nonresponse. The fourth algorithm is decision trees which uses branching of auxiliary variables to predict response or nonresponse. All four algorithms used a bagging technique that included both bootstrapping and k-fold cross validation. There were 10 folds and 100 bootstrap samples. This bagging technique reduces the chance of bias of response propensities due to machine learning methods and provides input to calculate confidence intervals.

2.6.2 Comparing Response Propensity Models

To compare models, a baseline measure was calculated for each model. The baseline assumed that the propensity of response was equal to the prior quarter's response rate. For each model, the four algorithms could be compared to the baseline. The root mean squared error (RMSE) provides a metric for comparison, measuring how close the predicted values are to the actual values, with smaller RMSEs indicating a more accurate model. The formula for RMSE is shown below:

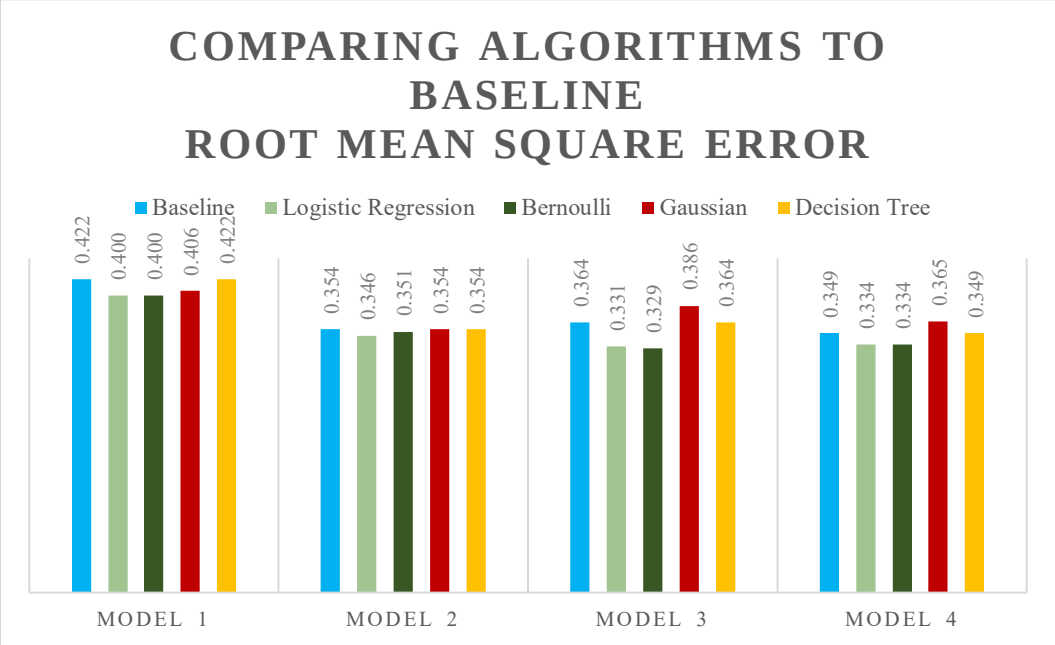
$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(Predicted_i - Actual_i)^2}{n}}$$

where:

- $RMSE \rightarrow$ Root mean squared error
- $n \rightarrow$ Sample size of test set
- $Predicted_i \rightarrow$ Predicted values of test set using algorithm
- $Actual_i \rightarrow$ Known values of test set

The most appropriate algorithm can be selected by comparing its performance to that of the baseline. The algorithms that result in lower RMSE than the baseline are preferable options for selection. Figure 2.6.2 contains a bar graph of the RMSE for the baseline and all four algorithms for each of the four models.

Figure 2.6.2: Comparison of Root Mean Square Error Between Baseline and Different Algorithms



Source: QFR survey 2017q4-2018q4 https://www.census.gov/econ/qfr/

The results show that the logistic regression and Bernoulli algorithms have lower RMSE than the baseline for every model, while the Gaussian and decision tree algorithms have higher RMSE for nearly every model. When comparing the logistic regression and Bernoulli results, it is notable that the RMSE is similar between the two algorithms for all four models individually. Given the similar levels of accuracy, logistic regression would likely be selected for use because it is simpler and more transparent than the Bernoulli machine learning algorithm.

2.6.3 R-Indicator Results

The R-Indicator relies on the predicted response propensities of individual corporations. Using the four algorithms to predict these response propensities for each model yields the R-Indicators and corresponding confidence intervals shown in Figure 2.6.3.

Figure 2.6.3: R-Indicator for the Four Models based on Different Algorithms

Model 1 (17q4-18q1)	R-Indicator	95% CI	RMSE
Baseline	N/A	N/A	0.422
Logistic Regression	0.405	[0.387,0.422]	0.400
Bernoulli	0.406	[0.388,0.424]	0.400
Gaussian	0.190	[0.166,0.214]	0.406
Decision Tree	0.361	[0.342,0.38]	0.422

Model 2 (17q4-18q2)	R-Indicator	95% CI	RMSE
Baseline	N/A	N/A	0.354
Logistic Regression	0.328	[0.308,0.348]	0.346
Bernoulli	0.261	[0.239,0.283]	0.351
Gaussian	0.121	[0.095,0.147]	0.354
Decision Tree	0.286	[0.265,0.308]	0.354

Model 3 (17q4-18q3)	R-Indicator	95% CI	RMSE
Baseline	N/A	N/A	0.364
Logistic Regression	0.305	[0.284,0.326]	0.331
Bernoulli	0.178	[0.153,0.202]	0.329
Gaussian	0.109	[0.083,0.136]	0.386
Decision Tree	0.268	[0.247,0.29]	0.364

Model 4 (17q4-18q4)	R-Indicator	95% CI	RMSE
Baseline	N/A	N/A	0.349
Logistic Regression	0.324	[0.304,0.345]	0.334
Bernoulli	0.167	[0.142,0.192]	0.334
Gaussian	0.110	[0.083,0.137]	0.365
Decision Tree	0.301	[0.28,0.322]	0.349

Source: QFR survey 2017q4-2018q4 https://www.census.gov/econ/qfr/

Since the logistic regression and Bernoulli algorithms performed better than the baseline in terms of RMSE, the analysis will focus on the R-Indicators derived from these two algorithms. The R-Indicators from these algorithms range in value from 0.167 to 0.406 and appear to be lower than other industry studies due to using prior response as an auxiliary variable (Schouten, 2009). These low values suggest potential bias, with respondents being different from the overall sample.

Although the relatively low R-Indicators suggest potential differences between respondents and the overall sample, this may be explained in part by the longitudinal nature of the QFR survey. This is particularly true since these models are only looking at

certainties. The prior response is such a powerful feature in the model that it negatively impacts the final R-Indicator value due to the nature that corporations that respond continue to respond and nonrespondent corporations continue to not respond.

The R-Indicators are rather consistent over time and have narrow confidence intervals. For example, the logistic regression R-Indicators values in Models 2, 3, and 4, range from 0.305 to 0.328 with overlapping confidence intervals of less than 5%. The robustness of this measure suggests that the R-Indicator may be helpful for signaling changes in nonresponse bias over time. By monitoring the R-Indicator, analysts can be alerted to potential problems that require further investigation.

3. Conclusion and Recommendations

While directly measuring nonresponse bias is not practical, the six bias measures in this study suggest that the level of nonresponse bias in QFR is at a manageable level. The OMB provides guidance based on the URR and TQRR levels. The OMB states that if the URR is below 80%, then a nonresponse bias study needs to be conducted. It also states that URR or TQRR below 60% could be indicative of problems with quality. For the QFR, the URR is never above the OMB threshold of 80% for any of the industry sectors, but they are above 60% after a single quarterly revision. It shows that every subsequent revision improves the URR. The TQRR is above 80% for all industry sectors and continues to show improvement with every quarterly revision.

Similarly, additional bias measures show that the overall bias appears to be reasonable. Correlation coefficients between the IRS and frame assets are high among most industries. Among certainties, all industries have average correlation coefficients above 50% while 89% of noncertainties have average correlation coefficients above 50%. Relative nonresponse bias shows that 78% of the industries have relative bias less than 30%. The Mann-Whitney U Test finds that most industries have 4 or fewer quarters where the test was significant. Of the certainties and noncertainties, 64.4% and 73.3% met this criterion respectively.

Although most industry sectors show little evidence for a concerning level of bias, some bias measures in this study highlight potential concerns at the detailed 3-digit industry level. For example, certainty industries 386 and 545 (Aerospace Products and Computer Systems Design) have extreme relative bias (>30%) and 7 or more quarters of significant differences in the Mann-Whitney U Test. However, Aerospace Products may be experiencing high relative bias and significant Mann-Whitney U Tests due to the lower size of its industry based on assets. Computer Systems Design warrants further research as it contains many smaller asset corporations. Its certainty cutoff asset value and imputation methods may be worth investigating. Researching the paradata of the survey response portal could show a pattern that could lead to possible methods on improving response rates, thereby reducing nonresponse bias.

A sixth measure of nonresponse bias analyzed in this study is the R-Indicator. The research suggests that the R-Indicator may not be a good measure to directly measure nonresponse bias for a longitudinal survey like the QFR. However, since the R-Indicators for the QFR tend to be consistent over time, perhaps they could be used for signaling changes in nonresponse bias that could negatively impact the QFR survey results. For example, a change in survey questionnaire could be compared before and after the change and see if there is a statistically significant change in the R-Indicator.

Furthermore, the predictive response propensities built as part of the R-Indicator analysis could be used to prioritize follow-up actions and determine the type of follow-up that is the most effective. For example, it could identify corporations that are the most likely to respond so that resources can be used more efficiently.

To ensure data quality over time, QFR will continue to monitor the six nonresponse bias measures in this study. URR and TQRR measures are calculated and published for every quarter's release, including revisions up to four quarters before the current quarter being released.. Another full nonresponse bias study may be needed if the URR and TQRR provide evidence for concern.

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Appendix

Figure A: Average Pearson's Correlation Coefficients (2017q4 – 2019q3) between Frame and Survey Assets

		Certainty Outlier-Adjusted		Noncertainty Outlier-Adjusted	
NAICS	**Description**	**Respondents**	**Nonrespondents**	**Respondents**	**Nonrespondents**
211	Oil and Gas Extraction	0.869	0.689	0.689	0.367
212	Mining (except oil and gas)	0.872	0.765	0.765	0.195
213	Support Activities for Mining	0.936	0.726	0.726	0.406
311	Food	0.954	0.883	0.883	0.793
312	Beverage and Tobacco Product	0.962	0.961	0.961	0.825
313	Textile Mills and Products	0.981	0.972	0.972	0.883
315	Apparel	0.932	0.976	0.976	0.816
321	Wood Products	0.960	0.951	0.951	0.864
322	Paper	0.918	0.926	0.926	0.748
323	Printing and Related Support	0.512	0.969	0.969	0.904
324	Petroleum and Coal Products	0.889	0.959	0.959	0.805
325	All Other Chemicals	0.965	0.902	0.902	0.752
326	Plastics and Rubber Products	0.892	0.877	0.877	0.802
327	Nonmetallic Minerals	0.943	0.965	0.965	0.820
331	Foundries	0.998	0.968	0.968	0.796
332	Fabricated Metal Products	0.903	0.907	0.907	0.760
333	Machinery	0.937	0.849	0.849	0.792
334	All Other Electronic	0.880	0.834	0.834	0.777
335	Electrical Equipment, Appliances	0.964	0.950	0.950	0.815
336	All Other Transportation	0.972	0.938	0.938	0.752

		Certainty Outlier-Adjusted		Noncertainty Outlier-Adjusted	
NAICS	**Description**	**Respondents**	**Nonrespondents**	**Respondents**	**Nonrespondents**
337	Furniture & Related Products	0.876	0.944	0.944	0.873
339	Miscellaneous Manufacturing	0.804	0.909	0.909	0.825
371	Iron, Steel, & Ferro alloys	0.965	0.953	0.953	0.827
374	Computers & Peripherals	0.890	0.898	0.898	0.803
375	Basic Chemicals	0.880	0.904	0.904	0.778
376	Motor Vehicles & parts	0.953	0.895	0.895	0.751
381	Nonferrous Metals	0.745	0.952	0.952	0.823
384	Communications Equipment	0.974	0.941	0.941	0.855
385	Pharmaceuticals	0.815	0.859	0.859	0.731
386	Aerospace Products	0.923	0.932	0.932	0.833
421	Wholesale Durable Goods	0.782	0.755	0.755	0.576
422	Wholesale Nondurable Goods	0.932	0.833	0.833	0.794
441	Motor Vehicle and parts dealers	0.912	0.817	0.817	0.356
445	Food and Beverage Stores	0.977	0.902	0.902	0.714
448	Clothing and General Merchandise stores	0.997	0.872	0.872	0.529
450	All Other Retail	0.962	0.749	0.749	0.597
511	Publishing Industries (except Internet)	0.695	0.638	0.573	0.477
512	Motion Picture and Sound Recording Industries	0.786	0.691	0.691	0.513
515	Broadcasting (except Internet)	0.931	0.768	0.768	0.070
517	Telecommunications	0.985	0.834	0.834	0.529
519	All Other Information Services	0.878	0.662	0.662	0.477
545	Computer Systems Design	0.973	0.646	0.646	0.521

		Certainty Outlier-Adjusted		Noncertainty Outlier-Adjusted	
NAICS	**Description**	**Respondents**	**Nonrespondents**	**Respondents**	**Nonrespondents**
546	Management, Scientific, and Technical Consulting Services	0.762	0.689	0.689	0.178
547	Scientific Research and Development Services	0.827	0.672	0.672	0.542
549	All Other Professional, Scientific, and Technical Services (except Legal Services)	0.896	0.679	0.679	0.625

Source: QFR survey 2017q4 - 2019q3 https://www.census.gov/econ/qfr/
The yellow highlights indicate that the correlations are below 0.6.

Figure B: Relative Bias Between Certainty Respondents and Nonrespondents of QFR Survey Assets (Item 223), For Eight Quarters from 2017q4 through 2019q3

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Mean	Flag
211	Oil and Gas Extraction	24.61	20.76	21.42	30.83	24.52	14.98	21.40	25.54	23.01	*
212	Mining (except oil and gas)	35.59	-2.94	22.30	31.94	30.35	20.05	19.89	22.84	23.24	*
213	Support Activities for Mining	26.65	21.19	17.03	35.73	19.26	18.93	29.29	54.05	27.77	*
311	Food	15.34	15.32	-5.16	13.84	13.64	7.43	9.20	10.43	11.30	
312	Beverage and Tobacco Product	2.96	-4.45	-7.83	51.34	41.07	43.79	53.75	64.56	33.72	*
313	Textile Mills and Products	42.95	23.74	55.93	45.50	38.17	26.72	13.57	30.25	34.60	*
315	Apparel	12.33	16.73	18.56	31.98	22.38	26.75	22.46	26.27	22.18	*
321	Wood Products	33.54	22.04	19.65	28.48	23.97	25.27	32.10	27.42	26.56	*
322	Paper	31.31	32.25	24.68	28.08	28.31	15.74	31.97	29.22	27.70	*
323	Printing and Related Support	11.13	9.91	13.12	25.08	19.02	18.76	21.22	25.75	18.00	
324	Petroleum and Coal Products	38.59	31.66	27.01	26.10	16.75	23.01	23.08	31.39	27.20	*
325	All Other Chemicals	21.41	17.80	15.69	31.84	28.52	22.84	22.86	32.69	24.21	*
326	Plastics and Rubber Products	24.81	22.90	26.13	50.48	15.53	15.80	23.24	37.88	27.10	*
327	Nonmetallic Minerals	6.93	-0.45	24.22	12.62	2.44	4.70	16.26	7.42	9.38	
331	Foundries	55.22	85.78	120.67	39.45	22.89	18.39	10.54	20.15	46.64	*
332	Fabricated Metal Products	18.75	19.23	24.32	24.28	18.24	15.78	17.93	18.52	19.63	
333	Machinery	28.14	17.55	22.17	25.66	21.42	-0.87	21.06	22.21	19.89	
334	All Other Electronic	35.77	7.97	10.98	14.54	7.66	2.35	5.76	3.61	11.08	
335	Electrical Equipment, Appliances	15.39	12.38	4.71	18.86	7.40	7.14	16.99	21.16	13.00	
336	All Other Transportation	30.86	41.94	34.14	22.92	22.81	22.78	22.11	16.78	26.79	*
337	Furniture & Related Products	-1.35	-4.46	-5.48	3.70	0.33	7.71	6.44	0.22	3.71	

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Mean	Flag
339	Miscellaneous Manufacturing	37.47	24.50	25.70	27.77	23.44	24.62	26.35	22.55	26.55	*
371	Iron, Steel, & Ferro alloys	18.74	18.19	22.09	27.58	18.20	16.46	21.33	17.73	20.04	*
374	Computers & Peripherals	45.85	14.76	14.47	10.48	18.18	10.14	13.90	10.16	17.24	
375	Basic Chemicals	18.38	9.62	11.04	20.78	13.81	10.35	13.25	20.75	14.75	
376	Motor Vehicles & parts	28.77	16.28	19.94	23.38	22.80	15.44	14.67	20.56	20.23	*
381	Nonferrous Metals	36.77	21.46	21.88	22.32	25.26	20.00	8.31	23.34	22.42	*
384	Communications Equipment	77.62	22.82	19.57	23.90	11.63	18.19	20.64	29.34	27.96	*
385	Pharmaceuticals	20.38	19.96	15.08	18.04	13.74	26.49	18.42	15.35	18.43	
386	Aerospace Products	64.05	39.71	33.94	59.29	45.62	33.64	27.32	48.76	44.04	*
421	Wholesale Durable Goods	6.42	10.47	-0.51	-2.23	1.33	6.92	0.29	11.77	4.99	
422	Wholesale Nondurable Goods	26.53	21.21	24.82	21.09	21.90	20.93	20.57	25.63	22.84	*
441	Motor Vehicle and parts dealers	3.01	4.09	3.07	3.71	2.56	3.17	5.32	11.12	4.51	
445	Food and Beverage Stores	1.13	4.32	-1.02	19.54	8.11	-11.69	-6.95	25.46	9.78	
448	Clothing and General Merchandise stores	52.37	54.95	56.50	51.07	59.51	59.97	60.97	46.99	55.29	*
450	All Other Retail	35.23	36.41	31.47	29.20	34.15	29.72	31.43	28.79	32.05	*
511	Publishing Industries (except Internet)	31.31	28.50	20.89	33.10	26.14	22.28	28.89	42.14	29.16	*
512	Motion Picture and Sound Recording Industries	62.65	34.73	19.69	36.68	42.13	51.40	73.53	61.44	47.78	*
515	Broadcasting (except Internet)	18.84	12.04	19.25	26.66	22.42	18.50	19.17	44.44	22.67	*
517	Telecommunications	20.49	30.57	34.33	37.96	40.16	33.70	31.42	33.12	32.72	*

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Mean	Flag
519	All Other Information Services	41.37	25.92	33.31	39.23	29.21	32.98	27.94	35.57	33.19	*
545	Computer Systems Design	57.95	37.19	38.76	40.54	35.60	35.67	36.20	37.79	39.96	*
546	Management, Scientific, and Technical Consulting Services	15.86	6.67	10.39	5.04	16.45	10.99	9.49	14.35	11.16	
547	Scientific Research and Development Services	5.45	2.42	8.25	1.24	11.60	3.54	8.54	7.05	6.01	
549	All Other Professional, Scientific, and Technical Services (except Legal Services)	41.14	31.65	17.63	38.29	23.38	22.63	26.12	30.86	28.96	*

Source: QFR survey 2017q4 - 2019q3 https://www.census.gov/econ/qfr/

Figure C: Mann-Whitney U Test for Certainty Corporations for QFR Survey Assets

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Number Significant
211	Oil and Gas Extraction	0.0004	0.0001	0.0001	0.0000	0.0000	0.0004	0.0006	0.0010	8
212	Mining (except oil and gas)	0.1330	0.2111	0.0578	0.0511	0.0308	0.0570	0.2249	0.2837	1
213	Support Activities for Mining	0.0299	0.0079	0.0360	0.0002	0.0388	0.0566	0.0680	0.0010	6
311	Food	0.0219	0.0047	0.0316	0.2666	0.0552	0.1001	0.0273	0.0157	5
312	Beverage and Tobacco Product	0.6231	0.5510	0.7086	0.2814	0.1213	0.1700	0.0525	0.0873	0
313	Textile Mills and Products	0.1743	0.4304	0.3772	0.2667	0.1743	0.1393	0.3433	0.7431	0
315	Apparel	0.3194	0.1138	0.2515	0.0504	0.1084	0.0749	0.0704	0.0178	1
321	Wood Products	0.0528	0.1057	0.0696	0.3894	0.0361	0.0162	0.0170	0.2694	3
322	Paper	0.0031	0.0006	0.0056	0.0362	0.0032	0.0597	0.0021	0.0026	7
323	Printing and Related Support	0.6713	0.4196	0.3631	0.0414	0.0602	0.1016	0.1740	0.0512	1
324	Petroleum and Coal Products	0.1168	0.2262	0.2156	0.3133	0.2710	0.2037	0.1912	0.0025	1
325	All Other Chemicals	0.1064	0.0526	0.0504	0.0003	0.0002	0.0019	0.0008	0.0013	5
326	Plastics and Rubber Products	0.0124	0.0011	0.0012	0.0000	0.0966	0.0559	0.0014	0.0004	6
327	Nonmetallic Minerals	0.2811	0.3901	0.1212	0.2581	0.2852	0.3118	0.1593	0.3906	0
331	Foundries	0.4556	0.2101	0.4556	0.1715	0.3608	0.8961	0.1637	0.2888	0

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Number Significant
332	Fabricated Metal Products	0.5547	0.0190	0.0040	0.0170	0.0190	0.1113	0.1673	0.0051	5
333	Machinery	0.0116	0.0016	0.0023	0.0001	0.0141	0.1264	0.0296	0.0001	7
334	All Other Electronic	0.0014	0.0504	0.0049	0.0014	0.1001	0.1278	0.1936	0.1589	3
335	Electrical Equipment, Appliances	0.5709	0.1442	0.1947	0.0458	0.6310	0.6896	0.9535	0.7941	1
336	All Other Transportation	0.1952	0.1501	0.1623	0.1551	0.3197	0.1768	0.3197	0.2614	0
337	Furniture & Related Products	0.4410	0.3914	0.3509	0.2582	0.8393	0.4378	0.4936	0.6698	0
339	Miscellaneous Manufacturing	0.1930	0.0010	0.0213	0.1251	0.0231	0.0378	0.2548	0.0847	4
371	Iron, Steel, & Ferro alloys	0.7165	0.1408	0.0812	0.1718	0.1134	0.3199	0.4246	0.2024	0
374	Computers & Peripherals	0.0748	0.1699	0.1350	0.1016	0.0095	0.0703	0.1171	0.0809	1
375	Basic Chemicals	0.9898	0.8678	0.9468	0.4000	0.2594	0.1678	0.3885	0.8966	0
376	Motor Vehicles & parts	0.1197	0.1165	0.0112	0.1646	0.0509	0.0342	0.2040	0.0171	3
381	Nonferrous Metals	0.0401	0.1106	0.2029	0.4623	0.3488	0.6997	0.8079	0.2116	1
384	Communications Equipment	0.1449	0.0371	0.1903	0.0128	0.7640	0.3001	0.3578	0.4606	2
385	Pharmaceuticals	0.0219	0.0109	0.2172	0.1225	0.3889	0.0821	0.0228	0.0629	3
386	Aerospace Products	0.1131	0.0103	0.0499	0.0027	0.0089	0.0499	0.0489	0.0123	7

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Number Significant
421	Wholesale Durable Goods	0.0071	0.0002	0.0097	0.0132	0.0005	0.0002	0.0000	0.0000	8
422	Wholesale Nondurable Goods	0.0218	0.0308	0.1466	0.1971	0.0161	0.0055	0.0045	0.0769	5
441	Motor Vehicle and parts dealers	0.1398	0.0556	0.2646	0.0490	0.1583	0.0787	0.3004	0.1639	1
445	Food and Beverage Stores	0.3768	0.2139	0.2619	0.3462	0.0230	0.7189	0.5676	0.3996	1
448	Clothing and General Merchandise stores	0.3666	0.0759	0.2115	0.4988	0.8483	0.6645	0.0152	0.0513	1
450	All Other Retail	0.7973	0.4647	0.7222	0.8943	0.2873	0.8783	0.4852	0.5056	0
511	Publishing Industries (except Internet)	0.0003	0.0002	0.0013	0.0000	0.0001	0.0033	0.0001	0.0000	8
512	Motion Picture and Sound Recording Industries	0.1031	0.0301	0.1237	0.0832	0.0705	0.0605	0.0011	0.0028	3
515	Broadcasting (except Internet)	0.0338	0.0286	0.0054	0.0500	0.0132	0.0288	0.0048	0.0010	8
517	Telecommunications	0.1142	0.0003	0.0022	0.1147	0.0003	0.0004	0.0140	0.1069	5
519	All Other Information Services	0.2382	0.0442	0.1234	0.0194	0.0015	0.0127	0.0172	0.0250	6
545	Computer Systems Design	0.0003	0.0002	0.0000	0.0006	0.0003	0.0003	0.0001	0.0000	8

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Number Significant
546	Management, Scientific, and Technical Consulting Services	0.0167	0.0509	0.0504	0.3968	0.0961	0.2755	0.2267	0.0118	2
547	Scientific Research and Development Services	0.1831	0.2857	0.2548	0.6315	0.0075	0.3611	0.1520	0.0143	2
549	All Other Professional, Scientific, and Technical Services (except Legal Services)	0.1424	0.0111	0.0050	0.0007	0.2450	0.2765	0.1653	0.1113	3

Source: QFR survey 2017q4 - 2019q3 https://www.census.gov/econ/qfr/
The yellow highlights indicate that the p-values are less than 0.05.

Figure D: Mann-Whitney U Test for Noncertainty Corporations for QFR Survey Assets (Weighted)

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Number Significant
211	Oil and Gas Extraction	0.2001	0.0184	0.0534	0.0393	0.0041	0.0026	0.0805	0.3001	4
212	Mining (except oil and gas)	0.0434	0.1522	0.3583	0.3010	0.0065	0.0035	0.0031	0.1832	4
213	Support Activities for Mining	0.7651	0.4924	0.6029	1.0000	0.0411	0.3650	0.1495	0.0256	2
311	Food	0.5274	0.2677	0.7206	0.4238	0.2162	0.7674	0.6539	0.1867	0
312	Beverage and Tobacco Product	0.4177	0.4795	0.3619	0.5362	0.7149	0.2711	0.4736	0.9585	0
313	Textile Mills and Products	0.5579	0.3724	0.1906	0.5425	0.6558	0.8365	0.0168	0.9439	1
315	Apparel	0.4197	0.9578	0.6375	0.9711	0.4151	0.4934	0.3052	0.5428	0
321	Wood Products	0.0826	0.7672	0.3664	0.1651	0.1917	0.0949	0.0243	0.0419	2
322	Paper	0.8765	0.0311	0.1347	0.0457	0.2795	0.0651	0.0241	0.3377	3
323	Printing and Related Support	0.0035	0.0091	0.0908	0.0177	0.0619	0.0271	0.1415	0.2535	4
324	Petroleum and Coal Products	0.1505	0.3519	0.5160	0.9786	0.5920	0.8200	0.2687	0.9216	0
325	All Other Chemicals	0.9297	0.7642	0.2696	0.7645	0.4809	0.3959	0.2833	0.0346	1
326	Plastics and Rubber Products	0.0212	0.2550	0.1128	0.1141	0.2964	0.5427	0.7976	0.0282	2
327	Nonmetallic Minerals	0.0035	0.0226	0.0844	0.0378	0.1872	0.4318	0.7510	0.1615	3
331	Foundries	1.0000	0.9870	0.6613	0.8784	0.2699	0.0540	0.2440	0.2298	0

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Number Significant
332	Fabricated Metal Products	0.1369	0.2643	0.1130	0.0502	0.0074	0.0130	0.0125	0.0029	4
333	Machinery	0.3460	0.0076	0.2346	0.0388	0.8917	0.9211	0.3608	0.0471	3
334	All Other Electronic	0.7290	0.8169	0.8938	0.5581	0.9212	0.6103	0.8100	0.9962	0
335	Electrical Equipment, Appliances	0.5715	0.9090	0.6401	0.1125	0.4437	0.6192	0.4612	0.7284	0
336	All Other Transportation	0.2180	0.1550	0.2901	0.3021	0.1595	0.2686	0.7784	0.1477	0
337	Furniture & Related Products	0.0442	0.2066	0.8033	0.5468	0.9345	0.1288	0.7316	0.7632	1
339	Miscellaneous Manufacturing	0.4618	0.5066	0.3212	0.0227	0.4955	0.4993	0.4169	0.5713	1
371	Iron, Steel, & Ferro alloys	0.3453	0.4968	0.4510	0.7368	0.1754	0.0821	0.1387	0.4313	0
374	Computers & Peripherals	0.2960	0.3617	0.1528	0.1534	0.0326	0.4736	0.5100	0.3940	1
375	Basic Chemicals	0.6350	0.4199	0.3767	0.9180	0.9849	0.4472	0.3554	0.7809	0
376	Motor Vehicles & parts	0.8175	0.2010	0.9228	0.2427	0.1678	0.5778	0.2073	0.9804	0
381	Nonferrous Metals	0.1780	0.4924	0.1351	0.0294	0.0127	0.0298	0.9559	0.2914	3
384	Communications Equipment	0.9425	0.3348	0.7256	0.5771	0.1341	0.8879	0.0801	0.3364	0
385	Pharmaceuticals	0.0820	0.0074	0.0904	0.1944	0.0428	0.0095	0.0065	0.0473	5
386	Aerospace Products	0.5721	0.0129	0.2374	0.1511	1.0000	0.0713	0.1732	0.7873	1

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Number Significant
421	Wholesale Durable Goods	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	8
422	Wholesale Nondurable Goods	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	8
441	Motor Vehicle and parts dealers	0.0001	0.0241	0.1379	0.0068	0.0212	0.0493	0.0343	0.0000	7
445	Food and Beverage Stores	0.0634	0.0090	0.2704	0.7280	0.4822	0.8196	0.9699	0.5587	1
448	Clothing and General Merchandise stores	0.0311	0.0364	0.0093	0.1241	0.0699	0.0818	0.0278	0.0029	5
450	All Other Retail	0.0000	0.0029	0.0027	0.0006	0.0027	0.0262	0.0000	0.0001	8
511	Publishing Industries (except Internet)	0.0002	0.0000	0.0001	0.0001	0.0001	0.0185	0.0296	0.0004	8
512	Motion Picture and Sound Recording Industries	0.3776	0.0435	0.5494	0.5228	0.3502	0.5613	0.2159	0.3314	1
515	Broadcasting (except Internet)	0.1702	0.1199	0.2343	0.1727	0.5325	1.0000	0.1886	0.8799	0
517	Telecom-munications	0.0334	0.0001	0.0011	0.0013	0.0007	0.0000	0.0042	0.0003	8
519	All Other Information Services	0.0082	0.0004	0.0081	0.0065	0.0124	0.0185	0.0003	0.0139	8

NAICS	Description	2019q3	2019q2	2019q1	2018q4	2018q3	2018q2	2018q1	2017q4	Number Significant
545	Computer Systems Design	0.0048	0.0001	0.0000	0.0184	0.0019	0.0000	0.0000	0.0001	8
546	Management, Scientific, and Technical Consulting Services	0.1709	0.6981	0.1510	0.2436	0.0901	0.3347	0.0646	0.0795	0
547	Scientific Research and Development Services	0.0024	0.1276	0.0519	0.0678	0.0022	0.0002	0.0001	0.0012	5
549	All Other Professional, Scientific, and Technical Services (except Legal Services)	0.0000	0.0000	0.0000	0.0004	0.0022	0.0104	0.0046	0.0365	8

Source: QFR survey 2017q4 - 2019q3 https://www.census.gov/econ/qfr/
The yellow highlights indicate that the p-values are less than 0.05.

Figure E: Response Rates for Certainty Corporations by Quarter

Response Rates

Year/Quarter	Frequency Nonresponse	Percent Nonresponse	Frequency Response	Percent Response
2017q4	1000	28.57%	2500	71.43%
2018q1	950	27.54%	2500	72.46%
2018q2	900	25.71%	2600	74.29%
2018q3	1000	28.57%	2500	71.43%
2018q4	1100	31.43%	2400	68.57%

Source: QFR survey 2017q4-2018q4 https://www.census.gov/econ/qfr/

Figure F: 2018q4 Sampling Frame Frequencies of Certainty Corporations by Industry

Industry	Frequency	Percent
INF	350	10.00%
MFG	1800	51.43%
MIN	200	5.71%
PTS	350	10.00%
RET	300	8.57%
WHS	500	14.29%

Source: QFR survey 2018q4-2019q3 https://www.census.gov/econ/qfr/

Figure G: Imputation Base for Sampling Frames

Figure G-1: Imputation Base for 2017q3-2018q3 Sampling Frame

Imputation Base

Industry	State	Log Frame Receipts	Log Frame Assets	Frequency	Percent
X	X	X	X	3,144	86.28%
X	X	X	N/A	26	0.71%
X	X	N/A	X	403	11.06%
X	X	N/A	N/A	71	1.95%

Source: QFR survey 2017q3-2018q3 https://www.census.gov/econ/qfr/

Figure G-2: Imputation Base for the 2018q3-2019q3 Sampling Frame

Imputation Base

Industry	State	Log Frame Receipts	Log Frame Assets	Frequency	Percent
X	X	X	X	3.040	86.86%
X	X	X	N/A	17	0.49%
X	X	N/A	X	390	11.14%
X	X	N/A	N/A	53	1.51%

Source: QFR survey 2018q3 - 2019q3 https://www.census.gov/econ/qfr/