Sample Improvement for the Quarterly Financial Report

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Abstract
Since 1947, the Quarterly Financial Report (QFR) has collected and published quarterly aggregate statistics on the financial results and position of U.S. corporations. The QFR is based on a stratified simple random sample. Historically, noncertainty and certainty sample stratum boundaries have been fixed and tied directly to publication tables. Because of economic growth over time, the fixed boundaries resulted in ever-increasing unsustainable sample sizes referred to as sample creep. Using simulation and other techniques, QFR staff researched a multi-pronged approach to tackle creep and improve the sample. The approach included evaluation of the smallest corporations, introduction of a new noncertainty stratum, introduction of a dynamic method to reevaluate and adjust the certainty boundary on a regular basis, and other techniques.

1. Overview of Quarterly Financial Report (QFR) Survey

The QFR, a principal economic indicator providing comprehensive and timely financial data, is 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 (MFG) corporations, and corporations in mining (MIN), wholesale trade (WHS), retail trade (RET), professional technical services (PTS), and information and technology services (INF) by industry and asset size.

Each year, QFR statistical methodologists build a sampling frame using corporate income tax returns stratified by industry classification, size of total assets, and gross receipts prior to sampling. 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 and canvassed every quarter. We select simple random samples from eligible noncertainty 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 noncertainty panel is in the survey for eight successive quarters. Each quarter, one noncertainty panel rotates out and a new panel rotates into the sample. This means that the noncertainty 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.

Congress enacted the Paperwork Reduction Act of 1995 to reduce reporting burden of small corporations. In implementation, 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. Corporations with assets greater than $250 million are not subject to time-in / time-out constraints by law.

The QFR collects accounting items via three industry-specific survey forms laid out in a traditional financial statement format. Each form has three interrelated sections that must balance. Although many survey edit functions are mechanized, forms submitted by complex corporations often require hands-on attention by Census Bureau accountants.

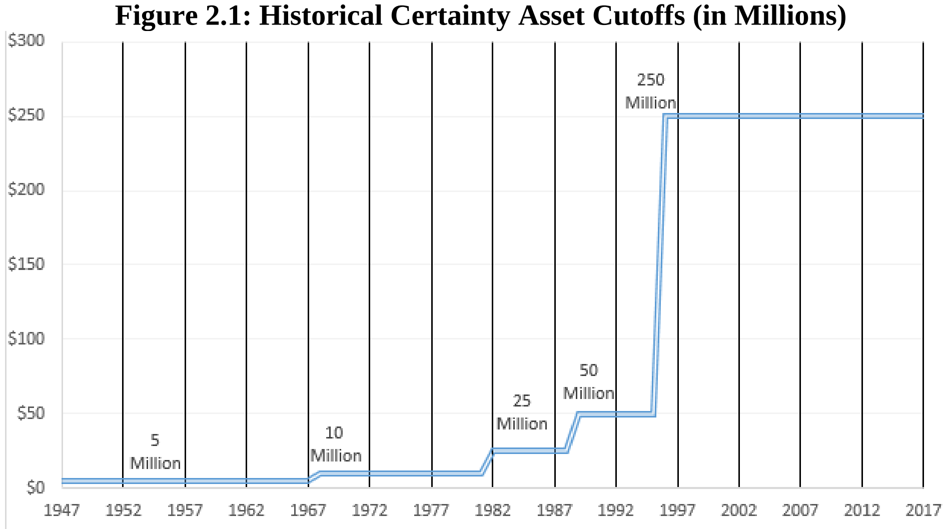
Typically, QFR data users are most interested in making comparisons between the same data item published at different points in time, such as quarter-to-quarter or year-to-year comparisons.

2. Introduction

Historically, the QFR noncertainty and certainty sample stratum boundaries have been tied directly to fixed publication tables. Because of economic growth and inflationary pressures over time, the fixed boundaries resulted in unsustainable sample size increases or 'sample creep'. From 2010Q4 to 2015Q4, the number of active corporations in the sample increased by 2,033. Noncertainty corporations in the sample increased by 1,472 and certainty corporations increased by 561.

Figure 2.1 demonstrates how budgetary constraints and changes in the economy have precipitated changes to the certainty cutoffs over the years. In 1981Q4, the certainty asset cutoff increased from $10 million to $25 million. During 1988Q4, the certainty asset cutoff increased from $25 million to $50 million. The last certainty asset cutoff increase occurred in 1995Q4 from $50 million to $250 million. The QFR was overdue for an adjustment.

Figure 2.1: Historical Certainty Asset Cutoffs (in Millions)

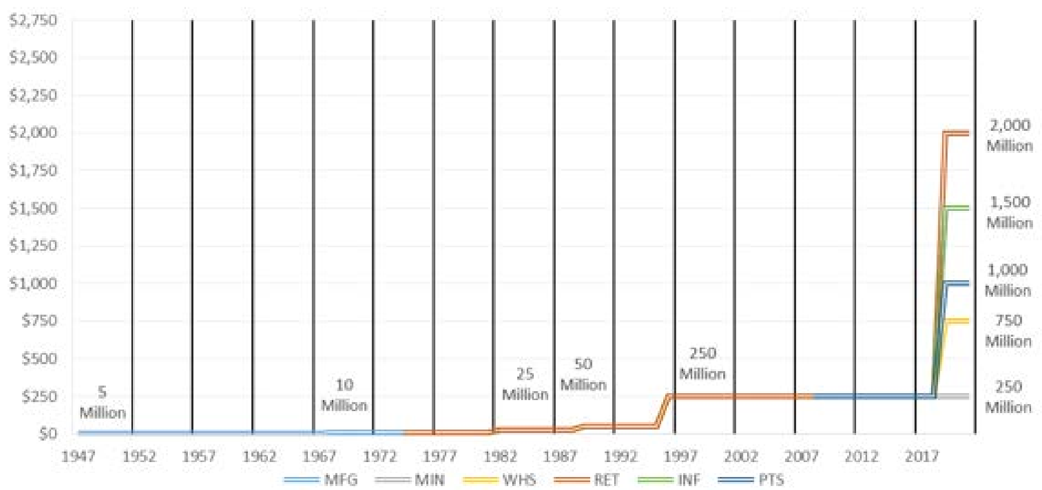


Data based on the QFR survey over time: https://www.census.gov/econ/qfr/

In 2016, the QFR statistical methodologists developed a multi-phased plan to improve the sample, control sample growth, and reduce respondent burden. Beginning with sample year 2016, QFR reduced the noncertainty sample size to a maximum of 5,000 corporations from the 5,253 corporations selected in sample year 2015. The noncertainty stratum reduction did not solve the sample growth in the certainty stratum because the asset size of the certainty stratum has no upper limit.

In sample year 2019, QFR increased the legacy certainty threshold (cutoff) of $250 million for all industry sectors to a new dynamic, sector-specific cutoff. The new certainty cutoffs were determined using the Glasser Method, described in Section 3. The right side of Figure 2.2 demonstrates the variation in the industry sector cutoffs. These cutoffs will be evaluated annually beginning in 2020 and updated periodically as needed. Note that some industry groups within some sectors are selected with certainty and are not subject to the new dynamic certainty cutoffs. These certainties are referred as predetermined certainties. The topic of why some industry groups are selected as predetermined certainties is discussed in Section 4.

Figure 2.2: 2019 Industry Sector Specific Certainty Cutoffs (in Millions)



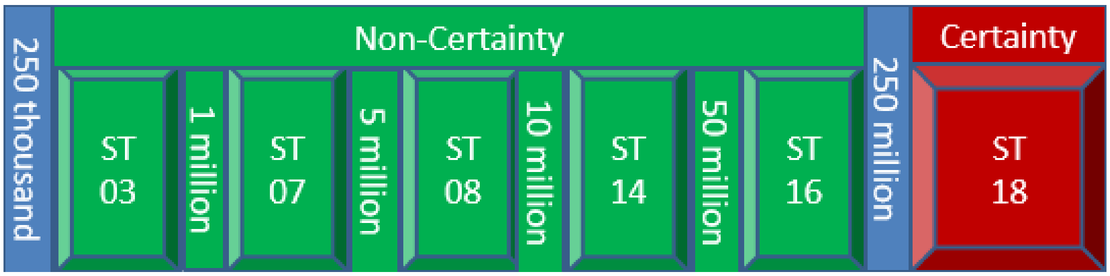
Data based on the QFR survey over time, including the Glasser Cutoffs: https://www.census.gov/econ/qfr/

*Manufacturing (MFG), Mining (MIN), Wholesale (WHS), Retail (RET), Information and Technical Services (INF), and Professional and Technical Services (PTS). MFG and INF sectors share the Glasser Cutoff of $1,500 million.

In sample year 2019 (first implemented in 2019Q4), QFR also introduced a new noncertainty stratum 17. Figure 2.3 illustrates the legacy noncertainty (green) and certainty (red) strata and respective cutoff values. As demonstrated in Figure 2.5, stratum 17 (purple) is carved from the legacy certainty stratum 18. Newly sampled stratum 17 corporations will be in the sample for 2 years and will rotate out (not eligible) for 1 year. After 1 year out of sample, there is a chance a corporation could be sampled again. A new stratum allows for a reduction in sample size while maintaining the quality of the estimates. This topic is discussed in detail in Section 3.

Historically, budgetary constraints and consideration for burden have driven decisions to update survey scope or coverage. QFR's coverage was last updated 1987Q1, removing companies with less than $250,000 in assets. During the sample improvement process, the QFR methodologists considered the response burden of the smallest corporations by researching the impact of smallest corporations (strata 03 and 07 whose assets are less than $5 million) on the final industry level estimates. Research confirmed a minimal impact to the estimates for most industries, allowing for the exclusion of corporations with assets below $5 million from sample coverage as shown in Figure 2.4. The topic of sample coverage is discussed in greater detail in Section 5: Consideration of Response Burden for Small Corporations.

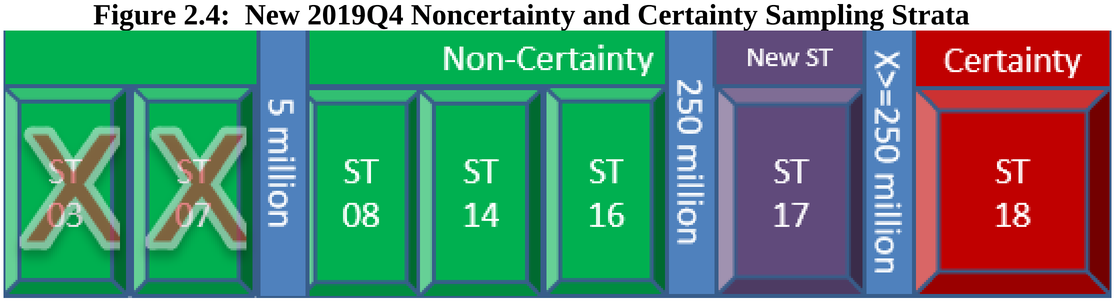
Figure 2.3: Legacy (Prior to 2019Q4) Noncertainty and Certainty Sampling Strata



Noncertainty Strata 03, 07, 08, and 14 represent the Manufacturing Sector

Data based on the QFR survey: https://www.census.gov/econ/qfr/ and Glasser Cutoffs

Figure 2.4: New 2019Q4 Noncertainty and Certainty Sampling Strata



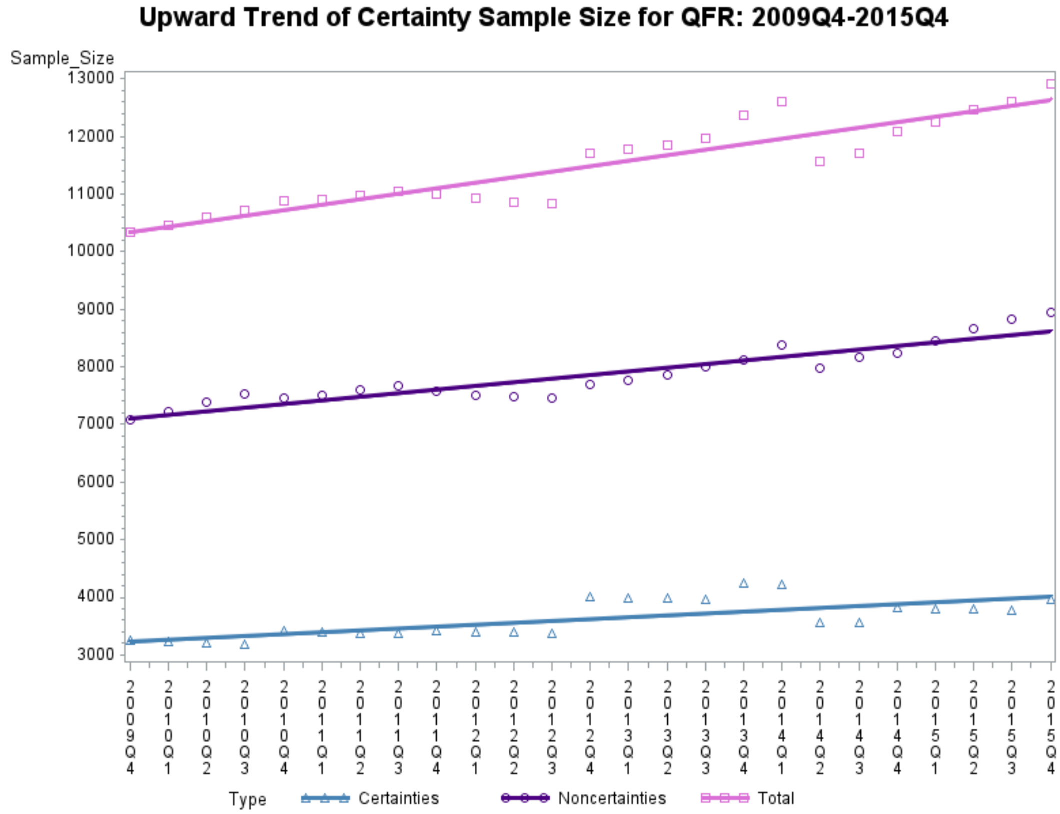
Noncertainty strata 03, 07, 08, and 14 represent the Manufacturing Sector

Data based on the QFR survey: https://www.census.gov/econ/qfr/ and Glasser Cutoffs

3. Developing the Certainty Boundaries

A major adjustment was needed for the ever increasing sample size of the certainty stratum 18. The number of corporations had become larger over time as the economy and inflation continued to increase. Figure 3.1 demonstrates the unsustainable upward trend of the overall sample size shown in pink from 2009Q4 to 2015Q4. The certainty component is displayed in light blue.

Figure 3.1: Upward Certainty Sample Size Trend



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

Past revisions to certainty boundaries were made globally, without regard to industry sector. A single fixed cutoff is problematic because the QFR covers a very broad spectrum of industries. Because industries have disparate asset sizes, certainty cutoffs that vary by industry sector would be ideal. QFR data is also skewed, especially in the largest strata, since the largest corporations disproportionately contribute to the estimates. The Glasser (1962) method for determining a certainty cutoff works well for skewed populations, when auxiliary data are available for all units in the sampling frame. According to Dr. Glasser a skewed population, a right skew for QFR, can lead to unequal strata. This type of skewness is represented by large dispersion of a few corporations that should be sampled with certainty. Glasser notes that these extreme values greatly affect the population variance which adversely impacts the reliability of the sample estimates. The cutoff represents the lowest point at which some improvement over unrestricted random selection is guaranteed. Thus an optimum was created.

It is desirable to vary the certainty cutoffs across sample years and industry sectors due to the differences in the distributions of the underlying sector populations. Stratum 16 was the largest legacy noncertainty stratum and stratum 18 was the legacy certainty stratum (as shown in Figure 2.3). Legacy strata 16 and 18 will become strata 16, 17, and 18 (as shown in Figure 2.4) after implementing the industry specific cutoffs. The smaller noncertainty strata (03, 07, 08, and 14) pertain to the manufacturing sector and were under review for possible elimination from survey scope (see Section 5), hence these strata were not included in the analysis. QFR's population size (N) is the known count of in-scope corporations from the sampling frame for legacy strata 16 and 18. The QFR (and most surveys) have a limit on how many cases can be sampled and this sample size is unknown.

Applying the Glasser method by industry and accounting for the predetermined certainty, our certainty cutoff by industry can be stated as

$$G_{IND_{YEAR}} = \mu_{npre} + \theta\sqrt{\frac{N}{n}} \quad (1)$$

$G_{IND_{YEAR}}$ = Asset certainty cutoff for a particular industry sector and sample year - anything above this is selected with certainty

μ_{npre} = Population mean of frame assets in strata 16 and 18, excluding predetermined certainties

θ = Population standard deviation of frame assets for strata 16 and 18

N = Population size - number of corporations in strata 16 and 18

n = Sample size - number of corporations mailed a survey form in strata 16 and 18

However, this formula cannot directly be used due to the fact that n is assumed to be an unknown exogenous variable. So one must rearrange (1) to be ready to apply the central limit theorem:

$$G_{IND_{YEAR}} = \mu_{npre} + \sqrt{N}\frac{\theta}{\sqrt{n}} \quad (2)$$

Since we will have a "sufficiently large sample size" (approximately n > 30), then using the central limit theorem one can make two assumptions:

a) $\bar{x} = \mu$
b) $\theta_{\bar{x}} = \frac{\theta}{\sqrt{n}}$

The most important and reliable auxiliary variable for QFR is corporate assets used to calculate $\bar{x}$ and $\theta_{\bar{x}}$ as shown below:

- $\bar{x}$ = Sample mean of assets – average sample assets for corporations in strata 16 and 18
- $\theta_{\bar{x}}$ = Sample standard deviation – extent of variability of sample assets for corporations in strata 16 and 18

We can now plug b) into (2):

$$G_{IND_{YEAR}} = \mu_{npre} + \sqrt{N} * \theta_{\bar{x}} \quad (3)$$

It is important that we have our equation in terms of the coefficient of variation (CV), which would be exogenous and user chosen, so we do not exceed an amount of sample error. So multiply $\theta_{\bar{x}}$ in (3) by the identity $\frac{\bar{x}}{\bar{x}}$ and plugging in $CV_{\bar{x}}$:

$$G_{IND_{YEAR}} = \mu_{npre} + \sqrt{N} * \frac{\theta_{\bar{x}}}{\bar{x}} * \bar{x} \quad (4)$$

$$G_{IND_{YEAR}} = \mu_{npre} + \sqrt{N} * CV_{\bar{x}} * \bar{x} \quad (5)$$

- $CV_{\bar{x}}$ = Coefficient of variation or $\frac{\theta_{\bar{x}}}{\bar{x}}$ represents the extent of variability in our sample in relation to the mean of the sample where $0 \leq CV < U$ where U is the upper bound of CV

Since $\bar{x}$ is not defined, we substitute a) into (5) and account for this upper bound determining the coefficient of variation ($CV_{\bar{x}}$) as well as a fraction of desired certainties (*fr*) discussed later:

$$G_{IND_{YEAR}} = \mu_{npre} + \sqrt{N} * CV_{\bar{x}}(fr, U) * \mu \quad (6)$$

Finally, after removing the predetermined certainties, $\mu_{npre} = \mu$, the final equation is.

$$G_{IND_{YEAR}} = \mu + \sqrt{N} * CV_{\bar{x}}(fr, U) * \mu \quad (7)$$

We calculated the cutoffs $G_{IND_{YEAR}}$ for sample years 2014 to 2016 and then averaged them to obtain more consistent cutoffs.

There are some benefits for using the Glasser method. The Glasser method can be used even when the underlying data is changing across time. Because asset values are increasing due to factors like inflation, acquisitions, and economic growth, the certainty cutoffs should change over time to reflect the continued drift. Additionally, future decisions will need to be made regarding the addition of new noncertainty strata. One could reapply the Glasser method to determine the new cutoffs with the possibility of the old cutoff being defined as the boundary for a new noncertainty stratum. The values of the Glasser method are exact and predictable. The resulting cutoffs may be rounded for easier interpretation by the subject matter or survey staff. One must continue to make new cutoffs over time if the drift continues.

The key target variable to change is the *fr*. This variable is derived from the generic Glasser formula and represents a small percentage of the population comprised of the most important corporations, while many other surveys use a fixed sample size. Costs are unknown so these are not optimized. Instead, the cutoff is exogenously determined by *fr* and optimized dependent on population mean, standard deviation, and sampling interval where *fr* is based on subject matter experience with the population (Glasser, 1962).

This formula is useful for determining the cutoff of any skewed survey. The main reason behind this the flexibility of the cutoff ($G_{IND_{YEAR}}$). The main variable that can change is the desired fraction of certainties (*fr*), which changes the coefficient of variation ($CV_{\bar{x}}$). This fraction is used as a key input to determine an acceptable $CV_{\bar{x}}$. The *fr* is very much dependent on a rough estimate of how many cases in the sample are assigned as certainties. The more cases that go into the *fr* will usually lower the $CV_{\bar{x}}$. If our *fr* is too large, our total sample size (*n*) increases. Conversely, if our *fr* is too small, we may miss important corporations. There is not an exact science to determine *fr*, much like the significance cutoff for a p-value. Next, we test an exceeding large level of variation, but we also want to be under a coefficient of variation limit. One must test a different *fr* and average this value across the selected set of sample years. This process is repeated for each industry sector and averaged across those sample years. Essentially, we want to obtain this *fr* without $CV_{\bar{x}}$ being exceeded. If the *fr* exceeds the $CV_{\bar{x}}$, we need to either increase the *fr*, accept a higher $CV_{\bar{x}}$, or come up with a fixed value to choose the certainty cutoff. A fixed value could be the mean or median of a specific key variable or it could be a fixed number that would increase over time. If the fr is reached, survey processing costs are reduced. This is because this optimum value will include fewer sampled corporations and still have an acceptable level of variation, where fewer sampled corporations requires a smaller budget to obtain the same level of precision.

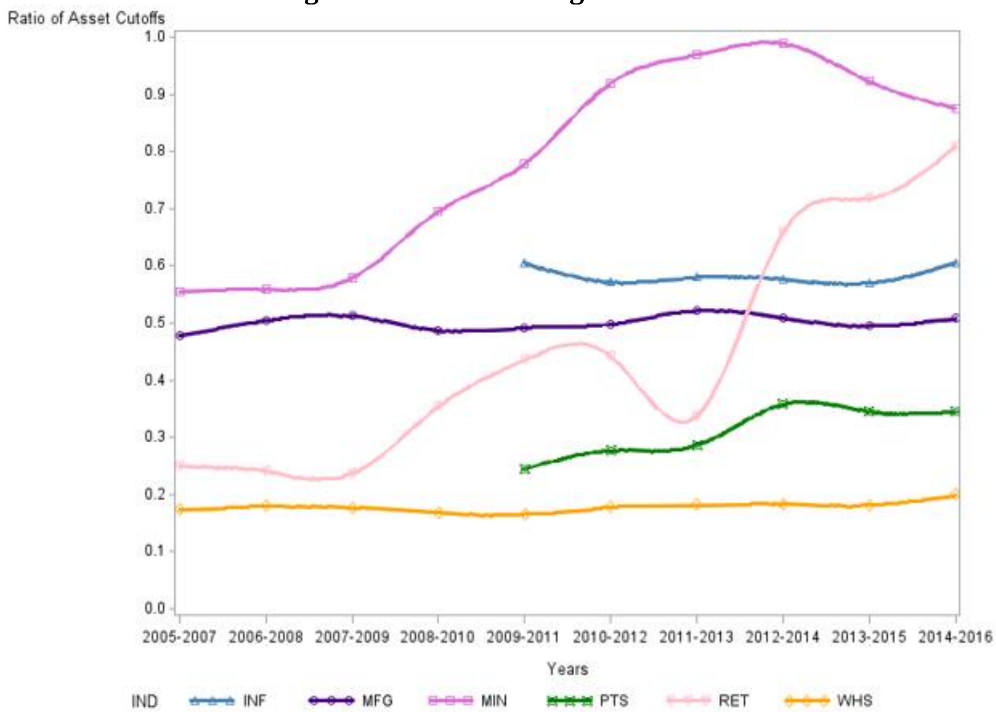
Based upon QFR subject matter expertise and based upon a realistic accountant workload, a good starting point for the fr is to target about 10% of corporations as certainties, though this number should change over time depending upon skew and population size. A larger skew requires a larger fr while a larger population size requires a smaller fr. In this example, we want to be under the upper limit of the $CV_{\bar{x}}$, sampling no more than 1 out of 10 certainty corporations.

To demonstrate, suppose we would like to calculate the Glasser cutoffs using ten years of QFR data. First, determine an acceptable $CV_{\bar{x}}$ such as 5%. Next, determine a value for fr, say 10%. Increase fr by small increments (e.g. 0.0025%) until the 10% fr is met to allow the acceptable $CV_{\bar{x}}$ to remain below 5%. If the fr is not reached, increase the fr to an acceptable percentage. For example, perhaps increase fr to 12% or find a fixed cutoff. Increasing the fr will usually lead to a lower certainty cutoff. If the fr is not reached, but the desired CV is reached first, then one would use a fr of less than 10% for a given industry. For a longitudinal survey such as QFR, one can average a series of data points, say 3 years in an annual survey frame, to make the cutoffs more consistent across time.

For the QFR, the ideal fr of 10% occurs about 44.44% of the time while the other 55.56% of the time QFR used the average value of the sampled assets as the cutoff value. As more and more corporations get added to the sample frame with large assets in the certainty group, this fr can be adjusted as well, and this will affect the cutoffs.

Figure 3.2 demonstrates the theoretical cutoff change over time for the QFR for an average of three years. Some industry sectors were not surveyed until the QFR expanded into the services sectors in 2009Q4. In Figure 3.2, we see a clear trend in retail cutoffs becoming larger and more skewed (light pink) and a tapering off in large mining corporations (dark pink) recently. The other industries are fairly consistent over time. These trends could always change in the future, but it is also clear that industry specific cutoffs are very important.

Figure 3.2 Cutoff Change Over Time



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

*Manufacturing (MFG), Mining (MIN), Wholesale (WHS), Retail (RET), Information and Technical Services (INF), and Professional and Technical Services (PTS)

4. Simulation

The sample size for industry h is determined by Neyman allocation or the following equation:

$$n_h = n * \frac{N_h * S_h}{\sum_i (N_i * S_i)}$$

- n = the total sample size for all stratum 17 industries
- N_h = the population size for industry h
- S_h = the standard deviation of reported assets for industry h.

Thus, sample size is allocated to industries proportional to industry population size and industry standard deviation (Khan and Sehar and Ahsan, 2005).

In order to determine the effect on the estimates and confidence intervals of the reduced sample that included the introduction of a new stratum 17 whose certainty cutoff varied by sector, we conducted a simulation study using data from quarters 2016Q2, 2016Q3, and 2016Q4. We selected one simple random sample for each stratum 17 dataset by quarter. We repeated this process 300 times, selecting 300 unique samples, and created a replicate based on each sample by simulating sample rotation, reimputing the non-respondent cases based on sample draw, calculating aggregated estimates of respondents and reimputed nonrespondents, calculating the relative difference between the replicate aggregate estimates and the population aggregate estimates, and calculating the relative standard error.

The simulation program also averaged all the replicate aggregate estimated differences for a given quarter, and created one large dataset containing all quarters' replicate averages of five key QFR items: total assets, sales, depreciation, net income before tax, and inventories.

As shown in Table 4.1, 19 of the 46 industries were assigned as certainty (i.e. n_h=N_h) industries during the simulation, because they had small populations, large variances, or large differences in estimates between the original production and reduced sample estimates. Corporations in stratum 17 certainty industries are considered to be predetermined certainties and are assigned a sample weight of 1, and treated as a traditional stratum 18 certainty.

Table 4.1: Stratum 17 Certainty Industries (Includes Rationale)

QFR Industry Recode	Description
Large Sample Variance	
211	**Oil and gas extraction**
212	**Mining, except oil and gas**
213	**Support activities for mining**
Large Difference in Estimates	
325	**All other chemicals**
326	**Plastics and rubber products**
327	**Nonmetallic mineral products**
381	**Nonferrous metals**
545	**Computer systems design and related services**
546	**Management and technical consulting services**
547	**Scientific research and development services**
Small Universe Size	
313	**Textile Mills**
315	**Apparel and leather products**
316	**Leather**
321	**Wood products**
323	**Printing**
331	**Foundries**
336	**Transportation equipment**
337	**Furniture**
371	**Iron, steel, and ferroalloys**

The QFR industry description is based on 2012 three-digit North American Industry Classification System (NAICS) codes and survey-specific recodes

After we determined the stratum 17 certainty industries, the next step was to calculate the fixed sample size of stratum 17 noncertainty industries for the QFR annual sample draw (four panels, one for each quarter). Table 4.2 gives the counts of three statistical periods in the simulation study:

Table 4.2: Counts for 2016Q2, 2016Q3 and 2016Q4 of Stratum 17

Statistical Period	Stratum 17 Certainty Industries Only		Final Fixed Sample Size (not including stratum 17 certainty industries)	Total Overall Sample Size (including stratum 17 certainty industries)
2016q4	686	+	1,123	1,809
2016q3	690	+	1,137	1,827
2016q2	696	+	1,153	1,849
3 qtr average	**690**	**+**	**1,138**	**1,828**

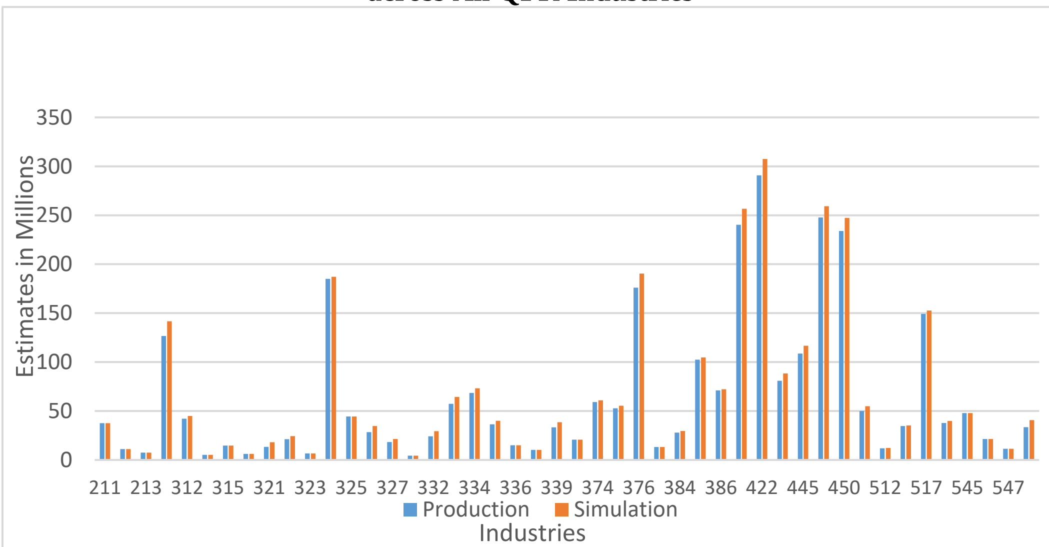
Data based on the QFR survey: https://www.census.gov/econ/qfr/ and Glasser Cutoff

QFR analysts reviewed the selected sample cases and made deletions and adjustments after the annual sample draw. Approximately 86% of the sample cases are retained in the production sample. Here we note the average sample size for the stratum 17 noncertainty industries (excluding the stratum 17 certainty industries shown in Table 4.1) in the production sample is 1,138. After incorporating the expected the retention rate, we selected approximately 1,324 (1,138/.86) corporations in the full sample (eight panels). The half sample (four panels) for new stratum 17 will contain 662 (1,324/.50) corporations.

We compared the estimates obtained from the simulation studies to production (published) estimates for a given quarter. For example, we compared the simulated estimates from 2016Q4 data values with the published production values for that quarter.

The graph in Figure 4.1 below shows the average simulated sales compared to the published production sales value for each QFR industry for 2016Q4. For most of the industries, the simulated estimates were larger than the production estimates, due to the weight added to the new stratum and sampling variations. We have similar graphs or results for the other key items: depreciation, inventories, and net income before tax. The relative standard error of the simulated estimates across all industries was small, less than 5%, with the exception of the item *income (loss) after income taxes* because it is derived from many items.

Figure 4.1: Comparison of Simulated and Production Estimates of Sales in 2016Q4 across All QFR Industries



Data based on the QFR survey: https://www.census.gov/econ/qfr/ and the simulation study

5. Consideration of Response Burden for Small Corporations

QFR made previous adjustments to the sample coverage to reduce the reporting burden of small corporations and meet changing budget constraints as shown in Table 5.1.

Table 5.1: Historical Changes to Sample Coverage of Noncertainties

Statistical Period	Change
1977Q3	From the third quarter 1977 through the fourth quarter 1986, the strata including very small manufacturing firms (those with assets less than $250,000) and all newly incorporated manufacturers were estimated using multivariate techniques. QFR stopped publishing the under $1 million breakout for manufacturing corporations.
1987Q1	In 1987Q1, QFR corporations with assets below $250,000 were excluded entirely and not estimated for.

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

In order to update sample coverage, QFR staff reviewed the smallest manufacturing noncertainty strata (03, 07, 08, and 14) for possible elimination and determined the impact of removing strata 08 and 14 ($5 million to less than $50 million) would have too great an effect on the estimates (greater than 20% in some industries). However, staff determined the impact of removing strata 03 and 07 (under $5 billion) was nominal. We researched the impact on the final estimates for key QFR items (sales, depreciation, assets, and net income before tax) for six quarters 2016Q4 through 2018Q1.

Impact is calculated as the percentage representation of small strata over the final estimates of all strata by industry sector. For example, the impact of strata 03 and 07 on the final estimates of industry sector Apparel and Leather (ANL) is calculated as:

$$impact = \frac{sum\ of\ estimates\ from\ strata\ 3\ and\ 7}{sum\ of\ estimates\ from\ all\ strata} * 100$$

Table 5.2 below shows the impact of asset size strata under $5 million on the final estimates for the item sales by industry sector. This table reveals that the impact is minimal. Similar results follow for the other key items: depreciation, net income before tax, and assets.

Table 5.2: Impact of Strata 03 and 07 on the Final Sales Estimates at the Industry Sector Level (Percent)

IND	2018Q1	2017Q4	2017Q3	2017Q2	2017Q1	2016Q4	MEAN
Item 101 (Sales)							
ANL	2.83	2.22	3.01	3.60	3.45	3.87	**3.16**
CHE	1.04	1.01	1.08	1.05	0.95	1.00	**1.02**
COM	1.63	2.01	1.80	1.88	1.75	1.59	**1.78**
DUR	4.72	4.56	4.93	5.01	4.89	4.73	**4.81**
NDU	1.96	1.97	2.14	2.13	2.08	2.20	**2.08**
PRI	2.11	1.91	2.14	2.22	2.68	2.04	**2.18**
TRA	0.78	0.78	0.63	0.78	0.75	0.56	**0.71**

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

*ANL = Apparel and Leather products, CHE = chemicals, COM = Computer and Electronic Products, DUR = Durable Manufacturing, NDUR = All Nondurable Manufacturing, PRI = Primary Metals, and TRA = Transportation Equipment

Industries dominated by very large corporations, such as petroleum manufacturing, pharmaceutical manufacturing, beverage and tobacco manufacturing, and computer equipment manufacturing had very little impact when the smallest two strata were removed. Industries with fewer large corporations, such as printing manufacturing and fabricated metals had a larger impact when the smallest strata were removed. QFR staff determined that the impact of updating sample coverage by increasing the asset level for inclusion of manufacturing corporations from $250,000 to $5 million through the removal of strata 03 and 07 would be small.

6. Results

In Section 4, we used simulation to research the addition of a new noncertainty stratum 17 created from the corporations residing on the lower end of the legacy certainty stratum 18. The Glasser method in Section 3 was employed to develop a sector specific dynamic cutoff between the new noncertainty stratum 17 and certainty stratum 18. The Glasser cutoffs resulted in a higher certainty cutoff for all sectors resulting in a reduction of 1,382 certainties between 2018q4 and 2019q4 (offset by an increase of 973 noncertainties) for a net reduction of 409 certainty corporations.

In Section 5, we researched updating sample coverage by increasing the asset level of inclusion for manufacturing corporations from $250,000 to $5 million. After removing the smallest manufacturing strata in 2019Q4, the overall manufacturing unit response rate increased to 60.5%, as shown in Table 6.1. The removal of strata 03 and 07 also reduced the sample size by 2,246 corporations between 2018Q4 and 2019Q4.

Table 6.1 Unit Response Rates for Manufacturing

Industry	Unit Response Rate (URR)		
	2018Q4	2019Q3	2019Q4
All manufacturing	56.5%	57.9%	60.5%

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

Table 6.2 presents the overall reduction in sample size from both sample improvements between 2018Q4 and 2019Q4 by sector. Table 6.3 shows the overall reduction in sample size from one year ago by certainty class.

Table 6.2: Sample Reductions by Industry Sector

Sector	2018Q4 Legacy Sample Size Includes Strata 03 and 07	2019Q4 New Reduced Sample Size Excludes Strata 03 and 07 Includes Stratum 17	Difference
MFG	7,631	5,147	-2,484
MIN	287	287	0
WHS	1,271	1,195	-76
RET	619	550	-69
INF	606	510	-96
PTS	705	775	+70
TOTAL	**11,119**	**8,464**	**-2,655**

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

Table 6.3: Sample Reductions by Certainty and Noncertainty

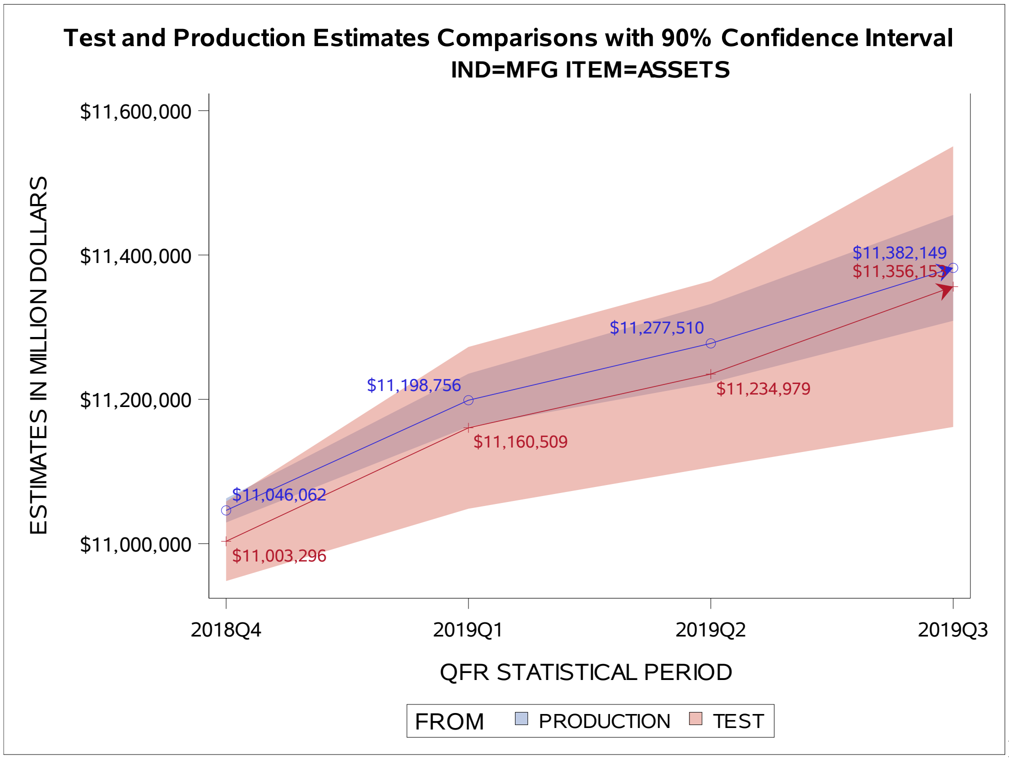
Certainty Class	2018Q4 Legacy Sample Includes Strata 03 and 07	2019Q4 New Reduced Sample Size Excludes Strata 03 and 07 Includes Stratum 17	Difference
Certainty	3,533	2,151	-1,382
Noncertainty	7,586	6,313	-1,273
TOTAL	**11,119**	**8,464**	**-2,655**

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

Figure 6.1 shows the difference between the manufacturing production (published) estimates (blue) and the test estimates (red) for quarters 2018Q4 through 2019Q3. It is important to note that the manufacturing production estimates include strata 03 and 07. The test estimates incorporate the new stratum 17 but do not include strata 03 and 07. The removal of strata 03 and 07 from the manufacturing sector results in a slightly lower test estimate when compared to production. The graph also depicts the confidence band of the estimates at the 90% confidence level. The light blue shaded portion of the graph is the confidence band for the production estimates. The light pink shaded portion is the confidence band around the test estimates. The graph reveals that the standard error for the test estimates is higher than that of production estimates. The addition of noncertainty strata 17 introduced more sampling variation. Other key items sales, depreciation, inventories, and NIBT show similar changes for manufacturing industries.

The differences between production and test estimates for other industry sectors mining (MIN), wholesale trade (WHS), retail trade (RET), professional and technical services except legal services (PTS), and information (INF) are minimal as compared to those of manufacturing industry.

Figure 6.1: Comparison between the Published Manufacturing Production Estimates (Blue) and the Test Estimates (Red)



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

7. Conclusion

Historically, noncertainty and certainty sample stratum boundaries for QFR have been fixed and tied directly to publication tables. Because of the economic growth and inflation over time, the fixed boundaries resulted in sample creep and escalating costs associated with conducting the survey. Each sampled corporation has a cost associated with it in terms of data collection, processing, review of tabulated data, publication, equipment, overhead, printing, mailing, support staff, etc. Additionally, there is a burden cost for each company responding to the survey.

Using a simulation and other techniques, we developed a multi-pronged approach to tackle sample creep and associated costs. The approach included evaluation of the smallest corporations, introduction of a new noncertainty strata, and use of the dynamic Glasser method to reevaluate and adjust the certainty boundary by industry sector at regular intervals. The techniques employed updated sample coverage, reduced sample size, controlled future sample growth, and reduced the respondent burden of the smallest corporations while maintaining the overall quality and precision of the estimates. The updated sampling methods reduced the number of corporations sampled by 2,655 between 2018Q4 and 2019Q4.

Beginning with sample year 2019 (2019Q4), we updated the QFR sample coverage by increasing the asset level of inclusion for manufacturing corporations from $250,000 to $5 million. The change in coverage had very little impact on industries dominated by very large corporations, such as petroleum manufacturing, pharmaceutical manufacturing, beverage and tobacco manufacturing, and computer equipment manufacturing. Larger differences were noticed in industries without as many large corporations, such as printing manufacturing and fabricated metals. On average, we observed less than a 10% change in overall estimates. The removal of strata 03 and 07 reduced the sample size by 2,246 corporations between 2018Q4 and 2019Q4.

During this same quarter, QFR introduced a new noncertainty stratum 17 and increased the certainty cutoff to sector specific dynamic cutoffs. These changes were necessary because the cutoffs for selecting sampling units with certainty were last modified in 1995Q4. Because of its ability to generate cutoffs for skewed economic data, the Glasser method was employed, resulting in a higher certainty cutoff for all sectors and allowing the number of certainties to be reduced by 1,382 between 2018Q4 and 2019Q4 (offset by an increase of 973 noncertainties) for a net reduction of 409 certainties. Roughly half of the sectors have an optimal cutoff value within a 5% level of coefficient of variation. This will reduce costs and still give reliable estimates.

The Glasser method is not without weaknesses. The Glasser method is optimal for surveys with available prior period data. The Glasser method also may not work within an acceptable level of variation, so it is up to the survey methodologist to accept a higher level of variation or a nonoptimal fixed cutoff.

Updates to sampling methodology may cause a change or shift in the estimates and this was true for QFR. To preserve quarter-to-quarter and year-to-year comparisons for our data users, we restated the four prior quarters (2019Q3 to 2018Q4) when we released the estimates for 2019Q4. The sample updates resulted in the overall reduction of the sample between 2018Q4 and 2019Q4 by 2,655 corporations, a significant savings for tax payers.

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