

Examining Effects of Nonresponse on Survey Data Quality for Surveys of Retail Trade

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Disclaimer: Any views expressed are those of the authors and not necessarily those of the U.S. Census Bureau.

Abstract

In this research, we investigate the relationship between nonresponse and data quality to provide nonresponse bias information relevant to operations in retail trade surveys. We 1) develop objective, comparable data quality metrics to consistently assess the impact of nonresponse on data quality, 2) establish a functional relationship between response rates and data quality measurement, and 3) evaluate the sensitivity of key estimates to changes in response rates. Further, we will apply a machine learning algorithm to estimate monthly data for nonresponse and to reduce the labor required for implementing imputation. The resulting product will inform survey response improvement targets.

Background

Advance Monthly Retail Trade Survey (MARTS) is conducted to produce early national estimates of total and month-to-month relative change in broad based retail trade activity in the United States. The MARTS estimates, as an economic indicator, are widely used and closely watched throughout government, academic, and business communities.

The MARTS is a company-level survey with a target population of retail and food service establishments. Of the 4,900 units selected for the sample, approximately 1,500 have a selection probability of 1.0000. Response to the survey is voluntary. Estimates are summarized by industry classification based on the North American Industry Classification System (NAICS).

The MARTS sample is a sub-sample of the 12,000-unit sample used for the Monthly Retail Trade Survey (MRTS), which provides later and more complete estimates of monthly retail sales as well as estimates of end-of-month inventories. MARTS level estimates are computed using a ratio of current-to-previous month weighted sales using data from responding units for both months, multiplied by the preliminary sales estimate for the previous month derived from the MRTS.

Definition

Unit Response Rate (URR)

The unit response rate is defined as the ratio of responding units (numerator) to the sum of eligible units and units of unknown eligibilities (denominator), expressed as a percentage.

Link Relative Estimator

MARTS uses a link-relative estimator

$$\hat{x}_{t-1} * \frac{\sum_{i \in C} x_t}{\sum_{i \in C} x_{t-1}}$$

Where

i = a tabulation unit

\hat{x}_{t-1} = the previous month's estimate from MRTS

C = the set of tabulation units used in the screened-sum ratio with comparable data between the current and previous months

x_t = the weighted sales of the i^{th} tabulation unit for the current month

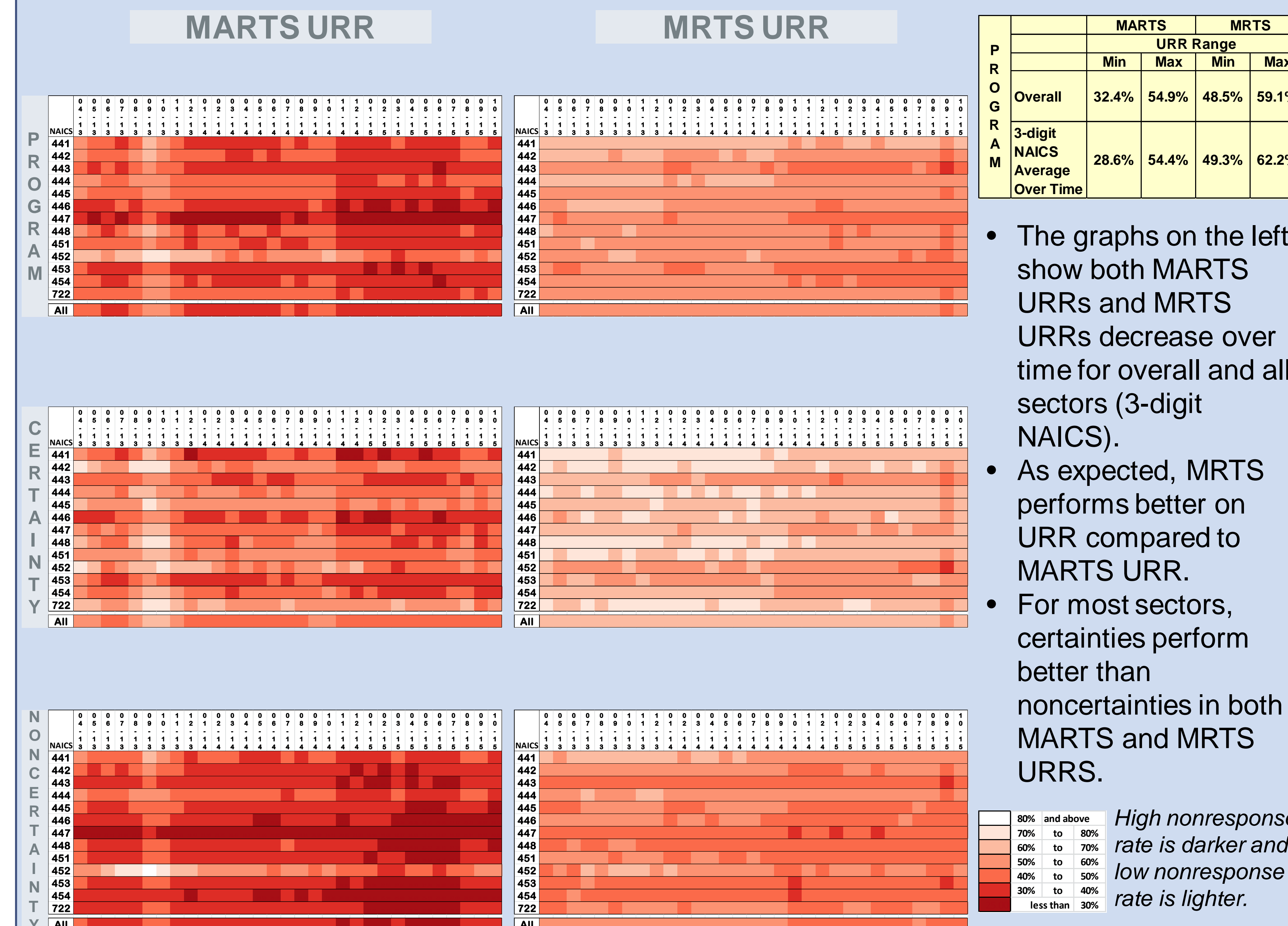
x_{t-1} = the weighted sales of the i^{th} tabulation unit for the previous month

The link-relative estimator is used to estimate the MARTS detailed NAICS levels. Aggregate NAICS estimates are the sum of their associated detailed link-relative estimates.

Analysis Results

Our analysis is conducted using the MARTS and the MRTS data from April 2013 to October 2015. The reason for using data from April 2013 is to include only samples from the current sample design in the analysis to reduce unknown sources of bias. The quality of MARTS estimates is tied to the quality of the MRTS estimates through the link-relative estimator. We do not have ground truth to anchor our analysis. We assume that MRTS estimates are more accurate than MARTS estimates, Annual Retail Trade Survey (ARTS) estimates are more accurate than the MRTS estimates, and the Economic Census estimates are more accurate than the ARTS estimates.

1. MARTS and MRTS nonresponse rate analysis

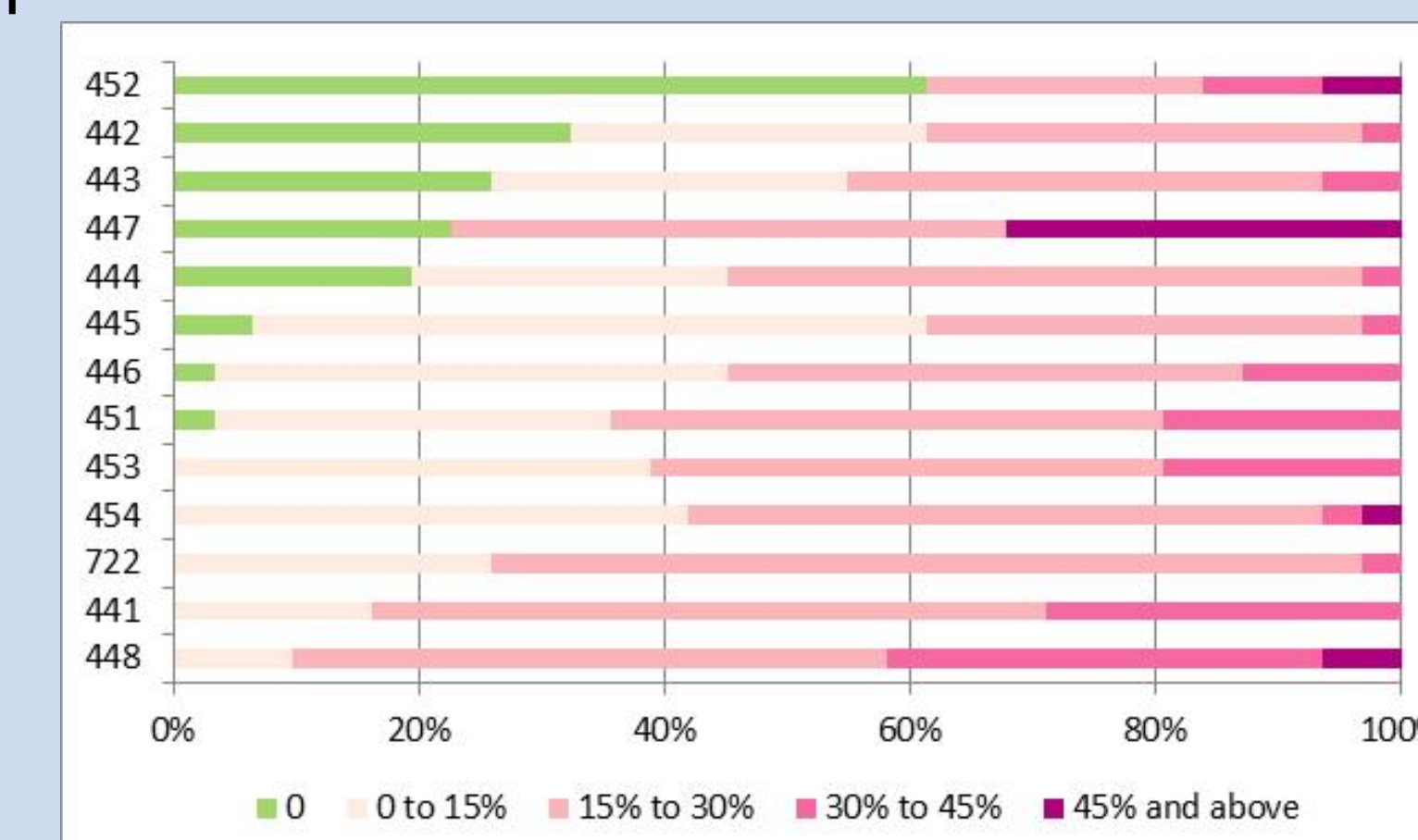


- The graphs on the left show both MARTS URRs and MRTS URRs decrease over time for overall and all sectors (3-digit NAICS).
- As expected, MRTS performs better on URR compared to MARTS URR.
- For most sectors, certainties perform better than noncertainties in both MARTS and MRTS URRs.

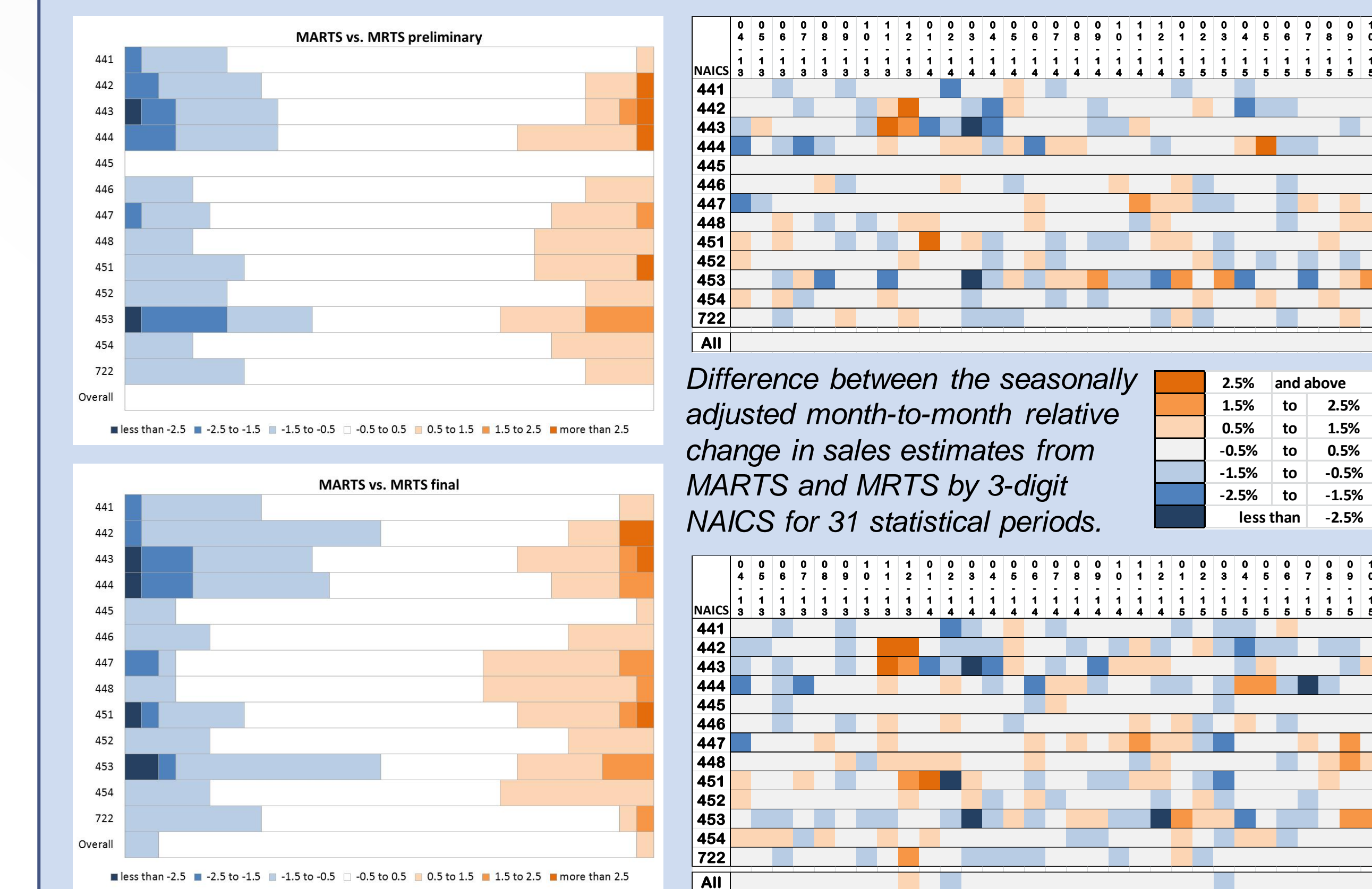
High nonresponse rate is darker and low nonresponse rate is lighter.

2. MRTS nonresponse bias analysis

- The underlying assumption for MRTS imputation is that response data are missing at random with minor missingness within imputation cells, which are based on industry and size.
- The bottom graph on the right summarizes the t-test results comparing means of 2009 annualized sales (as a measure of size) between respondents and nonrespondents within each imputation cell for MRTS sales.
- The colors represent the percent imputation cells with significant difference between respondents and nonrespondents. The percentage in the x-axis is the frequency of percent imputation cells with significant difference between respondents and nonrespondents, across a total of 31 statistical periods.
- Higher percentage shows more difference between respondents and nonrespondents, meaning the potential of missing at random is less.

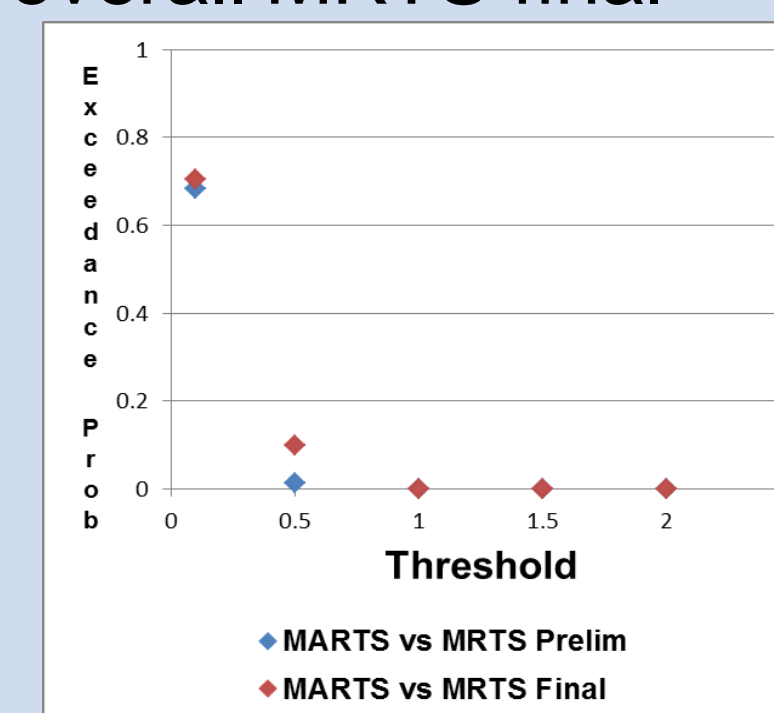


3. Analysis of revisions in month-to-month relative change in sales estimates



Difference between the seasonally adjusted month-to-month relative change in sales estimates from MARTS and MRTS by 3-digit NAICS for 31 statistical periods.

- The difference between overall MARTS and overall MRTS preliminary estimates is within $\pm 0.5\%$ over time.
- The difference between overall MARTS and overall MRTS final estimates is mostly within $\pm 0.5\%$ over time, except for three statistical periods.
- Overall, the likelihood that the revisions between overall MARTS estimates and Overall MRTS final estimates exceed 0.1% change is about 70%, exceed 0.5% change is about 10%.



Conclusion

- Based on our analysis, the sources of nonresponse bias in MARTS estimates are from:
 - Low MARTS URR - nonresponse bias is a function of response rates.
 - Fluctuation of MRTS response status for certainty companies – the population and samples for estimates of total sales are very skewed.
 - Default on MRTS imputation assumption that the response data are missing at random with minor missingness within imputation cells.
- The revisions in month-to-month relative change in sales estimates comparing MARTS to MRTS are not statistically significantly different, despite that MARTS URRs are noticeably lower than MRTS URRs.
- Depending on how month-to-month relative change in sales estimates are used, the magnitude of the revisions may or may not be a concern.

Future Direction

- Conduct an imputation/weighting study for MRTS.
- Investigate response improvement strategies for MARTS and MRTS to effectively increase data quality, e.g. targeting, outreach...etc.
- Stabilize imputation for certainty companies utilizing machine learning algorithm or other model-based methods.
- Study the relationship between MARTS, MRTS and ARTS estimates to understand how benchmarking influences data quality.
- Study how revisions in month-to-month relative change in sales estimates comparing MARTS to MRTS affect data users.