MEASURING THE EFFECT OF EARLY REPORTING ON RESPONSE ERRORS IN AN ECONOMIC SURVEY

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1. Introduction

Respondents sometimes commit errors when answering survey questions. The methodological literature on surveys of individuals and households identifies response errors that vary by the length of the recall period (telescoping and recall decay), depend on the salience associated with or frequency of an event occurring in a respondent's life, and change with self versus proxy reports. Many of the theories evolving out of this extensive literature have been derived by examining the response process of persons answering household surveys.

However, it has been suggested that the response process followed by respondents in business surveys differs from that followed by respondents in household surveys (Edwards & Cantor, 1991; Dutka & Frankel, 1991). Specifically, business survey respondents frequently make greater use of records or record information systems than do respondents in household surveys. This difference can alter the sources and causes of respondent error.

When examining errors of record retrieval in business surveys, Edwards and Cantor (1991) mention the importance of the timing of record look-up by a respondent. They explain that the optimal time for a business to provide data may not coincide with the time that the survey designers need the data to meet their users' needs for timely results. As Biemer and Fecso (1995) note, the timeliness of published results is of utmost importance for many business surveys. The results are frequently used by economic statistics agencies, such as the Bureau of Labor Statistics and the Bureau of Economic Analysis, to make policy decisions and by corporations for assessment of current earnings and for planning.

In this paper, we will attempt to examine the respondent error that is due to the relationship between the time when accurate records are available from a business and the time of the survey request, or, the error due to "early reporting." To do this, we will use monthly sales data collected in two U.S. Bureau of the Census surveys of the retail trade industry.

Previous studies on the error due to early reporting (see Section 4) indicate that the more time respondents are given to provide monthly sales data, the more accurate the data. In addition, these same studies conclude that when respondents are not given enough time to obtain accurate monthly sales data, they tend to provide an *underestimate* of the business' true monthly sales data.

In section 2, we compare monthly estimates of retail trade produced by the two Census Bureau surveys. Section 3 contains a description of the sampling, data collection, and estimation procedures for each of these surveys. Section 4 reviews previous research conducted on the effect early reporting has on a business' report of monthly sales data. In Section 5 we discuss our response error model. We present and interpret our results and draw conclusions based on our findings in Sections 6-8. The final section highlights areas of future research.

2. Monthly Estimates of Retail Trade

The Census Bureau's Services Division conducts two sample surveys of retail businesses each month. Out of these two surveys come three different estimates of total retail sales for the same reference month (the month about which the business is reporting data). These three estimates are produced using data collected at different time periods following the end of the reference month.

Nine working days after the end of the reference month, estimates of total retail sales for the United States are released using data collected in the Advance Monthly Retail Trade Survey (MARTS). Approximately one month later, a revision to the MARTS estimates is released using data collected in the larger Monthly Retail Trade Survey (MRTS). A second revision to the MARTS estimates is released another month after the first revision, using additional data collected in the MRTS. These three different estimates of total retail sales are frequently referred to as the *Advance*, *Preliminary*, and *Final* estimates, respectively.

Similarly, three different estimates of current month (CM) to previous month (PM) change in total sales are produced. The three current-to-previous-month change estimates are computed as ratios of the following current and previous month estimated sales totals: the CM Advance to PM Preliminary, the CM Preliminary to PM Final, and the CM Final to PM Final.

Figure 1 provides a comparison of seasonally adjusted Advance and Preliminary estimates with the Final estimates for automotive dealers for August, 1994, through July, 1995. Ideally, the Advance and Preliminary estimates would be equal to the Final estimate for each reference month, and the three estimates would fall on the same line (the dashed line in Figure 1). In practice, however, we might expect the Advance and Preliminary estimates to be randomly scattered on either side of this

ideal line with the Advance estimates exhibiting greater variability than the Preliminary estimates. (The Advance estimates are produced from a much smaller sample than the Preliminary or Final estimates.) Instead, the Advance estimates frequently fall below the dashed line and, as expected, are often farther from the dashed line than the Preliminary estimates.

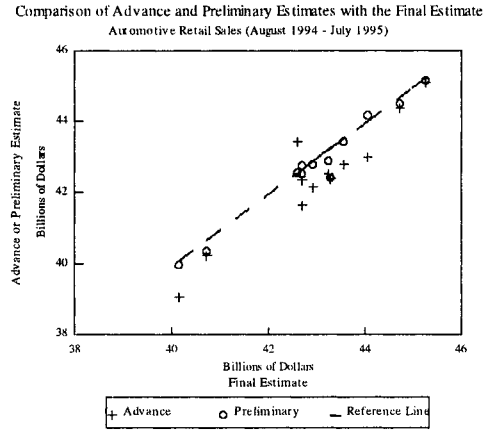

Figure 1

Figure 2 compares the three estimates of current-to-previous-month change for automotive dealers. Again, we would expect the Advance-to-Preliminary and Preliminary-to-Final estimates of current-to-previous-month change to randomly vary around the Final-to-Final estimate. However, the Advance-to-Preliminary estimate frequently falls below the reference line.

Thus, it appears that the Advance estimates tend to underestimate both the Preliminary and Final estimates.

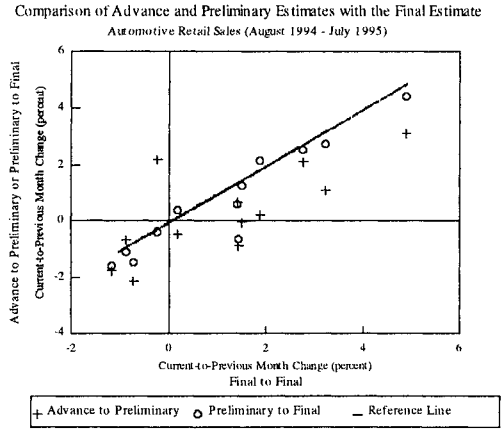

Figure 2

The purpose of the next section of the paper is to give the reader a brief description of the sampling, data collection, and estimation procedures for the MRTS and MARTS. It is our hope that this section will allow someone who is unfamiliar with these business surveys to more clearly understand how the Advance, Preliminary, and Final estimates are produced and to better interpret the remainder of the paper.

3. Design of the MRTS and MARTS

3.1. The Monthly Retail Trade Survey Sample

The MRTS sample is drawn every five years from the Census Bureau's Standard Statistical Establishment List (SSEL). The SSEL is a universe list of employer businesses constructed and periodically updated with administrative records from the Internal Revenue Service (IRS), the Social Security Administration, the Bureau of Labor Statistics, and the information obtained from our economic censuses and surveys.

In general, a retail establishment is an economic unit located at a single physical location that is engaged in the selling of merchandise for personal or household consumption. A business can consist of either a single establishment (singleunit) or many establishments (multiunit). For the MRTS, two types of sampling units make up the list frame. Multiunits with expected sales exceeding predetermined sales level cutoffs are considered *"company" sampling units*. All retail establishments owned or operated by the "company" are included under this sampling unit. Singleunits and multiunits whose expected sales do not exceed the sales level cutoffs are formed into *Employer Identification Number (EIN) sampling units*. The EIN is the IRS taxpayer identification number for employer businesses. EIN sampling units include all retail establishments that use the EIN to report quarterly payroll to the IRS. Thus, EIN sampling units can be single- or multiunit businesses. If the EIN is a singleunit with expected sales exceeding the predetermined sales level cutoffs previously mentioned, the EIN is selected into the sample with certainty. The remaining singleunit and multiunit EIN sampling units are assigned to strata based on industry classification codes and expected sales level and subjected to simple random sampling without replacement within strata.

The company and singleunit EIN certainty sampling units are assigned to a fixed panel (panel 0). The selected noncertainty (weight > 1) EIN sampling units are assigned to three rotating panels, panels 1, 2, and 3. One other panel of selected EIN sampling units, panel 5, contains some noncertainty businesses that have increased in size throughout the five-year life of the sample or have been assigned through quarterly birth processing.

At the time of the latest major sample reselection in early 1992, the MRTS sample consisted of 2,384 certainty companies and 922 singleunit EIN certainties in panel 0. Each of the three rotating panels contained about 8,500 sampled EIN units.

3.1.1. Data Collection for the MRTS

Self-administered survey forms for the MRTS are mailed on the last working day of the reference month. We request that units in panels 1, 2, and 3 provide data for two consecutive months, the current month and the previous month, at three month intervals; whereas, we request that units in panels 0 and 5 provide data each month for the current month. On the eighth working day after the end of the reference month, telephone follow-up begins for businesses that have returned their questionnaire by mail but have responses that failed edits. About a week later, telephone follow-up begins for businesses that haven't responded. This continues until the third working day of the second month following the reference month. At this point, data collection closes, final editing and analysis are performed, and estimates are released on the ninth working day of the second month following the reference month.

The unit response rate for the MRTS ranges between 65 and 70 percent each month, while the estimated dollar volume response rate is near 80 percent. Of those responding, about 50 percent are mail responses, 15 percent are FAX responses, and 35 percent are telephone responses.

3.1.2. MRTS Estimation Methods

MRTS estimates of total retail sales are calculated using a composite estimation procedure to produce Preliminary estimates for the current month and Final estimates for the previous month. As a first step in calculating these composite estimates, simple weighted estimates at detailed kind-of-business levels are calculated for both the current and previous months from the businesses in the nonrotating panels and the rotating panels for which current and previous month data were asked.

The Preliminary estimate for the current month is the weighted average of the simple weighted current month estimate (weight = 0.25) and a ratio estimate (weight = 0.75). The ratio estimate is obtained by multiplying the Preliminary estimate for the previous month by the ratio of the simple weighted current and previous month estimates.

The Final estimate for the previous month is the weighted average of the Preliminary estimate for the previous month (weight = 0.8) and the simple weighted estimate for the previous month (weight = 0.2).

3.2. The Advance Monthly Retail Trade Survey Sample

The MARTS sample is a small probability subsample selected from units in the MRTS sample at a chosen point in time. The sampling frame for the MARTS consists of panel 0 reporting units (in contrast to company sampling units), panel 5 reporting units, and one-quarter of the reporting units in panels 1, 2, and 3. (A reporting unit makes it more convenient for a business to report sales data from different establishments.) Units with irregular response patterns, or those that are out of business, out of scope, or refusals, are excluded from the MARTS sampling frame. The frame used for the sample initiated in 1993 contained about 9,000 sampling units. These units are then stratified generally by kind of business and a measure of expected monthly sales. Sample sizes within strata are determined using Neyman allocation with an upper bound of 3,400 sampled units placed on the total sample size. Once a business is selected for the MARTS sample, it remains in the sample for about two-and-a-half years and is asked to report data every month.

3.2.1. Data Collection for the MARTS

Self-administered survey forms are mailed five working days prior to the end of the reference month. The forms are due back two working days after the end of the reference month. On the third working day interviewers begin telephone follow-up of businesses failing to return their form by mail. This continues until the beginning of the seventh working day after the end of the reference month. At this point, data collection closes, final editing and analysis are performed, and the estimates are released at 8:30 a.m. on the ninth working day after the end of the reference month.

The unit and estimated dollar volume response rates for the MARTS fall between 60 and 65 percent each month. Of those responding, about 20 percent are mail responses, 20 percent are FAX responses, and the remaining 60 percent are telephone responses.

3.2.2. MARTS Estimation Methods

To compute dollar volume estimates for the MARTS, all the reporting units that provided sales data for both the current and previous months (two consecutive months) are used to calculate a ratio. The ratio for a detailed kind-of-business level is calculated by dividing the sum of the weighted current month sales by the sum of the weighted previous month sales. The ratios are then multiplied by the previous month MRTS Preliminary estimate of total dollar volume at the appropriate kind-of-business level to provide dollar volume sales estimates for each of the most detailed MARTS kind-of-business levels. Dollar volume estimates at broader kind-of-business levels (e.g. durables, nondurables, and total) are obtained by aggregation. Current-to-previous month change estimates at all kind-of-business levels are obtained by dividing the current month MARTS dollar volume estimates by the previous month MRTS Preliminary estimate of total dollar volume.

4. Previous Research on the MRTS

By examining the Advance, Preliminary, and Final estimates in Figure 1 and current-to-previous-month change estimates shown in Figure 2, it appears that the Advance estimates consistently underestimate the Preliminary and Final estimates. Does previous research support this apparent finding?

In a 1974 Census Bureau study, Waite examined nonsampling errors in the Preliminary and Final estimates produced by the MRTS. He used data obtained through a reinterview to measure expected biases that were caused by two different respondent errors: (1) misinterpreting the instructions on the MRTS questionnaire that tell the respondent what to include when reporting monthly sales data; and, (2) having to estimate the business' actual monthly sales data because more accurate data were not available from the business' record information system at the time of the survey request. The study was confined to businesses with fewer than eleven retail establishments. The businesses included in the sample fell into three categories: (1) those that reported sales data every month; (2) those that reported sales data in March, 1973, for February as a current month and January as a previous month; and, (3) those that reported sales data in April, 1973, for March as a current month and February as a previous month. The final sample included 1,849 businesses.

After about four months had elapsed since the original report had been received by the Census Bureau, interviewers conducted face-to-face interviews with 1,634 of these businesses. The interviewers were instructed to interview the person who had provided the original sales data. Revised sales data were obtained from those respondents who reported that the original sales data provided to the Census Bureau were estimated. In almost every case where the original sales data were deemed as estimates, the respondent reported the reason to be that monthly sales data were requested before more accurate data were available from records.

Additional results indicated respondents tended to *underestimate* the business' true monthly sales data. That is, the sales data obtained in the reinterview were frequently larger than the estimated sales data originally provided. Waite concluded that a large part of the increase in the corrected sales data was caused by respondents not including sales tax in the originally reported sales data. In addition, his results showed that a relatively large component of the increase seen in the corrected sales data was due to early reporting.

In another study, Cantwell et al. (1995) examined whether the noncertainty sample businesses in the MRTS reported their monthly sales data differently for the current and previous months. A statistically significant response effect was found between providing sales data for a current month versus a previous month in twelve of the sixteen kinds of business they tested. Furthermore, in every kind of business in which the response effect was found to be significant, the current month values were significantly less than previous month values for the same reference month.

Both of these studies suggest that MRTS respondents tend to provide inaccurate monthly sales data when not given an adequate amount of time to obtain more precise (book) figures. Furthermore, it appears the estimated monthly sales data provided by the respondent *underestimate* the business' actual monthly sales data. This paper attempts to extend the findings of these two studies on early reporting error in the MRTS to the sales data collected in the MARTS.

5. Measuring the Effect of Early Reporting

Based on the conclusions of the two studies discussed in Section 4, one would expect MARTS respondents to underestimate their business' actual monthly sales when not given adequate time to obtain more accurate data. To measure the expected magnitude (and direction) of the error respondents make when providing monthly sales data in the MARTS, we will build a model of response error using a small subset of businesses that provided data for the same reference months twice - first in the MARTS and later in the MRTS. In this model, we will treat the report of monthly sales data received in the MRTS as a proxy for the business' *true* monthly sales data. In doing so, we recognize that this proxy measure contains error due to early reporting as well. This will undoubtedly affect the ability of our model to detect and measure response errors due to early reporting in MARTS sales data.

The effect that early reporting has on a business' response in the MARTS can be investigated by considering the following simple respondent error model:

$$MARTS_i = \beta_0 + \beta_1 MRTS_i + \epsilon_i . \qquad (1)$$

$MARTS_i$ is the monthly sales as reported by business *i* in the MARTS and $MRTS_i$ is the monthly sales as reported by business *i* in the MRTS. It is important to recognize that some businesses will provide $MRTS_i$ as a current month (several weeks after they have provided $MARTS_i$) and other businesses will provide $MRTS_i$ as a previous month (over a month after they have provided $MARTS_i$). This led us to propose two separate models with which to analyze our subset of businesses, one for those responding in the MRTS for the reference month as a current month (**Current Month Model**) and one for those responding in the MRTS for the reference month as a previous month (**Previous Month Model**).

Based on our assumption (and previous research) that a business provides more accurate data when given more

time after the reference month, we believe that our best measure of the effect of early reporting on monthly sales data provided in the MARTS will be given by the Previous Month Model.

6. Analysis

We created a subset of businesses that provided monthly sales data for both the MARTS and MRTS for reference months May, June, and July, 1995. Three months of data were chosen so that businesses from all three MRTS rotating panels would be included in our analysis. Furthermore, because we believed that the response error properties of large (certainty in the MRTS) businesses could differ significantly from small (noncertainty in the MRTS) businesses, we excluded the large businesses from our analyses. Finally, we fit the models within kind-of-business classification to avoid the assumption that all businesses, regardless of their kind-of-business activity, make similar errors when providing monthly sales data.

In the proposed respondent error model of Section 5, the coefficients β_0 and β_1 can be thought of as allowing for additive and multiplicative components of error, respectively, when providing monthly sales data. Ideally, a plot of MARTS versus MRTS responses would result in a 45-degree line through the origin ($\beta_0 = 0$ and $\beta_1 = 1$). That is, every business' MARTS response would be equal to its MRTS response.

We will present results for automotive dealers. Figure 3 is a plot of MARTS versus MRTS sales data for automotive dealers used in the Previous Month Model. (To protect the confidentiality of our data, we have not labelled axes.) We can see that a strong linear relationship exists between the two variables. Notice that the data points tend to cluster at the lower end of the plot. This is an indication that the data come from a skewed population and is a common attribute of business survey data.

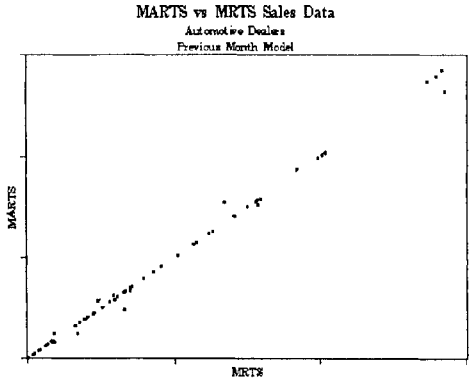

Figure 3

In an attempt to spread the data points at the lower end of the plot and to symmetrize the distribution of residuals from the regression model fit using equation (1), we transformed the MARTS and MRTS sales data using a fourth root transformation. The transformed sales data for automotive dealers are plotted in Figure 4 along with the fitted regression line.

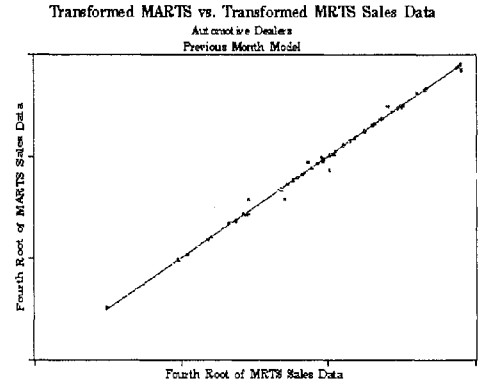

Figure 4

The estimated coefficients and their standard errors are given by model type for automotive dealers in Table 1. The estimated intercepts (β_0) in the Current and Previous Month Models are not significantly different from zero ($t_{CMM} = -1.08, p_{CMM} = 0.69$; $t_{PMM} = 0.394, p_{PMM} = 0.29$), and the estimated slope coefficients (β_1) in each of the models are not significantly different from one ($t_{CMM} = 0.440, p_{CMM} = 0.66$; $t_{PMM} = -0.460, p_{PMM} = 0.65$).

Table 1. Regression Results by Model Type for Automotive Dealers

Model	Intercept (β_0)	Slope (β_1)	Obs.
CMM	-0.403 (0.374)	1.004 (0.009)	47
PMM	0.157 (0.398)	0.996 (0.010)	54

Standard errors are shown in parentheses.

7. Conclusions

These results do not show the response effect due to early reporting that was hypothesized to be present in sales data collected in the MARTS and was seen in Waite's (1974) study of sales data collected from businesses in the MRTS. We suggest a few reasons why this occurred.

As previously mentioned, the businesses used to construct the models were not selected using probability sampling, but were a small subset of businesses that provided sales data in both the MARTS and the MRTS. We also recognize that our proxy measure for a business' true monthly sales ($MRTS_i$) contains error due to early reporting. This has undoubtedly affected the ability of our

model to detect and measure response errors due to early reporting in MARTS sales data. Finally, of the businesses that we used in this study, only about 50 percent revised their monthly sales data between the MARTS and MRTS.

These conclusions seem to suggest that, overall, respondents provide pretty good estimates of their business' actual monthly sales data and that the hypothesized response effect due to early reporting does not contribute a great amount of error to the MARTS estimates. Bienias et al. (1996) use a different approach to examine the effect that early reporting has on the MARTS estimates, with mixed results.

8. Sources of Error Not Considered

When interpreting the results of this paper, one must consider the other sources of survey error that might exist. Both the MARTS and the MRTS suffer some nonresponse. If these nonresponding businesses differ significantly from those that respond, monthly estimates of total sales and current-to-previous-month change will not reflect the actual state of all retail businesses in the United States. Furthermore, because both the MARTS and MRTS data collection activities include extensive CATI follow-up of businesses not responding via mail or FAX, interviewer error and error due to the mode of survey response might also be considered.

9. Future Research

Future research on response error in the MARTS might examine how the parameters of the proposed models used in this study change for other kinds of business and different reference months. The respondent's position (job title) in the business or the mode of data collection might also be considered. One might also look for improved models, or new approaches for estimating response errors due to early reporting. A reinterview study conducted on a sample of respondents in the MARTS would allow one to make a more statistically sound estimate of response error. Cox and Chinnappa's (1995) observations about the published results from many business surveys summarize nicely the objective of this paper and of future papers exploring measurement errors in business surveys:

> *"Because of the rapid and dynamic changes in economic data, timeliness of estimates is crucial for business surveys. Large discrepancies between preliminary and final estimates can lead to errors in decision-making and loss of confidence in the statistical series. Research is needed to identify methods that produce preliminary estimates that are good predictors of the final revised estimates."*

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