Relationships among Expenditure Reporting Rates, Household Characteristics, and Interview Process Variables in the U.S. Consumer Expenditure Interview Survey

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1. Introduction

1.1 The Consumer Expenditure Interview Survey (CEQ)

"Consumer expenditure (CE) surveys are specialized studies in which the primary emphasis is collecting data relating to family expenditures for goods and services used in day-to-day living." (BLS Handbook, 1997, p.160) One major use of the data is to provide the basis for revising weights and associated pricing samples for the Consumer Price Index (CPI). In addition, the BLS uses the data to produce estimates of mean expenditures and to produce public data sets of expenditures and income.

The CE Survey uses a stratified multistage probability sample of households, which represent the total U.S. civilian noninstitutional population. The primary sampling units (PSU) are groups of counties, or independent cities. The set of sample PSU's used for the survey consists of 101 areas; from which 87 urban areas were selected by BLS for the CPI program (BLS Handbook, 1997, p.163). Within each selected primary sample unit, a given sample consumer unit (CU, roughly equivalent to a household) is randomly assigned to one of two modes of data collection: interview or diary. The remainder of this paper will consider only data from the quarterly Consumer Expenditure Interview Survey (CEQ).

1.1 The CE Interview Survey Data

The purpose of the CE Interview Survey is to obtain detailed data on relatively large expenditure items such as property, automobiles, or major appliances, or on expenses that occur on a fairly regular basis, such as rent, utility bills, and insurance premiums. The CE Interview Survey includes rotating panels: each consumer unit (CU) in the sample is interviewed every 3 months over five calendar quarters and then is dropped from the survey. Approximately 20 percent of the addresses are new to the Survey each quarter. The interviewer uses a structured questionnaire to collect both demographic and expenditure data in the Interview survey. In the CE Interview Survey, approximately 8910 addresses are contacted in each calendar quarter, and the number of completed interviews per quarter is targeted at 6160.

Numerous adjustments are made to the data after collection, and they affect the amount of mean expenditures and the number of reports. For example, one expenditure of $120 listed for DINE_MOX, the usual monthly expense for dining out, could be split out ("allocated") into various subcategories at a later stage of data processing. Some of the adjustments which are discussed in Silberstein and Jacobs (1989) are the current-month adjustment, imputation, and aggregation. The data used for this study is a processed data, generated from the CE Phase 3 databases. Our example data comes from the 592 expenditure items of the 2000 U.S. CE Interview Survey.

2. Reporting Rates for Consumer Expenditure Survey Items

2.1 Aggregate Reporting Rate

Define J_{ic} as the number of non-zero reports obtained from an interview c, by an interviewer i, and w_{ic} is the associated probability weight. Then a probability-weighted estimator of the overall proportion of nonzero reports is:

$$\hat{\pi} = \frac{\sum_{i=1}^{n_i} \sum_{c=1}^{C_i} w_{ic} J_{ic}}{\sum_{i=1}^{n_i} \sum_{c=1}^{C_i} w_{ic} J} \qquad (2.1)$$

where n_i is the number of interviews conducted by interviewer *i,* C_i is the total number of interviews *conducted* by an interviewer *i,* and *J* is the total number of item categories in a questionnaire.

We also define $\hat{\pi}_{uw}$ as an unweighted estimator of the overall proportion of nonzero reports:

$$\hat{\pi}_{uw} = \frac{\sum_{i} \sum_{c} J_{ic}}{\sum_{i} \sum_{c} J} \qquad (2.2)$$

Define $\hat{\pi}_{i,uw}$ as an unweighted estimator of the proportion of nonzero reports for an interviewer *i*:

$$\hat{\pi}_{i,uw} = \frac{\sum_{c} J_{ic}}{C_i J} \qquad (2.3)$$

2.2 Reporting Rates and Response Rates

Reported expenditures are recorded at a relatively fine level of detail defined by the six-digit Universal Classification Code (UCC). In computing the reporting rate at the interviewer level, we divided non-zero reports of expenditures by the total possible expenditures that could be obtained by an interviewer. Note that the number of total possible expenditures that could be reported by a consumer unit (CU) varies across CUs. For example, the number of total possible expenditures that could be reported by a homeowner was greater than the one reported by a renter. In our study, the number of total possible expenditures is the number of expenditures asked in the CE monthly expenditure (MTAB) file. We included items that were asked in the 2nd, 3rd, 4th and 5th interview, and excluded items that were asked only in a specific interview. For the total possible expenditure count for each subgroup, we counted expenditures for four quarters and took the maximum. We found that the total numbers of expenditure were similar throughout four quarters for the year 2000 in each subgroup.

In principle, a selected consumer unit could provide nonzero expenditure amounts for up to 592 expenditure items in our analysis, but the mean number of nonzero expenditure reports per consumer unit (for an interview covering three consecutive months) is approximately equal to 28. Much of this difference may be attributed to the fact that few, if any, consumer units will have true expenditures in all 592 categories in a given three-month period (Eltinge and Cho, 2003).

The observed variability in the sample reporting rates $\hat{\pi}_{i,uw}$ may arise from a combination of three sources: variability across consumer units of the true purchase rate; Variability across consumer units and across interviewers in the item-level nonidentified nonresponse rates; Random variability associated with sample selection and with random processes from the two previous sources. Thus, the sample reporting rates $\hat{\pi}_{i,uw}$ depend on both the true purchase rates and the response rates. Consequently, in some cases, analyses of these reporting rates can offer insights into the properties of nonidentified nonresponse. In particular, there are several features of the interview process which generally will be independent of the consumer unit-level true purchase rates. Therefore, association of the $\hat{\pi}_{i,uw}$ terms with these features can, after accounting for random variability, provide an indication of association between nonidentified item nonresponse rates and interview number or workload.

3. Model Development

We fitted the logistic regression model using family characteristic predictors and interview predictors. We started with the basic logistic regression model that includes the intercept, the interviewer's workload and the indicator of the first recall month reports. Next, we fitted the models in such a way that for each, we added a family characteristic predictor or an interview characteristic predictor to the basic logistic regression model. Some examples of family characteristic predictors and interview characteristic predictors are family type, home ownership, number of respondents, age of respondent, education of the respondent, and gender of the respondent. We then ranked the models according to their coefficients of determination. In our final model, we fitted the model by adding predictors sequentially from the previous models with the highest value of R^2 until we cannot add an additional predictor into the model. We used the weighted least squares method to estimate the coefficients in models. Using the balanced repeated replication method, we estimated a standard error and a test statistic for each model. The predictors with greater values of coefficients of determination were home ownership, education of the respondent, family type, and record usage. However, by adding family size or respondent's age to the final model resulted in a singularity of matrix. A possible reason for this could be collinearity among the predictors. We also fitted the same models for the selected subgroups of CE expenditure data to see whether the results obtained from the overall expenditure still held. Some examples of subgroups are house furnishing, apparel, travel, or utility. We chose those subgroups based on the frequency of purchase and saliency of the expenditure. The expenditures variables for house furnishings and apparel were used by Silberstein (1989) in her study on recall effects.

3.1 Base Model

We consider the following logistic regression model based on initial exploratory analyses:

$$\ln\left(\frac{\hat{\pi}_j}{1-\hat{\pi}_j}\right) = \beta_0 + \beta_1 \ln(n_i) + \beta_2 I_{j,r1}$$

where $I_{j,r1} = 1$ if the weighted reporting rate $\hat{\pi}_j$ is from recall month 1 for an interviewer *i*; otherwise $I_{j,r1} = 0$, and n_i is the number of interviews conducted by interviewer *i*. We fit the model for the combinations of interviewer *i* and recall month *r* such that $n_i \geq 5$. We used weighted least squares to compute estimates $\hat{\beta}$ of the coefficients. We estimated a covariance matrix for $\hat{\beta} = (\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2)$ using the balanced repeated replication method. The following table presents coefficient estimates, standard error estimates, and associated test statistics:

Coeff	Est	S.E.	Test Statistic
B0	-2.969539	0.10348	-28.6974
B1	-0.028981	0.02505	-1.156893
B2	0.1261783	0.00629	20.072469

The cutoff point using the Bonferroni simultaneous inference method at α = 0.05 is 2.499.

3.2 Home Ownership as a Predictor Variable

$$\ln\left(\frac{\hat{\pi}_j}{1-\hat{\pi}_j}\right) = \beta_0 + \beta_1 \ln(n_i) + \beta_2 I_{j,r1} + \beta_3 I_{j,h}$$

For an interviewer *i*:
n_i : the number of interviews conducted.
$I_{j,r1} = 1$ if the reporting rate $\hat{\pi}_j$ is from recall month 1, otherwise $I_{j,r1} = 0$.
$I_{j,h} = 1$ if the reporting rate $\hat{\pi}_{irh}$ is from a consumer unit that owns a home, otherwise $I_{j,h} = 0$.

We fit the model for the combinations of interviewer *i*, recall month *r*, and home ownership in such a way that the number of observations to compute $\hat{\pi}_j$ is greater than or equal to 5. The following table presents coefficient estimates, standard error estimates, and associated test statistics:

Coeff	Est	S.E.	Test Statistic
B0	-3.31364	0.09934	-33.35522
B1	-0.025315	0.02478	-1.021735
B2	0.1053833	0.00532	19.803283
B3	0.4753006	0.01747	27.20109

The cutoff point using the Bonferroni simultaneous inference method at α = 0.05 is 2.616.

For Clothing data

Coeff	Est	S.E.	Test Statistic
B0	-3.105781	0.10557	-29.41981
B1	0.0024634	0.02132	0.1155287
B2	0.1884152	0.01393	13.52657
B3	0.2069783	0.02300	8.9997751

For Utility data

Coeff	Est	S.E.	Test Statistic
B0	-2.388815	0.06685	-35.7353
B1	0.0232519	0.01526	1.5241151
B2	0.0361462	0.00679	5.3256527
B3	0.4442779	0.01555	28.571269

3.3 Respondent’s Education as a Predictor Variable

$$\ln\left(\frac{\hat{\pi}_{ire}}{1-\hat{\pi}_{ire}}\right) = \beta_0 + \beta_1 \ln(n_i) + \beta_2 I_{i,r1} + \beta_3 I_{ir,e2} + \beta_4 I_{ir,e3} + \beta_5 I_{ir,e4}$$

$$\ln\{\hat{\pi}_j / (1-\hat{\pi}_j)\} = \beta_0 + \beta_1 \ln(n_i) + \beta_2 I_{j,r1} + \beta_3 I_{j,e2} + \beta_4 I_{j,e3} + \beta_5 I_{j,e4}$$

For an interviewer *i*:
n_i: the number of interviews conducted.

$I_{j,r1} = 1$ if the reporting rate $\hat{\pi}_j$ is from recall month 1, otherwise $I_{j,r1} = 0$.

$I_{j,e2} = 1$ if the respondent is a high school graduate, otherwise $I_{j,e2} = 0$.

$I_{j,e3} = 1$ if the respondent has more than a high school education but less than a Master’s level education, otherwise $I_{j,e3} = 0$.

$I_{j,e4} = 1$ if the respondent has an education higher than a Master’s level, otherwise $I_{j,e4} = 0$.

We fit the model for the combinations of interviewer *i*, recall month *r*, and record use in such a way that the number of observations to compute $\hat{\pi}_j$ is greater than or equal to 5. The following table presents coefficient estimates, standard error estimates, and associated test statistics:

Coeff	Est	S.E.	Test Statistic
B0	-3.359824	0.10558	-31.82208
B1	-0.024053	0.02496	-0.963621
B2	0.1183362	0.00552	21.441064
B3	0.2991504	0.02065	14.484582
B4	0.4709698	0.01903	24.746242
B5	0.6393536	0.02138	29.904065

The cutoff point using the Bonferroni simultaneous inference method at α = 0.05 is 2.776.

3.4 Family Type as a Predictor Variable

$$\ln\left(\frac{\hat{\pi}_j}{1-\hat{\pi}_j}\right) = \beta_0 + \beta_1 \ln(n_i) + \beta_2 I_{j,r1} + \beta_3 I_{j,t}$$

For an interviewer *i*:
n_i: the number of interviews conducted.

$I_{j,r1} = 1$ if the reporting rate $\hat{\pi}_j$ is from recall month 1, otherwise $I_{j,r1} = 0$.

$I_{j,t} = 1$ if the reporting rate $\hat{\pi}_j$ is from single family, otherwise $I_{j,t} = 0$.

The following table presents coefficient estimates, standard error estimates, and associated test statistics:

Coeff	Est	S.E.	Test Statistic
B0	-2.970157	0.09861	-30.12092
B1	-0.006596	0.02403	-0.274443
B2	0.1029552	0.00580	17.742832
B3	-0.396467	0.01517	-26.13

The cutoff point using the Bonferroni simultaneous inference method at α = 0.05 is 2.616.

For Clothing data:

Coeff	Est	S.E.	Test Statistic
B0	-2.939371	0.09079	-32.37384
B1	0.0149954	0.01976	0.7587087
B2	0.1807025	0.01404	12.870069
B3	-0.494349	0.02441	-20.25535

3.5 Record Usage as a Predictor Variable

$$\ln\left(\frac{\hat{\pi}_j}{1-\hat{\pi}_j}\right) = \beta_0 + \beta_1 \ln(n_i) + \beta_2 I_{j,r1} + \beta_3 I_{j,record}$$

For an interviewer *i*:
n_i : the number of interviews conducted.

$I_{j,r1} = 1$ if the reporting rate $\hat{\pi}_j$ is from recall month 1, otherwise $I_{j,r1} = 0$.

$I_{j,record} = 1$ if the reporting rate $\hat{\pi}_j$ is from a CU, which used records, otherwise $I_{j,record} = 0$.

We fit the model for the combinations of interviewer *i*, recall month *r*, and record use in such a way that the number of observations to compute $\hat{\pi}_j$ is greater than or equal to 5. The following table presents coefficient estimates, standard error estimates, and associated test statistics:

Coeff	Est	S.E.	Test Statistic
B0	-3.271522	0.08590	-38.086
B1	0.000213	0.02103	0.010129
B2	0.1199704	0.00603	19.905821
B3	0.3010902	0.02099	14.345294

The cutoff point using the Bonferroni simultaneous inference method at α = 0.05 is 2.616.

3.6 Record Usage, Family Type, Home Ownership and Respondents as Predictor Variables (with UCC Count =592)

$$\ln\left(\frac{\hat{\pi}_j}{1-\hat{\pi}_j}\right) = \beta_0 + \beta_1 \ln(n_i) + \beta_2 I_{j,r1} + \beta_3 I_{j,record} + \beta_4 I_{j,t} + \beta_5 I_{j,h} + \beta_6 I_{j,e2} + \beta_7 I_{j,e3} + \beta_8 I_{j,e4}$$

For an interviewer *i*:
n_i : the number of interviews conducted.

$I_{j,r1} = 1$ if the reporting rate $\hat{\pi}_j$ is from recall month 1, otherwise $I_{j,r1} = 0$.

$I_{j,record} = 1$ if the reporting rate $\hat{\pi}_j$ is from a CU, which used records, otherwise $I_{j,record} = 0$.

$I_{j,t} = 1$ if the reporting rate $\hat{\pi}_{itr}$ is from single family, otherwise $I_{j,t} = 0$.

$I_{j,h} = 1$ if the reporting rate $\hat{\pi}_{irh}$ is from a consumer unit that owns a home, otherwise $I_{j,h} = 0$.

$I_{j,e2} = 1$ if the respondent is a high school graduate, otherwise $I_{j,e2} = 0$.

$I_{j,e3} = 1$ if the respondent has more than a high school education but less than a Master's level education, otherwise $I_{j,e3} = 0$.

$I_{j,e4} = 1$ if the respondent has an education higher than a Master's level, otherwise $I_{j,e4} = 0$.

We fit the model for the combinations of interviewer *i*, recall month *r*, and record use in such a way that the number of observations to compute $\hat{\pi}_j$ is greater than or equal to 5. The following table presents coefficient estimates, standard error estimates, and associated test statistics:

Coeff	Est	S.E.	Test Statistic
B0	-3.743339	0.08571	-43.67498
B1	0.0170643	0.02060	0.8285086
B2	0.0807838	0.00443	18.254595
B3	0.2063674	0.01946	10.604723
B4	-0.312162	0.01360	-22.94995
B5	0.3395291	0.01480	22.946255
B6	0.1969154	0.01959	10.049516
B7	0.4056152	0.01769	22.931512
B8	0.4884736	0.02422	20.164609

The cutoff point using the Bonferroni simultaneous inference method at α = 0.05 is 2.931.

For Utility data:

Coeff	Est	S.E.	Test Statistic

B0	-2.608238	0.05833	-44.71145
B1	0.0453811	0.01355	3.3494444
B2	0.0195858	0.00664	2.9512775
B3	0.1057562	0.01543	6.8560251
B4	-0.172626	0.01157	-14.92015
B5	0.3789227	0.01562	24.251179
B6	0.1028815	0.01965	5.2356718
B7	0.2050832	0.01993	10.288297
B8	0.2030745	0.02488	8.1632596

4. Future Work

There are several areas in which additional related work could be carried out. For example, since April 2003, the CE Survey began utilizing the Computer Assisted Personal Interview (CAPI) instrument for data collection. With CAPI, there are variables available which indicate whether an interview was conducted by field representative (FR) or supervisory field representative (SFR). It also provides information on whether an interview was a converted refusal case as well as the number of visits to complete an interview. It will be interesting to compare the reporting rate study results from the 2000 and 2002 data with the 2003 data which has added variables.

In addition, the assignment of interviewers to sample consumer units may not necessarily be a random process. For example, more experienced interviewers such as supervisory field representatives may be more likely to be assigned to consumer units that are expected to be more problematic (e.g., a consumer unit that consists of a single young male, or a consumer unit with which interviewers had difficulty in previous quarterly interviewers). This is somewhat analogous to the non-random processes in epidemiology through which certain subjects receive certain treatments. In response to this, the epidemiological literature has developed a set of estimation methods in which models are adjusted for the "propensity to receive treatment." See, e.g., Rosenbaum and Rubin (1983). Consequently, it would be worthwhile to consider modeling of the propensity of a sample consumer unit to be assigned to a supervisory field representative, and to consider variants on the models in Sections 2 and 3 that account explicitly for these propensity values.

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Table 1: Main respondent and consumer unit characteristics (2000). Reported in Percent

Age	100	Education	100
Under 30	16	Less than HS	15
30 -39	21	HS	30
40 -64	43	HS< & <=Master	46
65 and over	20	More than Master	9
Child status	100	Home ownership	100
With children	43	Owned	66
Other	57	other	34
Family size	100	Recall status	100
One member	27	First month	33
Two members	31	Other	67
Other	42		
		Record usage	100
Family type	100	Record used	57
Single family	27	Other	43
Other	73		
		Sex	100
		Female	61
		Male	39

Table 2: UCC counts (2000)

	2000 Q1	2000 Q2	2000 Q3	2000 Q4	2000
All items	563	560	562	565	**592**
Apparel	76	76	76	76	**76**
Home furnishing	109	110	110	108	**110**
Trip	18	18	18	18	**18**
Utility	35	35	34	34	**36**

Table 3: Coefficients of determination for finer cells

	Overall	Apparel	House furnishing	Trip	Utility
Base model	0.0186307	0.0305242	0.0291444	-0.002534	-0.008969
+ HomeOwn	0.2730397	0.0551822	0.0345524	0.0027139	0.3133936
+ ResEdu	0.189645	0.0382437	0.0418059	**	0.0450419
+ FamType	0.1534774	0.1407625	0.0397506	0.0615197	0.0704309
+ RecordUse	0.1199399	0.0325841	0.0524232	-0.003718	0.0371517
+ HomeOwn + ResEdu	0.4069945	0.0614927	0.0472369	**	0.3454216
+ ResEdu + RecordUse	0.2658741	0.0395659	0.0623862	**	0.0821757
+ All above	0.5505382	0.1682478	0.0761624	**	0.3998502

** Matrix $x'wx$ is singular.