Nonresponse Bias in the Consumer Expenditure Quarterly Survey.

John Dixon, Bureau of Labor Statistics, Room 4915, 2 Massachusetts Ave., NE,
Washington, DC 20212-0001
Dixon_J@bls.gov
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Introduction

The Consumer Expenditure Survey is a household survey which provides part of the "market basket" of consumer expenditures which are the basis of the CPI as well as other indices. Selected housing units remain in sample during a 5 quarter period. The households are interviewed for 5 consecutive quarters. These interviews are referred to as "time-in-sample" (TIS) 1 to 5.

Matching households between quarters allows an analysis of the relationship between nonresponse and estimates of the proportions of expenditures. Since change in expenditures may be related to the household's participation, the estimates of the "market basket" may be affected. A recent studies of a different survey by Tucker and Kojetin (1997) and Dixon (2001) showed that unemployment rates were related to nonresponse in the CPS. "Converts" (households that do not participate in the prior month) do not completely make up for the number of "Attriters" (households that do not participate in the following month), so their relative effect may not be offset. Moreover, they may differ on important characteristics, e.g.; race, age, or gender. The current study examines the nature of this relationship through an analysis of demographics and nonresponse and their resulting effect on estimates of the proportions of expenditures in the Consumer Expenditure Survey.

Gross Flows

In this study "gross flows" uses the availability of information on one month to contrast the estimates from another month. For example, expenditure estimates in quarter 2 are contrasted based on whether a household responded in quarter 1, and similarly are contrasted based on whether a household responded in quarter 3. This allows an examination of the effect of "attrition" and "conversion". For example; if the expenditure pattern for quarter 2 is different for households who continued to respond in month 3 compared to those who did not respond, and this was not balanced by a difference in the other direction for those who responded in quarter 2 but did not respond in quarter 1, then some the estimates would be biased due to nonresponse.

Design

The CEQ is a the household expenditure survey for the United States conducted by the U.S. Census Bureau for the U.S. Bureau of Labor Statistics. Approximately 8,910 eligible addresses are sampled each quarter, with 6,160 completed interviews typical. Households (or more correctly: consumer units) were matched for the years 1997 through 1999. The response rate is usually in the range of 80-83 percent. In this study 5112 households were matched across the 5 quarters.

The measures of consumer expenditure are divided up into 12 categories: Housing, Food, Transportation, Personal Insurance, Entertainment, Apparel, Education, Tobacco, Personal Care, Miscellaneous, Alcoholic Beverages, and Reading. Medical expenditures were left out of the analysis.

Analysis

The estimates used are based on the proportions of monthly expenditures for a household. Since the proportions add up to 100%, the data is of a "compositional" nature (Aitchison, 1986). The centered log transform is used with these data to make the assumptions of linear models more realistic. The analysis begins with a multivariate analysis of variance contrasting TIS 2 households which consistently responded to those which had nonresponse in the prior or subsequent quarter. Univariate analyses examine which consumer categories contributed to the overall test. The nonresponse is further broken into refusal and noncontact, attrition and conversion, and the analyses repeated. The type of nonresponse is indicated by "II" for respondents in both months, "IR" for respondents who subsequently refused (attrition), "IN" (noncontact attrition), "RI" (refusal conversion), and "NI" (noncontact conversion). Covariates and interactions are added to the model to see what household characteristics may be related to bias effects.

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Results

Table 1 in Appendix A shows the mean proportions for the 2nd quarter of the CEQ by those who were interviewed compared to those who were converted from the 1st quarter and those who dropped out in the 3rd quarter. The overall Manova was significant ($p<.0001$) indicating that the pattern of expenditures was different for the nonresponders compared to the responders. The manova and the univariate anovas were based on the centered logs, but the table shows the mean proportions for ease of interpretation. The "housing" category showed the largest effect, with nonresponders having higher expenditures. Other categories which had higher expenditures were "transportation" and "alcoholic beverages". This was counterbalanced by lower expenditures in "personal insurance", "entertainment", and "food".

Table 2 shows the same effects separated by type of nonresponse. "*" indicates a significant difference between response status. Bold indicates the higher value different from the lower italicized value. The higher proportions for "housing" came from refusals(IR and RI vs. II and NI) and "food"(RI vs. IN and NI), while for "transportation" it was limited to converted refusals(RI vs. II). The lower proportions came from converted refusals for "personal insurance" and "entertainment"(RI vs. NI).

Household Characteristics

Consumer unit size, respondent age, expenditure amount, tenure, children present, respondent gender, race, population density, respondent education, income, length of interview, and multi-unit structure were examined in a series of 13 Manovas. The results for nonresponse can be seen in Tables 3 and 4(Note: Tables 3-7 and Figures 1-10 couldn't be included due to space limitations, a full paper is available from the author. All of the covariates were related to expenditure patterns (the covariate effect in Table 3, but only those which affected interview status either through an interaction or by making the interview status non-significant (suppressor effect) will be discussed in this paper.

Total expenditures interacted with interview status. Nonresponding households with higher total expenditures had relatively higher entertainment expenditures, and personal insurance was relatively lower (Figures 1 and 2).

There were several measures of income available. The "Consumer Unit Income" measure with 14 ordered categories showed no interaction effects, but a more continuous estimate showed some interactions. This suggests the analysis may be sensitive to the distribution of income. Family income interacted with interview status for transportation where nonresponding higher income households had relatively lower transportation expenditures (Figure 3).

Multiple unit structures (such as apartments) interacted with interview status for nonresponding households in multiunit structures having relatively higher expenditures for apparel and entertainment, and relatively lower for alcohol. Overall multiunit households had lower entertainment expenditures.

Homeowners spent more on apparel, housing, and transportion. Ownership interacted with interview status such that for nonresponding households which owned their home spent relatively less on apparel and transportation but more on housing.

Urban/Rural interacted with interview status for nonresponding rural households having relatively lower entertainment, education and alcohol expenditures. Overall rural had higher entertainment and lower alcohol expenditures.

Education and race of the respondent suppressed the effect of interview status, suggesting that they were related to any bias differences from nonresponse. Age of respondent and CU size also showed slight suppressor effects.

Type of Nonresponse

Table 5 shows the p-values from manovas with covariates contrasting the 5 types of nonresponse. The three models which show no effect for "Interview Status" or the interaction but show a covariate effect are examples of suppressors. The education and race of the respondent were similar to the effects found for overall nonresponse, and age of respondent also showed an effect.

Table 6 shows four models; one with response status (5 levels) by itself and three models with on of the covariates associated with suppression. This should indicate which expenditures may be related to the bias measures. The effects were related to all the variables associated with bias (food, housing, apparel, transportation, and entertainment). Personal care was less of a factor for the education and race covariates. Age showed a stronger effect for personal care, but less of a suppressor effect for personal insurance.

Table 7 shows the interaction effects for "Structure type" and "Urban/rural". Consistent respondents (II) had higher expenditures for apparel, entertainment, and reading. Reading was different from the others because the converted refusers (RI) were in the same direction as the II group. The converted refusals and attrition refusals were in opposite directions.

Urban households tended to spend less on entertainment, except for refusal attrition (IR). They spent more on alcohol, except for the converted groups (NI, RI). The urban nonresponse groups (IN, IR, NI, and RI) all spent relatively more on education.

The interactions between the continuous covariates (total expenditures and income) are shown in Figures 4 though 9. Apparel had higher expenditures associated with higher total expenditures for the refusal groups (IR, RI) but less of a relationship for the noncontact groups (IN, NI). The reverse effect was found for miscellaneous expenditures. Personal insurance showed a higher expenditure pattern for responders and refusers, but less of a relationship for the noncontact groups. Income was related to relatively higher expenditures for personal care for the attriting noncontact group (IN) but lower for the converting noncontact (NI) and attriting refusal (IR) groups. The noncontact effect reversed for education expenditures, and personal insurance expenditures increased with income, but at a slower rate for converted noncontacts.

Time in Sample

Time in Sample effects are shown in Figure 10. The indicator of relative bias is the sum of the absolute difference between the estimates for respondents and the different types of nonresponse. This is a very crude estimate, but it may serve to stimulate further research. The converted nonrespondents generally had larger differences than the attritions (although there were more attritions, so the impact on estimates wouldn't be as great. There seemed to be a drop in bias for the noncontacts, and a mixed pattern for refusals. TIS 3 showed refusal conversions different from the other types of nonresponse.

Discussion

The nonrespondents had higher relative expenditure estimates for housing and transportation, offset by lower expenditures for personal insurance and entertainment. The magnitude of the bias depends on how similar the attrition and conversion groups are to those who never responded. Swanson (2002) found that "the nonresponses of the intermittent responders appear to have a relatively small effect on the CEQ's published expenditure estimates." The methods of this study differed from Swanson's in that the relative expenditure between categories was examined, rather than the expenditure amount.

This study found the age of the reference person was related to slight bias due to nonresponse. Swanson (2002) found "the average age of the reference person in complete responder CU's is greater (50.6 versus 40.9)". This agreed with Groves and Couper (1998) for refusal, but older households had greater noncontact. Since the CEQ has proportionately more refusal this is consistent. Similarly, Tucker (1992) found younger respondents had more item nonresponse in the Consumer Expenditure Diary survey. This study also had younger nonresponders.

Swanson also found for complete responders: "the average quarterly expenditure per CU on all items is greater ($8981 versus $7,504), and the average expenditure per person is greater ($3,442 versus $3,212) than for intermittent responders". This study found the relative expenditure for entertainment was lower for complete responders, offset by relatively higher insurance expenditures. Income should have been related to this variable, but family income was related to relatively higher expenditures for transportation. Further bias research would be useful to determine if they measure of the source of the income, it's overall amount, household composition, and age interact. A much larger sample size would be necessary.

"Complete responder CU's are also more likely to have both husbands and wives present in the household (57.2% versus 39.8%), less likely to be single consumers (25.3% versus 37.5%)" (Swanson, 2002). Groves and Couper (1998) and Tucker and Dixon (2000) found larger households were more likely to be nonresponders (due to noncontact), which would seem to disagree with the finding for single consumer units. Since much of the nonresponse in the CEQ is due to refusal rather than noncontact, the difference in household characteristics may not be so different. This study found size of household may be slightly related to nonresponse bias, with nonresponding households being smaller. This may be related to the age effect.

Swanson found complete responders were "more likely to be homeowners (73.2% verus 41.0%), and more likely to have only one CU

living in the household (98.3% versus 87.3%)." Similar to household size, Groves and Couper found homeowners less likely to have noncontact, but more likely to have refusal. This study found that homeowners spent more on apparel, housing, and transportation. Ownership interacted with interview status so that responders spent relatively more on apparel and transportation, but less on housing. This may be related to income.

Children present was related to complete responders in Swansons' (2002) study, and lower refusal and noncontact in Groves and Couper (1998, p.92) The effect may disappear or reverse if adjusted for other variable (p.113). Tucker and Dixon (2000) found lower probability of noncontact even adjusting for other variables (although the model was different).

The gender of the respondent didn't relate to nonresponse bias in this study. Although there seemed to be a difference in expenditures (Table 3) there wasn't either a suppressor effect or an interaction with nonresponse. Tucker and Dixon (2000) found males more difficult to contact and more likely to refuse.

Race showed a suppressor effect in terms of nonresponse bias. "Asian/Pacific Islander" (Asian) and "American Indian/Eskimo/Alaska Native" (AI) had higher nonresponse than White or Black respondents, but comprised a very small part of the sample. Both Asian and AI showed suppressor effects, while White and Black did not. While the sample sizes make any conclusions tentative, the significant effects for response status disappeared in the presence of either Asian or AI analyses.

Multi-unit structures had been associated with higher refusal and nonresponse by both Groves and Couper (1998) and Tucker and Dixon (2000). In this study multi-unit households spent less on entertainment, but nonrespondents from those households spent relatively more on entertainment as well as apparel, making up for it by spending relatively less on alcohol. With a larger sample size it would be interesting to see if there is an interaction with age.

The type of nonresponse seemed to make a difference. Attrition noncontact showed little biasing effects. The effects of refusal were strongest in housing and transportation. The other effects tended to counterbalance one another (for example: apparel had lower expenditures for refusal attrition but higher for refusal conversion).

Limitations and Future Research

There are two methodological issues future research should address. A larger sample size would allow more study of interactions. The distributions of several of the expenditures (tobacco and medical in particular) and covariates need to be further explored. While the "compositional analysis" method was interesting, it didn't adjust for all the features of the data.

The effect of time in sample should be examined. Since attrition and conversion occur at relatively high rates there is some rotation of the sample between interview periods. The bias doesn't seem to change overall, but refusals seem to have a varied pattern.

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Apendix A: Table 1 Gross Flows due to nonresponse for 2nd quarter of the CEQ.

		Interview	NonResponse	All	P-value
Phousin2	Mean	0.384	0.393	0.385	<.0001
	StdErr	(0.002)	(0.007)	(0.002)	
Pfoodto2	Mean	0.202	0.197	0.202	0.0484
	StdErr	(0.002)	(0.005)	(0.002)	
Ptranpr2	Mean	0.163	0.186	0.166	0.0016
	StdErr	(0.002)	(0.008)	(0.002)	
Pperlin2	Mean	0.092	0.079	0.090	0.0067
	StdErr	(0.001)	(0.004)	(0.001)	
Pentrmn2	Mean	0.054	0.049	0.053	0.0142
	StdErr	(0.001)	(0.003)	(0.001)	
Pappare2	Mean	0.042	0.040	0.042	0.1123
	StdErr	(0.001)	(0.002)	(0.001)	
Peducat2	Mean	0.011	0.010	0.011	0.8069
	StdErr	(0.001)	(0.002)	(0.001)	
Ptobacc2	Mean	0.014	0.011	0.014	0.3481
	StdErr	(0.001)	(0.001)	(0.000)	
Ppercar2	Mean	0.012	0.013	0.012	0.1000
	StdErr	(0.000)	(0.001)	(0.000)	
pmisc1_2	Mean	0.011	0.008	0.010	0.3561
	StdErr	(0.001)	(0.001)	(0.001)	
Palcbev2	Mean	0.009	0.010	0.009	0.0484
	StdErr	(0.000)	(0.001)	(0.000)	
Preadin2	Mean	0.006	0.005	0.006	0.3407
	StdErr	(0.000)	(0.001)	(0.000)	
All	N	4557	555	5112	<.0001

Table 2

* Lambda p<.0001		II	IN	IR	NI	RI	All
Phousin2	Mean	*0.384*	0.394	**0.414**	*0.357*	**0.389**	0.385 *
	StdErr	(0.002)	(0.019)	(0.012)	(0.016)	(0.014)	(0.002)
Pfoodto2	Mean	0.202	*0.180*	0.205	*0.182*	**0.203**	0.202 *
	StdErr	(0.002)	(0.011)	(0.009)	(0.013)	(0.009)	(0.002)
Ptranpr2	Mean	*0.163*	0.188	0.168	0.191	**0.204**	0.166 *
	StdErr	(0.002)	(0.024)	(0.011)	(0.018)	(0.017)	(0.002)
Pperlin2	Mean	0.092	0.082	0.077	**0.106**	*0.064*	0.090 *
	StdErr	(0.001)	(0.010)	(0.007)	(0.010)	(0.006)	(0.001)
pentrmn2	Mean	0.054	0.054	0.046	**0.057**	*0.045*	0.053 *
	StdErr	(0.001)	(0.008)	(0.003)	(0.006)	(0.005)	(0.001)
pappare2	Mean	0.042	0.046	*0.034*	**0.046**	0.040	0.042 *
	StdErr	(0.001)	(0.007)	(0.003)	(0.005)	(0.005)	(0.001)
peducat2	Mean	0.011	0.011	0.009	0.010	0.011	0.011 -
	StdErr	(0.001)	(0.005)	(0.003)	(0.005)	(0.004)	(0.001)
ptobacc2	Mean	0.014	0.015	0.009	0.012	0.011	0.014 -
	StdErr	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)	(0.000)
ppercar2	Mean	0.012	*0.009*	**0.014**	0.013	0.012	0.012 *
	StdErr	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)	(0.000)
pmisc1_2	Mean	0.011	0.007	0.009	0.004	0.008	0.010 -
	StdErr	(0.001)	(0.003)	(0.003)	(0.001)	(0.003)	(0.001)
palcbev2	Mean	0.009	0.010	0.008	0.013	0.009	0.009 -
	StdErr	(0.000)	(0.003)	(0.001)	(0.003)	(0.002)	(0.000)
preadin2	Mean	0.006	0.005	0.006	0.006	0.004	0.006 -
	StdErr	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
All	N	4557.0	71.000	210.00	109.00	165.00	5112.0

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Table 3 – MANOVA p-values for nonresponse & covariates

Covariate name	Interview Status	Covariate	Interaction
Ztotal2	0.0006	<.0001	0.0149
Nsize2	<.0001	<.0001	0.1994
Neducre2	0.1445	<.0001	0.2139
Ageref2	0.0258	<.0001	0.1153
Qcusize2	0.0253	<.0001	0.7900
Finc2	<.0001	<.0001	0.0391
Kid2	<.0001	<.0001	0.5483
Mul	<.0001	<.0001	0.0009
Time2	0.0016	<.0001	0.4721
Own2	0.0018	<.0001	0.0318
Urban	<.0001	<.0001	0.0072
Sexref2	<.0001	<.0001	0.1309
Qcurace2	0.5095	<.0001`	0.8031