Estimation With Response Error and Nonresponse: Food-Stamp Participation in the SIPP

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Error in survey data originates from failure to contact the sample and from false answers to verifiable questions. These errors may be systematic and associated with uncooperative or unreliable respondents. Zabel modeled attrition in the Survey of Income and Program Participation and found systematic demographic and design effects. Bollinger and David modeled response error and identified correlations to income per capita. In this analysis, we link missing interviews in a panel and response error through a trivariate probit analysis. Robustness of the correlation between attrition and response error is examined by comparing variants of the model. The joint model of response error and attrition becomes the first stage of a pseudolikelihood estimate of a model of food-stamp participation. The model is significantly different from naive probit on the survey data.

KEY WORDS: Measurement error; Multivariate probit; Psuedolikelihood

Participation in the food-stamp program by eligible households rose 20% from 1988 to 1993 and declined substantially after 1995 (Cody and Trippe 1997; Castner and Cody 1999). Policy makers were astounded by these fluctuations. The astonishment demonstrates the need to understand behavior that leads eligible households to apply for benefits. The long history of scholarly modeling of participation in transfer programs relies on household survey data (Keane and Moffitt 1998; Moffitt 1992). Unfortunately, those data fail to reveal all participants in the food-stamp program because survey responses are known to have errors.

Food-stamp-program participation is measured in a number of surveys. The Survey of Income and Program Participation (SIPP) panel is the most accurate because it was designed to measure the use of transfer programs by U.S. households. Nevertheless, SIPP underestimates food-stamp program recipiency because some respondents fail to report benefits received (Bollinger and David 1997; Marquis and Moore 1990). Estimates of models of participation clearly need to incorporate adjustments for response errors.

Previous work by Bollinger and David (1997) found that response error in the SIPP was related to demographic characteristics. Estimates of models of food-stamp participation adjusted for response error are significantly different from estimates that fail to account for response error. Models of response error are estimated on validated responses to the first interview of the SIPP. Models of food-stamp participation are estimated using data from the fourth interview because it elicits the detailed asset information needed to measure eligibility. How probability of response error is related to interview nonresponse (either missing individual interviews or attrition from the panel) is not understood. Since the households remaining at wave 4 may have a different nonresponse pattern than those who were present at the first interview, it is important to establish how response error and interview nonresponse are related.

Zabel (1995) and Rendtel and Büchel (1994) clearly established that attrition is determined both by the characteristics of the respondent and the characteristics of the survey methodology. Zabel's (1998) estimate of a dynamic model of attrition reveals nearly monotonic declines in attrition probabilities. He also found that number of item imputations predicts subsequent attrition. He found comparable relationships for the Panel Survey of Income Dynamics. This suggests that respondents first fail to answer some questions and subsequently refuse to answer any questions. Further, a change in interviewer is also found to be positively related to attrition. One explanation for the latter finding is that respondents learn to trust an interviewer: those with a high level of distrust react to a strange interviewer by refusing to be interviewed. Similar findings occur in the German Socio-economic Panel (Rendtel 1990).

We hypothesize that a latent variable—propensity to cooperate—determines both response error and missed interviews. Cooperative respondents, with high positive propensity to cooperate, attempt to provide correct information to the enumerator and make themselves available for interviews. Noncooperators, with negative values for propensity to cooperate, may be unavailable for interviews. Alternatively, they may be interviewed and fail to respond truthfully, particularly to cognitively difficult or sensitive questions. The following results demonstrate a positive relationship between failure to report food-stamp participation and missing interviews during the first year of the 1984 SIPP panel. We then examine the impact of a multivariate model of response error and missed interviews on estimates of food-stamp-participation behavior. The differences between the simple correction proposed by

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Bollinger and David (1997) and the multivariate cooperator correction estimated here are small. Nonetheless, differences may be more important for other populations or later in the panel.

Section 1 develops a model for food-stamp participation that analytically incorporates response error in survey reports of participation and extends that model to include interview nonresponse. The model assumes a latent variable, the unobserved propensity to cooperate, that determines the propensity to commit errors in reporting food-stamp receipt and the propensity to miss interviews. Section 2 briefly describes the data. Section 3 presents estimates of the joint models of response error and interview nonresponse. Section 4 uses the results from Section 3 to estimate models of food-stamp participation. Assumptions concerning the model of response are tested.

1. MODELS OF FOOD-STAMP PARTICIPATION AND RESPONSE ERROR

1.1 Food-Stamp Participation and Response Error

The Bollinger and David (1997) model of response error leads to estimation of food-stamp-program participation using a pseudolikelihood function. (We call this model the *simple response-error* model.) The function incorporates conditional expectations of propensities to respond incorrectly. The model of participation at time t is formulated on household i's true food-stamp-participation indicator, FS^*_{it}.

The probit model of food-stamp participation for households who are eligible is given by

$$FS^*_{it} = \begin{cases} 1 & \text{if } X_{it,F}\beta_F + \epsilon_{it,F} > 0 \\ 0 & \text{otherwise} \end{cases},$$
$$i = \{\text{asset-eligible}\}, \quad (1)$$

where $\varepsilon_{it,F} \sim N(0, 1)$.

Data for the model of food-stamp participation come from the fourth interview (wave) of the 1984 SIPP panel. The sample is limited to households headed by a married couple who are asset-eligible for the food-stamp program. Asset-eligible families have little to live on in the absence of current income sources. The food-stamp program also requires income eligibility—gross and net income less than established thresholds. The choice to become eligible may entail reducing some income source; therefore, income is endogenous and codetermined with food-stamp participation. The data are described more completely later. Regressors in the participation model can be grouped into three categories:

1. *Earning capacity of the household*: *Hwagehigh* and *Hwagelow* measure the conditional expectation of the husband's wage. *Wwagehigh* and *Wwagelow* measure the conditional expectation of the wife's wage. These regressors are used to avoid endogeneity of earnings and food-stamp participation. See Section 2.3 for additional discussion.

2. *Demographics*: *Fpovmw4* is the poverty threshold for the household based on official poverty thresholds that depend largely on the number of adults and children. *Kidlt18* measures the number of children in the household. *Disabledh* indicates that the head of the household is disabled. *SMSA* indicates households living in a standard metropolitan statistical area.

3. *Assets*: *Lassets* measures liquid assets counted in the eligibility test. *Hhtheq* measures equity in the ownership of the residence. *Othwlt* measures any other assets held.

The true participation variable is not measured in survey data. Only the household's report of participation, FS_{it}, is available. An indicator for an error of omission (a false negative) is denoted by $O_{it} = 1$. An indicator for an error of commission (a false positive report) is denoted by $C_{it} = 1$. The relationship between observed and true food-stamp participation is given by the identity

$$FS_{it} \equiv (1 - O_{it})FS^*_{it} + C_{it}(1 - FS^*_{it}). \quad (2)$$

Taking the expectation of Equation (2) conditional on X_{it} and using the law of iterated expectations yields

$$\begin{aligned} \Pr[FS_{it} = 1|X_{it}] &= (1 - \Pr[O_{it} = 1 | X_{it}, FS^*_{it} = 1] \\ &\quad - \Pr[C_{it} = 1 | X_{it}, FS^*_{it} = 0])F(X_{it,F}\beta_F) \\ &\quad + \Pr[C_{it} = 1 | X_{it}, FS^*_{it} = 0], \end{aligned} \quad (3)$$

where $F(.)$ is the cdf of the standard normal distribution. This relationship can be expressed as

$$\Pr[FS_{it} = 1|X_{it}] = (1 - p_{it} - q_{it})F(X_{it,F}\beta_F) + p_{it}, \quad (4)$$

where p_{it} and q_{it} are the probability of the household committing errors of commission and omission, respectively. The probabilities are conditional on characteristics of household i at time t. Relevant sample characteristics include, potentially, the missingness or attrition patterns that emerge as the panel evolves.

Hausman, Abrevaya, and Scott-Morton (1998) examined a model similar to the simple response-error model. They assumed $p_{it} = p$ and $q_{it} = q$. Generally incorrect specification for p_{it} and q_{it} leads to biased estimates. Bollinger and David (1997) refuted the assumption of invariant propensity to err for the SIPP data used here.

1.2 Response Error and Nonresponse

Bollinger and David (1997) estimated probit models for p_{it} and q_{it} using a subsample of the SIPP that was matched to administrative records for three states. This subsample contains both the true state of the household, FS^*_{it}, and the household response, FS_{it}. Sample measurements permit calculation of the indicators O_{it} and C_{it} and subsequent estimation of probit models of the response errors:

$$O_{it} = \begin{cases} 1 & \text{if } X_{it,0}\beta_0 - \epsilon_{it,0} > 0 \\ 0 & \text{otherwise} \end{cases} \quad \text{if } FS^*_{it} = 1 \quad (5)$$

and

$$C_{it} = \begin{cases} 1 & \text{if } X_{it,c}\beta_c - \epsilon_{it,c} > 0 \\ 0 & \text{otherwise} \end{cases} \quad \text{if } FS^*_{it} = 0. \quad (6)$$

The two probits partition the population. The error terms $\varepsilon_{i1\,o}$ and $\varepsilon_{i1\,c}$ are unobservable. We assume that the distributions of the two errors are standard normal distributions that lead to probit models. The vector $X_{i1\,c}$ contains one regressor, per capita earnings. We estimate the model with three different specifications for the vector $X_{i1\,o}$. The parsimonious model includes the single regressor per capita earnings. Our preferred model includes earnings, three demographic variables, and homeownership. A saturated model includes all 13 regressors in the missed-interview probit.

The response-error models must be augmented to account for nonresponse because nonresponse determines the available sample, and our hypothesis implies that nonresponse correlates with response errors. We discuss these two factors briefly. Households interviewed in the fourth interview (wave) report asset data needed to determine eligibility for food stamps. The interviews taken comprise a choice-based subsample of the households interviewed at wave 1. Table 1 underscores the increasing selectivity of available data. The probability of missing individuals at the first contact is 4.9% (column labeled 0). Subsequent attrition is shown in the remaining columns. By the fourth contact, attrition has cumulated to 16.9%. Additional nonresponse comes from others who miss the wave-4 interview but complete later interviews.

Our cooperator hypothesis, set out in the introduction, ascribes missed interviews and response errors to behavior that can be captured by a single latent variable. Hence the simple response-error models estimated by Bollinger and David (1997) ignore an important observable characteristic—the interview nonresponse pattern of the household during the entire panel. This omission is particularly important when the timing of the available data is considered. Recall that the models of response error can only be estimated on data derived from the first interview. Models of food-stamp participation can only be estimated on data derived from the fourth. Since the wave-4 interview occurs eight months (25% of sample) or a year (75% of sample) after the first interview, the relationship between response error and subsequent interview nonresponse is important.

Thus we broaden the simple response-error model of Bollinger and David (1997) to include a relationship with measures of missed interviews. The latent variable, propensity to cooperate, measures the household's willingness and ability to provide accurate data at each interview and to continue to provide interviews. The multivariate cooperator model for response error and interview nonresponse incorporates three indicators as dependent variables—O_{i1}, C_{i1}, $A_{it}(T)$.

The variable $A_{it}(T) = 1$ indicates some interview nonresponse for the ith household at time t for the window $1 \leq t \leq T$. (When the time window is clear from context, we drop the argument of A.) Individual interview nonresponse is aggregated to the household, assuring comparable units of analysis in every dimension of the model. Nonresponse is aggregated over a time window that begins in the first wave of interviewing. (The sample design assures that every household at time t includes at least one person interviewed in wave 1.)

A probit model is applied to an indicator for any household interview nonresponse during the window. Formally,

$$A_{i1}(T) = \begin{cases} 1 & \text{if } X_{it\,A}\beta_A - \epsilon_{it}(T) > 0 \\ 0 & \text{otherwise} \end{cases}, \quad T = 4, 8. \qquad (7)$$

Probit estimation entails the assumption that $\varepsilon_{i1\,A}(T)$ is normally distributed.

One multivariate model that can apply to Equations (5), (6), and (7) is a fixed-effects model. The error terms in Equations (5), (6) and (7), can be written as

$$\varepsilon_{it,c} = v_i + \eta_{it\,o}$$
$$\varepsilon_{it} = v_i + \eta_{it\,c}$$
$$\varepsilon_{it\,A}(T) = v_i + \eta_{it\,A}(T). \qquad (8)$$

The common term v_i is the fixed "cooperator effect." Larger values of this term indicate a larger propensity to cooperate resulting in both more accurate responses in period t and lower probability of interview nonresponse during the window $[1, T]$. The multivariate model that is applied to the four indicator variables is summarized in Table 2.

The cooperator model is defined by the last three rows of the preceding table. It joins the models of omission, commission, and nonresponse. The cooperator model tests hypothesis 1: $\rho_{o} > 0$. ρ_{o} measures the proportion of the variance of $\varepsilon_{it,o}$ that can be explained by the common fixed effect. We interpret a positive correlation between $\varepsilon_{\cdot it,A}(T)$ and $\varepsilon_{\cdot it\,o}$ to mean that latent cooperativeness induces individuals to provide interviews and accurate responses. Technically, the cooperator hypothesis also implies that $\rho_c > 0$ and $\rho_{co} > 0$. However, errors of commission are extremely rare; significant results for the correlation between ε_A and ε_c are not expected. We cannot simultaneously observe errors of omission and commission in a cross-section, so the parameter ρ_{co} is not identified.

An alternative to the fixed-effect specification is a dynamic specification with v_i autoregressive or state-space dependent. Under those regimes, households are moved to cooperate by the net impact of random shocks received up to the present time or by past decisions to cooperate. The data we have available do not identify a unique stochastic mechanism.

The cooperator model of response error and nonresponse is a trivariate probit model with parameters β_A, β_o, β_c, ρ_o, and ρ_c. Cross-sectional data from the first contact with the sample and the cumulative history of giving interviews to T generate coefficient estimates of the cooperator model by multiple like-

Table 1 Attrition Through the 1984 SIPP Panel

Contact	0	1	2	3	4	5	6	7	8	Total
Percent attriting (individuals)	4.9	5.9	6.1	5.4	4.8	4.4	3.7	2.6	0	37.8

By definition attritors must miss the two interviews prior to the last interview

Table 2 Cooperator Model Summary

Behavior	*Variable*	*Regressors*	*Random*	*Slope*	*Covariance*			
True FS	FS^*_{it}	$X_{it,F}$	$\varepsilon_{it,F}$	β_F	1	0	0	0
Nonresponse	$A_{it}(T)$	$X_{it,A}$	$\varepsilon_{it,A(T)}$	$\beta_{A(T)}$	0	1	ρ_o	ρ_c
Omission	O_{it}	$X_{it,O}$	$\varepsilon_{it,O}$	β_o	0	ρ_o	1	ρ_{oc}
Commission	C_{it}	$X_{it,C}$	$\varepsilon_{it,C}$	β_c	0	ρ_c	ρ_{oc}	1

NOTE ρ_{oc} represents the unidentified correlation between errors of omission and commission

lihood estimator. A subsample of the observations is validated by administrative records. As a result, the log-likelihood of the sample data includes three terms. The first term is a bivariate probit on the subsample of households in which administrative records indicate true receipt of food stamps ($FS^*_{i1} = 1$). The second term is a bivariate probit on the subsample of observations in which administrative records indicate no receipt of food stamps ($FS^*_{i1} = 0$). The final term is a univariate probit for the nonresponse model on the remaining households in which no administrative records are available. Identification and estimation of (ρ_o, β_o) hinges on the first term and identification and estimation of (ρ_c, β_c) hinges on the second term. Parameters in the nonresponse model β_A are found in all three terms.

The likelihood function is

$$\begin{aligned}\mathcal{L}_1 = \sum_{FS^*_{i1}=1} &\{A_{i1}\cdot O_{i1}\cdot PO_{11} + A_{i1}\cdot(1-O_{i1})\\ &\cdot PO_{10} + (1-A_{i1})\cdot O_{i1}\cdot PO_{01} + (1-A_{i1})\\ &\cdot(1-O_{i1})\cdot PO_{00}\} + \sum_{FS^*_{i1}=0}\{A_{i1}\cdot C_{i1}\cdot PC_{11}\\ &+A_{i1}\cdot(1-C_{i1})\cdot PC_{10} + (1-A_{i1})\cdot C_{i1}\cdot PC_{01}\\ &+(1-A_{i1})\cdot(1-C_{i1})\cdot PC_{00}\}\\ &+ \sum_{FS^*_{i1}=\text{missing}} A_{i1}\cdot F(X_{i1,A}\beta_A)\\ &+(1-A_{i1})\cdot F(-X_{i1,A}\beta_A). \end{aligned} \tag{9}$$

The terms $PO_{r,s}$ denote the log probability of observing $A_{i1} = r$ and $O_{i1} = s$, and terms $PC_{r,s}$ denote the log probability of observing $A_{i1} = r$ and $C_{i1} = s (r, s = 0, 1)$. For example, two of the corresponding integrals of the normal density function are given by

$$PO_{11} = \ln\int_{-X_{i1,o}\beta_o}^{\infty}\int_{-X_{i1,A}\beta_A}^{\infty} f(\varepsilon_A, \varepsilon_o; \rho_o)\,d\varepsilon_A\,d\varepsilon_o \tag{10}$$

and

$$PC_{11} = \ln\int_{-X_{i1,c}\beta_c}^{\infty}\int_{-X_{i1,A}\beta_A}^{\infty} f(\varepsilon_A, \varepsilon_c, \rho_o)\,d\varepsilon_A\,d\varepsilon_c, \tag{11}$$

where $f(.)$ is the pdf of the standard normal distribution. Conditioning variables for modeling O_{i1}, C_{i1} are specified by considering economic incentives and rules for receiving food stamps. Specification of conditioning variables for the nonresponse model follows Zabel (1995).

The parameters of the participation model [Eq. (1)] are estimated in a second step. Estimates of the cooperator model are used to calculate expected propensities to omission error, $\hat{p}_{i4}$, and commission error, $\hat{q}_{i4}$, on the sample of wave-4 households that are asset-eligible for food stamps. These propensities vary over households because the conditioning variables vary for households giving interviews at wave 4. The predicted $\hat{q}_{i4}$ and $\hat{p}_{i4}$ [see Eqs. (12) and (13)] estimate points on the underlying continua of error propensities. These propensities are used to form a pseudolikelihood function that is maximized with respect to the parameter β_F. The likelihood function for the participation model is given by

$$\begin{aligned}\mathcal{L}_2 = \sum_{i\text{-asset eligible}} &FS_{i4}\cdot\ln\{((1-p_{i4}(T)-q_{i4}(T))\\ &\times F(X_{i4,F}\beta_F) + p_{i4}(T))\} + (1-FS_{i4})\\ &\ln\{((1-p_{i4}(T)-q_{i4}(T))\\ &\times F(-X_{i4,F}\beta_F) + q_{i4}(T))\}. \end{aligned} \tag{12}$$

The pseudolikelihood approach replaces p_{i4} and q_{i4} with the predicted values for the wave-4 eligible sample based on estimates of the cooperator model. Alternative specifications for p_{it} and q_{it} clearly alter the likelihood function and affect the estimates of β_F.

Predicted propensities to err, $\hat{p}_{i4}$ and $\hat{q}_{i4}$, contain a novel element because of ρ_o. If the cooperator hypothesis is confirmed, missing interviews and propensity to err are correlated, *after* conditioning for all pertinent household characteristics. That implies that $\hat{p}_{i4}$ and $\hat{q}_{i4}$ are conditioned on the predetermined $\varepsilon_{i1,o}$ through ρ_o and the conditioning variables for A. Households interviewed in wave 4 will include some that have never missed interviews and some whose members missed interviews after the first wave. Since being observed in the sample in wave 4 is clearly related to the missing interview pattern in previous waves, failure to account for this in the propensity to err leads to a bias in estimation of β_F.

$\mathcal{L}_2$ is a pseudomaximum likelihood function. Its history and desirable asymptotic properties were surveyed by Gourieroux, Monfort, and Trognon (1984). For this problem, estimation of $\mathcal{L}_2$ requires three assumptions:

Assumption 1: Models of response error apply to the U.S. population, even though they are estimated on a subsample of the SIPP.

Assumption 2: The coefficients in the cooperator model are time invariant.

Assumption 3: The covariances between ε_F and $(\varepsilon_A, \varepsilon_o, \varepsilon_c)$ are 0.

Assumption 1 is necessary, since the matched validation data that allow for observation of the true variable FS_{it}^{*} are only available for Pennsylvania, Florida, and Wisconsin subsamples of the SIPP. Bollinger and David (1997) discussed this issue and provided evidence that this subsample is not markedly different in observable characteristics from the *SIPP* sample as a whole. Assumption 2 is required since estimation of the participation model must use wave-4 data in which detailed asset information is available to construct a sample of eligible households.

The covariance matrix in Table 2 embodies Assumption 3. It implies that the model of food-stamp participation and the cooperator model are separable and can be independently estimated. To test the assumption that ε_1 and ε_i are uncorrelated, we estimated the take-up model including a sample-selection term estimated from a first-stage probit on household presence in wave 4. We find that the coefficient on the selection term is not statistically significant in any of the participation models. These results are not presented here but are available from the authors on request.

2. DATA

The data all derive from the 1984 panel of the SIPP. The 1984 SIPP panel consists of eight interviews covering a 32-month period. The first interviews were conducted in October 1983. Each interview, termed a "wave," asks a standard set of questions concerning sources of income, participation in government transfer programs, and labor-force activity. Each wave also contains questions on special topics. Different topics are covered at each wave. Of importance for the models of food-stamp participation is the supplemental information on asset holdings obtained at wave 4. These data define the subsample of food-stamp-eligible households. Assets also appear as conditioning variables in the food-stamp-participation models.

2.1 Response Error

The data used for estimation of the joint model of response error and nonresponse come from a special subsample of the SIPP for which state administrative records of food-stamp-program participation are available. Florida, Pennsylvania, and Wisconsin provided the Census Bureau with administrative records of participants in the food-stamp program. These records were matched by the Census Bureau to the SIPP data for waves 1 and 2. The match was based on name, social security number, address, and demographic information. These data are referred to as the validation data. Any discrepancy between reported food-stamp participation and the administrative record is considered response error. Bollinger and David (1997) discussed the assumption that administrative records are correct. Details of the match process were given by Marquis and Moore (1990).

Table 3 presents descriptive statistics for the variables used in estimation of the cooperator model. The underreporting of food-stamp participation in the survey data can be clearly seen by comparing the first two rows. Table 4 shows the extent of error in reporting receipt of food stamps in household questionnaires relative to administrative records. The counts pertain to the reference month prior to the interview. Net underreporting is smaller than errors of omission because some households falsely declare receipt of food stamps.

Table 5 tabulates the gross correlation of errors of omission and commission by a measure of missed interviews, *anymiss4*.

Table 3. Descriptive Statistics Validation and Nonresponse Data (last month prior to interview)

Label	*Definition*	*N*	*Mean*	*Std dev.*
RFS	FSP record food stamps rec'd	2 685	067	25
QRS	SIPP response food stamps rec'd	2, 685	062	24
pcearn	Per capita household earnings	19, 856	656	837
anymiss	Any adult misses any interview (8 waves)	19, 856	28	45
anymissu	*Anymiss* plus out-of-scope cases (8 waves)	19, 856	31	46
anyatt	Any adult misses last two interviews (8 waves)	19 856	18	.39
anyattu	*Anyatt* plus out-of-scope cases (8 waves)	19, 856	21	.41
anymiss4	*Anymiss* on waves 2-4 only	19 856	16	37
anymiss4u	*Anymiss4* plus out-of-scope waves 2-4 only	19 856	18	38
anyatt4	*Anyatt* on waves 2-4 only	19, 856	069	25
anyatt4u	*Anyatt4* plus out-of-scope waves 2-4 only	19, 856	078	27
headmiss4u	Head of household miss any wave 2-4	19, 856	15	35
headmiss4	Head of household miss any wave 2-4	19, 856	14	.34
headatt4u	Head of household attrit by wave 4	19, 856	064	25
headatt4	Head of household attrit by wave 4	19, 856	058	23
pcfinc	Total family income/family size	19, 856	984	1, 707
headage	Age of head of household	19 856	48	18
headsex	Gender of head (1 = female)	19, 856	32	47
headwhite	Race of head (1 - white)	19, 856	87	34
headms	Marital status of head (1 - married)	19, 856	59	49
headed	Education of head	19, 856	12 1	3.5
homeown	Ownership of residence (1 if own)	19, 856	64	48
fkidlt18	Number of minor children in family	19, 856	70	1 1
fkidgt18	Number of adult children in family	19, 856	23	59
oldest	Age—17 of oldest adult child, 0 otherwise	19, 856	4 3	10 3
nonfam	Number of people not in primary family	19, 856	074	35
nonfinc	Income of people not in primary family	19, 856	50 1	299

Table 4. Households Receiving Food Stamps

Administrative report	Survey response No	Yes	Total	Error rate
No	2,496	8	2,504	0.3%
Yes	22	159	181	12.2
Total	2,518	167	2,685	

NOTE Validation sample last month prior to interview, 1983

interview nonresponse and response error are related. The left half of Table 5 demonstrates that overall 13.8% of participating households have a missing interview prior to wave 4 but nearly 32% of participating households with an error of omission have a missing interview. Conversely, 12% of participating households have an error of omission, but 28% of participating households with a missing interview have an error of omission. A chi-squared test of independence based on this contingency table results in a test statistic of 7.02. The null hypothesis of independence between omission and a missing interview is rejected at conventional levels. The right half of Table 5 demonstrates that overall 16% of nonparticipating households have a missing interview, but 37.5% of nonparticipating households with an error of commission have a missing interview. Similarly, 3% of nonparticipating households have an error of commission, but .75% of nonparticipating households with a missing interview have an error of commission. The differences shown are more systematically analyzed in the cooperator model. A chi-squared test on this table results in a test statistic of 2.66. The null hypothesis of independence cannot be rejected. However, it is questionable whether any conclusions could ever be drawn on errors of commission due to their infrequent occurrence.

2.2 Nonresponse

Four aspects of missed interviews are considered in the measures presented here—period at risk, attrition and nonattrition patterns, aggregation of household members, and treatment of out-of-scope members of the sample. The first two aspects define four measures of interview nonresponse. The more inclusive definition corresponds to the indicators *anymiss* and *anymiss4*. These indicators equal 1 if any member of the household at the first interview misses any subsequent interview. The time windows $T = 8, 4$ are applied to all members of the household. *Anymiss* is measured on the time window that includes all waves for which a member of the household was eligible for interview. *Anymiss4* refers to interviews missed from waves 2–4. Attrition patterns of missed interviews are a subset of all missed interviews and correspond to the indicators *anyatt* and *anyatt4*. These indicators equal 1 if any member of the household missed the last two interviews for which that person was eligible. This construction requires that at least two consecutive noninterviews are recorded. Individuals who miss only the last interview for which they were eligible are not counted in *anyatt* or *anyatt4* (but would be counted in *anymiss* and *anymiss4*).

In addition we calculate the indicators for interviews missed by the head of the household over the window $T = 4$. Those indicators are labeled *headmiss4* and *headatt4*. Since all members of the household are asked about food-stamp participation and any positive response is taken to mean household participation, restricting missingness to the interviews given by the head of the household should not lead to a less error-prone measure of cooperation. However, we include it here for completeness.

Variants of the six preceding measures deal with the scope of the definition. The cooperator model of noninterviews relates to respondent behavior. The most pertinent measure of interview nonresponse includes cases in which individuals in a household take action to avoid giving an interview—refusing to give an interview, for example. When a person moves out of scope of the sampling frame, the meaning of the code for nonresponse becomes ambiguous. An individual is deemed out of scope by the Census Bureau for many reasons. Moving out of the United States or to remote areas, death, entering an institutional living arrangement, or entering the military are all classified as out of scope. Some of these actions constitute choices to be noncooperative. Others may be related to a household crisis and may indicate inability to provide accurate answers. Some are simply random acts unrelated to noncooperation. Because information is incomplete and reasons for being out of scope are aggregated, it is not clear that out-of-scope individuals should be classified as missing interviews. The six variables previously described exclude all out-of-scope cases. The variables *anymissu*, *anyattu*, *anymiss4u*, *anyatt4u*, *headmiss4u*, and *headatt4u* include out-of-scope cases.

Relationships among the various measures of interview nonresponse should be noted. Considering the measures aggregated over the entire panel, approximately two-thirds of the households with any individual missing an interview (*anymiss* = 1) had an individual who left the sample (*anyatt* = 1). When nonresponse is aggregated over the second through the fourth waves, 40% of households with any missed interviews include an individual who leaves the sample. Results are similar when out-of-scope cases are included in the measure of missed interviews.

Table 5. Response Errors and Anymiss

Anymiss4	Error of omission No	Yes	Total	Rate	Error of commission No	Yes	Total	Rate
None	141	15	156	9.6	2,098	5	2,103	.24
Some	18	7	25	28.0	398	3	401	.75
Total	159	22	181	12.2	2,496	8	2,504	.32
Missing rate	11.3	31.8	13.8		15.9	37.5	16	

A_{it} depends on household membership at a point in time. Individuals enter and leave households throughout the panel. The point in time that is relevant to the cooperator model is $t = 1$; $t = 4$ is relevant to the participation model. A household that contained noncooperators at interview 1 may no longer contain those individuals at interview 4, and the willingness and ability to cooperate changes accordingly. For example, a household that is under stress from marital disruption may be less willing or able to provide accurate responses in interview 1. A year later, the event that caused stress has been resolved in such a way that some individuals live elsewhere. They may now be more willing to give interviews and correct answers. The remaining persons may also be more willing or able to provide accurate answers. We do not assume that cooperation in marriage and survey cooperation are related, although correlation is possible. We point out that events may affect willingness and ability to provide accurate answers and meet with interviewers and may precipitate exits from the household.

Our preferred measure of nonresponse is *anymiss4*. Participation is a wave-4 estimation problem, *anymiss4* has conformable timing. We prefer to exclude out-of-scope cases since it is not clear what they imply. Finally, we prefer the missingness criterion for the early panel. It is highly correlated with later attrition in any case, while attrition prior to wave 4 is rare.

2.3 Regressors: Cooperator Model

Regressors can be considered in four groups

1. *Demographic variables for the head of the household.* *Headage* is the age of the head of the household, *headsex* indicates female-headed households, *headwhite* indicates that the head of the household is white, *headms* indicates households headed by a married couple, and *headed* measures the level of education in years. *Singlemale* and *singlefemale* are calculated from *headsex* and *headms* and indicate households headed by a single male or female

2. *Financial variables*: *Pcfinc* is the total income from all sources for the adults in the primary family of the household divided by the number of individuals in that family In most cases, the primary family is the entire household The attrition literature suggests that total income or *pcfinc* should appear in the model for nonresponse (Zabel 1995) *Pcearn* is the employment earnings for all adults in the household divided by the number of individuals in the household. Bollinger and David (1997) suggested that *pcearn* should appear in the models for response error for food-stamp participation since *pcinc* includes food-stamp income. In the estimates reported in Table 6, row 3, we use per capita income instead of earnings in the omission model. Last, *homeown* indicates that the household owns the housing unit in which they reside

3. *Family characteristics*: *Fkidlt18* is the number of children in the primary family under age 18. *Fkidgt18* is the number of children in the primary family over age 17. *Oldest* is the age of the oldest adult child in the primary family minus 17

4. *Persons other than the primary family*: *Nonfam* is the number of people in the household not in the primary family.

Table 6 Cooperator Model of Response Error and Missed Interviews

Variable	anymiss4u	anymiss4	anyatt4u	anyatt4
	Dependent variable in nonresponse model			
Coefficients from interview nonresponse model (β_A)				
Constant	- 55[1]	– 66[1]	–1 1[1]	–1 2[1]
	(08)	(07)	(.09)	(.08)
headage	003[1]	– 004	- .003[1]	– 003[1]
	(0008)	(0008)	(0009)	(001)
headsex	- 03	– 01	– 05	– 05
	(03)	(03)	(04)	(04)
hwhite	18[1]	– 18[1]	– 08[1]	– 08[1]
	(03)	(03)	(04)	(04)
headms	06[1]	– 02	– 08	– 05
	(03)	(03)	(04)	(04)
headed	007	008[1]	003	005
	(004)	(004)	(004)	(005)
pcfinc (000s)	- 075[1]	– 07[1]	– 07[1]	–.05
	(018)	(02)	(02)	(02)
*pcfinc*²s(millions)	004[1]	004[1]	004[1]	003[1]
	(001)	(001)	(002)	(002)
homeown	-- 16[1]	– 11[1]	– 12[1]	– 09[1]
	(.03)	(03)	(03)	03)
fkidlt18	.06[1]	– 05[1]	– 07[1]	– 06[1]
	(01)	(01)	(02)	(02)
fkidgt18	2[1]	19[1]	15[1]	14[1]
	(03)	(03)	(03)	(.04)
oldest	002	002	001	001
	(002)	(002)	(002)	(.002)
nonfam	29[1]	28	22[1]	17[1]
	(03)	(03)	(04)	04)
nonfinc (000s)	04	05	03	– 03
	(04)	(04)	(04)	(05)
Coefficients from error of omission model (β_O)				
Constant	- 1 11[1]	–1 10[1]	–1 12[1]	–1 14[1]
	(46)	(44)	(47)	(48)
pcearn	004[1]	003	003[1]	003[1]
	(001)	(001)	(001)	(001)
singlefemale	03	– 003	04	03
	(31)	(27)	(31)	(.32)
singlemale	88	82[1]	85[1]	.84[1]
	(37)	(36)	(38)	(38)
headed	- 08[1]	– 08[1]	– 07[1]	– 07[1]
	(04)	(04)	(04)	(04)
homeown	40	40	37	37
	(28)	(27)	(28)	(28)
Coefficients from error of commission model (β_C)				
Constant	- 2 5[1]	–2 5[1]	–2 5[1]	–2 5
	(2)	(2)	(2)	(2)
pcearn (000s)	66[2]	– 67[2]	– 68[2]	- 68[2]
	(38)	(38)	(38)	(38)
Omission ρ	45	.50[1]	45[3]	43[3]
	(18)	(.17)	(34)	(.33)
Commission ρ	16	18	09	11
	(16)	(16)	(20)	(20)
Log-likelihood	46	– 44	– 27	– 25

[1] Significance at the 5% two-tailed test
[2] Significance at 5% one tailed test
[3] Significance at the 10% one-tailed test

Nonfinc is the total income from all sources of the nonfamily members of the household.

Table 3 presents descriptive statistics for all variables in the nonresponse model on the 19,856 households used to estimate the noninterview indicator, $A_{it}(T)$ Variables are listed in the order in which they appear in the cooperator submodel.

3. ESTIMATES

3.1 Cooperator Model

The simple response-error model of Bollinger and David (1997) is nested within the cooperator model Our preferred specification for the cooperator model uses the variable *anymiss4* to measure nonresponse. The rationale is that the measure is close in time to when response errors were measured Furthermore, attrition, which entails missing consecutive interviews prior to the termination of data collection, is a narrow measure of uncooperativeness that will not register persons with temporary problems who miss interviews and freely give interviews at a later time.

Table 6 presents the estimated cooperator model when interview nonresponse is measured for $T = 4$. This window is particularly relevant for two reasons. First, wave-4 data are used to estimate a model of food-stamp participation. Interview nonresponse prior to and including wave 4 is relevant to sample selection. Second, the time window is a year or less after the measurements of response error. One would expect that the strongest relationship between response error and interview nonresponse would manifest itself in adjacent periods. That is, noncooperators are more likely to commit errors and begin missing interviews early in the panel

Estimates of ρ_o are the main focus of the model as they test the cooperator hypothesis. If ρ_o is positive and significant, then estimation of the model of participation must incorporate the cooperator model. Table 6 reveals estimates of ρ_o that vary in significance. When *anymiss4* is used for the measure of nonresponse, the estimate is .504. The one-tailed test of the cooperator hypothesis ($H_{\text{null}} : \rho_o \leq 0$, $H_{\text{Accept}} : \rho_o > 0$) gives a test statistic of 2.89, which supports the cooperator hypothesis at all conventional levels. When *anymiss4u* is used, the estimate is .446. The one-tailed test gives a test statistic of 2.49, which is again significant at all conventional levels. Even the estimated models using the *anyatt4u* and *anyatt4* yield test statistics greater than 1.29, the one-tailed 10% level critical value. The one-tailed p values for these two estimates are both .09. Clearly there is evidence in favor of the cooperator hypothesis using this model.

We also estimate variants of the model:

1. $T = 8$ that incorporates nonresponse over the entire panel (*Anymissu*, *Anymiss*, *Anyattu*, and *Anyatt*)
2. a parsimonious model for omission [comparable to the commission model and the model reported by Bollinger and David (1997)]
3. a "saturated" model for omission that includes all variables from the model for A
4. A that measures noninterviews only for the head of the household

We expect that the results will be weaker when nonresponse over the entire panel is used Events late in the panel are separated in time by as much as 2 2/3 years from the initial interview in which response error is measured. Table 7 presents estimates of the correlation coefficient ρ_o for the 16 alternative specifications. The slope coefficients in these models are qualitatively similar to those in Table 6 (available on request).

Table 7 Estimates of ρ_o Alternative Models

Nonresponse variable regressor specification	*anymissu*	*anymiss*	*anyattu*	*anyatt*
1 Preferred (full panel measures of nonresponse)				
Same omission model as Table 6	28[2]	16	13	– 01
	(18)	(19)	(27)	(25)
2 Parsimonious (waves 2–4 measure same as Table 6)				
Only *PCearn* in omission model	34[1]	41[1]	34	.37
	(18)	(19)	(30)	(28)
3 Saturated (waves 2–4 measure same as Table 6)				
Same X's in attrition and omission models	32[2]	391[1]	.12	13
	(24)	(18)	(.40)	(49)
4 Preferred Head of HH determines A (waves 2–4 measure)				
Same omission model as Table 5	446[1]	29[1]	49	44
	(19)	(.17)	(42)	(41)

[1] Significance at 5% one-tailed test
[2] Significance at the 10% one-tailed test

The first row (1. Preferred omission model) reports estimates of ρ_o when the nonresponse variables are measured over the entire panel. As can be seen, three of the estimates are positive The fourth is negative but insignificant. The strongest result here uses *anymissu* as the measure of nonresponse and is positive and significant at the 6% one-tailed level. The one-tailed p value for the test statistic is .054. Although this model does not provide strong evidence for the cooperator model, it is consistent with the model and prior expectations.

The second row (2. Parsimonious omission model) reports estimates of ρ_o when only the per capita earnings measure is included in the omission model (comparable to the commission model). Bollinger and David (1997) used this model to correct for response error and justified it over a model similar to the model reported in Table 6 based on the fact that the estimated participation models were not substantially different using one model of omission or another. We include these results here for comparison The estimated correlation is smaller because the term $\eta_{it\,o}$ will have more variance when fewer regressors are included. As the variance of ε_o is normalized to 1, the correlation, ρ_o, is the proportion of variance of ε_o that is attributable to the fixed effect v_i More variance in $\eta_{it\,o}$ implies lower correlation.

The third row (3. Saturated omission model—all X's from nonresponse) of Table 7 presents estimates of the cooperator model using the wave 2–4 measures of nonresponse (same measures as in Table 6). The omission model is expanded to include additional regressors. We used all 13 regressors from the nonresponse model. These models again provide support for the cooperator hypothesis. Significance varies, the *anymiss4u* and *anymiss4* are significant at the 10% and 5% one-tailed level. The estimates based on the attrition measures are not significant.

Variation in the number of regressors in the cooperator model reveals two kinds of robustness. Parameters of the models for errors and missed interviews are stable. The values of ρ_o are indistinguishable from the values for the preferred model in Table 6. Furthermore, the models incorporating *anymiss4* are consistently positive for each set of regressors. No evidence suggests that our preferred model is misspecified and that large values of ρ_o are artifacts.

The last model in Table 7, variant 4, uses measures of nonresponse pertaining to the head of the household. This version is included to provide comparability to other models in which characteristics of the householder are used to explain household behavior. These results are presented in the fourth row (4. Preferred omission model—head of HH missing/attrit.). Again, the model supports the cooperator hypothesis, estimates using *headmiss* show $\rho_o > 0$. The estimates using *headmiss4u* and *headmiss4* are significant at the 5% level for the one-tailed test.

We draw three conclusions from this array of models. (1) $\rho_o > 0$ for preferred models (2) The fixed effect is larger using missingness rather than attrition. Because attrition occurs for only one of three who miss interviews and a smaller proportion than the probability of omission errors, that result is not surprising. (3) The small sample of households receiving food stamps implies that the covariance of omission errors and missed interviews is difficult to measure precisely.

In previous research (Bollinger and David 1995), we estimated simple models of errors of omission and commission in which the measures of interview nonresponse were included as right-side variables. Those results are similar. We prefer the preceding structural model over these simpler models since it incorporates a causal mechanism and is not just descriptive regression.

3.2 Food-Stamp Participation

The sample used for estimation of the food-stamp-participation model, called the primary sample, derives from the fourth interview of the 1984 panel of the SIPP. Married-couple households in which both husband and wife were of working age (18–64) are included. Households whose assets exceed the threshold for eligibility are excluded. Asset eligibility can only be established at the fourth and seventh waves, when questions are asked about asset holdings and debt. Table 8 presents descriptive statistics for each of the variables used in estimation of the participation model.

3.2.1 Regressors of Principal Interest. The model of participation focuses on the effect assets have on the decision to participate. Hence, three variables that sum to net worth are included in the analysis—*lassets*, *hhtheq*, and *othwlt*. The variable *lassets* contains liquid assets that determine eligibility for the food-stamp program, including checking accounts, savings accounts, stocks, and bonds, less associated debt. The variable *hhtheq* is the self-reported value of the house owned by the householder less the amount of outstanding mortgages. The final variable *othwlt* contains net wealth from automobiles, businesses, second homes, and other sources that are not counted in the other two categories.

Earnings capacity for the husband and wife, *hwage* and *wwage*, were predicted from standard human-capital models (Bollinger and David 1997). The models predict wage rates from schooling, experience, and family life cycle. The models employ standard corrections for selectivity. The predicted values are independent of the earner's current level of work activity, thereby avoiding the simultaneity bias that would be associated with earnings as a regressor. The coefficient estimated describes a response to earnings capacity (Garfinkel and Haveman 1977; Morgan, David, Cohen, and Brazer 1962).

Earnings capacity for the husband and wife and the asset variables *hhtheq* and *othwlt* are splined. The spline allows a nonlinear response and assures that responses estimated for the lower part of the distribution of these four variables are not affected by outliers in the upper tail of the distribution.

3.2.2 Estimates. The likelihood function for the observed report of food-stamp participation is a function of the probabilities of errors of omission and commission [Eq. (4)]. Using the model of joint response error and interview nonresponse estimated in the previous section, a pseudolikelihood function for FS_{it} can be constructed. The probability of omission errors conditional on nonresponse can be derived as

$$\begin{aligned} q_{it} &= \Pr[O_{it} = 1 \mid X_{it}, A_{it} = 1] \\ &\quad * A_{it} + \Pr[O_{it} = 1 \mid X_{it}, A_{it} = 0] * (1 - A_{it}) \\ &= \frac{\Pr[O_{it} = 1, A_{it} = 1 \mid X_{it}]}{\Pr[A_{it} = 1 \mid X_{it}]} \\ &\quad * A_{it} + \frac{\Pr[O_{it} = 1, A_{it} = 0 \mid X_{it}]}{\Pr[A_{it} = 0 \mid X_{it}]} * (1 - A_{it}), \end{aligned} \quad (13)$$

Table 8. Descriptive Statistics for Primary Sample

Variable	*Definition*	*Mean*	*Std. dev.*
FS	Survey response: Food stamps rec'd	098	298
hwagelow	Predicted husband's wage below mean	12 07	1.59
hwagehigh	Predicted husband's wage above mean	1 19	2 74
wwagelow	Predicted wife's wage below mean	6 77	1 03
wwagehigh	Predicted wife's wage above mean	62	88
fpovmw4	Poverty threshold	870	250
fkidlt18	Number of minor children	1 46	1 32
othwltlow	Other wealth below $75K	4,751	15,801
othwlthigh	Other wealth above $75K	1,965	18,362
hhtheqlow	Home equity below $75K	15,972	22,016
hhtheqhigh	Home equity above $75K	1,200	8,473
lassets	Liquid assets	393	472
disabledh	Disabled head of HH	12	33
SMSA	Live in SMSA	45	50
$N = 2{,}623$			

while commission errors can be derived as

$$\begin{aligned} p_{it} &= \Pr[C_{it} = 1 \mid X_{it}, A_{it} = 1] \\ &\quad *A_{it} + \Pr[C_{it} = 1 \mid X_{it}, A_{it} = 0] * (1 - A_{it}) \\ &= \frac{\Pr[C_{it} = 1, A_{it} = 1 \mid X_{it}]}{\Pr[A_{it} = 1 \mid X_{it}]} \\ &\quad *A_{it} + \frac{\Pr[C_{it} = 1, A_{it} = 0 \mid X_{it}]}{\Pr[A_{it} = 0 \mid X_{it}]} * (1 - A_{it}). \qquad (14) \end{aligned}$$

Parameters from the Table 6 model *anymiss4* are used to calculate household-level predictions $W = \{(\hat{p}_{i4}, \hat{q}_{i4})\}$. As noted previously, *anymiss4* is the preferred measure of A. Of the three models using *anymiss4* presented in Tables 6 and 7, the model in Table 6 has the highest mean likelihood of -.43657. The model presented in row 2 of Table 6 has a mean likelihood of $-$ 43690; in row 3 the likelihood is $-$ 43674 It should be noted that likelihoods cannot be compared across different measures of nonresponse.

The calculation takes the household membership for the month prior to interview at the wave-4 contact. This means that some "split-offs" from wave-1 households now are in separate dwellings. The noninterview behavior of their "roommates" is aggregated into the nonresponse measure, even though those persons may not have been in the sample at wave 1. The measure A_{i4} results from this construction. Reported standard errors are computed to account for sampling variance from the first-stage estimation of the models for p_{it} and q_{it}. See Gourieroux et al. (1984) and Bollinger and David (1997) for detailed explanations.

Conditioning the predicted propensity to commit errors on interview nonresponse is clearly important for correct specification. Households that have missed interviews are more likely to have omitted food-stamp use. Models that fail to account for interdependence of missed interviews and errors will not fully correct for response errors. Another clear problem is that choice-based selection affects the estimates of food-stamp participation from wave 4. A rigorous treatment of the selection problem is beyond the scope of this article. However, we compared the estimates here with estimates produced by the standard Heckman (1974) procedure. Each of the three take-up estimates following was also estimated including an additional selection term. In each case, the coefficient on the selection term was insignificant, even at the 10% level The estimated coefficients were nearly the same as the models to be reported. (Results are available from the authors.)

The primary sample contains households that are clearly ineligible to receive food stamps because they have high incomes (although they are asset-eligible). The primary sample has a much higher mean for $\hat{p}_{i4}$ than the value observed for households known to receive food stamps, $FS^* = 1$. The probit model for errors of omission predicts that households with sufficient income to be ineligible are very likely to withhold information. But those same households are very unlikely to receive food stamps. This tension results in the difference in estimates between the *naive probit* and models incorporating response errors.

Table 9 compares alternative estimates of probits on food-stamp-program indicators with response errors in a sample

Table 9 Food-Stamp-Participation Model (eligible households, Aug.–Nov 1984)

Variable	*Naive probit*	*Simple response error*	*Cooperator*
$\bar{p}_4, \bar{q}_4$	0 0	006, 417	002, 425
(stand dev of p, q)		(004, 305)	(002, .323)
Constant	1 5	1 92	1 85[1]
	(4)	(46)	(44)
hwagelow	14	– 15[1]	– 14
	(03)	(04)	(04)
hwagehigh	– 07[1]	13	– 13
	(02)	(04)	(04)
wwagelow	– 21	21	– 21[1]
	(05)	(06)	(06)
wwagehigh	– 19	– 19	– 20
	(09)	(12)	(12)
fpovmw4	0003	0004	0003
	(0002)	(0003)	(0003)
fkidlt18	10[1]	08	07
	(04)	(05)	(05)
othwltlow (millions)	4 8	–4 2	–4 8
	(4 6)	(5 8)	(5 7)
othwlthigh (millions)	39	1 1	– 8
	(54)	(7 3)	(7 1)
hhtheqlow (millions)	–11	12	-11
	(3)	(5)	(5)
hhtheqhigh (millions)	1 1	3 3	2 5
	11 9	(14 6)	(14 5)
lassets	001[1]	002	- 002[1]
	(0001)	(0004)	(0005)
disabledh	1 31	1 63[1]	1 61[1]
	(15)	(25)	(24)
SMSA	09	09	10
	(09)	(12)	(12)
Log-likelihood	–564 0	–515 7	–513 2
$N = 2{,}623$			

[1] Significant at 5%

Table 10. Mean Probability of Food-Stamp Participation

Model	Classifier				
	A Earning capacity husband (1984 $/hour)				
	5	9	13	17	21
Naive probit	23	10	03	02	.007
	(07)	(02)	(006)	(004)	(003)
Simple response error	23	09	03	007	.002
	(10)	(04)	(01)	(004)	(001)
Cooperator	26	11	.04	01	.002
	(11)	(04)	(.02)	(006)	(002)
	B Liquid assets (100's)				
	None	5	10	15	20
Naive probit	08	03	007	002	0002
	(009)	(005)	(003)	(001)	(0002)
Simple response error	13	02	0007	0000	0000
	(02)	(008)	(001)	(0001)	(0001)
Cooperator	13	02	002	0001	0000
	(03)	(01)	(003)	(0002)	(0001)

that has interview nonresponse. The naive probit model makes no correction for response error; it is biased because it cannot account for false negative answers. The *simple response-error* model uses predictions for p_{it} and q_{it} based on the omission and commission models estimated, *without* the interview nonresponse—that is, without accounting for $\rho_{..}$. Since the cooperator hypothesis was confirmed, the simple response-error model is misspecified. Error-prone households are more likely to miss interviews than correct reporters. The cooperator model uses the calculation in Equations (13) and (14) for predicted p_{it} and q_{it}.

A Wald test comparing the estimated coefficient vectors between the three models is informative. [Although tests can be performed, as we do here, they are not technically correct. The three participation models are not nested. The likelihood functions used to calculate each one are different in the given values for $\hat{p}_{it}$ and $\hat{q}_{it}$. The correct locus for testing the cooperator model against the naive or simple response-error models is on the cooperator model (tests shown in Sec. 3). Technically, $\mathcal{L}_1$ [Eq. (9)] and $\mathcal{L}_2$ [Eq. (12)] can be added and jointly maximized. The joint model is nested. However, the test for comparing models would again be tests on the parameters in the models of response error and $\rho_{..}$ already shown.] As shown by Bollinger and David (1997), the estimates based on the correction from the simple response-error model rejects the naive model: The chi-squared test is 27.9, a p value of .014. The estimates based on the correction from the cooperator model also reject the naive model, but the test value is only 22.70, a p value of .065. However, the cooperator model cannot reject the simple response-error model. Use of the simpler model for corrections cannot be rejected. However, estimates may be biased. More validation data will be needed to indicate circumstances under which each model has minimum mean squared error.

Another measure of the importance of the response-error correction is differences in the predictive results of the models. Evaluating the three estimated models at the means of the sample yields predicted participation probabilities of .0347 for the naive model, .0255 for the simple correction, and .0336 for the cooperator correction. These differences may seem trivial. However, keep in mind the very low participation rates actually predicted. The difference between 2.55% participation (the predictions from uncorrected models) and 3.36% participation would increase the predicted number of participants by 31.7%. Even the modest difference between the simple correction and the cooperator correction decreases the predicted number of participants by about 3%. This difference obviously impacts budgets.

The model estimates reveal that the husband's potential wage coefficients and the coefficients on liquid assets are two of the more important differences across the models. We calculate the predicted probability of receiving food stamps for each household, varying the level of these two important conditioning variables. Other variables are set at their sample means. Table 10 presents these predicted probabilities of food-stamp participation for all three models. For both potential wage and liquid assets, the cooperator model has a participation rate that drops off markedly faster than the uncorrected model and is higher than the simple correction. Participating households are more concentrated at the low end of potential earnings and assets than either the simple model or the naive model would predict. The naive model overpredicts participation at high potential-earning and high asset-holdings levels. This implies that conventional estimates are likely to lead researchers to the mistaken conclusion that a significant proportion of participants have high potential earnings and high (relative to the eligibility criteria) asset holdings. Policy makers may incorrectly conclude that tightening the asset test may reduce participation. They may also conclude that many "high earners" use food stamps when this is contrary to best estimates. Only correct specification of error rates and accounting for missed interviews will lead to accurate predictions.

4. CONCLUSIONS

Positive correlation between response error and interview nonresponse is the most important finding in this analysis. Section 3.1 presents evidence that families with higher than average response error in the first interview also exhibit higher than average interview nonresponse in the first year of the panel. This finding supports hypothesis 1 and a theory of cooperativeness. Cooperators reveal themselves by willingness and availability to give interviews throughout the panel and by the accuracy of their data. Noncooperators reveal themselves by missed interviews and the inaccuracy of their data

Estimated ρ_o vary, but a maintained assumption that $\rho_o \equiv 0$ is clearly refuted and appears robust for a measure of interviews missed by household members within one year after giving validated reports. None of 20 different models contradict the cooperator hypothesis that $\rho_o > 0$. Estimates of the cooperator model can be combined with data from other survey samples measuring food-stamp participation so long as assumptions 1–3 can be maintained. The simpler corrections for response error reported by Bollinger and David (1997) and the second column in Table 9 may be adequate, but we know nothing about the empirical conditions under which they could be substituted for the cooperator model.

The findings demand additional data collection and estimation. Stability of response-error models over time needs to be established, and correlation of missed interviews and error propensities needs to be investigated. Validation data need to be collected from samples that are coordinated with major panel studies. We do not know enough about circumstances that lead to poor-quality response nor do we know which attributes cause response errors to vary systematically In many areas of economic study, particularly the collection of asset and asset-related income data, aggregate data lead to a presumption that underreporting is substantial. The lapse of resources directed at measuring response error since Ferber, Forsythe, Guthrie, and Maynes (1969a,b) and Lansing, Ginsberg, and Braaten (1961) needs to be erased. A second conclusion is that validation data need to be accessible to a large community of users so that appropriate models of error can be scientifically developed.

Perhaps most important though is the implication that the levels of response error may evolve over a panel as individuals enter or leave the panel. This implies that validation needs to be an ongoing process in any panel. Very few studies have been able to look at validation over repeated measures, and stability of response-error processes needs to be studied. A second implication is that scientists can no longer presume that nonresponse and response errors are separable. Both confound model estimation. Conventional weighting schemes for nonresponse will often not improve model estimates. In panel data it may be that nonresponse profiles can proxy for some part of response error. The extent to which that proxy assists estimation can only be determined from careful validation of a substantial number of domains of survey measurement. Should our hypothesis 1 be supported in many studies of validation data, survey design would need to redirect resources that are now directed at reducing nonresponse toward measuring response errors.

Support for the cooperator model also suggests that response error may be related across variables. This implies that validation of data should be broad and far-reaching, and simply examining one or two variables may not fully capture the problem. Clearly of interest here are the income and asset variables determining both eligibility and participation. Morgenstern (1963) called for validation as a regular aspect of data collection. Our findings suggest that this validation must encompass more variables and repeated measures in panel data.

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