# Food Stamp Program Participation and Food Insecurity: An Instrumental Variables Approach

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The relationship between Food Stamp Program (FSP) participation and household food insecurity (FI) is investigated using data from the 1996–1997 National Food Stamp Program Survey. Endogeneity of FSP participation is accommodated with an instrumental variables approach. In contrast to other findings reported in the literature, results suggest participation in the FSP reduces the severity of FI. Sociodemographic variables play important roles in FSP participation and FI. Underreporting of FSP participation and limited observations of food-insecure households in previous studies may have also been factors.

*Key words*: censored dependent variable, food insecurity, food stamp program, instrumental variables, National Food Stamp Program Survey.

The U.S. Department of Agriculture (USDA) implements sixteen Food Assistance and Nutrition Programs as a food safety net to provide low-income families and children with access to healthy diets. The sixteen programs were funded at a level of $52.8 billion in fiscal year (FY) 2006 (U.S. Department of Agriculture, Food and Nutrition Service [USDA-FNS] 2007). An estimated one in five Americans participates in one or more programs at some point in a typical year. Still, the most recent food security survey, sponsored by the USDA, indicates that 11% of U.S. households (22.7 million people) were uncertain of having or unable to acquire sufficient food to meet the nutritional needs of all their members during the year owing to lack of financial or other resources (Nord, Andrews, and Carlson 2006). Of these food-insecure households, approximately 3.9% (7.6 million people) experienced very low food security (VLFS) and 7.6% (15.1 million people) experienced low food security.[1] There were 34.9 million people in 2002 who lived in households where at least one person was food insecure. According to the National Food Stamp Program Survey (NFSPS), a sample containing low-income households (those below 150% of the poverty level) used in the current study, 26.2% of the sample reported some degree of food insecurity (FI) during the thirty days prior to the interviews.[2]

The Food Stamp Program (FSP) is designed to provide food assistance via benefit payments

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[1] In 2005, USDA introduced a new language to describe ranges of severity of food insecurity. The labels "low food security" and "very low food security" replaced "food insecurity without hunger" and "food insecurity with hunger," respectively. These changes were made in response to recommendations by an expert panel convened at USDA's request by the Committee on National Statistics (CNSTAT) of the National Academies. A report produced by the panel discusses at length the use of the FI measure for policy-relevant analysis of food assistance program impacts (National Research Council 2006).

[2] To be classified as food insecure in the USDA annual statistics, a household must affirm that, over the past twelve months, they experienced at least three of the conditions included in the scale. At a minimum this would require admitting worry about running out of food, not being able to afford balanced meals, and finding that household food did not last. This classification scheme may result in an upward bias in FI estimates. We thank one anonymous reviewer for suggesting this.

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to households that meet the eligibility criteria. It is the largest component of the USDA's nutrition program. The FSP budget for FY 2007 was $34.8 billion, comprising 63.9% of the Department's food assistance budget (USDA 2007, p. 4). Within the food-insecure population, not all food stamp–eligible households participate in the program. With so much of the nation's food assistance resources distributed by the FSP, it is important that policy makers have improved analytical tools for evaluating program participation and for estimating the impacts of FSP participation on the food security status of program participants.

There is a body of literature pertaining to the determinants and consequences of food security status in the United States, including the role of the FSP.[3] Early studies using the single-item food sufficiency measure found food insufficiency was significantly associated with underintakes of a number of nutrients among adult women and the elderly, but not among preschoolers (Rose and Oliveira 1997a, 1997b), and that households with higher incomes, owning a home, headed by a high school graduate, or with an elderly member(s) present were less likely to be food insufficient (Rose, Gundersen, and Oliveira 1998). Gundersen and Oliveira (2001) investigated food insufficiency and FSP participation using data from the 1991 and 1992 panels of the Survey of Income and Program Participation (SIPP) and concluded FSP participants had the same probability of food insufficiency as nonparticipants. Using longitudinal panel data from the SIPP and the Survey of Program Dynamics (SPD), Ribar and Hamrick (2003) also found no evidence that food stamps alleviate food insufficiency and no causal impact of FSP participation.

More recent studies utilized measures of food insecurity or VLFS. On the basis of data from the 1995 and 1999 Current Population Survey Food Security Supplement (CPS-FSS), Nord (2001) noted that households participating in the FSP registered much higher rates of FI and VLFS than nonparticipating low-income households and that households receiving food stamps registered almost no change in the measured prevalence of FI or VLFS. Kabbani and Yazbeck (2004) pooled multiple years of data from the CPS, using a two-stage estimation procedure to control for endogenous program participation. Results suggested that participation in the FSP moderated the observed differences for households with children ages 5–18, but not significantly. Using logit analysis with households that had experienced VLFS in the past year, Kabbani and Kmeid (2005) found that the FSP benefit amount and participation in the National School Lunch program reduced the probability of being classified as VLFS in the past thirty days.

Hofferth (2004), using longitudinal data from the Panel Study of Income Dynamics (PSID), found that the association between transitions in FSP participation status and FI reflected variation in families' unmet needs for food rather than a true effect of program participation. Wilde and Nord (2005) using the CPS found that a fixed-effects panel data model to control for time-invariant unobservable factors reduced but did not eliminate the appearance that FSP participation was associated with poorer food security status. Data from the Early Childhood Longitudinal Survey (ECLS) were used by Gibson-Davis and Foster (2006) to compare the food security status of matched participants and nonparticipants with similar predicted probabilities. They concluded that food stamps did not affect the probability of being classified as FI.

Weakness of nonexperimental research designs and research designs for experimental methods to evaluate food assistance program impacts are discussed by Hamilton and Rossi (2002). Two studies looking at the linkage between FI and FSP participation followed a unique approach that exploited a "natural experiment." Bartfeld and Dunifon (2006), using hierarchical linear models, found significant but small beneficial effects of higher FSP participation rates on the food security status among near-poverty and low-income households but not for poor or higher-income households. Borjas (2004) found that immigrant populations whose program eligibility was restricted in the 1996 welfare reforms experienced a significant relative deterioration in food security status.

The apparent inconsistency among previous results suggests that a more careful investigation of FSP participation and FI is needed. This article presents the results of a study of participation in the FSP and its relationship to

[3] Wilde (2007) reviewed many recent studies that investigated the effects of the FSP on FI and hunger, categorizing these studies into six approaches.

FI using an instrumental variables approach. The NFSPS data offer a unique opportunity for such a pursuit. Not only do they include the eighteen items of the food security module that are used for annual monitoring of FI, they also include follow-up questions that allow the examination of FI status in the thirty days preceding the interviews (Nord 2002). As in other studies, FSP participation is measured for the prior month, but the NFSPS did not rely entirely on self-reports to identify FSP participants since part of the sample was selected from administrative records.

Measuring FI status based on questions that reference the past thirty days improves estimation of FSP impacts because both endogenous variables are measured over the same time period. Only Kabbani and Yazbeck (2004) and Kabbani and Kmeid (2005) have examined the impact of FSP on FI status over the past thirty days. State-level variations in electronic benefit transfer (EBT) adoption and recertification periods provide better instruments than those used in previous studies except Kabbani and Wilde (2003) and Kabbani and Yazbeck (2004). The methodology employed in this study allows for the endogeneity of FSP participation in modeling FI status, and the results suggest that participation in the FSP improves FI status.

## Econometric Model

As an income supplement, the FSP provides additional resources for households to buy food and is thereby expected to improve nutritional well-being. Yet, FSP participation is voluntary and is an individual decision. On the one hand, FI may prompt an eligible household to begin receiving food stamps. On the other hand, FSP participation may improve FI. Clearly, the determination of causality, as opposed to simple correlation, can be quite difficult in the case of these two variables. To confront this important issue, we use an instrumental variables approach with binary FSP participation and a FI outcome that is censored at zero. To motivate such a model, consider first a simple equation for FI ($y_2$), with observation subscript suppressed,

$$(1) \qquad y_2 = \gamma y_1 + \mathbf{x}'\boldsymbol{\beta}_1 + \mathbf{w}'\boldsymbol{\beta}_2 + \mathbf{r}'\boldsymbol{\beta}_3 + v$$

where $y_1$ is a binary variable for FSP participation, $\mathbf{x}$ and $\mathbf{w}$ are vectors of observable traits such that $\mathbf{x}$ affects both FI and FS, $\mathbf{w}$ determines FI only, and $\mathbf{r}$ is a vector of unobservable characteristics that affect both FI and FS; $\gamma$ is a scalar parameter; $\boldsymbol{\beta}_1$, $\boldsymbol{\beta}_2$, and $\boldsymbol{\beta}_3$ are conformable parameter vectors; and $v$ is the random error. In a single-equation framework, one would estimate

$$(2) \qquad y_2 = \gamma y_1 + \mathbf{x}'\boldsymbol{\beta}_1 + \mathbf{w}'\boldsymbol{\beta}_2 + v^*$$

with error term $v^* = \mathbf{r}'\boldsymbol{\beta}_3 + v$. Ordinary least-squares (OLS) estimation of equation (2) produces a biased estimate for $\gamma$, the effect of FS, because $E(v^* \mid y_1, \mathbf{x}, \mathbf{w}) \neq 0$. One remedial measure is to estimate the FI equation with an instrumental variable approach. In addition, to accommodate the censored FI and discrete FSP variables for the current application, variables $y_1$ and $y_2$ are replaced with their latent counterparts $y_1^*$ and $y_2^*$, so that

$$(3) \qquad y_1^* = \mathbf{x}'\boldsymbol{\alpha}_1 + \mathbf{z}'\boldsymbol{\alpha}_2 + u_1$$

$$(4) \qquad y_2^* = \gamma y_1^* + \mathbf{x}'\boldsymbol{\beta}_1 + \mathbf{w}'\boldsymbol{\beta}_2 + u_2$$

where $\mathbf{z}$ is a vector of observable characteristics (instruments) determining FSP participation only, $\boldsymbol{\alpha}_1$ and $\boldsymbol{\alpha}_2$ are conformable parameter vectors, and the error terms $[u_1, u_2]'$ reflect stochastic innovations or unmodeled random effects that are assumed to be distributed as bivariate normal with zero means, correlation $-1 \leq \rho \leq 1$, finite variances $[\sigma_1^2, \sigma_2^2]'$, and covariance matrix

$$(5) \qquad \boldsymbol{\Sigma} = \begin{bmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{bmatrix}.$$

The correlation ($\rho$) may account for possible omitted common factors in the two equations for which instruments are needed. The reduced-form equation system constitutes equation (3) and

$$(6) \qquad y_2^* = \mathbf{x}'(\gamma\boldsymbol{\alpha}_1 + \boldsymbol{\beta}_1) + \mathbf{z}'(\gamma\boldsymbol{\alpha}_2) + \mathbf{w}'\boldsymbol{\beta}_2 + u_2^*$$

where $u_2^* = \gamma u_1 + u_2$ and the error vector $[u_1, u_2^*]'$ is distributed as bivariate normal with zero means, correlation $\tau$, finite variances $[\omega_1^2, \omega_2^2]'$, and covariance matrix

(7)
$$\boldsymbol{\Omega} = \begin{bmatrix} \omega_1^2 & \tau\omega_1\omega_2 \\ \tau\omega_1\omega_2 & \omega_2^2 \end{bmatrix} = \begin{bmatrix} \sigma_1^2 & \gamma\sigma_1^2 + \rho\sigma_1\sigma_2 \\ \gamma\sigma_1^2 + \rho\sigma_1\sigma_2 & \gamma^2\sigma_1^2 + 2\gamma\rho\sigma_1\sigma_2 + \sigma_2^2 \end{bmatrix}.$$

On the basis of the reduced-form equations (3) and (6), binary FSP participation and censored FI are characterized by

(8)
$$y_1 = 1(y_1^* > 0)$$
$$y_2 = \max(0, y_2^*)$$

where $1(A)$ denotes the indicator function, taking value 1 if event $A$ holds, and 0 otherwise. Because the outcomes of $y_1$ are binary, the standard deviation $\sigma_1$ is normalized at unity and therefore, $\omega_1 = \sigma_1 = 1$. The other elements of the covariance matrix $\boldsymbol{\Omega}$ in equation (7) can be simplified as well by factoring out $\sigma_1$ (and $\omega_1$). Maddala (1983, p. 246) discussed a two-step estimation procedure for a similar model in which latent variable $y_2^*$ also appears on the right-hand side of the latent equation (3) for $y_1^*$. We develop a more efficient maximum-likelihood (ML) estimation procedure. Denote the deterministic components of the right-hand sides of equations (3) and (6) as $\mathbf{H}'\boldsymbol{\Pi}_\mathbf{1}$ and $\mathbf{H}'\boldsymbol{\Pi}_\mathbf{2}$, respectively, where $\mathbf{H} = [\mathbf{x}', \mathbf{z}', \mathbf{w}']'$, $\boldsymbol{\Pi}_\mathbf{1} = [\boldsymbol{\alpha}_1', \boldsymbol{\alpha}_2', \mathbf{0}]'$, and $\boldsymbol{\Pi}_\mathbf{2} = [(\boldsymbol{\gamma}\boldsymbol{\alpha}_1 + \boldsymbol{\beta}_1)', \boldsymbol{\gamma}\boldsymbol{\alpha}_2', \boldsymbol{\beta}_2']'$. In addition, define a dichotomous indicator $\kappa_1 = 2y_1 - 1$, and let $\phi(\cdot)$ and $\Phi(\cdot)$ be the univariate standard normal probability density function (pdf) and cumulative distribution function (cdf), and $\Psi(\cdot, \cdot; \tau)$ be the bivariate standard normal cdf with correlation $\tau$. Then, the sample likelihood function is

(9)
$$L = \prod_{y_2=0} \Psi\left(\kappa_1\mathbf{H}'\boldsymbol{\Pi}_\mathbf{1}, \frac{-\mathbf{H}'\boldsymbol{\Pi}_\mathbf{2}}{\omega_2}; -\kappa_1\tau\right) \times \prod_{y_2>0} \frac{1}{\omega_2}\phi\left(\frac{y_2 - \mathbf{H}'\boldsymbol{\Pi}_\mathbf{2}}{\omega_2}\right) \times \Phi\left(\kappa_1 \frac{\mathbf{H}'\boldsymbol{\Pi}_\mathbf{1} + \tau(y_2 - \mathbf{H}'\boldsymbol{\Pi}_\mathbf{2})/\omega_2}{(1-\tau^2)^{1/2}}\right).$$

Estimation requires numerical evaluations of univariate and bivariate standard normal cdf's.

## Data

Data are drawn from the 1996–1997 National Food Stamp Program Survey (NFSPS) conducted for Food and Nutrition Service (FNS) by Mathematica Policy Research, Inc. The objectives of the survey were to assess the quality of FSP customer service offered to current and potential clients, to gain a perspective on the food shopping opportunities of FSP participants and other low-income households, and to examine food security of FSP participants (Cohen et al. 1999).

The NFSPS conducted computer-assisted telephone interviews (CATI) of FSP participants and income-eligible nonparticipants from a random digit dialing (RDD) sample ($n = 1{,}319$) and an FSP list frame ($n = 1{,}042$).[4] After excluding observations with missing information on important variables, a final sample of 2,179 observations was used for analysis. The FSP list frame included only FSP participants, and the RDD sample included both FSP participants and nonparticipants. The surveys, conducted between June 1996 and January 1997, collected an array of economic, social, and demographic data designed to evaluate the decision making for FSP participation among income-eligible households.

The first endogenous variable is FSP participation. Each respondent chosen from the RDD sample was asked, "Did you or anyone in your household receive food stamps or food stamps benefits in the past 30 days?" (Cohen et al. 1999). The FSP variable is coded as 1 for households with a positive response to the question, and 0 otherwise in a manner similar to the identification of participants by self-reports on other national surveys. Respondents chosen from the list frame sample were coded as participants.[5] Combing the two sampling frames resulted in a more accurate representation of the FSP participant population but an unbalanced sample proportion of FSP participants. Sample weights were applied so that the weighted proportion of FSP participants in the combined sample, 67%, was close to the national FSP participation rate of 64% for September 1996. Details on development of the weights are available in Ohls et al. (1999).

[4] The list frame sample was made up of administrative lists of food stamp participants provided by social service offices in thirty-five counties selected as Primary Sampling Units.

[5] There were four cases from the list frame where respondents said they were not receiving food stamps. These were excluded from the sample.

The other endogenous variable, FI, was constructed from each household's responses to the thirty-day follow-up questions to the twelve-month FI module (Hamilton et al. 1997a, 1997b). The thirty-day FI scale was used for this study because its reference period corresponds to the FSP participation variable. The CPS-FSS has, since 1995, collected information on food security–related conditions, behaviors, and experiences that occurred in the respondents' households during the twelve months prior to the survey. For a subset of questions, respondents were also asked whether the condition occurred during the last thirty days. Affirmative responses to the thirty-day questions were followed up with a question that asks, "In the last 30 days, how many days did (the experience or behavior) occur?" The thirty-day scale, initially developed by Hamilton et al. (1997b), included seventeen items—nine items indicating occurrence of conditions at any time during the previous thirty days and eight items indicating recurrence of selected conditions on five or more days. Following recommendation by Nord (2002), only items corresponding to those in the twelve-month scale were included. The items included are whether the following conditions occurred in the past thirty days: any adult(s) cut size of meals or skipped meals, adult(s) cut or skipped on three or more days, respondent ate less than felt he or she should, respondent was hungry but did not eat because he or she could not afford it, respondent lost weight, any adult(s) did not eat for the whole day, and adult(s) did not eat three or more whole days. Items relating to children were excluded given recent evidence that households with and without children may have differential response patterns (Wilde 2004). Responses to these seven questions are combined into a scaled measure of the severity of FI experienced by each household using statistical methods based on the Rasch measurement model (Fischer and Molenaar 1995). See Nord (2002) for details on the use of the Rasch methodology and its application to food insecurity measurement. Scores for households that did not respond affirmatively to any of the items in the scale are undefined and, in this study, recorded as zeros. In order to accommodate the unknown value of the scale scores, FI is treated as a censored variable, with values ranging from 0 to 10.85 and a weighted sample means of 7.36 (FSP nonparticipants) and 6.88 (FSP participants) among those reporting some measure of FI (i.e., conditional on $FI > 0$). In contrast to previous studies in which FI was coded as a binary (Gundersen and Oliveira 2001) or ordinal (Jensen 2002) variable, treating the variable as censored has the advantage that information on both discrete outcomes (food insecure vs. secure) and severity (i.e., to what extent) of FI is used. For subsequent exploratory analyses a binary variable was created on the basis of scale scores. Households with scale scores indicative of at least three affirmative answers were coded as VLFS.

For the initial censored system, the nonlinear identification criteria are met even without exclusion restrictions due to the functional form and distributional assumptions for the system, although nonlinear functional forms often fail to generate sufficient variation to identify the coefficients.[6] To avoid overburdening the nonlinear functional forms for parameter identification, some exclusion restrictions are useful. While researchers have struggled with a lack of credible exclusion restrictions in similar models, we have some relevant variables that can serve as good instruments. Explanatory variables used in both the FSP participation and FI equations are household income, shopping frequency, number of dependent children, marital status of household head (married, divorced/separated, widowed), gender of respondent, household type (single-headed, one-person household), presence of an elderly person or children, race (Black, Asian, other races), ethnicity (Hispanic), home ownership, urbanization (rural, urban), and region (Midwest, South, and West). Variables used only in the FI equation are travel time to the store where most food shopping is done and a binary indicator of dissatisfaction with shopping in their neighborhoods. These variables are included only in the FI equation because they may not directly affect respondents' FSP participation decisions but may change their FI status due to access to grocery stores.

Four sets of variables are included in the FSP equation only under the maintained exclusionary hypothesis that they have no direct effect on FI. The first variable is a binary indicator of whether the respondent resides in

[6] A more pessimistic view is any violation of the functional form or distributional assumptions would make the parameter estimates inconsistent, and quite possibly worse than OLS estimates. As discussed later, our results are fairly robust with respect to exclusion conditions. Further investigation might consider the use of parametric or nonparametric modeling procedures without the assumption of normal errors, which are beyond the scope of the current analysis.

a state with a recertification period shorter than six months. Short recertification periods require more frequent recertification of FSP eligibility and therefore may discourage participation. The second variable is the percentage (coded as proportion) of FSP benefits issued by EBT in the respondent's state. The EBT system may help encourage participation by reducing stigma in the use of food stamps, though the system also makes it more difficult for persons unfamiliar with debit cards to access benefits (e.g., Kabbani and Wilde 2003). The third variable used in the FSP equation is the population share of admitted immigrants. Immigrants were qualified for FSP benefits before the 1996 Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA) eliminated food stamp eligibility for approximately 825,000 legal immigrants. Even though the data for this study were collected before the immigrant restrictions went into effect, there might have been a "chilling effect" during the data collection period that inhibited immigrant households from seeking assistance through the FSP. Finally, a set of four stigma variables is included to capture the effect of "welfare stigma," that is, the "disutility arising from participation in a welfare program per se" (Moffitt 1983, p. 1023). These are four dummy variables indicating whether the individual had avoided telling (people about receiving food stamps), shopped (at stores) where (they are) unknown, (been treated with) disrespect shopping (with food stamps), or (been treated with) disrespect telling (people about being on food stamps). Detailed definitions and sample statistics of all variables are presented in table 1.

## Results

The model is estimated by maximizing the likelihood function (9), weighted by the sample weights.[7] Asymptotic standard errors of parameter estimates are calculated by inverting the numerical Hessian matrix of the likelihood function. ML estimates are presented in table 2. One empirical issue for the type of instrumental variables model considered is that empirical estimates are often not robust with respect to the explanatory variables used. Our use of the four stigma variables in the FSP participation equation is supported by economic theory (Moffitt 1983), and there is no obvious reason why these variables would affect the FI equation directly. The other instruments are state-level variables short recertification period, EBT percentage, and immigrants. We investigate the robustness of the parameter estimates by excluding these state-level variables from the FSP participation equation, but find no discernable differences in parameter estimates. As the stigma and state-level variables are jointly significant in the FSP participation equation, our analysis below is based on results from this fully specified model.

The estimated error correlation ($\rho$) is positive and statistically significant at the 5% level, which suggests that the two structural equations should be estimated jointly because the unobserved factors in the two equations are correlated and affect the propensity to participate in the FSP and FI in the same direction. Of the two variables used in the FI equation only, dissatisfaction about shopping environment in the neighborhood is positive and significant at the 1% level, whereas travel time to store is insignificant. FSP has a significant and negative coefficient in the FI equation at the 1% level, suggesting that participation in the FSP ameliorates FI. This negative effect of FSP participation on FI is in sharp contrast to that reported in a growing body of literature. Huffman and Jensen (2003) and Gundersen and Oliveira (2001), for instance, found that FSP participation did not affect FI.[8] Gibson-Davis and Foster (2006) used propensity score matching and found no impact of FSP participation on the likelihood of being food insecure, although they reported a reduction in the level of FI associated with participation in the FSP.

Since we found a very different result in this study in terms of the effect of FSP on FI from that reported in the literature, we explored the causes of this difference and summarize the findings here. First, we estimated a few variations of our model with both two-step (Maddala 1983, p. 246) and ML procedures using the same sample: (1) one with the latent FI variable in the FSP participation equation

[7] The model was estimated with alternative initial values, including single-equation OLS, probit, and Tobit estimates for the exogenous model (i.e., with observed FSP in the FI equation) and two-step estimates for the system, and all converged to the same estimates.

[8] The model used in Gundersen and Oliveira (2001) and Huffman and Jensen (2003) was based only on binary FI (and FSP) information and was estimated with a two-step procedure suggested by Mallar (1977), which is less efficient than the ML procedure developed here.

**Table 1. Summary Statistics**

| Variable | Definition | FSP Nonparticipants Mean | FSP Nonparticipants SD | FSP Participants Mean | FSP Participants SD |
|---|---|---|---|---|---|
| FI | Thirty-day adult-scale FI score, censored at 0 | 1.94 | 3.38 | 1.69 | 3.08 |
| | Among those reporting an FI score (i.e., FI > 0) | 7.36 | 1.84 | 6.88 | 1.68 |
| | Percent reporting an FI score | 26.22 | | 26.15 | |
| | Continuous Exogenous Variables | | | | |
| EBT percentage | Proportion of FSP benefits issued by EBT in state | 0.14 | 0.32 | 0.11 | 0.30 |
| Immigrants | Share of admitted immigrants per 1,000 population | 3.06 | 2.52 | 3.14 | 2.55 |
| Travel time | Time to store where most food shopping is done (hours) | 0.39 | 0.55 | 0.37 | 0.56 |
| Income | Household monthly gross income (dollars) | 829.43 | 416.45 | 715.00 | 567.32 |
| Shop. frequency | Shopping frequency per week | 2.20 | 0.90 | 2.62 | 1.03 |
| Dep. children | Number of dependent children age < 13 | 0.82 | 1.20 | 1.25 | 1.33 |
| | Binary Exogenous Variables (yes = 1; no = 0) | | | | |
| Short recert. period | Estimated recertification period less than six months | 0.24 | | 0.15 | |
| Avoid telling | Have avoided telling people about receiving food stamps | 0.28 | | 0.23 | |
| Shop where unknown | Have gone out of their ways to shop at a store where no one knows them | 0.20 | | 0.11 | |
| Disrespect shopping | Have been treated with disrespect when shopping with food stamps | 0.26 | | 0.24 | |
| Disrespect telling | Have been treated disrespectfully when telling people they received food stamps | 0.21 | | 0.12 | |
| Dissatisfied–shop. | Dissatisfied with shopping in the neighborhoods | 0.22 | | 0.29 | |
| Married | Respondent is married | 0.44 | | 0.18 | |
| Divorced/sep. | Respondent is divorced or separated | 0.19 | | 0.34 | |
| Widowed | Respondent is widowed | 0.19 | | 0.10 | |
| Never married | Respondent was never married (reference) | 0.18 | | 0.38 | |
| Female | Respondent is female | 0.77 | | 0.86 | |
| Single-headed | Household headed by a single head | 0.09 | | 0.39 | |
| One-person HH | Only one person in the household | 0.28 | | 0.22 | |
| Elderly | Member(s) age > 60 present in household | 0.39 | | 0.22 | |
| Children < 18 | Child(ren) age < 18 present in household | 0.47 | | 0.67 | |
| Black | Race is Black | 0.19 | | 0.33 | |
| Asian | Race is Asian | 0.02 | | 0.01 | |
| Other races | Race is other non-White | 0.18 | | 0.20 | |
| White | Race is White (reference) | 0.60 | | 0.46 | |
| Hispanic | Of Hispanic origin | 0.14 | | 0.16 | |
| Homeowner | Household owns a home | 0.47 | | 0.17 | |
| Rural | Resides in a rural area | 0.19 | | 0.15 | |
| Urban | Resides in an urban area | 0.52 | | 0.56 | |
| Suburb | Resides in a suburban area (reference) | 0.29 | | 0.29 | |
| Midwest | Resides in the Midwest | 0.25 | | 0.22 | |
| South | Resides in the South | 0.22 | | 0.24 | |
| West | Resides in the West | 0.39 | | 0.36 | |
| Northeast | Resides in the Northeast (reference) | 0.14 | | 0.18 | |
| Sample size | | 267 | | 1912 | |

Note: Total sample size is 2,179. All sample statistics are weighted; see text for details. Weighted sample proportion of FSP participation is 0.67. Among those reporting a score, FI score ranges from 4.92 to 10.85.

**Table 2. Maximum Likelihood Estimates of FSP Participation and FI Equations**

| | FSP Participation | | FI | |
|---|---|---|---|---|
| Variable | Estimate | SE | Estimate | SE |
| Latent Variable | | | | |
| FSP | | | −3.604*** | 1.335 |
| Other Explanatory Variables | | | | |
| Short recert. period | −0.206** | 0.094 | | |
| EBT percentage | −0.087 | 0.105 | | |
| Immigrants | −0.019 | 0.017 | | |
| Avoid telling | 0.183** | 0.094 | | |
| Shop where unknown | −0.340*** | 0.113 | | |
| Disrespect shopping | −0.073 | 0.080 | | |
| Disrespect telling | −0.510*** | 0.094 | | |
| Travel time | | | 0.545 | 0.501 |
| Dissatisfied–shop. | | | 3.525*** | 0.587 |
| Income (÷1,000) | −0.196*** | 0.062 | 0.336 | 0.617 |
| Shop. frequency | 0.175*** | 0.033 | 0.358 | 0.386 |
| Dep. children | 0.060* | 0.035 | 0.249 | 0.312 |
| Married | −0.578*** | 0.097 | −3.636*** | 1.182 |
| Divorced/sep. | −0.022 | 0.090 | 1.496** | 0.722 |
| Widowed | −0.390*** | 0.120 | 1.369 | 1.181 |
| Female | 0.144* | 0.082 | −0.317 | 0.792 |
| Single-headed | 0.635*** | 0.105 | 0.966 | 1.232 |
| One-person HH | 0.019 | 0.106 | 0.886 | 0.983 |
| Elderly | 0.033 | 0.088 | −3.904*** | 0.819 |
| Children < 18 | 0.229** | 0.118 | −0.572 | 1.100 |
| Black | 0.189** | 0.084 | 0.471 | 0.793 |
| Asian | −0.229 | 0.305 | −4.388 | 2.732 |
| Other races | −0.086 | 0.205 | 3.844** | 1.664 |
| Hispanic | 0.127 | 0.219 | −3.840** | 1.789 |
| Homeowner | −0.683*** | 0.075 | −4.608*** | 1.144 |
| Rural | −0.019 | 0.097 | −1.046 | 0.897 |
| Urban | −0.136* | 0.082 | −1.161 | 0.731 |
| Midwest | −0.227** | 0.113 | −1.393 | 0.967 |
| South | −0.046 | 0.110 | 0.277 | 0.906 |
| West | −0.092 | 0.119 | −0.864 | 0.913 |
| Constant | 0.500*** | 0.193 | −2.395 | 1.665 |
| $\sigma$ | | | 9.500*** | 0.529 |
| $\rho$ | | | 0.277** | 0.136 |
| Log likelihood | −3754.159 | | | |

Note: Estimation was weighted by the sample weights; see text for details. Asterisks indicate levels of significance: *** = 1%, ** = 5%, * = 10%.

as well;[9] (2) models in which the FI variable is recoded as the binary VLFS and with and without the VLFS variable in the FSP participation equation (see footnote 11 for model details);[10] (3) the above models as well as our primary model (equations (4) and (3)) with alternative exclusion restrictions (including one with only one stigma variable in the FSP participation equation as in Gunderson and Oliveira [2001]). We obtained fairly robust estimates—negative effect of FSP participation on FI and VLFS, which are similar to that reported in this article.

Second, we reestimated the binary-binary model using the same data set used in Gundersen and Oliveira (2001) from the 1991–1992

[9] Including FI in the FSP participation equation relates better to the simultaneous-equations models estimated in other studies (Gundersen and Oliveira 2001; Huffman and Jensen 2003) and complicates the reduced-form equations (3) and (6) and the error covariance matrix (7) only slightly. In fact, our model can be viewed as a restricted version of this more general model in which the coefficient of FI in the FSP participation equation is set to zero. A more appropriate FI variable to explain FSP participation would be a lagged variable, which is not available in our single cross-sectional data set.

[10] The scale score used as a cut point to define the binary variable was that associated with affirmatives to three or more of the seven items on the adult thirty-day scale. In other studies, a similar cut point has been used to define households with very low food security in the past thirty days (i.e., the condition previously identified as hunger in the past thirty days).

SIPP, with an identical set of variables but with the ML procedure. We replicated the insignificant mutual effects between FSP participation and food insufficiency reported by Gundersen and Oliveira (2001). Such similar results are not surprising as the two-step estimates are consistent and ML estimation only increases statistical efficiency.

We conclude from this exploratory analysis that our estimates are robust with respect to specifications and not simply artifacts of the ML estimation procedure, but rather the results of the unique data set used. We might note that 26.2% of our sample reported an FI score, whereas the sample in Gundersen and Oliveira (2001) contains only 5.8% of food-insufficient individuals.

The definitions of the reduced-form parameters above, the correlation between the error terms in the structural and reduced-form equations, and the very complex forms of the probability, conditional, and unconditional mean expressions derived below suggest that the effects of the exogenous explanatory variables cannot be properly quantified and determined without calculating marginal effects. We derive relevant conditional means for the FI variable. Following the conditional moments of the truncated bivariate normal distribution (Rosenbaum 1961), the mean of $y_2$ conditional on being food insecure ($y_2 > 0$) and on FSP participation ($y_1 = 1, \kappa_1 = 1$) or nonparticipation ($y_1 = 0, \kappa_1 = -1$) are

$$
\begin{aligned}
&E(y_2 \mid \kappa_1 v_1 > -\kappa_1 \mathbf{H}'\boldsymbol{\Pi}_1, v_2 > -\mathbf{H}'\boldsymbol{\Pi}_2) \\
&= \mathbf{H}'\boldsymbol{\Pi}_2 + \omega_2 \left[\Psi(\kappa_1 \mathbf{H}'\boldsymbol{\Pi}_1, \mathbf{H}'\boldsymbol{\Pi}_2/\omega_2; \kappa_1\tau)\right]^{-1} \\
&\quad \times \left\{ \phi(\mathbf{H}'\boldsymbol{\Pi}_2/\omega_2)\Phi\left(\frac{\kappa_1 \mathbf{H}'\boldsymbol{\Pi}_1 - \kappa_1\tau\, \mathbf{H}'\boldsymbol{\Pi}_2/\omega_2}{(1-\tau^2)^{1/2}}\right) \right. \\
&\quad \left. + \kappa_1\tau\, \phi(\kappa_1 \mathbf{H}'\boldsymbol{\Pi}_1)\Phi\left(\frac{\mathbf{H}'\boldsymbol{\Pi}_2/\omega_2 - \tau\, \mathbf{H}'\boldsymbol{\Pi}_1}{(1-\tau^2)^{1/2}}\right) \right\}. \qquad (10)
\end{aligned}
$$

According to equation (10), the effects of FSP participation on FI are

$$
\begin{aligned}
&\Delta y_2 \\
&= E(y_2 \mid \kappa_1 v_1 > -\kappa_1 \mathbf{H}'\boldsymbol{\Pi}_1, v_2 > -\mathbf{H}'\boldsymbol{\Pi}_2)|_{\kappa_1 = 1} \\
&\quad - E(y_2 \mid \kappa_1 v_1 > -\kappa_1 \mathbf{H}'\boldsymbol{\Pi}_1, v_2 > -\mathbf{H}'\boldsymbol{\Pi}_2)|_{\kappa_1 = -1} \qquad (11)
\end{aligned}
$$

conditional on being food insecure. At the weighted sample means of all exogenous variables among the food insecure, the FI score is predicted at 5.81 (SE = 0.22) for FSP nonparticipants and 5.41 (SE = 0.19) for participants, suggesting that participation in the FSP decreases the FI score by 0.40 (SE = 0.15) among those who are food insecure. This effect of FSP participation is small relative to the predicted FI scores.

The effects of exogenous variables on the probabilities of FSP participation and FI are calculated by differentiating (or differencing, for discrete variables) a number of conditional and marginal probabilities. On the basis of the reduced-form equations (3) and (6) and the censoring rule (8), the joint probabilities of alternative outcomes for FSP participation and FI are

$$
\begin{aligned}
&\Pr[y_1 \in (0,1), d_2 \in (0,1)] \\
&\quad = \Psi\left(\kappa_1 \mathbf{H}'\boldsymbol{\Pi}_1,\ \frac{\kappa_2 \mathbf{H}'\boldsymbol{\Pi}_2}{\omega_2}; \kappa_1\kappa_2\tau\right) \qquad (12)
\end{aligned}
$$

where $d_2 = 1(y_2 > 0)$ and $\kappa_2 = 2d_2 - 1$.[11] Alternative conditional and marginal probabilities can be defined using (12). For instance, the marginal probability of FI is $\Phi(\mathbf{H}'\boldsymbol{\Pi}_2/\omega_2)$, and the probability of FI conditional on FSP nonparticipation is $\Psi(-\mathbf{H}'\boldsymbol{\Pi}_1, \mathbf{H}'\boldsymbol{\Pi}_2/\omega_2; -\tau)/\Phi(-\mathbf{H}'\boldsymbol{\Pi}_1)$. The marginal effects of exogenous variables, along with their standard errors derived by the delta method (Rao 1973, p. 388), are presented in table 3. Note that although short recertification period, EBT percentage, immigrants, and the stigma variables are not used in the structural equation for FI, they do appear as exogenous variables in the reduced-form equation for FI. Likewise, travel time to store and dissatisfaction with shopping in the neighborhood, used only in the FI equation, also appear in the reduced form for FSP participation. This highlights the importance of calculating the net marginal effects of exogenous variables from the reduced-form equations.

The marginal effects of most variables on the probability of FSP participation, while different in magnitudes, are qualitatively consistent in signs and significance whether they are conditional or unconditional on FI. This is also the case with the marginal effects of variables on the probabilities of FI.

Of the two variables used only in the FI equation, dissatisfaction with shopping environment in the neighborhood contributes to

[11] Similar to the case of the bivariate probit model, these bivariate probabilities, at $\omega_2 = 1$, would be the likelihood contributions for the corresponding binary-binary model, also estimated in our exploratory analysis.

**Table 3. Marginal Effects of Exogenous Variables on Probabilities of FSP Participation and Food Insecurity**

| | Probability of FSP Participation | | | Probability of Food Insecure | | |
|---|---|---|---|---|---|---|
| Variable | Conditional on Food Insecure | Conditional on Food Secure | Unconditional | Conditional on FSP Participation | Conditional on FSP Nonparticipation | Unconditional |
| | | | Continuous Exogenous Variables | | | |
| EBT percentage | −0.030 | −0.028 | −0.029 | 0.009 | 0.010 | 0.011 |
| | (0.037) | (0.034) | (0.035) | (0.012) | (0.012) | (0.014) |
| Immigrants | −0.007 | −0.006 | −0.006 | 0.002 | 0.002 | 0.002 |
| | (0.006) | (0.005) | (0.006) | (0.002) | (0.002) | (0.002) |
| Travel time | 0.002 | 0.001 | 0.000 | 0.009 | 0.021 | 0.019 |
| | (0.002) | (0.001) | (0.000) | (0.007) | (0.019) | (0.018) |
| Income (÷1,000) | −0.067*** | −0.062*** | −0.066*** | 0.032* | 0.034* | 0.037** |
| | (0.022) | (0.020) | (0.011) | (0.018) | (0.020) | (0.018) |
| Shop. frequency | 0.062*** | 0.057*** | 0.059*** | −0.006 | −0.006 | −0.010 |
| | (0.012) | (0.011) | (0.011) | (0.009) | (0.010) | (0.009) |
| Dep. children | 0.022* | 0.019* | 0.020* | 0.002 | 0.003 | −0.001 |
| | (0.013) | (0.012) | (0.012) | (0.010) | (0.011) | (0.010) |
| | | | Binary Exogenous Variables | | | |
| Short recert. period | −0.074** | −0.068** | −0.071** | 0.022* | 0.023* | 0.027** |
| | (0.035) | (0.032) | (0.034) | (0.012) | (0.013) | (0.013) |
| Avoid telling | 0.062** | 0.057** | 0.059** | −0.019** | −0.020** | −0.023** |
| | (0.032) | (0.028) | (0.030) | (0.010) | (0.011) | (0.011) |
| Shop where unknown | −0.124*** | −0.116*** | −0.121*** | 0.037** | 0.038** | 0.044*** |
| | (0.043) | (0.041) | (0.042) | (0.016) | (0.017) | (0.017) |
| Disrespect shopping | −0.026 | −0.024 | −0.025 | 0.008 | 0.008 | 0.009 |
| | (0.028) | (0.026) | (0.027) | (0.010) | (0.010) | (0.011) |
| Disrespect telling | −0.188*** | −0.178*** | −0.185*** | 0.056** | 0.058** | 0.068*** |
| | (0.036) | (0.035) | (0.036) | (0.025) | (0.027) | (0.026) |
| Dissatisfied–shop. | 0.011** | 0.007*** | 0.000 | 0.127*** | 0.140*** | 0.131*** |
| | (0.005) | (0.003) | (0.000) | (0.022) | (0.024) | (0.022) |
| Married | −0.222*** | −0.205*** | −0.207*** | −0.061** | −0.072** | −0.053* |
| | (0.037) | (0.035) | (0.036) | (0.027) | (0.031) | (0.028) |
| Divorced/sep. | −0.003 | −0.004 | −0.007 | 0.055** | 0.060** | 0.057** |
| | (0.032) | (0.029) | (0.030) | (0.024) | (0.026) | (0.024) |
| Widowed | −0.139*** | −0.131*** | −0.140*** | 0.194** | 0.100*** | 0.104*** |
| | (0.047) | (0.045) | (0.046) | (0.039) | (0.042) | (0.040) |

(*Continued*)

**Table 3. Continued**

| Variable | Probability of FSP Participation | | | Probability of Food Insecure | | |
|---|---|---|---|---|---|---|
| | Conditional on Food Insecure | Conditional on Food Secure | Unconditional | Conditional on FSP Participation | Conditional on FSP Nonparticipation | Unconditional |
| Female | 0.050* | 0.047* | 0.049* | −0.027 | −0.028 | −0.030 |
| | (0.031) | (0.028) | (0.029) | (0.026) | (0.028) | (0.027) |
| Single-headed | 0.208*** | 0.186*** | 0.194*** | −0.035 | −0.032*** | −0.046* |
| | (0.031) | (0.027) | (0.028) | (0.026) | (0.030) | (0.027) |
| One-person HH | 0.010 | 0.008 | 0.006 | 0.029 | 0.032 | 0.029 |
| | (0.038) | (0.034) | (0.035) | (0.033) | (0.036) | (0.034) |
| Elderly | −0.001 | −0.004 | −0.011 | −0.127*** | −0.144*** | −0.132*** |
| | (0.032) | (0.029) | (0.029) | (0.022) | (0.026) | (0.023) |
| Children < 18 | 0.079* | 0.073* | 0.078** | −0.044 | −0.047 | −0.050 |
| | (0.043) | (0.039) | (0.040) | (0.035) | (0.039) | (0.036) |
| Black | 0.066** | 0.060** | 0.062** | −0.004 | −0.003 | −0.007 |
| | (0.029) | (0.026) | (0.027) | (0.023) | (0.026) | (0.024) |
| Asian | −0.099 | −0.086 | −0.081 | −0.108* | −0.125* | −0.109* |
| | (0.119) | (0.112) | (0.113) | (0.062) | (0.074) | (0.066) |
| Other races | −0.019 | −0.020 | −0.029 | 0.152*** | 0.165*** | 0.158*** |
| | (0.075) | (0.069) | (0.071) | (0.060) | (0.064) | (0.061) |
| Hispanic | 0.031 | 0.033 | 0.041 | −0.128*** | −0.145*** | −0.134*** |
| | (0.077) | (0.068) | (0.069) | (0.043) | (0.050) | (0.044) |
| Homeowner | −0.264*** | −0.244*** | −0.244*** | −0.082*** | −0.096*** | −0.073*** |
| | (0.029) | (0.027) | (0.028) | (0.021) | (0.025) | (0.022) |
| Rural | −0.010 | −0.008 | −0.006 | −0.033* | −0.037 | −0.040 |
| | (0.035) | (0.032) | (0.033) | (0.027) | (0.031) | (0.028) |
| Urban | −0.051* | −0.046* | −0.046* | −0.025 | −0.029 | −0.024 |
| | (0.029) | (0.027) | (0.027) | (0.022) | (0.024) | (0.023) |
| Midwest | −0.086** | −0.078** | −0.079** | −0.023 | −0.028 | −0.020 |
| | (0.043) | (0.039) | (0.040) | (0.029) | (0.032) | (0.030) |
| South | −0.015 | −0.014 | −0.016 | 0.015 | 0.016 | 0.016 |
| | (0.040) | (0.036) | (0.037) | (0.029) | (0.032) | (0.030) |
| West | −0.035 | −0.031 | −0.031 | −0.020 | −0.023 | −0.019 |
| | (0.043) | (0.039) | (0.040) | (0.028) | (0.032) | (0.029) |

Note: Asymptotic standard errors in parentheses. Asterisks indicate levels of significance: *** = 1%, ** = 5%, * = 10%.

participation in the FSP. Among the instruments for FSP participation, three of the four stigma variables have significant effects on the probability of FSP participation. Surprisingly, individuals who have avoided telling people about being on food stamps are more likely to participate in the FSP, whereas the effects of shopping where unknown and disrespect from telling have negative effects on FSP participation. These counterintuitive results suggest that the causality between welfare stigma and program participation would be an interesting area for further research. The mixed effects of these component stigma variables would have been disguised by the use of a stigma index as in other studies (e.g., Gundersen and Oliveira 2001). The other contributing factors of FSP participation include dissatisfaction with the shopping environment in the neighborhood, shopping frequency, number of dependent children, being female, residing in a single-headed household, presence of children under 18, and being Black. Higher income, short recertification period, being married, being widowed, owning a home, residing in an urban area, and residing in the Midwest all decrease the probability of participation in the FSP. Surprisingly, presence of an elderly person has no effect on FSP participation. While simple bivariate comparisons have consistently shown that FSP participation and FI are particularly low for this age group, our result echoes a finding by Gundersen and Oliveira (2001) that after controlling for FI, the coefficient of elderly became insignificant. The fact that households with an elderly person(s) are not more likely to participate in the FSP suggests that this segment of the population can be targeted for promotion of FSP participation, which in reference to the negative effect of FSP participation on FI, in turn, can help reduce FI among these individuals.

The more counterintuitive effects on FI are seen in household income, with an increase of $1,000 per month increasing the probability of FI by 0.03, conditional or unconditional on FSP participation, all else equal.[12] This positive effect of income on the probability of FI, while small in magnitude, may be due to having to drop out of the FSP because the household is less likely to meet the income eligibility criterion.

Other variables that have positive effects on the probability of FI are short recertification period, stigma variables shopping where unknown and disrespect from telling, dissatisfaction about the shopping environment, being divorced/separated, widowed, and of the other races. Factors that decrease the probability of FI are avoiding telling people about receiving food stamps, being married, homeowner, Asian, and Hispanic, presence of an elderly person, residing in a single-headed household, and in the rural area. Negative effects of the presence of an elderly person on the probability of FI were also reported by Gundersen and Oliveira (2001). These findings have obvious policy implications. For instance, the negative effects of home ownership and marriage on the probability of FI suggest that there could be food sharing within the family that helps to reduce FI. The government would, therefore, have a good reason to encourage marriage and home buying as a means of reducing FI. Establishment of more easily accessible and friendly shopping facilities may also improve consumer satisfaction with shopping experiences in their neighborhoods, which will help reduce FI.

We also calculate the marginal effects of exogenous variables on FI based on a number of conditional and unconditional means. Using equation (10) and noting from the censoring rules in equation (8) that

$$\Pr(\kappa_1 v_1 > -\kappa_1 \mathbf{H}'\mathbf{\Pi_1}, v_2 > -\mathbf{H}'\mathbf{\Pi_2}) = \Psi(\kappa_1 \mathbf{H}'\mathbf{\Pi_1}, \mathbf{H}'\mathbf{\Pi_2}/\omega_2; \kappa_1\tau) \tag{13}$$

$$E(y_2 \mid v_1 \le -\mathbf{H}'\mathbf{\Pi_1}, v_2 \le -\mathbf{H}'\mathbf{\Pi_2}) = E(y_2 \mid v_1 > -\mathbf{H}'\mathbf{\Pi_1}, v_2 \le -\mathbf{H}'\mathbf{\Pi_2}) = 0 \tag{14}$$

the unconditional mean of $y_2$ is

$$\begin{aligned} E(y_2) = {} & \Psi(-\mathbf{H}'\mathbf{\Pi_1}, \mathbf{H}'\mathbf{\Pi_2}/\omega_2; \tau) \\ & \times E(y_2 \mid v_1 \le -\mathbf{H}'\mathbf{\Pi_1}, v_2 > -\mathbf{H}'\mathbf{\Pi_2}) \\ & + \Psi(\mathbf{H}'\mathbf{\Pi_1}, \mathbf{H}'\mathbf{\Pi_2}/\omega_2; \tau) \\ & \times E(y_2 \mid v_1 > -\mathbf{H}'\mathbf{\Pi_1}, v_2 > -\mathbf{H}'\mathbf{\Pi_2}). \end{aligned} \tag{15}$$

Using equation (15) and given that $\Pr(y_2 > 0) = \Phi(\mathbf{H}'\mathbf{\Pi_2}/\omega_2)$, which follows from equation (13), the mean of $y_2$ conditional on FI is

[12] Note that these marginal effects of income do not vary with income. A squared income term was included in both the FSP and FI equations but was insignificant.

**Table 4. Marginal Effects of Exogenous Variables on Levels of Food Insecurity**

| Variable | Conditional on FSP = 0, FI > 0 | Conditional on FSP = 1, FI > 0 | Conditional on FI > 0 | Unconditional |
|---|---|---|---|---|
| | | Continuous Exogenous Variables | | |
| EBT percentage | 0.067 | 0.064 | 0.077 | 0.081 |
| | (0.085) | (0.079) | (0.095) | (0.100) |
| Immigrants | 0.014 | 0.014 | 0.017 | 0.017 |
| | (0.016) | (0.013) | (0.015) | (0.015) |
| Travel time | 0.144 | 0.130 | 0.134 | 0.141 |
| | (0.133) | (0.120) | (0.123) | (0.130) |
| Income (÷1,000) | 0.240* | 0.224* | 0.256** | 0.270** |
| | (0.137) | (0.124) | (0.127) | (0.134) |
| Shop. frequency | −0.040 | −0.043 | −0.067 | −0.071 |
| | (0.071) | (0.064) | (0.065) | (0.069) |
| Dep. children | 0.020 | 0.016 | 0.008 | 0.009 |
| | (0.074) | (0.067) | (0.069) | (0.072) |
| | | Binary Exogenous Variables | | |
| Short recert. period | 0.161* | 0.153* | 0.185** | 0.199** |
| | (0.089) | (0.082) | (0.093) | (0.101) |
| Avoid telling | −0.139* | −0.134* | −0.160** | −0.167** |
| | (0.074) | (0.070) | (0.079) | (0.081) |
| Shop where unknown | 0.270** | 0.254** | 0.310*** | 0.337*** |
| | (0.120) | (0.110) | (0.118) | (0.132) |
| Disrespect shopping | 0.056 | 0.054 | 0.065 | 0.069 |
| | (0.071) | (0.067) | (0.078) | (0.083) |
| Disrespect telling | 0.411** | 0.383** | 0.472*** | 0.520*** |
| | (0.191) | (0.175) | (0.180) | (0.206) |
| Dissatisfied–shop. | 0.991*** | 0.891*** | 0.918*** | 1.025*** |
| | (0.176) | (0.155) | (0.160) | (0.188) |
| Married | −0.501** | −0.434** | −0.373* | −0.383** |
| | (0.218) | (0.193) | (0.199) | (0.200) |
| Divorced/sep. | 0.423** | 0.381** | 0.396** | 0.427** |
| | (0.183) | (0.165) | (0.170) | (0.188) |
| Widowed | 0.709** | 0.650** | 0.731*** | 0.825** |
| | (0.303) | (0.274) | (0.285) | (0.340) |
| Female | −0.198 | −0.184 | −0.209 | −0.225 |
| | (0.199) | (0.179) | (0.185) | (0.203) |
| Single-headed | −0.227 | −0.238 | −0.320* | −0.331* |
| | (0.208) | (0.186) | (0.188) | (0.191) |
| One-person HH | 0.223 | 0.200 | 0.204 | 0.218 |
| | (0.254) | (0.228) | (0.235) | (0.256) |
| Elderly | −1.004*** | −0.905*** | −0.937*** | −0.929*** |
| | (0.183) | (0.163) | (0.168) | (0.157) |
| Children < 18 | −0.331 | −0.307 | −0.347 | −0.370 |
| | (0.273) | (0.246) | (0.254) | (0.273) |
| Black | −0.020 | −0.027 | −0.051 | −0.054 |
| | (0.178) | (0.159) | (0.165) | (0.172) |
| Asian | −0.878* | −0.786 | −0.785 | −0.726* |
| | (0.539) | (0.485) | (0.505) | (0.395) |
| Other races | 1.184*** | 1.068*** | 1.114*** | 1.278** |
| | (0.481) | (0.432) | (0.446) | (0.548) |
| Hispanic | −1.018*** | −0.921*** | −0.963*** | −0.912*** |
| | (0.361) | (0.325) | (0.334) | (0.279) |
| Homeowner | −0.665*** | −0.581*** | −0.512*** | −0.521*** |
| | (0.174) | (0.151) | (0.155) | (0.152) |
| Rural | −0.257 | −0.231 | −0.235 | −0.243 |
| | (0.214) | (0.192) | (0.199) | (0.200) |
| Urban | −0.203 | −0.177 | −0.165 | −0.174 |
| | (0.170) | (0.153) | (0.158) | (0.167) |
| Midwest | −0.192 | −0.164 | −0.140 | −0.146 |
| | (0.224) | (0.201) | (0.209) | (0.215) |
| South | 0.110 | 0.101 | 0.110 | 0.117 |
| | (0.224) | (0.202) | (0.208) | (0.224) |
| West | −0.157 | −0.137 | −0.130 | −0.136 |
| | (0.220) | (0.198) | (0.206) | (0.215) |

Note: Asymptotic standard errors in parentheses. Asterisks indicate levels of significance: *** = 1%, ** = 5%, * = 10%.

(16)
$$E(y_2 \mid y_2 > 0) = E(y_2)/\Pr(v_2 > -\mathbf{H}'\mathbf{\Pi_2}) = E(y_2)/\Phi(\mathbf{H}'\mathbf{\Pi_2}/\omega_2).$$

Marginal effects are obtained by differentiating equations (10), (15), and (16), and the results are presented in table 4. An examination of these marginal effects suggests that the effects of variables on FI are qualitatively similar whether conditional or unconditional on FSP participation and/or FI, though the effects do differ by magnitudes. All else equal, as household income increases by $1,000 per month, the FI level increases by between 0.22 (conditional on FSP participation and FI) and 0.27 (unconditional), whereas presence of an elderly person contributes to an FI score of between 0.9 and 1.0. Other variables that contribute to FI are short recertification period, shopping where unknown, disrespect from telling, dissatisfaction about shopping environment, being divorced/separated, widowed, and of other races. Factors that ameliorate FI are avoiding telling people about participation in the FSP, being married, residing in a single-headed household, presence of an elderly, being Hispanic, and home ownership.

## Concluding Remarks

We find that participation in the FSP reduces FI. Our results contrast with findings reported in the existing empirical literature, which suggests predominantly insignificant or nonexistent relationships between FSP and FI. It was, perhaps, due to this controversial set of findings that Nord, Andrews, and Carlson (2004) cautioned that the relationship between food assistance programs and FI is complex because of the two-way causality. The causality issue was examined in the present study by estimating an instrumental variables model of FSP participation and FI. Our results suggest that the lack of association between FSP participation and FI in previous studies is most likely due to the small proportion of food-insecure individuals in data used by other authors, the dependence on self-report for identification of FSP participants in prior studies,[13] and a failure to accommodate the joint determination of FSP participation and FI.

On the empirical front, as in Borjas (2004), the state-level FSP policy variables used in this study have greatly improved the quality of instruments and allowed us to draw more policy-relevant interpretations. We conclude that a short recertification period reduces an FSP-eligible individual's likelihood to participate in the FSP because of increased transaction costs. However, no significant effect was found for EBT implementation, which may be related to the combined effect of reduced welfare stigma and reticence to use them owing to a lack of experience with debit or credit cards.

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[13] In a recent paper, Gundersen and Kreider (2007) suggest that the FI paradox hinges unreliability in the measurement of outcome and conditioning variables. In particular, FSP participation is widely acknowledged to be underreported in surveys at levels greater than 12%. They find that this type of nonclassical measurement error impedes precise estimation of the effects of FSP participation on FI.

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