Household history, SNAP participation, and food insecurity

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Abstract:

Food security in an important public policy issue. In 2015, approximately 1 in 8 U.S. households experienced food insecurity at some point in the year. Low-income families are at higher risk for food insecurity than other families, and these families may also face higher levels of disruption (e.g., moves, loss of income, or individuals entering or leaving the household) than other families. I use data from the Survey of Income and Program Participation to explore the relationship between food insecurity, the household's history during the previous year, and SNAP participation. The results indicate that a number of aspects of the household's recent experience including negative income shocks, moves, and both increases and decreases in household size increase the probability of being food insecure while SNAP participation is estimated to reduce the probability of being food insecure.

Keywords: food security | SNAP | food stamps

Article:

1. Introduction

Approximately 1 in 8 U.S. households were food insecure at some point during 2015 (Coleman-Jensen et al., 2016).[1] At the individual level, 42.2 million individuals lived in a household that was food insecure at some point during the year (Coleman-Jensen et al., 2016), Evidence suggests that food insecurity is associated with a number of poor health outcomes (Gundersen and Ziliak, 2015) and negatively affects child development and academic performance (Jyoti et al., 2005). Consequently, understanding the determinants of food insecurity is an important area of research.

Low-income families are at higher risk for food security than other households. These families also face stresses beyond a lack of resources, and these stresses may independently affect food insecurity. For example, low income families tend to experience higher levels of "family chaos" than higher income families, and family chaos has been shown to be related to food insecurity

[1] Food security is commonly defined as "access by all people at all times to enough and appropriate food to provide the energy and nutrients needed to maintain an active and healthy life" (Bartlett, 2002).

(Fiese et al., 2016). Chaos in the household may be created or exacerbated by disruptive events such as moving, frequent changes in household membership or events such as marriage.[2]

In this paper I focus specifically on the effect of recent household experiences on food insecurity. I consider both the economic history of the household, characterized by the household's income during the preceding year and the experience of a negative income shock, and non-economic household experiences, characterized by recent moves, changes in household size, and changes in marital status. Because much of the literature on food insecurity focuses on the effect of participation in the Supplemental Nutrition Assistance Program (SNAP), I also consider the role of SNAP participation and allow participation to be endogenous. Data for the analysis come from multiple panels of the Survey of Income and Program Participation. The results indicate that recent income, recent income shocks, moves, and changes in household size are all important determinants of food insecurity but that recent changes in marital status are not. After allowing for SNAP participation to be endogenous, participation in SNAP is estimated to reduce the probability of being food insecure. The results highlight the importance of recent household experience in understanding food insecurity.

2. Previous literature

Most of the literature exploring a relationship between household history and food insecurity has focused on the income and employment history of the household. Gundersen and Gruber (2001) used data from the 1991 and 1992 Survey of Income and Program Participation and found that food insufficient households have lower average income and are more likely to have experienced a negative income shock in the previous eight months. Using the 1993 SIPP and the Survey of Program Dynamics, Ribar and Hamrick (2003) found evidence that higher levels of past income is negatively correlated with becoming food insufficient though this effect becomes insignificant after controlling for current income. For a sample of welfare recipients in Michigan, Heflin et al. (2007) found a positive but statistically insignificant relationship between food insufficiency and recent job losses. Leete and Bania (2010) found that food insecurity is negatively related to average income measured over the preceding 12 or 24 months, positively related to a recent decrease in income, and negatively related to a recent increase in income. Using data on 331 families in Toronto, Loopstra and Tarasuk (2013) explored the relationship between changes in household income, employment, and welfare participation and food insecurity. The results indicate that increases in income and gains in employment were associated with reductions in the food insecurity measure. Taken together, these studies provide evidence that the recent economic experience of the household is related to food insecurity.

There is more limited evidence on other types of household history and food insecurity. Using data collected through the Children's Healthwatch study, Cutts et al. (2011) found that frequent moves are associated with an increase in the odds of being food insecure. Other work indicates that gaining a household member (Brown et al., 1997 as described in Rose, 1999) increases the likelihood of being food insufficient and that changing household composition increases the probability of becoming food insufficient (Ribar and Hamrick, 2003). In a small study of

[2] Although not considered in this paper, other work has explored additional factors that may disproportionally affect low-income families including food prices (Gregory and Coleman-Jensen, 2013), non-standard employment patterns Coleman-Jensen, 2011), and financial management skills (Gundersen and Garasky, 2012).

management of food resources among low income families, Campbell and Desjardins (1989) found that 85% of households experienced a significant change in the past twelve months. These included receiving an eviction notice, moving, and changes in household composition as well as the more commonly studied economic changes such as job loss.

Compared to household history, there is a much larger literature on the relationship between SNAP participation and food security.[3] In simple comparisons of means, studies (e.g., Ratcliffe et al., 2011, Shaefer and Gutierrez, 2013, Coleman-Jensen et al., 2015) consistently find that the proportion of SNAP recipients who are food insecure is higher than the proportion of eligible non-recipients who are food insecure. Controlling for observed characteristics reduces but does not eliminate this positive relationship (e.g., Alaimo et al., 1998, Gibson-Davis and Foster, 2006).

Given that SNAP participation is expected to reduce food insecurity – or as a worst case to have no effect – this positive effect is unexpected and is believed to arise because SNAP participants are self-selected on unobserved characteristics. This selection means SNAP participation is "endogenous", and studies that address non-random selection into SNAP have used a number of different empirical strategies to address the endogeneity. These include two stage least squares (e.g., Borjas, 2004, Greenhalgh-Stanley and Fitzpatrick, 2013), simultaneous equations (e.g., Gundersen and Oliveira, 2001, Jensen, 2002), dummy endogenous variables models (e.g., Yen et al., 2008, Mykerezi and Mills, 2010, Ratcliffe et al., 2011, Shaefer and Gutierrez, 2013), and panel data methods (e.g., Hofferth, 2004, Wilde and Nord, 2005, Greenhalgh-Stanley and Fitzpatrick, 2013). Recent studies have also focused on families that stop participating in SNAP (e.g., Nord and Coleman-Jensen, 2010, Nord, 2011) or begin participating in SNAP (e.g., Mabli et al., 2013).[4] Generally speaking, studies employing dummy endogenous variable models and studies that focus on families beginning or ending participation have found the most consistent evidence of a beneficial effect of SNAP participation on food insecurity. The present study employs a dummy endogenous variable model similar to Ratcliffe et al. (2011) and Shaefer and Gutierrez (2013).

3. Empirical methodology

3.1. Conceptual framework

Consider a model where utility depends on food security and the consumption of non-food goods and where a household is food insecure if food purchased falls below a threshold that depends on household needs and on the ability of the household to convert food purchases into food security.[5] Let F_i be the amount of food purchased by household i, and let $\tilde{F}_i$ be the amount of food needed to avoid being food insecure. A household will be food insecure if $\tilde{F}_i > F_i$ and will be food secure if $\tilde{F}_i \leq F_i$.

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[3] Bartlett (2002) provides an extensive international review of food security and food assistance programs while Currie (2003) provides a comprehensive overview of U.S. food assistance programs. Caswell and Yaktine (2013) and Fox et al. (2004) survey studies of food security and food stamps/SNAP.

[4] Wilde (2007) and Gregory et al. (2015) survey these different approaches and others.

[5] Gundersen and Gruber, 2001, Bartlett, 2002, Jensen, 2002, and Ribar and Hamrick (2003) provide economic models of food insecurity.

For a given $\tilde{F}_i$, the likelihood of being food insecure decreases with increases in food purchased, and the amount of food purchased is assumed to increase as economic resources increase. Therefore, participation in SNAP and higher levels of current income should decrease the likelihood of being food insecure. Similarly, a low level of earnings during the past year or a negative income shock is expected to increase the likelihood of food insecurity by reducing the ability to save or increasing borrowing depending on the household's circumstances (Gundersen and Gruber, 2001, Leete and Bania, 2010). Additionally, events such as moves, increases in the number of household members, marriages, or divorces may impose costs on the household. These costs are expected to increase the likelihood that a household is food insecure.

For a given level of food purchases, the likelihood of being food insecure increases as $\tilde{F}_i$ increases. $\tilde{F}_i$ depends on household characteristics (e.g., food requirements increase with household size) and on how efficiently the household uses purchased food to produce food security. Fiese et al. (2016) conjecture that "chaos disrupts the ability to make use of available resources" (p 148), and Campbell and Desjardins (1989) note that the households they studied had developed strategies for managing their resources and that dramatic changes – whether good or bad – upset the strategies they had developed. If disruption upsets routines and results in less efficient use of purchased food items, then significant changes such as moving, a change in marital status, or individuals joining or leaving the household will increase the risk of food insecurity.

3.2. Empirical methods

Estimating the effect of household history on food insecurity in the absence of SNAP participation is straightforward. Food insecurity for household i, FI_i, is a binary variable equal to 1 if the household is food insecure and 0 otherwise. Let $F_i^* = \tilde{F}_i - F_i$ where $\tilde{F}_i$ and F_i are defined above.[6] Household i is assumed to be food insecure, $FI_i = 1$, if $F_i^* > 0$ and food secure, $FI_i = 0$, if $F_i^* \leq 0$. I assume that Fi$*$ is a linear function of the household history variables (H_i), other determinants of food insecurity (X_i), and an idiosyncratic error term (ε_i):

$$F_i^* = H_i'\gamma_f + X_i'\beta_f + \varepsilon_i.$$

The vectors γ_f and β_f are parameters to be estimated. After making an assumption about the distribution of ε_i, such as $\varepsilon_i \sim N(0,1)$, it is straightforward to estimate the parameters of this model, and estimates of this model are presented below.

Under the assumption that SNAP participation is exogenous, it is similarly straightforward to include SNAP participation, denoted S_i, as an explanatory variable, and estimates of this model are also presented below. However, as discussed above, previous work has found evidence that SNAP participation is endogenous. In order to address the endogeneity, I model food insecurity and SNAP participation jointly. The equations of interest are

[6] I do not observe $\tilde{F}_i$ or F_i so the empirical model cannot not distinguish the effect of, for example, a negative income shock on $\tilde{F}_i$ or F_i separately.

$$F_i^* = H_i'\gamma_f + S_i\delta + X_i'\beta_f + \varepsilon_i$$

and

$$S_i^* = H_i'\gamma_f + Z_i'\alpha + X_i'\beta_f + \eta_i$$

where F_i^* is defined as above S_i^* is the net benefit of SNAP participation.

As above, a household is assumed to be food insecure if $F_i^* > 0$ and food secure if $F_i^* \leq 0$. Similarly, a household is assumed to participate in SNAP, $S_i = 1$, if $S_i^* > 0$ and to not participate in SNAP, $S_i = 0$, when $S_i^* \leq 0$. The vectors H_i and X_i are as defined above, and Z_i is a vector of instrumental variables that are assumed to influence participation but not food insecurity. δ is a scalar parameter to be estimated, and γ_f, β_f, γ_s, and β_s are vectors of parameters to be estimated.

Estimation of a discrete choice model with an endogenous binary variable is in general challenging. However, if the error terms have a bivariate normal distribution,

$$\begin{bmatrix}\varepsilon_i \\ \eta_i\end{bmatrix} \sim N\left(\begin{bmatrix}0 \\ 0\end{bmatrix}, \begin{bmatrix}1 & \rho \\ \rho & 1\end{bmatrix}\right),$$

then Greene (2012) and Maddala (1983) show that this model may be estimated as a standard bivariate probit model.

Because the coefficients of the bivariate probit model are not directly informative about the magnitude of effects, for some models I also present "marginal effects" (Wooldridge, 2010). For a binary explanatory variable, the marginal effect gives the predicted change in the probability of being food insecure when that variable changes from 0 to 1. Specifically, the marginal effect for the k[th] household history variable assuming it is a binary indicator variable is

$$\frac{\Delta Pr(FI=1)}{\Delta H_k} = \frac{1}{N}\sum_{j=1}^{N}\left[Pr\left(FI_j = 1 \middle| H_{jk} = 1\right) - Pr\left(FI_j = 1 \middle| H_{jk} = 0\right)\right].$$

When computing the marginal effect for variable H_k, all variables other than H_k are evaluated at their observed values. The marginal effect for a continuous history variable replaces the difference in probabilities with $\frac{\partial Pr(FI_j=1)}{\partial H_{jk}}$.

4. Data

4.1. The survey of income and program participation

I use data from the Survey of Income and Program Participation. The SIPP has been used in a number of studies of food security (Gundersen and Gruber, 2001, Ribar and Hamrick, 2003, Ratcliffe et al., 2011, Leete and Bania, 2010, Shaefer and Gutierrez, 2013). Fourteen SIPP panels have been completed, and this paper uses data from the 1996, 2001, 2004, and 2008 panels. These panels have data on between 40,000 and 52,000 households over a period of

between 36 and 52 months. Each panel contains monthly data on SNAP participation, income, and other household characteristics. Food security is measured once in the 1996, 2001, and 2004 panels and twice in the 2008 panel.

SIPP respondents are interviewed every four months. Each round of interviews is referred to as a "wave", and each wave includes a core set of questions as well as one or more "topical modules". The questions needed to measure food insecurity are asked in the Adult Well-Being topical module. In the 1996 and 2001 panels, these questions were asked in wave 8; in the 2004 panel, they were asked in wave 5; and in the 2008 panel they were asked in waves 6 and 9. The nature of the SIPP interview structure means that these each wave is fielded over a four month period. The relevant time period for the food security questions in the 1996 panel is April to July 1998; in the 2001 panel it is February to May 2003; in the 2004 panel it is February to May 2005; and for the 2008 panel it is January to March 2010.[7] These time periods cover different economic and policy conditions, and models include state, month, and year indicators to capture changing economic conditions and other differences across states and over time.[8]

4.2. Selection of the analysis sample

The SNAP program has both income and asset tests. Broadly speaking, the gross income limit is 130% of the poverty threshold and the net income limit is 100% of the poverty threshold. There are exceptions for households where all members are receiving TANF or SSI and for households with elderly or disabled members. Similarly, the asset limit depends on the presence in the household of someone 60 years old or older.[9]

When studying SNAP and food security, some authors use an income cutoff higher than the statutory threshold to determine sample inclusion. The rationale is that a small change in labor supply or wages would make these households eligible. Like Ratcliffe et al., 2011, Shaefer and Gutierrez, 2013 and Mykerezi and Mills (2010), I include households with income less than 150% of poverty. Specifically, a household is included in the sample if its income in the month when food security is measured is less than 150% of the poverty line. Because this paper considers the household history during the year prior to the measurement of food security, I impose an additional restriction. Households are included in the sample if average household income during the preceding year is below 300% of poverty. Thus, high income households who happen to have low income in the food security measurement month are not included in the analysis.[10] Finally, I follow the majority of the literature by not imposing an asset test.

I use the three waves prior to the measurement of food security to construct variables measuring the household's history during the prior year. For example, in 1996, food security is measured in wave 8 so waves 5, 6, and 7 are used to construct the history variables. Because multiple waves are used and because households and families are not necessarily stable over time, I center the

[7] Because I am not using panel data methods, I use only the wave 6 information for the 2008 panel.
[8] There are studies that explore how specific economic conditions and policies affect food security. See for example, Nord and Prell (2011) which explores the effect of 2009's American Recovery and Reinvestment Act (ARRA) and Nord (2013) which explores the effect of the subsequent reduction in real benefits following the ARRA.
[9] See http://www.fns.usda.gov/snap/eligibility for information about SNAP eligibility.
[10] Section 5.3 explores the sensitivity of the results to specific cutoffs chosen.

household on the person who is the household reference person in the first reference month in the wave when food security is measured. I refer to this person as the "reference person" even though that person may not be the SIPP-defined household reference person in every month. Thus the household history variables are constructed based on the household in which the reference person resided during the year prior to the measurement of food security. The primary analysis sample includes information on 23,693 families.

4.3. Food security

The USDA measures food security using a set of 10 or 18 questions depending on the presence of children. In the SIPP, five household- or adult-oriented questions and one child-focused were asked. Nord (2006) indicates that the answers to the five adult-oriented questions may be used to create indicators of food security that are largely consistent with indicators derived from the full scale.[11] The five questions are

1. The food that (I/WE) bought just didn't last and (I/WE) didn't have money to get more. Was that often, sometimes, or never true for you in the last four months?
2. (I/WE) couldn't afford to eat balanced meals. Was that often, sometimes, or never true for you in the last four months?
3. In the past four months did you or the other adults in the household ever cut the size of your meals or skip meals because there wasn't enough money for food?
4. In the past four months did you or the other adults in the household ever eat less than you felt you should because there wasn't enough money to buy food?
5. In the past four months did you or the other adults in the household ever not eat for a whole day because there wasn't enough money for food?

Answers of "often" or "sometimes" for questions 1 and 2 and "yes" for questions 3, 4, and 5 are considered affirmative responses. Households answering 0 or 1 questions affirmatively are considered food secure, and households answering 2 or more questions affirmatively are considered to be food insecure (Nord, 2006). Sample means for the full sample are presented in the first column of Table 1. About 22 percent of the sample is food insecure.

Table 1. Means.

[Empty Cell]	**Full sample**	**Food secure**	**Food insecure**	**|t|**	**p-value**
Food insecure	0.223	0.000	1.000	–	–
SNAP	0.317	0.271	0.476	28.80	0.000
Household history					
Negative income shock	0.231	0.217	0.281	9.68	0.000
Average income to needs ratio	1.123	1.158	1.003	17.22	0.000
Number of moves	0.171	0.154	0.232	11.28	0.000
Number of times HH size increases	0.127	0.116	0.165	8.46	0.000
Number of times HH size decreases	0.155	0.145	0.191	7.00	0.000
Married ≤ one year	0.014	0.013	0.016	1.51	0.132
Divorced ≤ one year	0.028	0.029	0.026	1.25	0.210

[11] Of the full scale, questions 3, 4, 7, 8, 9, and 12 are asked in the SIPP. Nord (2006) uses the answers to questions 3, 4, 8, 9, and 12 to construct a food security scale. See Bickel et al. (2000) for details on measuring household food security including the specific questions in the full scale.

[Empty Cell]	**Full sample**	**Food secure**	**Food insecure**	**|t|**	**p-value**
Married > one year	0.293	0.305	0.250	7.79	0.000
Divorced > one year	0.437	0.440	0.428	1.49	0.137
Household characteristics					
Income to needs ratio	0.869	0.890	0.795	14.38	0.000
Own home	0.448	0.487	0.309	23.21	0.000
Someone employed	0.290	0.294	0.278	2.28	0.023
Number of kids	0.889	0.830	1.097	12.89	0.000
Number of adults	1.553	1.543	1.587	3.63	0.000
Number disabled	0.357	0.300	0.557	28.44	0.000
Some elderly	0.076	0.077	0.073	0.99	0.325
All elderly	0.306	0.350	0.151	28.05	0.000
Unemployment rate	6.546	6.537	6.577	1.05	0.296
Metro	0.721	0.712	0.754	6.07	0.000
Household head characteristics					
Female	0.651	0.644	0.677	4.36	0.000
Education = HS	0.310	0.312	0.305	0.85	0.394
Education > HS	0.355	0.360	0.338	2.95	0.003
Black	0.214	0.198	0.273	11.80	0.000
Hispanic	0.142	0.132	0.178	8.30	0.000
Other race	0.058	0.055	0.067	3.16	0.002
Age	51.864	53.473	46.242	24.56	0.000
Citizen	0.909	0.912	0.898	3.22	0.001
Instruments					
Fingerprint	0.249	0.245	0.263	2.70	0.007
Certification	0.107	0.107	0.105	0.58	0.560
Number of observations	23,693	18,421	5272		

4.4. SNAP participation

The SIPP asks about SNAP participation during each month of the survey, and information is available at the individual, family, and household level. I measure SNAP participation during the first month of the reference period and create an indicator equal to 1 if the household reports receiving food stamps and equal to 0 otherwise. We see in Table 1 that just under one third of the sample reports receiving food stamps.[12]

4.5. Household history variables

The longitudinal nature of the SIPP makes it possible to construct measures of changes in household circumstances in the year leading up to the food security measurement. To measure the household's longer term economic circumstances, I include the average income-to-needs ratio calculated over the 12 months preceding the food security measurement. The income-to-needs ratio is the household's income divided by the poverty threshold for the appropriate household size. To capture a negative income shock, I include an indicator equal to 1 if household earned income falls to zero in at least one month during the preceding year.

[12] Underreporting of program receipt is a problem in all surveys. However, recent evidence suggests that underreporting of SNAP receipt is lower in the SIPP than in the CPS or PSID (Meyer et al., 2015). Gundersen and Kreider (2008) and Kreider et al. (2012) consider the effects of misreported SNAP participation.

As discussed above, household chaos may affect food security, and such chaos may be related to disruption of household routines. The models include a number of variables meant to capture disruption. I refer to these variables as describing the non-economic household history although, as described earlier, they may also affect the household's economic situation. The variables are the number of times the household moved during the preceding twelve months, the number of times the number of household members increased, the number of times the number of household members decreased, an indicator equal to 1 if the household reference person was married within the previous year, and an indicator equal to 1 if the household reference person had a marriage end within the previous year. Although technically not part of the recent household history, for convenience I include the remaining marital status variables (an indicator if married more than one year and an indicator if divorced more than one year) in this group. Because moving, changing household membership, and recent marital status changes are all disruptive, I expect all of these variables to be positively related to food insecurity. Because the omitted group for marital status is never married, I expect longer term marriage to be negatively associated with food insecurity, and I have no expectation of the effect of long-term divorce.

4.6. Instruments

Although not required for identification of the bivariate probit model (Wilde, 2000), I include instrumental variables that help determine SNAP participation but do not determine food insecurity (except through their role in determining SNAP participation). The most natural instruments to use are SNAP program rules that change the cost of participation. Information about SNAP program rules is available from the SNAP Rules Database (ERS undated) which provides monthly information on a number of state policies from January 1996 through December 2011. Like Shaefer and Gutierrez (2013), I use two instruments. The first is an indicator equal to one if the state requires SNAP applicants to be fingerprinted. In some states, the requirement is statewide while in others it applies only to parts of the state. I create an indicator variable that is equal to 1 if fingerprinting is required in any part of the state and equal to 0 otherwise.[13] I expect a fingerprinting requirement to reduce the likelihood of SNAP participation.

The second instrument used is the "proportion of SNAP units with earnings with 1–3 month recertification periods" (ERS undated). Previous research (e.g., Ribar et al., 2008) has shown that SNAP exits are higher in recertification months, and thus shorter recertification windows can be expected to reduce SNAP participation. Consequently, I expect an increase in this variable to decrease SNAP participation.

4.7. Control variables

A number of additional variables are included in the analysis. These variables are divided into those characterizing the household and those describing the household reference person. The household variables measure the economic circumstances of the household (the current period income-to-needs ratio, an indicator equal to one if there is at least one employed adult in the

[13] I test the sensitivity of the results to this assumption and find that the results do not change if alternative assumptions (e.g., the indicator equals 1 only if fingerprinting is required for the entire state) are made.

household, and an indicator equal to one if the household is owns its home as opposed to renting) and the composition of the household (an indicator equal to 1 if there are any elderly members (age ≥ 60) in the household, an indicator variable equal to 1 if the household is composed entirely of elderly members, the number of disabled adults in the household, the number of children in the household, and the number of adults in the household). The models also include an indicator for residence in a metropolitan area and the state-month unemployment rate. The variables characterizing the reference person include age and indicators if the reference person has a high school education, has more than a high school education, is African-American, is of Hispanic origin, is another race/ethnicity, is female, and is a US citizen.

5. Results

5.1. Descriptive analysis

As a first step, I explore differences in the characteristics of food insecure and food secure households. The second and third columns of Table 1 give the sample means for food secure and food insecure households for each explanatory variable. The table also includes the absolute value of the t-statistic for a test of the equality of the means and its associated p-value.

Food insecure and secure households differ in many ways. Importantly for this paper, food secure and insecure households differ in their household histories. Food insecure households have lower average income in the preceding year. They also move more frequently and experience greater rates of changes in household size – both increases and decreases. There is no statistically significant difference for recent marriage or divorce. Additionally, consistent with the previous literature food insecure households are much more likely receive SNAP.

Food insecure and secure households also differ in household and reference person characteristics. Food insecure households are less likely to include an employed individual, and they have a lower current income-to-needs ratio. They have more disabled members but are less likely to have older members, and food insecure households are significantly less likely to own their home. Compared to household heads in food secure households, heads of food insecure households are less likely to have more than a high school education, are more likely to be female, are more likely to be non-white, and are less likely to be citizens.

While there are significant differences in most of the explanatory variables, this comparison of means only considers one variable at a time. The next step is a multivariate analysis where the effect of each variable is found conditional on the other included variables.

The most basic way to examine the effect of SNAP participation is to compare the rates of food insecurity among households that do and do not receive SNAP. The mean of food insecurity among SNAP households is 0.335 compared to a mean of 0.170 for households that did not receive SNAP. This implies that SNAP participation is associated with an increase of 0.165 in the likelihood of being food insecure. Of course this effect controls for neither observed nor unobserved differences across participants and non-participants.

5.2. Multivariate results

I begin with a simple probit model of food insecurity. These results are presented in Table 2. The first column omits SNAP participation. In this specification, a number of the household history variables are statistically significantly related to food insecurity and have the anticipated signs. The exceptions are increases in household size and short term marriage and divorce. The second column adds an indicator for SNAP participation. Similar to previous research that does not account for the possible endogeneity of SNAP, the coefficient on SNAP participation is positive and statistically significant. Including SNAP results in less negative estimate of average income during the previous year and a smaller and now statistically insignificant effect of increases in the number of household members.

Marginal effects are not reported for the probit model. However, it is useful to note that the marginal effect associated with the coefficient of 0.219 is 0.061 suggesting that on average participating in SNAP increases the probability of being food insecure by 0.061. Thus controlling for observed characteristics reduces the positive relationship between participation and food insecurity from 0.165 to 0.061. I next turn to the bivariate probit model which, as described above, allows SNAP participation to be endogenous.

Table 2. Food insecurity probit coefficients.

[Empty Cell]	**Excluding SNAP indicator**	**Including SNAP indicator**
SNAP	–	0.219*** (0.024)
Household history		
Negative income shock	0.057** (0.024)	0.057** (0.024)
Average income to needs ratio	−0.145*** (0.020)	−0.116*** (0.020)
Number of moves	0.072*** (0.022)	0.071*** (0.022)
Number of times HH size increases	0.051* (0.027)	0.041 (0.027)
Number of times HH size decreases	0.046* (0.025)	0.045* (0.025)
Married ≤ one year	−0.020 (0.082)	−0.016 (0.082)
Divorced ≤ one year	−0.038 (0.065)	−0.027 (0.066)
Married > one year	−0.104*** (0.033)	−0.080** (0.033)
Divorced > one year	0.123*** (0.028)	0.126*** (0.028)
Household characteristics		
Income to needs ratio	0.014 (0.027)	0.029 (0.028)
Own home	−0.233*** (0.022)	−0.201*** (0.023)
Someone employed	−0.120*** (0.026)	−0.096*** (0.026)
Number of kids	0.018** (0.009)	0.0004 (0.009)
Number of adults	0.002 (0.017)	−0.001 (0.017)
Number disabled	0.308*** (0.018)	0.278*** (0.019)
Some elderly	−0.136*** (0.044)	−0.144*** (0.044)
All elderly	−0.268*** (0.044)	−0.271*** (0.045)
Unemployment rate	0.027** (0.012)	0.028** (0.012)
Metro	0.058** (0.025)	0.068*** (0.025)
Household head characteristics		
Female	0.048** (0.022)	0.031 (0.022)
Education = HS	−0.088*** (0.025)	−0.076*** (0.025)
Education > HS	−0.146*** (0.026)	−0.124*** (0.026)
Black	0.189*** (0.026)	0.171*** (0.027)

[Empty Cell]	**Excluding SNAP indicator**	**Including SNAP indicator**
Hispanic	0.198*** (0.034)	0.188*** (0.034)
Other race	0.148*** (0.043)	0.139*** (0.043)
Age	0.027*** (0.004)	0.026*** (0.004)
Age 2/100	−0.03*** (0.004)	−0.032*** (0.004)
Citizen	0.049 (0.037)	0.032 (0.037)
Log-likelihood	−11345.875	−11300.111

Notes: Robust standard errors in parentheses. Number of observations = 23,693.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

The coefficient estimates for the bivariate probit model are presented in Table 3. Most of the household history variables continue to have the predicted signs. The average income-to-needs ratio during the preceding year is negatively associated with being food insecure, and a negative income shock is positively related to food insecurity. Moving and the number of times household size increases or decreases are all positively related to food insecurity. Counter to the expectation that recent changes in marital status should increase the probability of being food insecure, the effects for both recent marriage and divorce are negative and statistically insignificant. Being married for more than one year is protective while being divorced for more than one year increases the probability of being food insecure.

Table 3. Bivariate probit coefficients.

[Empty Cell]	**Food_Insecurity**	**SNAP_Participation**
SNAP participation	−0.274*** (0.089)	–
Household history		
Negative income shock	0.057** (0.024)	0.014 (0.026)
Average income to needs ratio	−0.183*** (0.023)	−0.515*** (0.023)
Number of moves	0.072*** (0.022)	0.014 (0.024)
Number of times HH size increases	0.065** (0.027)	0.164*** (0.030)
Number of times HH size decreases	0.048* (0.025)	0.036 (0.027)
Married ≤ one year	−0.028 (0.082)	−0.088 (0.085)
Divorced ≤ one year	−0.044 (0.064)	−0.100 (0.067)
Married > one year	−0.130*** (0.034)	−0.361*** (0.035)
Divorced > one year	0.123*** (0.028)	0.012 (0.028)
Household characteristics		
Income to needs ratio	−0.004 (0.028)	−0.183*** (0.029)
Own home	−0.277*** (0.026)	−0.555*** (0.023)
Someone employed	−0.150*** (0.027)	−0.370*** (0.027)
Number of kids	0.040*** (0.011)	0.268*** (0.010)
Number of adults	0.007 (0.017)	0.060*** (0.019)
Number disabled	0.344*** (0.021)	0.479*** (0.020)
Some elderly	−0.118*** (0.044)	0.154*** (0.048)
All elderly	−0.256*** (0.044)	0.075* (0.045)
Unemployment rate	0.024** (0.012)	−0.015 (0.012)
Metro	0.044* (0.025)	−0.132*** (0.025)
Household head characteristics		
Female	0.067*** (0.023)	0.244*** (0.022)
Education = HS	−0.105*** (0.025)	−0.215*** (0.025)

[Empty Cell]	**Food_Insecurity**	**SNAP_Participation**
Education > HS	−0.172*** (0.027)	−0.351*** (0.026)
Black	0.218*** (0.027)	0.335*** (0.026)
Hispanic	0.219*** (0.034)	0.246*** (0.036)
Other race	0.164*** (0.043)	0.197*** (0.045)
Age	0.028*** (0.004)	0.016*** (0.004)
Age2 / 100	−0.035*** (0.004)	−0.021*** (0.004)
Citizen	0.067* (0.037)	0.240*** (0.041)
Instruments		
Fingerprint	–	−0.445*** (0.163)
Certification	–	−0.211*** (0.065)
Correlation between errors	0.294*** (0.051)	
Log likelihood	−22161.313	

Notes: Robust standard errors in parentheses. Number of Observations = 23,693.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

As described in Section 3, the bivariate probit model allows for endogeneity of SNAP participation by allowing for correlation in the unobserved determinants of food insecurity and SNAP participation, and a test of endogeneity is whether the correlation in the errors terms is different from zero. The estimated correlation is 0.294 (s.e. = 0.051). The positive correlation indicates that unobserved factors that increase the likelihood of being food insecure also increase the likelihood of participating in SNAP. After allowing for endogeneity, the coefficient estimate on SNAP participation changes from 0.219 to −0.274 and is statistically significant at the 1 percent level. The negative coefficient on SNAP participation in the bivariate probit model implies that SNAP participation reduces the probability of food insecurity.

Turning to the household characteristics, the current income-to-needs ratio is not predictive of food insecurity, but owning a home and having at least one employed household member are negatively related to food insecurity. The number of children, but not the number of adults, is positively related to food insecurity. The number of disabled persons is positively related to food insecurity. The likelihood of being food insecure decreases for households with some elderly members and falls further for households with all elderly members. Finally, living in a metropolitan area is estimated to increase the likelihood of being food insecure as is a higher unemployment rate.

Having a female reference person is estimated to increase the probability of being food insecure. The probability of being food insecure is decreasing in the household head's education, and it is higher for households with a non-white reference person. The estimated probability of being food insecure is increasing in reference person age until age 44 after which it is decreasing, and being a citizen is estimated to increase food insecurity. As a whole, the estimates of the household characteristics and reference person characteristics are consistent with the previous literature.

The second column of Table 3 presents the results of the SNAP participation equation in the bivariate probit model. The household history variables are generally weaker in this equation.

Only the average income-to-needs ratio during the preceding year and increases in household size are significantly related to SNAP participation.

Unlike food insecurity, for SNAP participation the current income-to-needs ratio is statistically significant even after controlling for income-to-needs during the previous year. Owning a home and having workers in the household are both negatively related to SNAP participation. Having more children, adults, or disabled individuals is estimated to increase the probability of SNAP participation. Households with some elderly members have a higher probability of SNAP participation followed by households with all and no elderly members, respectively. The household head characteristics are all statistically significant and have the same signs as with the food insecurity equation.

Because they aid in identification of the model, the instruments are particularly important. Both the requirement that applicants be fingerprinted and rules that require shorter recertification periods are statistically significant and are estimated to reduce the probability of SNAP participation, and the instruments are jointly statistically significant at $p = 0.0001$ ($\chi^2(2)=18.16$).

The coefficient estimates are informative about the direction of a relationship but not the magnitude. For example, the coefficient estimate of 0.057 on a negative income shock in the first column of Table 3 indicates that a negative income shock increases the probability of being food insecure, but it is not informative about the magnitude.

To better understand the roles household history and SNAP participation play in food security, I turn to marginal effects as described in Section 3. The marginal effects for the food insecurity equation in Table 3 are presented in the first column of Table 4. Participation in SNAP is estimated to reduce the probability of food insecurity by 7.1 percentage points. Experiencing a negative income shock in the preceding 12 months is estimated to increase the probability of being food insecure by 1.5 percentage points. The results suggest that increasing the average income-to-needs ratio by one (e.g., from 1 to 2; the mean is 1.12) reduces the probability of being food insecure by 4.9 percentage points. Each move in the preceding year increases the probability of being food insecure by 1.9 percentage points.[14] Each time the household size increases, the probability of food security is estimated to increase by 1.7 percentage points while each time it decreases, the probability increases by 1.3 percentage points.

Table 4. Bivariate probit marginal effects.

[Empty Cell]	**Food insecure**	**SNAP**
SNAP participation	−0.071*** (0.022)	–
Household history		
Negative income shock	0.015** (0.007)	0.004 (0.007)
Average income to needs ratio	−0.049*** (0.006)	−0.133*** (0.006)
Number of moves	0.019*** (0.006)	0.004 (0.006)
Number of times HH size increases	0.017** (0.007)	0.042*** (0.008)
Number of times HH size decreases	0.013* (0.007)	0.009 (0.007)
Married ≤ one year	−0.008 (0.022)	−0.023 (0.022)
Divorced ≤ one year	−0.012 (0.017)	−0.026 (0.017)

[14] For reference, the maximum number of moves observed is 4; the maximum number of times the household size increases is 5; and the maximum number of times the household size decreases is 5.

[Empty Cell]	**Food insecure**	**SNAP**
Married > one year	−0.035*** (0.009)	−0.093*** (0.009)
Divorced > one year	0.033*** (0.008)	0.003 (0.007)
Household characteristics		
Income to needs ratio	−0.001 (0.008)	−0.047*** (0.007)
Own home	−0.074*** (0.007)	−0.146*** (0.006)
Someone employed	−0.040*** (0.007)	−0.093*** (0.007)
Number of kids	0.011*** (0.003)	0.069*** (0.003)
Number of adults	0.002 (0.005)	0.015*** (0.005)
Number disabled	0.093*** (0.006)	0.123*** (0.005)
Some elderly	−0.031*** (0.011)	0.041*** (0.013)
All elderly	−0.067*** (0.011)	0.019* (0.011)
Unemployment rate	0.007** (0.003)	−0.004 (0.003)
Metro	0.012* (0.007)	−0.034*** (0.007)
Household head characteristics		
Female	0.018*** (0.006)	0.062*** (0.006)
Education = HS	−0.029*** (0.007)	−0.057*** (0.007)
Education > HS	−0.047*** (0.007)	−0.091*** (0.007)
Black	0.060*** (0.008)	0.089*** (0.007)
Hispanic	0.060*** (0.010)	0.064*** (0.010)
Other race	0.044*** (0.012)	0.051*** (0.012)
Age	−0.001*** (0.0003)	−0.001*** (0.0003)
Citizen	0.018* (0.010)	0.059*** (0.010)
Instruments		
Fingerprint	–	−0.115*** (0.042)
Certification	–	−0.054*** (0.017)

Notes: Robust standard errors in parentheses. Number of observations = 23,693.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

The second column of Table 4 presents marginal effects for the SNAP participation estimates from Table 3. An increase of 1 in the average income to needs ratio is estimated to reduce the probability of SNAP participation by 13.3 percentage points while each increase in household size increases the probability of SNAP participation by 4.2 percentage points. Among household characteristics, owning a home, having an employed adult in the household, and the number of disabled individuals all have large effects on the probability of SNAP participation.

5.3. Sensitivity analysis

Table 5 presents the marginal effects for SNAP participation and the household history variables estimated under a number of different assumptions. For ease of exposition, the first column reproduces the marginal effects from Table 4.

Table 5. Sensitivity analysis.

[Empty Cell]	**Base model**	**Reduce current period income cutoff[+]**	**Increase current period income cutoff[++]**	**Increase previous year income cutoff[+++]**	**No instruments**	**Weights**
SNAP	−0.071*** (0.022)	−0.054** (0.025)	−0.075*** (0.018)	−0.054** (0.022)	−0.078*** (0.022)	−0.080*** (0.023)
Negative income shock	0.015** (0.007)	0.018** (0.007)	0.008 (0.006)	0.015** (0.006)	0.015** (0.007)	0.010 (0.007)

[Empty Cell]	Base model	Reduce current period income cutoff+	Increase current period income cutoff++	Increase previous year income cutoff+++	No instruments	Weights
Average income to needs ratio	−0.049*** (0.006)	−0.045*** (0.007)	−0.048*** (0.005)	−0.039*** (0.004)	−0.050*** (0.006)	−0.044*** (0.007)
Number of moves	0.019*** (0.006)	0.023*** (0.007)	0.019*** (0.005)	0.019*** (0.006)	0.019*** (0.006)	0.018*** (0.007)
Number of times HH size increases	0.017** (0.007)	0.015* (0.008)	0.012** (0.006)	0.016** (0.007)	0.018** (0.007)	0.022*** (0.008)
Number of times HH size decreases	0.013* (0.007)	0.006 (0.008)	0.018*** (0.006)	0.011* (0.006)	0.013* (0.007)	0.013* (0.008)
Married ≤ one year	−0.008 (0.022)	−0.005 (0.025)	−0.009 (0.018)	0.006 (0.021)	−0.008 (0.022)	0.039 (0.049)
Divorced ≤ one year	−0.012 (0.017)	−0.003 (0.019)	−0.008 (0.015)	−0.011 (0.017)	−0.012 (0.017)	−0.015 (0.019)
Married > one year	−0.035*** (0.009)	−0.038*** (0.010)	−0.031*** (0.008)	−0.033*** (0.009)	−0.036*** (0.009)	−0.037*** (0.010)
Divorced > one year	0.033*** (0.008)	0.035*** (0.008)	0.029*** (0.006)	0.034*** (0.007)	0.033*** (0.008)	0.029*** (0.008)
Number of observations	23693	19576	30853	24819	23693	23693

Notes: Robust standard errors in parentheses. The Base Model is the first column of Table 4. All models include household characteristics; household reference person characteristics; and state, year, and month effects.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.
+ Households are included if average income in the previous year is <300% of poverty and current income is less than 130% of poverty.
++ Households are included if average income in the previous year is <300% of poverty and current income is less than 185% of poverty.
+++ Households are included if the average income in the past year is <600% of poverty and current income is less than 150% of poverty.

Recall from Section 4 that households are included in the analysis if their income is less than 150% of poverty at the time food security is measured and if their average income to needs ratio during the preceding year is less than 300% of poverty. Columns 2 through 4 present marginal effects from models where the inclusion restrictions are varied.

The statutory gross income eligibility threshold for SNAP eligibility is 130% of poverty, and the second column presents results where the sample is chosen using this more stringent cutoff for current period income with no change to the cutoff for prior year income. The estimated effects of the household history variables are slightly larger in absolute value, and the estimated effect of SNAP participation falls in magnitude from −7.1 to −5.4. However, none of the conclusions are altered.

I next consider the effect of increasing the current period income threshold from 150% of poverty to 185. The rationale is that other assistance programs such as WIC have an eligibility threshold of 185% of poverty so increasing the cutoff may include households receiving other benefits even if receipt of those benefits is not modeled. The sample size is substantially larger, but there are only small changes in any of the marginal effects.

The results in the fourth column explore the effect of relaxing the cutoff for average income during the preceding year. For the sensitivity analysis, this cutoff is increased to 600% of poverty while setting the current period threshold to 150% of poverty. This results in only about 1000 more households being included in the analysis. The most notable changes are reductions in the

marginal effects for SNAP participation and the average income to needs ratio, but the general conclusions remain unchanged.

As described earlier, the econometric model is identified on functional form alone without the need for instruments. To assess the empirical value of the instruments, the next to last column of Table 5 presents marginal effects from a model where instruments are omitted. The estimated effect of SNAP participation is modestly larger, and there are essentially no changes in the household history variables. Thus, while the instruments are individually and jointly statistically significant, they are not necessary for identification of this model. Shaefer and Gutierrez (2013) also reported results with and without instruments and found only small differences. This results suggests that the estimates may be sensitive to the bivariate normality assumption inherent in the bivariate probit model.

Finally, to this point the estimation has not included sample weights. To test the sensitivity of the results to this assumption, the last column of Table 5 reports marginal effects from a model using sample weights. The results are generally similar to the base model. The effect of a negative income shock is smaller than the base case and no longer statistically significant, and the effect of SNAP participation is larger. The remainder of the results are quite similar.

6. Discussion and conclusion

The results indicate that a household's recent experience is related to food insecurity. In particular, a lower level of income during the previous year, a negative income shock, moving, and increases or decreases in the number of people in the household are all estimated to increase the likelihood of being food insecure. The magnitudes of these effects are generally consistent across a number of specifications including omitting SNAP participation, treating it as exogenous, or treating it as endogenous as well as a number of different income cutoffs used to determine the sample.

In the preferred specification, the results indicate that each additional move increases the probability of being food insecure by 1.9 percentage points, each time household size increases the probability of being food insecure increases by 1.7 percentage points, and each time household size decreases the probability of being food insecure increases by 1.3 percentage points. For comparison, SNAP participation, after allowing for endogeneity, is estimated to reduce the probability of food insecurity by 7.1 percentage points, owning a home by 7.4 percentage points and having a high school degree (relative to not having a high school degree by 2.9 percentage points. Of the household history variables, across all specifications, the most robust estimates are for average income during the preceding year, the number of moves, the number of times household size increases, and being married or divorced for more than one year. The estimates for a negative income shock and decreases in household size are weaker. The results support the hypothesis that recent household experiences are important determinants of food insecurity. For future work, it would be interesting to further explore how these recent changes in circumstances affect food security. For example, one might move from indicators of increases or decreases in household size to consider the number of people who enter or leave as well as whether the individuals who leave are for example, employed adults or children.

Additionally, the models only provide estimates of an average effect. It is possible that the effect of SNAP participation varies across households.

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