UKCPR
University of Kentucky
Center for
Poverty Research

Discussion Paper Series
DP 2013-10

ISSN: 1936-9379

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Preferred citation
Gregory,C. Rabbitt, M. & Ribar, D. The Supplemental Nutrition Assistance Program and Food Insecurity. *University of Kentucky Center for Poverty Research Discussion Paper Series, DP2013-10*. Retrieved [Date] from http://www.ukcpr.org/Publications/DP2013-10.pdf.

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December 2013

Abstract: This chapter reviews recent theory and empirical evidence regarding the effect of SNAP on food insecurity and replicates the modelling strategies used in the empirical literature. The authors find that recent evidence suggesting an ameliorative effect of SNAP on food insecurity may not be robust to specification choice or data. Most specifications mirror the existing literature in finding a positive association of food insecurity with SNAP participation. Two-stage least squares and control function methods do show that SNAP reduces food insecurity, but effects are not consistent across sub-populations and are not always statistically significant.

* Earlier versions of this paper were presented at the "Five Decades of Food Stamps" research conference, September 20, 2013 in Washington, DC and at the 16th Labour Econometrics Workshop, August 10, 2013 in Melbourne, Australia. The authors thank John Pepper, Steven Stillman, and conference participants for helpful comments. The views expressed in this paper are those of the authors and not necessarily those of the ERS or USDA.

The Supplemental Nutrition Assistance Program and Food Insecurity

Introduction

The Supplemental Nutrition Assistance Program (SNAP, formerly the Food Stamp Program) is intended to help low-income households obtain more nutritious food than they could otherwise afford. In so doing, the SNAP should—in both a normative and a positive sense—reduce households' food hardships. However, only recently has research begun to confirm this common sense association.

Since 1995, the United States has regularly measured food hardships nationally, using the Food Security Scale, a 10-to-18-item index that is intended to capture households' "access at all times to enough food for an active, healthy life" (Coleman-Jensen et al. 2012). The latest data indicate that 85 percent of U.S. households were food secure in 2011, while 15 percent (17.9 million households with 50.1 million people) were not. More often than not, researchers find that the receipt of SNAP benefits is associated with more, rather than fewer, food hardships. For example, Coleman-Jensen et al. (2012) report that among households with incomes below 130 percent of the poverty line (households that meet the gross income test for SNAP receipt), 52 percent of SNAP participants reported being food insecure compared to 28 percent of non-participants.

Obviously, this example demonstrates simple association, rather than causation. But it hasn't been until quite recently that any methods have begun to get results consistent with the expectation that SNAP would reduce food insecurity. Are our common-sense predictions wrong, or are there statistical problems that confound the estimates? What are the methodological and,

more importantly, the policy and well-being implications of the results? This chapter reviews and synthesizes previous research on these questions and conducts new analyses using several years of data from the Food Security Supplement of the Current Population Survey (CPS-FSS).

Measuring Food Insecurity and Other Food Hardships

The principal instrument for measuring food security in the U.S. is the Food Security Module of the CPS-FSS. The module asks 10 questions of all households and an additional 8 questions of households with children, regarding progressively more severe hardships that range from anxiety over food running out to shortages of amounts and kinds of food to episodes of adults and children going without food for an entire day. All of the questions refer to the previous 12 months and are framed in terms of either shortages of money or affordability. The CPS-FSS also asks 30-day questions based on the same items. The items in the 12-month module are listed in Appendix A.

The Food Security Module was developed after extensive research that began with a conceptualization of food security and insecurity and proceeded to qualitative fieldwork to elicit themes for potential items, the development of candidate items, statistical and qualitative analyses of the items' validity and reliability, a selection of items, and a final scaling (see Hamilton et al. 1997). The testing included formal Item Response Theory modelling (specifically Rasch modelling) and indicated that the items were consistent with a unidimensional underlying, or latent, measure.

Household food security status is determined by summing the affirmed responses from the module. Households that affirm two or fewer items are classified as being "food secure," meaning that they have "consistent, dependable access to enough food for active, healthy living" (Coleman-Jensen et al. 2012, p. v). Households without children that affirm three to five items

and households with children that affirm three to seven items are classified as experiencing "low food security," meaning that they "reported multiple indications of food access problems, but typically … reported few, if any, indications of reduced food intake" (Ibid, p. 4). Households that affirm more items (six or more for households without children and eight or more for households with children) are classified as experiencing "very low food security," meaning that the "food intake of one or more members was reduced and eating patterns (were) disrupted because of insufficient money and other resources for food" (Ibid, p. 4). The low and very low food security categories together constitute food insecurity.

The CPS-FSS Food Security Module has some limitations that should be kept in mind. In a careful review of the food security scale, the National Academy of Sciences (Wunderlich and Norwood 2006) identified several problems, including that the module captures other relevant food hardships, such as problems with the supply, safety, or quality of food; that the unidimensional model for developing the scale might not be appropriate; and that the CPS-FSS is based on a household sampling frame that omits institutionalized and homeless people. Also, to lower the response burden on CPS subjects and to reduce the risks of false positive indications, the module is not asked of all households in the CPS-FSS but rather only of households that are at risk of insecurity because they have incomes below 185 percent of the poverty line, indicated that they are food insufficient, or indicated that they undertook actions to stretch their food budget. Although the food security measure is strongly associated with households' income-to-needs ratios (see, e.g., Coleman-Jensen et al. 2012), researchers have found that it has weak external validity in terms of some nutritional outcomes (Bhattacharya et al. 2004) and food expenditures (Gundersen and Ribar 2011) and that items may have low reliability among parents and children (Fram et al. 2011).

In addition to the 12-month, 18-item food security scale, research on the SNAP has used other measures of food hardships. One of these, the food insufficiency measure, has already been mentioned. The food insufficiency question asks households if they have, "enough of the kinds of food (they) want to eat, enough but not always the kinds of food (they) want to eat, sometimes not enough to eat, or often not enough to eat?" The CPS-FSS also follows up affirmative responses to the 12-month food security questions with questions about whether the hardships were experienced in the last 30 days; the responses from these questions are used to construct a 30-day measure of food insecurity.

The 18-item food security module has been included in other U.S. surveys, such as the Panel Study of Income Dynamics and the National Health and Nutrition Examination Survey. However, due to time and budget constraints, some other surveys either ask the single-item food sufficiency question or a subset of the food security questions. For example, recent panels of the Survey of Income and Program Participation (SIPP) have asked six food security questions covering the previous four months; a food security scale has been developed from responses to five of these questions. The National Health Interview Survey currently fields the 10-item questionnaire. In general, measures derived from the full 18-item module, the food sufficiency question, and shorter modules are highly correlated.

Conceptual analysis

To consider the ways in which SNAP might affect food hardships, we rely on Barrett's (2002) theoretical rational-choice model of how household food security is determined.[1] Barrett extended the household production framework of Becker (1965) and Gronau (1977) and the

[1] Caswell and Yaktine (2013), Gundersen and Gruber (2001), Gundersen and Oliveira (2001), Huffman and Jensen (2003), Meyerhoefer and Yang (2011), and Ribar and Hamrick (2003) also provide conceptual models.

health production framework of Grossman (1972) to include household nutrition and food security. In Barrett's model, households choose purchases, savings or borrowing, and allocations of time to further the objective of maximizing their members' physical well-being and general consumption in the present, where they have full information about their circumstances, and in the future, where they have expectations about circumstances. Households pursue these objectives subject to production, health, budget, and time constraints. Specifically, each period's physical well-being depends on the level of well-being from the previous period; inputs of nutrition, other goods or services, and activities; and arbitrary shocks from illnesses and injuries. The nutritional inputs to physical well-being, in turn, are produced using inputs of food and other goods and of members' time. Each of these production functions is also conditioned by the household members' human capital. Also, households face subsistence constraints in the form of minimum amounts of nutrition to avoid hunger and minimum amounts of physical well-being to avoid impairment. With respect to the budget constraint, households' total per-period expenditures on food, other goods, and services must not exceed the sum of the members' earnings plus the return on their savings and other assets plus any borrowing and less any savings. The household members also have limits on the time available each period to work or participate in other activities.

From Barrett's framework, we can identify structural characteristics of households that increase the risk of food hardships. First, hardships are more likely to occur if household members have low labor productivity (through circumstances such as disability, a lack of education, or very young or old age) that reduce their ability to work in the home and the labor market. Second, households are at greater risk for hardships if they confront adverse terms of trade in the form of either low wages for the work they perform or high prices for the goods they

purchase. Third, households are also at increased risk of hardships if they lack access to labor markets or goods markets. Fourth, risks are higher for households with low levels of savings and assets and for households with limited abilities to borrow and save. Fifth, risks increase if households have weak social or public support systems. Sixth, households face higher risks of food insecurity if their circumstances frequently leave them near the subsistence or food security thresholds, as this increases the chances that a given shock will knock them below the thresholds. Seventh, a general susceptibility to negative shocks, perhaps because of marginal health, residence in an area with a volatile economy, or work in a vulnerable industry, increases the risks of becoming food insecure.

We can also use Barrett's model to consider how the SNAP should affect households' food security. In principle, the program's EBT assistance should expand participating households' budget sets and relax their resource constraints. This should allow households to purchase more food and reduce the incidence of food hardships, including food insecurity. We would also anticipate complementary effects from the educational component of SNAP, which should increase household members' shopping, planning, and food preparation skills and thereby make them more effective at transforming budgetary and other resources into nutritional inputs and physical well-being outcomes.

At the same time, other elements of SNAP participation might work against these effects. First, means-testing of SNAP eligibility and benefits imposes an extra tax on market work, reducing poor people's incentives to work and earn (or possibly incentivizing them to work "off-the-books" in less stable informal jobs). These effects might be especially strong for households with children, where the receipt of SNAP confers categorical eligibility for free meals under the National School Lunch Program (NSLP) and School Breakfast Program (SBP) and adjunctive

financial eligibility for the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) program. Second, program participants are vulnerable to losses of benefits if they fail to comply with program rules regarding recertification and mandated work activities (Ribar et al. 2008, 2010). Ribar and Edelhoch (2008) found that recertification had especially detrimental participation effects for recipients who were marginally eligible financially and for recipients in very unstable circumstances. More generally, income volatility could both increase the risks of food insecurity (Gundersen and Gruber 2001) and affect eligibility for food assistance (see, e.g., Jolliffe and Ziliak 2008). Third, monthly cycles associated with SNAP issuance, spending, and benefit exhaustion could give rise to periodic shortages of food (Wilde and Ranney 2000). Fourth, the increased time and preparation associated with SNAP-eligible food purchases as compared to other types of food purchases might negatively affect families. Although each of these issues might reduce the effectiveness of the SNAP, we would still expect the program's net effects to be positive.

Although theory predicts a positive effect of SNAP on food security, there are many reasons why results produced from an observational empirical analysis might differ. First and foremost, participation in the SNAP is endogenous. Food security and SNAP participation are each influenced by a host of characteristics, and failure to measure or account for these characteristics in an empirical analysis can give rise to spurious associations. For example, Joyce et al. (2012) document a host of hardships, including health problems, housing insecurity, and losses of utilities, that often accompany food hardships. There is also a possibility that food hardships may prompt SNAP participation and that the empirical association may be affected by simultaneity bias. Nord and Golla (2009) examined trajectories of food hardships prior to and after entering the SNAP; they found that food hardships rose in the months leading up to SNAP

entry, suggesting that increased hardships motivated entry. As we discuss in the next section, the endogeneity of SNAP participation has been a predominant methodological concern in empirical research. Finally, mismeasurement and misreporting of food hardships and of SNAP participation may alter the observed relationships.

Previous research

A vast number of studies have investigated the impacts of the SNAP on American's food outcomes. Comprehensive reviews by Barrett (2002), Currie (2003), and Fox et al. (2004) summarize the research as consistently indicating that the SNAP is associated with higher expenditures on food and greater food and nutrient availability within households. However, Currie (2003), Fox et al. (2004), and Wilde and Nord (2005) reach much different conclusions regarding the impact of SNAP on food insecurity and insufficiency and report that the results across studies are mixed and inconsistent. A more recent review by Caswell and Yaktine (2013) is more sanguine about the studies of SNAP and food hardships, although it also acknowledges many inconclusive and counter-intuitive results. Our review will focus on the statistical methodologies that studies have employed, summarize findings associated with those methodologies, and draw interpretations regarding potential biases.[2]

Comparisons of SNAP participants and non-participants. Most of the research on the potential effects of the SNAP on food hardships has been based on comparisons of outcomes for program participants and non-participants. The studies generally restrict their analyses to people with incomes that are below or near the gross-income eligibility limit for the SNAP.[3] The restrictions are intended to make the samples of participants and non-participants more

[2] In addition to these reviews, Meyerhoefer and Yang (2011) have summarized research on the association of SNAP with people's body weight and health.
[3] Borjas' (2004) multivariate analysis is a notable exception.

comparable. For studies that use the CPS-FSS, the restrictions also ensure that everyone in the samples was asked the questions in the food security module and thus avoid an artificial sample selection issue that arises from the screening conditions for the module.

Descriptive results (comparisons of means) from each year's CPS-FSS are reported by the Economic Research Service in its *Household Food Security in the United States* series (e.g., Coleman-Jensen et al. 2012). Descriptive methods were also used in early research, such as Cohen et al. (1999). The descriptive comparisons indicate that food insecurity is substantially higher in SNAP households than in other households.

Multivariate statistical models include other observed measures, such as household size, race, and education of the household head, that are likely to be associated with both food hardships and SNAP participation and that may be sources of spurious associations. Several researchers, including Alaimo et al. (1998) and Bhattacharya and Currie (2001) estimated standard binary or continuous regression models of food hardships, and Ribar and Hamrick (2003) estimated binary event-history models of entry into and exit from these conditions. Although the use of observed controls reduced the associations of SNAP participation and food hardships in these studies, substantial positive conditional associations remained.

A few standard-regression studies have generated different findings using narrower analysis samples and alternative participation comparisons in attempts to mitigate selection issues. Kabbani and Kmeid (2006) found that SNAP participation was negatively associated with 30-day food insecurity among a low-income sample of CPS-FSS households that were food insecure according to the 12-month measure. Rather than considering general comparisons of SNAP participants and non-participants, Gundersen and Gruber (2001) and Mykerezi and Mills (2010) focused on households that had lost benefits and found that such losses raised

households' risks of food insufficiency and insecurity. Mabli et al. (2013) compared food security outcomes for SNAP households at the starts of their participation spells and six months into those spells and found that food hardships decreased with households' SNAP tenures.

Matching techniques offer a more general and robust approach to addressing selection based on observable characteristics. Gibson-Davis and Foster (2006) employed propensity-score matching (PSM, Rosenbaum and Rubin 1983) to compare SNAP participants and non-participants. They found that matching led to lower associations between SNAP and the incidence of food insecurity than standard logistic binary regressions but that many of the associations remained significantly positive. In a few specifications, that jointly (a) considered the food insecurity Rasch score, (b) were restricted to households that affirmed at least one food security item, and (c) were limited to a narrow range of propensity scores, Gibson-Davis and Foster found the expected negative associations.

Standard regression models and matching techniques address selection based on observable variables. If we assume that the theoretical model is indeed correct, the preponderance of counter-intuitive findings from the regression and matching studies indicates that selection must be coming from unobservable characteristics or simultaneity. When longitudinal data are available, multivariate fixed-effects methods can be used to account for time-invariant unobserved characteristics that might be confounded with both SNAP participation and food hardships. Wilde and Nord (2005) estimated household-level fixed effects models using the two-year panels that can be constructed from the CPS-FSS, and Greenhalgh-Stanley and Fitzpatrick (2013) estimated fixed effects models using data on households with elderly people from the Health and Retirement Survey. Both studies found that SNAP participation continued to be positively associated with food insecurity, even after fixed-effects

controls were applied. The findings suggest that time-varying unobserved influences or simultaneity are a source of bias.

Instrumental variables methods, including two-stage least squares (2SLS), endogenous latent variable models, and dummy endogenous variable models, can address these other sources of bias. 2SLS and endogenous latent variable models rely on variable exclusions for identification. For these exclusions to be valid, the excluded variables—the instruments—must be strongly predictive of SNAP participation and must only affect food hardships through their effects on SNAP participation (i.e., must not independently predict food hardships). Dummy endogenous variable models, such as bivariate probit, can be formally identified through the functional forms in the model if there is sufficient variation in the explanatory variables (Wilde 2000). In practice, however, this source of identification can be weak, and researchers typically bolster identification through variable exclusions. A challenge for endogenous variable studies has been to uncover appropriate instruments.

Results based on two-stage and latent endogenous variable methods have been inconclusive. Borjas (2004) examined the effects of public assistance (including but not limited to SNAP receipt) on food insecurity, using citizenship and years since migration as instruments. Borjas found the anticipated negative associations, but most of his estimates were only marginally significant. Gundersen and Oliveira (2001) and Huffman and Jensen (2003) applied endogenous latent variable methods but obtained imprecise and statistically insignificant results. Greenhalgh-Stanley and Fitzpatrick (2013) estimated 2SLS models for elderly households from the Health and Retirement Survey in specifications that also included household-specific fixed effects. They generated estimates that were imprecise and statistically insignificant. Shaefer and Gutierrez (2012) also estimated 2SLS models using data from three panels of the SIPP and

obtained statistically insignificant results.

In contrast, researchers who have applied dummy endogenous variable models have estimated strong negative associations. Yen et al. (2008) found that SNAP participation was negatively associated with households' 30-day food insecurity Rasch scores; however, the researchers used a choice-based sample (the 1996-7 National Food Stamp Program Survey) with an over-representation of SNAP participants.[4] Mykerezi and Mills (2010) estimated a negative association between households' SNAP participation and food insecurity using data from the Panel Study of Income Dynamics. Ratcliffe et al. (2011) and Shaefer and Gutierrez (2012) obtained similar findings with data from the Survey of Income and Program Participation. Shaefer and Gutierrez estimated dummy endogenous variable models with and without variable exclusion restrictions with little change in their results, which suggested that identification for this entire group of studies may have been obtained mainly from functional form.

The preceding statistical approaches all make strong assumptions in order to identify an effect of SNAP on food hardships. Additionally, these methods differ in what they measure. For example, propensity score matching models identify the average effect of the treatment on the treated (ATET), while 2SLS methods isolate the local average treatment effect (LATE)—that is, the effect of SNAP participation for those whose decision to participate is altered by the value of instruments or excluded variables. The dummy endogenous variables models mentioned here are aimed at identifying the average treatment effect (ATE) of SNAP—that is, the expected outcome if SNAP were given to a randomly assigned person in the population of interest. While the ATE might also be identified by longitudinal models, such models rely on the additional assumption that endogenous unobservables are time-invariant; as noted, this assumption seems to be at odds

[4] The researchers used sampling weights to address this issue.

with current evidence.[5]

An alternative approach to introducing model assumptions *a priori* is to bound the possible impacts first using logical probability restrictions and then introducing relatively weak assumptions (see Manski 1995 as general reference). While this approach reduces the reliance on strong assumptions, it tends to produce a wide range of plausible effects. Gundersen and Kreider (2008) have used the bounds approach to show that the same data that generate counter-intuitive differences in participants' and non-participants' food hardships are also consistent with underlying negative impacts when the possible influence of measurement error is accounted for.

Dose-response relationships. Another branch of the research literature has considered how food hardships change with more generous SNAP benefits or more intense participation (i.e., with a higher "dose" of the SNAP "treatment"). For example, in the most recent *Household Food Security in the United States* report, Coleman-Jensen et al. (2012) estimate that the rate of food insecurity was 56.0 percent among households that received SNAP benefits for 1 to 11 months during the preceding year but only 49.1 percent among households that receive SNAP benefits for all 12 months. Similarly, Mabli et al. (2013) found that food security prevalence decreased significantly for households that participated in SNAP for six months.

Studies with multivariate designs find similar evidence. Rose et al. (1998) estimated logit models of food insufficiency and found that higher levels of SNAP benefits were significantly negatively associated with food insufficiency. DePolt et al. (2009) obtained similar results, estimating longitudinal multiple-indicator, multiple cause models of food insecurity. Van Hook and Balistreri (2006) used predicted measures of unmet program need in the form of reduced probabilities of SNAP participation and reduced SNAP allotments and found that these were

[5] A fuller discussion of these issues in relation to food assistance programs can be found in Meyerhoefer and Yang (2011).

positivity associated with hardships. Watson et al. (2012) found a strong dose-response effect of SNAP in reducing children's food insecurity.

Indirect analyses. All of the preceding studies examined how an individual household's receipt or use of SNAP benefits was associated with its own food hardships. Several studies have investigated how measures of characteristics that are associated with the general availability of SNAP are associated with hardships. For example, Borjas (2004) showed how food insecurity for non-citizen immigrants jumped relative to food insecurity for native and naturalized citizens following the enactment of the Personal Responsibility and Work Opportunities Act of 1996. Nord and Prell (2011) compared 30-day food insecurity before and after SNAP benefits were increased as part of the American Recovery and Reinvestment Act of 2009; they found that food insecurity fell for households that were income-eligible for the SNAP but not for near-eligible households, suggesting that the higher benefits reduced hardships. Other studies, however, have found weaker associations or no associations. Using data from the CPS-FSS, Bartfeld and Dunifon (2006) found that state-level SNAP participation was associated with food security for above-poverty, low-income households but not for below-poverty households. Using data from Oregon, Bernell et al. (2006) found that county-level SNAP participation was not associated with food insecurity.

Replication Analysis

Although there are many consistent results and patterns across the empirical studies of SNAP and food hardships, there are also considerable differences. Besides differing in their statistical methodologies, previous studies have differed in their measures of food hardships, measures of SNAP receipt, choice of surveys and time periods, and selection of analysis samples within those surveys. In this section, we attempt to replicate previous findings by employing

most of the statistical methodologies to a single dataset—the 2009-2011 waves of the CPS-FSS.[6]

For each of these years of the CPS-FSS, we select households with annual incomes at or below 130 percent of the federal poverty line. Besides being the income cut-off used to examine SNAP in the annual *Household Food Security in the United States* reports, this threshold also leads to a sample that meets the gross-income test for SNAP and that satisfies the screen for answering the Food Security Module. We additionally restrict our analysis sample to households that responded to the FSS, that provided sufficient information to determine their food security status, and that provided information for other FSS measures that we use as explanatory variables.

For our analyses, we consider a sample that combines all households that meet the preceding criteria, but we also consider four mutually exclusive subsets of households: unmarried parent households with children under age 18, married parent households with children under age 18, households consisting entirely of members who are age 60 or older, and other adult-only households. These types of low-income households differ in their susceptibility to food hardships, are subject to different rules under the SNAP, and are differently eligible for other types of public assistance. Disaggregating this way increases the comparability of households within groups; it also helps us to ascertain the robustness of our findings and the findings of previous studies that have adopted different analysis groups.

The outcome variable in most of our analyses is a binary indicator for the household being food insecure, which is constructed from the 12-month, 18-item Food Security Module. Our principal explanatory variables are indicators for the receipt of any SNAP benefits and a

[6] We focus on 2009-2011 because it is the most recent period available with consistent federal policies. The period includes the 15-percent benefit increase and other provisions from the American Recovery and Reinvestment Act of 2009. Extending the analysis further back would entail accounting for these policy changes.

continuous measure of SNAP benefits. In some of our analyses, we use an indicator for the receipt of SNAP benefits any time during the preceding year. This is the first SNAP question that is asked in the CPS-FSS, and its reference period corresponds with the reference period for the Food Security Module items. In other analyses, we use an indicator for the receipt of SNAP benefits in the month preceding the interview. Although this question is asked conditional on the annual measure, it may be more reliably reported. We also consider this measure because of its use in previous research and because preliminary analyses showed that it led to a distinct result pattern. For our final analyses, we use a continuous measure of annual SNAP benefits which allows us to examine the dose-response of households to SNAP.

For our multivariate analyses, we incorporate numerous additional controls that are available in the CPS-FSS; most of these are standard and have been used in previous research. The controls include the household head's gender, age, race, ethnicity, nativity, marital status, education, and employment status; numbers of adults, children, and disabled members in the household; age of youngest member (households with children); an indicator for elderly members; residence in urban area; the state unemployment rate; household income; home ownership; food needs; receipt of SBP, NSLP, and WIC benefits (households with children); the use of food banks and soup kitchens; and state and year fixed effects. Means and standard deviations for our explanatory variables, calculated separately for SNAP participants and non-participants, for in each of our four analysis subsamples are in Appendix B.

We start our replication analysis by estimating linear probability models (LPMs) of households' food insecurity status. Estimated coefficients and standard errors for the SNAP receipt explanatory variable from alternative specifications and analysis samples are listed in Table 1. All of the regressions in Table 1 incorporate sampling weights provided with the CPS-

FSS that adjust for the CPS sampling design and for differential response in the FSS. Estimates for the entire combined sample of households are reported in the first column of the table. The subsequent columns report estimates separately for the mutually exclusive subsamples of unmarried parent households, married parent households, households composed entirely of elderly members, and other adult-only households. The top panel lists estimates from models that include measures of any SNAP receipt in the previous year, while the bottom panel lists results from models of SNAP receipt in the previous month.

[Table 1 about here].

The first row in each panel of Table 1 reports coefficients from simple univariate LPMs of food insecurity regressed on SNAP receipt. The estimates, which represent unconditional differences in average food insecurity between SNAP participants and non-participants, are all strongly positive and consistent with estimates from previous descriptive analyses, such as Coleman-Jensen et al. (2012). The differences are largest for the two groups of adult-only households and smallest for single-parent households. Also consistent with previous analyses, the differences in food insecurity are appreciably larger when SNAP receipt is measured on a previous-year basis rather than a previous-month basis.

The second rows in the panels list coefficients from LPMs that add controls for demographic characteristics of the households and their heads, geographic attributes, and state and time fixed effects. Adding these controls substantially reduces the estimated associations between SNAP receipt and food insecurity for the two groups of adult-only households but only slightly reduces the associations for the two groups of households with children.

The third rows report coefficients from specifications that also add controls for employment status, household income, home ownership, and subjectively-assessed food needs,

and the use of these controls attenuates the associations between SNAP receipt and food insecurity more. Finally, the last rows in the panels add controls for SBP, NSLP, and WIC program participation for the households with children and food bank and soup kitchen use for all households. Although these controls further reduce the estimated coefficients, the conditional associations between SNAP receipt and food insecurity remain positive and statistically distinguishable from zero. The patterns of results are consistent with previous research findings that observed controls attenuate but do not eliminate the counter-intuitive positive associations between SNAP participation and food insecurity.

We next consider matching estimates as a more general way to mitigate confounding influences from observable characteristics. Results from this analysis are reported in Table 2, which follows the organization from Table 1 with estimates arranged by analysis groups in columns, by the periodicity of SNAP receipt in top and bottom panels, and by the type or specification of the estimator in rows within panels. Because of questions regarding the interpretation of sample weights in matching analyses, we report results computed with unweighted data. For purposes of comparison with our previous estimates, we report unconditional differences in food insecurity between SNAP participants and non-participants in the first rows of the panels and report coefficients from LPMs with our standard and economic controls (the same parameterizations as the third rows from Table 1) in the second rows. The estimates in the first two rows indicate that weighting has no substantive impact on the estimates for households with children but modest impacts for the two groups of adult-only households.

[Table 2 about here].

The third rows of the panels in Table 2 list the differences between the average rates of food insecurity between our participant samples and matched non-participant samples. The

samples were matched using predicted probabilities from logit models of SNAP participation that included our standard and economic controls. For the matching itself, we selected nearest match neighbors with replacement and restricted the matches to the common support of the predicted probabilities (virtually the entire range of probabilities). Analyses (not shown) confirm that the matched samples were balanced in terms of the observed control variables. Turning to the results in the table, differences in food insecurity in the matched samples are mostly smaller than the unconditional differences and the regression-based conditional differences. Despite the general attenuation in the estimated differences, all of them remain significantly and substantively positive, mirroring the results reported by Gibson-Davis and Foster (2006) for the incidence of food insecurity.

We next consider longitudinal estimators. The design of the CPS, in which rotation groups of households are interviewed for four consecutive months, left alone for eight months, and then re-interviewed for four more consecutive months, allows the construction of short, two-year panels from adjoining years of the CPS-FSS. As with Wilde and Nord (2005), we take advantage of this feature to produce longitudinal analysis datasets and to estimate panel data models. The longitudinal data from the CPS-FSS have some limitations beyond their short lengths. Most importantly, the units that the CPS follows are physical addresses, not individuals or households. Thus, people who move between surveys cannot be longitudinally linked and effectively attrit from the panels. Also, the CPS does not produce sampling weights for longitudinally-linked CPS-FSS households, so we conduct our statistical analyses using unweighted data.

Results from our longitudinal analyses are reported in Table 3. For purposes of comparison, we estimate LPMs with our standard and economic controls but using the

unweighted longitudinal sample. Estimates from these specifications in the first rows of the panels are all very similar to the LPMs for the full sample. The results reassure us that there is little, if any, selection bias associated with CPS-FSS longitudinal sample attrition.

[Table 3 about here].

Estimates from panel-data random- and fixed-effect LPMs are reported in the second and third rows of the top and bottom panels of Table 3. Comparisons of these estimates reveal that accounting for unobserved time-invariant characteristics through the use of fixed effects reduces the estimated associations between SNAP receipt and food insecurity. However, large and statistically significant associations remain for all groups except for unmarried parent households when SNAP is measured on the basis of the previous month. Formal specification tests are reported below the random- (Breusch-Pagan) and fixed- effect (Hausman-Wu) LPM estimates in the top and bottom panels of Table 3. The LPMs are strongly rejected by the Breusch-Pagan test in favor of the random effect LPMs for all household types, regardless of how SNAP is measured. Hausman-Wu tests fail to reject the null that the random effect LPMs are consistent for unmarried parent households. For all other groups, the random effect LPM is rejected in favor of the fixed effect LPM. This result strengthens when SNAP is measured on the basis of the previous month.

To investigate the possible sensitivity of these findings to the use of LPMs rather than more specialized binary outcome models, we re-estimated the standard and fixed-effects models using standard and conditional, fixed-effect logit specifications, respectively. Average marginal effects were calculated for these models to facilitate comparison with the LPMs. Marginal effects from the logit models are qualitatively similar to the coefficients from the LPMs in most cases, though the marginal effects from the fixed-effect logit models are all statistically insignificant.

Next, we investigate evidence from 2SLS and dummy endogenous variable models. For each type of model, we consider two potential instruments: an indicator for the household head being a non-citizen and an estimate derived from the SNAP Quality Control files of the median certification interval from SNAP cases in the household's state of residence. Non-citizen status is a consistently significant explanatory variable in models of SNAP participation for our samples. However, its use as an instrument is controversial because cultural and assimilation differences between non-citizens and other U.S. residents could contribute directly to experiences and reporting of food hardships. Certification intervals have a stronger theoretical basis for serving as instruments, but they are only modestly predictive in our samples.[7] To test the sensitivity of our 2SLS and dummy endogenous variable results, we estimate models first using both instruments and then using just the certification interval instrument. Estimates from our specifications are reported in Table 4.

[Table 4 about here].

For convenience, we reproduce the LPM estimates from our specifications with standard and economic explanatory variables in the first rows of the panels of Table 4. The second rows list estimates and a Hausman-Wu test from 2SLS models that are identified from exclusions on non-citizenship status and certification intervals. The coefficient estimates for all households and for households with children are large and negative, while the coefficient estimates for households with all elderly members are large and positive. However, all of the coefficients are wildly imprecise and unable to discriminate between large positive or large negative effects. The Hausman-Wu test for all households provides evidence that SNAP is endogenous at the five

[7] In preliminary analyses, we also experimented with state-level measures of broad-based categorical eligibility policies and standard utility allowance provisions (two policies that are the focus of debate as the U.S. Congress considers the re-authorization of the SNAP). However, neither of these policy variables was predictive of SNAP receipt in our samples.

percent level; however, this result weakens when SNAP is measured on the basis of the previous month. For the groups separately, we find no evidence of SNAP being endogenous. In the third row, we list results from 2SLS models that rely entirely on certification intervals for identification. These estimates are even less precise than the preceding estimates. In contrast to the previous 2SLS model, the Hausman-Wu tests do not indicate SNAP is endogenous for any specifications.

In the next four rows, we list results from probit specifications. The first row lists average marginal effects from standard probit specifications, and these generate estimates that are qualitatively and quantitatively similar to the LPM estimates. The next row lists estimates from a bivariate probit model that imposes exclusion restrictions on non-citizenship status and certification intervals. The marginal effects for the combined and married-parent samples are significantly negative. While these particular results are potentially encouraging for the theoretical model, they appear to stem entirely from functional form restrictions in the bivariate probit model. In the final rows of Table 4, where we report results from bivariate probit models without any variable exclusion restrictions, the marginal effect estimates are nearly identical in sign, magnitude, and precision to the preceding estimates. Thus, the results from the bottom four rows of Table 4 seem to bear out the findings of Greenhalgh-Stanley and Fitzpatrick (2013) and Shaefer and Gutierrez (2012).

Finally, we investigate the dose response of SNAP on food insecurity using cross sectional and longitudinal models. For each model, we consider two measures of SNAP; an indicator for receipt of SNAP benefits within the past 12 months and the inflation adjusted annual SNAP benefit amount. Including an indicator for the receipt of SNAP benefits allows us to assess the extent of selection bias in the dose-response literature, while the annual measure of

SNAP benefits facilitates replication of the existing literature. We begin our dose response analysis by estimating LPMs, followed by random- and fixed- effect LPMs. Estimated coefficients and standard errors for the SNAP receipt and annual SNAP benefit variables from alternative specifications are listed in Table 5. The SNAP receipt coefficients are generally consistent with the discussion presented above, so we will limit our discussion here to the annual SNAP benefit coefficients. While including observable controls and household fixed-effects reduces the association between SNAP receipt and food insecurity, a strong and highly significant relationship remains. The top panel lists estimates from cross sectional models, while the bottom panel lists results from longitudinal models.

[Table 5 about here]

The first rows of the top panel list coefficients from simple univariate LPMs of food insecurity, SNAP receipt, and the annual benefit amount estimated with the cross sectional sample. The coefficient on annual SNAP benefits is negative and significant for all groups of households. These patterns continue in the second, third, and fourth rows when increasing sets of observed controls are added.

The bottom panel of Table 5 considers longitudinal models. For the purposes of comparison, we estimate LPMs with standard and economic controls. The first rows report coefficients for LPMs. The associations between food insecurity and annual SNAP benefits are smaller for all groups with the exception of married parent households when compared to LPMs estimated using the cross sectional sample.

Estimates from panel-data random- and fixed-effect LPMs are reported in the second and third rows of the bottom panel of Table 5. Comparisons of these estimates reveal that accounting for unobserved time-invariant household characteristics through the use of fixed effects reduces

the estimated associations between annual SNAP benefits and food insecurity. The coefficients on annual SNAP benefits are negative and insignificant for all household groups except households with all elderly members. Breusch-Pagan and Hausman-Wu tests are reported below the random- and fixed- effect LPMs, respectively. The LPMs are strongly rejected for all household groups by the Breusch-Pagan test in favor of the random-effect LPMs models. In contrast to the participant/non-participant analyses, the Hausman-Wu tests fail to reject the random-effect LPM for all-elderly households. For unmarried parent households, the Hausman-Wu test still fails to reject random-effect LPM; however, the p-value is very close to the 10 percent confidence level. The random-effect LPM is rejected for all other groups.

Sensitivity Analyses. The replication analysis is based on a sample of households with incomes at or below 130 percent of the federal poverty line. However several previous studies estimate models with larger income cut-offs. A concern in these studies is that marginally eligible households will adjust their labor supply to ensure program eligibility, potentially affecting the observed relationship between SNAP and food insecurity. We examined the sensitivity of our findings to the choice of income limits by estimating models with a sample that restricted household income to 185 percent of the federal poverty line. We used the 185 percent of the federal poverty line threshold because it is the income screen used by the CPS-FSS for the food security questions. Models estimated using the 185 percent of the federal poverty line threshold (results not shown) were very similar to those using our primary (130-percent) sample.

Another potential concern is the use of a single binary measure of food insecurity. For the replication analysis we concentrate on a binary measure of food insecurity, which is consistent with most of the previous studies. As DePolt et al. (2009), Gundersen et al. (2011) and others have pointed out, these comparisons cast aside a considerable amount of information. To

examine how the findings are affected by the choice of the food insecurity measure we re-estimated models using the count of affirmed food security questions, which under the assumptions of the measurement model used to determine food security status should be a sufficient statistic of the underlying food security scale. Estimating models with the count of affirmed food security questions generated results that were consistent with our reported findings using the binary food insecurity measure.

The replication analysis uses an annual measure of SNAP benefits to examine the dose response of SNAP on food insecurity. An alternative to the dollar amount of SNAP benefits is the number months of program receipt. We tested the sensitivity of our dose response findings to the choice of dose variable by estimating models with the count of months of SNAP receipt. A comparison of the estimates suggests our findings are robust to the choice of dose variable. All of our sensitivity analyses are available upon request.

Conclusions

It would be hard to overstate the importance of SNAP in the food assistance landscape. It is the largest food assistance program administered by the U.S. Department of Agriculture in terms of expenditures and participation. However, despite recent research that suggests SNAP reduces food insecurity, the evidence taken as a whole is somewhat inconsistent. In an effort to understand the empirical results that have grown up around the question of SNAP's effectiveness on food insecurity, we have examined theory, literature, and empirical evidence that looks at this question and have replicated methods used in previous research.

The main finding of this study is that recent results showing that food assistance reduces food insecurity may not be robust to specification choice or data. As in other research, most of our simple models suggest a higher conditional mean of food security prevalence associated with

SNAP. Moreover, our results for propensity score and longitudinal models mirror those in the empirical literature in showing, quite counterintuitively, that SNAP is associated with increases in food security prevalence. Our 2SLS results are a bit more consistent with recent findings, although the estimated sizes of the effects are statistically insignificant. Similarly, our findings using dummy endogenous approaches yield somewhat inconsistent results, with many of the statistically significant results being for two-parent households with children. We note that most of the results using this method yield parameter estimates with the appropriate sign, even when they are not significant. Our dose-response models are consistent with previous research in that they suggest larger amounts of SNAP benefits are associated with a reduction in the likelihood of food insecurity. Finally, while we did not try to replicate the methods of Gundersen and Kreider (2008) or Kreider et al. (2012), which involve using data and logical assumptions to identify plausible bounds for the effect of food assistance on food insecurity, our results are, broadly speaking within the bounds for their least restrictive models. This is true for models that do take account of measurement error and those that do not.

Taken together, these results suggest some directions for future research. For example, some models that have most consistently found that SNAP reduces food insecurity share an assumption about the functional form of the residuals in selection and outcome processes—bivariate normal. A next step could be to examine similar models while relaxing the bivariate normal assumption, perhaps by use of maximum simulated likelihood methods and factor structures—both discrete and continuous. Additionally, such a consideration should take into account that a full switching regression framework—in which the outcome is estimated separately for each treatment state, but simultaneously with treatment—may yield different

results.[8] In addition, given that the results of our dose-response models are consistent with both the literature and with economic intuition about the effect of SNAP, further exploration into the uses of these methods and the design of surveys to exploit these relationships should be a priority. Nord and Prell (2011) offer a recent example of this kind of work. Finally, to the degree possible, studies using indirect methods and natural experiments should also be encouraged.

[8] This has recently been found by Gregory and Coleman-Jensen (forthcoming), who find that the ATE for SNAP participation is positive in a switching regression framework with bivariate normal errors, but negative in a simple bivariate probit.

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Table 1. Coefficients on SNAP receipt from linear probability models

	All households	HHs with children and unmarried parents	HHs with children and married parents	Households with all elderly members	Other adult-only households
Received SNAP in last year					
LPM with no other controls	0.288***	0.188***	0.237***	0.290***	0.314***
	(0.007)	(0.015)	(0.017)	(0.018)	(0.012)
LPM with standard controls [a]	0.226***	0.184***	0.231***	0.229***	0.256***
	(0.008)	(0.016)	(0.018)	(0.019)	(0.014)
LPM with standard and economic controls [b]	0.207***	0.164***	0.209***	0.215***	0.234***
	(0.008)	(0.016)	(0.019)	(0.019)	(0.014)
LPM with standard, economic, and other assistance controls [c]	0.136***	0.088***	0.116***	0.175***	0.161***
	(0.008)	(0.017)	(0.019)	(0.020)	(0.014)
Received SNAP in last month					
LPM with no other controls	0.256***	0.140***	0.198***	0.272***	0.293***
	(0.007)	(0.015)	(0.018)	(0.019)	(0.013)
LPM with standard controls [a]	0.187***	0.131***	0.188***	0.206***	0.227***
	(0.008)	(0.016)	(0.019)	(0.020)	(0.014)
LPM with standard and economic controls [b]	0.166***	0.108***	0.162***	0.192***	0.204***
	(0.008)	(0.016)	(0.019)	(0.020)	(0.015)
LPM with standard, economic, and other assistance controls [c]	0.095***	0.032*	0.066***	0.152***	0.132***
	(0.009)	(0.016)	(0.020)	(0.020)	(0.014)

Note: LPMs estimated using weighted household data from the 2009-11 CPS-FSS. Robust standard errors appear in parentheses.

[a] Control for household head's gender, age, age squared, race, ethnicity, nativity, marital status, and education; numbers of adults, children, and disabled members in household; age of youngest member (households with children); elderly members; residence in urban area; state unemployment rate; and state and year fixed effects. LPMs for all households also control for household type.

[b] Control for head's employment status, log of household income, home ownership, log of food needs, and indicator for missing food needs.

[c] Control for participation in SBP, NSLP and WIC (households with children) and use of food pantries or soup kitchens.

* Significant at 0.10 level. ** Significant at 0.05 level. *** Significant at 0.01 level.

Table 2. Coefficients on SNAP receipt from simple, LPM, and PSM comparisons

	All households	HHs with children and unmarried parents	HHs with children and married parents	Households with all elderly members	Other adult-only households
Received SNAP in last year					
Bivariate comparison	0.281***	0.186***	0.234***	0.274***	0.300***
	(0.006)	(0.013)	(0.015)	(0.013)	(0.010)
LPM	0.197***	0.165***	0.208***	0.218***	0.227***
	(0.007)	(0.014)	(0.016)	(0.013)	(0.011)
PSM comparison	0.191***	0.169***	0.211***	0.233***	0.228***
	(0.011)	(0.022)	(0.024)	(0.022)	(0.018)
Received SNAP in last month					
Bivariate comparison	0.252***	0.144***	0.199***	0.258***	0.278***
	(0.006)	(0.013)	(0.016)	(0.013)	(0.011)
LPM	0.159***	0.114***	0.166***	0.200***	0.196***
	(0.007)	(0.014)	(0.017)	(0.014)	(0.012)
PSM comparison	0.139***	0.094***	0.166***	0.174***	0.197***
	(0.011)	(0.021)	(0.024)	(0.023)	(0.019)

Note: Estimates from unweighted household data from the 2009-11 CPS-FSS. LP and PSM models control for household head's gender, age, age squared, race, ethnicity, nativity, marital status, education, and employment status; numbers of adults, children, and disabled members in household; age of youngest member (households with children); elderly members; residence in urban area; state unemployment rate; log of household income; home ownership; log of food needs; missing food needs; and state and year fixed effects. Models for all households also control for household type. PSM comparisons use nearest-neighbor matching with replacement. Robust standard errors appear in parentheses.

* Significant at 0.10 level. ** Significant at 0.05 level. *** Significant at 0.01 level.

Table 3. Coefficients and Marginal Effects for SNAP receipt from longitudinal models

	All households	HHs with children and unmarried parents	HHs with children and married parents	Households with all elderly members	Other adult-only households
Received SNAP in last year					
LPM	0.188***	0.149***	0.184***	0.193***	0.214***
	(0.011)	(0.024)	(0.025)	(0.023)	(0.019)
Random effects LPM	0.176***	0.135***	0.178***	0.190***	0.193***
	(0.010)	(0.024)	(0.023)	(0.018)	(0.018)
Breusch-Pagan Test	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Fixed effects LPM	0.114***	0.090***	0.126***	0.168***	0.098***
	(0.016)	(0.034)	(0.039)	(0.031)	(0.029)
Hausman-Wu Test	[0.000]	[0.174]	[0.074]	[0.000]	[0.000]
Logit	0.169***	0.147***	0.174***	0.163***	0.197***
	(0.011)	(0.024)	(0.024)	(0.022)	(0.019)
Fixed effects logit	0.085	0.049	0.196	0.045	0.102
	(0.073)	(0.090)	(0.136)	(0.119)	(0.078)
Received SNAP in last month					
LPM	0.159***	0.098***	0.166***	0.183***	0.182***
	(0.011)	(0.024)	(0.026)	(0.024)	(0.020)
Random effects LPM	0.146***	0.085***	0.155***	0.179***	0.163***
	(0.010)	(0.023)	(0.024)	(0.019)	(0.019)
Breusch-Pagan Test	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Fixed effects LPM	0.082***	0.046	0.085**	0.155***	0.072**
	(0.016)	(0.033)	(0.038)	(0.031)	(0.029)
Hausman-Wu Test	[0.000]	[0.197]	[0.022]	[0.000]	[0.000]
Logit	0.140***	0.095***	0.156***	0.156***	0.164***
	(0.011)	(0.023)	(0.025)	(0.021)	(0.020)
Fixed effects logit	0.051	0.024	0.091	0.025	0.078
	(0.048)	(0.048)	(0.151)	(0.076)	(0.066)

Note: Models estimated using unweighted longitudinally-linked household data from the 2009-11 CPS-FSS and control for household head's gender, age, age squared, race, ethnicity, nativity, marital status, education, and employment status; numbers of adults, children, and disabled members in household; age of youngest member (households with children); elderly members; residence in urban area; state unemployment rate; log of household income; home ownership; log of food needs; missing food needs; and state and year fixed effects. Models for all households also control for household type. Robust standard errors appear in parentheses .P values are in brackets.
* Significant at 0.10 level. ** Significant at 0.05 level. *** Significant at 0.01 level.

Table 4. Coefficients and Marginal Effects for SNAP receipt from LPM, 2SLS, probit, & bivariate probit models

	All households	HHs with children and unmarried parents	HHs with children and married parents	Households with all elderly members	Other adult-only households
Received SNAP in last year					
LPM (exogenous)	0.207***	0.164***	0.209***	0.215***	0.234***
	(0.008)	(0.016)	(0.019)	(0.019)	(0.014)
2SLS—citizenship	-0.169	-0.159	-0.369	0.549	-0.092
& cert. interval instr.	(0.193)	(0.572)	(0.780)	(0.373)	(0.216)
Hausman-Wu Test	[0.039]	[0.557]	[0.418]	[0.372]	[0.557]
2SLS—certification	-0.130	-0.153	-0.576	-0.328	0.204
interval instrument	(0.428)	(0.686)	(0.867)	(6.177)	(0.573)
Hausman-Wu Test	[0.413]	[0.636]	[0.285]	[0.921]	[0.958]
Probit (exogenous)	0.199***	0.164***	0.207***	0.194***	0.227***
	(0.008)	(0.016)	(0.018)	(0.019)	(0.014)
Biprobit—citizenship	-0.142***	0.359	-0.108	-0.032	-0.171**
& cert. interval instr.	(0.055)	(0.271)	(0.207)	(0.071)	(0.074)
Biprobit—certification	-0.165***	0.376	-0.126	-0.068	-0.208***
interval instrument	(0.060)	(0.243)	(0.194)	(0.072)	(0.081)
Biprobit—no	-0.178***	0.420**	-0.139	-0.066	-0.222***
instruments	(0.061)	(0.183)	(0.218)	(0.071)	(0.075)
Received SNAP in last month					
LPM (exogenous)	0.166***	0.108***	0.162***	0.192***	0.204***
	(0.008)	(0.016)	(0.019)	(0.020)	(0.015)
2SLS—citizenship	-0.174	-0.112	-0.331	0.767	-0.102
& cert. interval instr.	(0.197)	(0.396)	(0.734)	(0.570)	(0.240)
Hausman Test	[0.072]	[0.574]	[0.486]	[0.283]	[0.191]
2SLS—certification	-0.124	-0.114	-0.569	-0.152	0.228
interval instrument	(0.405)	(0.507)	(0.818)	(2.690)	(0.643)
Hausman-Wu Test	[0.461]	[0.657]	[0.319]	[0.892]	[0.970]
Probit (exogenous)	0.158***	0.108***	0.160***	0.172***	0.196***
	(0.008)	(0.016)	(0.019)	(0.019)	(0.015)
Biprobit—citizenship	-0.206***	0.126	-0.205	-0.020	-0.148**
& cert. interval instr.	(0.040)	(0.313)	(0.162)	(0.070)	(0.070)

Biprobit—certification interval instrument	-0.228*** (0.039)	0.167 (0.307)	-0.225 (0.144)	-0.035 (0.070)	-0.163** (0.077)
Biprobit—no instruments	-0.238*** (0.037)	0.252 (0.265)	-0.236 (0.155)	-0.032 (0.070)	-0.173** (0.074)

Note: Models estimated using weighted household data from the 2009-11 CPS-FSS and control for household head's gender, age, age squared, race, ethnicity, nativity, marital status, education, and employment status; numbers of adults, children, and disabled members in household; age of youngest member (households with children); elderly members; residence in urban area; state unemployment rate; log of household income; home ownership; log of food needs; missing food needs; and state and year fixed effects. Models for all households also control for household type. Robust standard errors appear in parentheses. P values are in brackets.

* Significant at 0.10 level. ** Significant at 0.05 level. *** Significant at 0.01 level.

Table 5. Coefficients on SNAP Receipt and Annual Benefit Amount from Cross Sectional and Longitudinal Models

	All Households		HHs with children and unmarried parents		HHs with children and married parents		Households with all elderly members		Other adult-only households	
	SNAP Indicator	Annual SNAP Benefit	SNAP Indicator	Annual SNAP Benefit	SNAP Indicator	Annual SNAP Benefit	SNAP Indicator	Annual SNAP Benefit	SNAP Indicator	Annual SNAP Benefit
Cross Sectional Models										
LPM with no other controls	0.351***	-0.024***	0.283***	-0.029***	0.331***	-0.029***	0.345***	-0.045**	0.391***	-0.043***
	(0.011)	(0.004)	(0.023)	(0.006)	(0.029)	(0.008)	(0.029)	(0.020)	(0.019)	(0.009)
LPM with standard controls [a]	0.299***	-0.031***	0.276***	-0.030***	0.319***	-0.027***	0.292***	-0.056***	0.327***	-0.041***
	(0.011)	(0.004)	(0.023)	(0.006)	(0.030)	(0.008)	(0.029)	(0.021)	(0.020)	(0.009)
LPM with standard and economic controls [b]	0.286***	-0.035***	0.264***	-0.035***	0.309***	-0.032***	0.283***	-0.061***	0.312***	-0.045***
	(0.011)	(0.004)	(0.023)	(0.006)	(0.030)	(0.008)	(0.029)	(0.021)	(0.020)	(0.009)
LPM with standard, economic, and other assistance controls [c]	0.222***	-0.041***	0.194***	-0.039***	0.227***	-0.038***	0.235***	-0.052***	0.234***	-0.044***
	(0.011)	(0.004)	(0.023)	(0.006)	(0.030)	(0.008)	(0.029)	(0.020)	(0.020)	(0.009)
Longitudinal Models										
LPM	0.261***	-0.031***	0.245***	-0.029***	0.270***	-0.025**	0.251***	-0.054*	0.284***	-0.039***
	(0.016)	(0.005)	(0.035)	(0.009)	(0.041)	(0.011)	(0.038)	(0.028)	(0.029)	(0.013)
Random effects LPM	0.238***	-0.025***	0.212***	-0.023***	0.249***	-0.020**	0.250***	-0.053***	0.247***	-0.028**
	(0.014)	(0.005)	(0.034)	(0.008)	(0.037)	(0.010)	(0.027)	(0.019)	(0.026)	(0.012)
Breusch-Pagan Test	[0.000]		[0.000]		[0.000]		[0.000]		[0.000]	
Fixed effects LPM	0.152***	-0.012*	0.128***	-0.009	0.173***	-0.012	0.238***	-0.053*	0.115***	-0.003
	(0.021)	(0.007)	(0.046)	(0.011)	(0.052)	(0.014)	(0.044)	(0.030)	(0.039)	(0.017)
Hausman-Wu Test	[0.000]		[0.108]		[0.033]		[0.137]		[0.000]	

Note: Models estimated using weighted household data from the 2009-11 CPS-FSS and control for household head's gender, age, age squared, race, ethnicity, nativity, marital status, education, and employment status; numbers of adults, children, and disabled members in household; age of youngest member (households with children); elderly members; residence in urban area; state unemployment rate; log of household income; home ownership; log of food needs; missing food needs; and state and year fixed effects. Models for all households also control for household type. Robust standard errors appear in parentheses. P values are in brackets.

* Significant at 0.10 level. ** Significant at 0.05 level. *** Significant at 0.01 level.

Appendix A. Questions in the Food Security Module

Questions asked of all households:

1. "We worried whether our food would run out before we got money to buy more." Was that **often, sometimes**, or never true for you in the last 12 months?

2. "The food that we bought just didn't last and we didn't have money to get more." Was that **often, sometimes**, or never true for you in the last 12 months?

3. "We couldn't afford to eat balanced meals." Was that **often, sometimes**, or never true for you in the last 12 months?

4. In the last 12 months, did you or other adults in the household ever cut the size of your meals or skip meals because there wasn't enough money for food? (**Yes**/No)

5. (If yes to question 4) How often did this happen—**almost every month, some months but not every month**, or in only 1 or 2 months?

6. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food? (**Yes**/No)

7. In the last 12 months, were you ever hungry, but didn't eat, because there wasn't enough money for food? (**Yes**/No)

8. In the last 12 months, did you lose weight because there wasn't enough money for food? (**Yes**/No)

9. In the last 12 months did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food? (**Yes**/No)

10. (If yes to question 9) How often did this happen—**almost every month, some months but not every month**, or in only 1 or 2 months?

Questions asked only of households with children under 18 years of age:

11. "We relied on only a few kinds of low-cost food to feed our children because we were running out of money to buy food." Was that **often, sometimes**, or never true for you in the last 12 months?

12. "We couldn't feed our children a balanced meal, because we couldn't afford that." Was that **often, sometimes**, or never true for you in the last 12 months?

13. "The children were not eating enough because we just couldn't afford enough food."

Was that **often, sometimes**, or never true for you in the last 12 months?

14. In the last 12 months, did you ever cut the size of any of the children's meals because there wasn't enough money for food? (**Yes**/No)

15. In the last 12 months, were the children ever hungry but you just couldn't afford more food? (**Yes**/No)

16. In the last 12 months, did any of the children ever skip a meal because there wasn't enough money for food? (**Yes**/No)

17. (If yes to question 16) How often did this happen—**almost every month, some months but not every month**, or in only 1 or 2 months?

18. In the last 12 months did any of the children ever not eat for a whole day because there wasn't enough money for food? (**Yes**/No)

Note: "Affirmative" responses indicated in **bold**.

Definitions of food security status for households with and without children

Food security status	Households with children	Households without children
Food secure	0-2 affirmative responses	0-2 affirmative responses
Low food security	3-7 affirmative responses	3-5 affirmative responses
Very low food security	8-18 affirmative responses	6-10 affirmative responses

Appendix B. Characteristics of analysis households

	Households with children and unmarried parents			Households with children and married parents			Households with all elderly members			Other adult-only households		
	No SNAP last year	Received SNAP last year	Received SNAP last month	No SNAP last year	Received SNAP last year	Received SNAP last month	No SNAP last year	Received SNAP last year	Received SNAP last month	No SNAP last year	Received SNAP last year	Received SNAP last month
Food Insecure	0.347	0.534	0.525	0.287	0.524	0.511	0.135	0.425	0.415	0.270	0.584	0.579
	(0.476)	(0.499)	(0.499)	(0.453)	(0.500)	(0.500)	(0.342)	(0.495)	(0.493)	(0.444)	(0.493)	(0.494)
Real SNAP	0.000	3.153	3.376	0.000	3.020	3.297	0.000	1.119	1.170	0.000	1.593	1.708
Ben. ($000)	(0.000)	(1.753)	(1.670)	(0.000)	(1.841)	(1.767)	(0.000)	(0.880)	(0.880)	(0.000)	(1.183)	(1.181)
Standard explanatory variables												
Female head	0.750	0.858	0.863	0.435	0.469	0.464	0.643	0.706	0.709	0.453	0.567	0.574
	(0.433)	(0.349)	(0.344)	(0.496)	(0.499)	(0.499)	(0.479)	(0.456)	(0.454)	(0.498)	(0.496)	(0.495)
Age	38.597	35.336	35.323	40.767	36.831	37.001	73.407	70.468	70.580	42.668	47.443	47.790
	(12.940)	(11.567)	(11.530)	(11.107)	(10.174)	(10.284)	(8.140)	(7.756)	(7.821)	(15.743)	(13.173)	(12.973)
White	0.663	0.587	0.585	0.796	0.797	0.796	0.815	0.729	0.734	0.735	0.639	0.647
(reference)	(0.473)	(0.492)	(0.493)	(0.403)	(0.403)	(0.403)	(0.388)	(0.445)	(0.442)	(0.441)	(0.480)	(0.478)
Black	0.268	0.359	0.362	0.111	0.127	0.123	0.139	0.225	0.222	0.184	0.304	0.298
	(0.443)	(0.480)	(0.481)	(0.314)	(0.333)	(0.329)	(0.346)	(0.418)	(0.416)	(0.388)	(0.460)	(0.457)
Other	0.069	0.053	0.053	0.093	0.076	0.080	0.046	0.046	0.044	0.081	0.057	0.055
	(0.254)	(0.225)	(0.224)	(0.290)	(0.266)	(0.271)	(0.209)	(0.210)	(0.204)	(0.272)	(0.231)	(0.229)
Hispanic	0.309	0.240	0.236	0.403	0.360	0.344	0.088	0.162	0.157	0.157	0.137	0.141
	(0.462)	(0.427)	(0.425)	(0.491)	(0.480)	(0.475)	(0.283)	(0.368)	(0.364)	(0.363)	(0.344)	(0.348)
Married,	0.000	0.000	0.000	1.000	1.000	1.000	0.238	0.099	0.098	0.207	0.139	0.134
spouse present							(0.426)	(0.298)	(0.298)	(0.405)	(0.346)	(0.340)
< high school	0.265	0.302	0.306	0.316	0.352	0.354	0.352	0.460	0.460	0.192	0.325	0.337
(reference)	(0.441)	(0.459)	(0.461)	(0.465)	(0.478)	(0.479)	(0.478)	(0.499)	(0.499)	(0.394)	(0.468)	(0.473)
Some college	0.651	0.661	0.661	0.562	0.592	0.590	0.555	0.475	0.481	0.642	0.620	0.609
	(0.477)	(0.474)	(0.474)	(0.496)	(0.492)	(0.492)	(0.497)	(0.500)	(0.500)	(0.479)	(0.485)	(0.488)
College	0.084	0.038	0.033	0.122	0.056	0.055	0.093	0.064	0.059	0.166	0.055	0.055
graduate	(0.278)	(0.190)	(0.179)	(0.327)	(0.231)	(0.229)	(0.290)	(0.246)	(0.236)	(0.372)	(0.227)	(0.227)
Immigrant	0.271	0.156	0.146	0.465	0.366	0.355	0.138	0.204	0.196	0.189	0.103	0.106
	(0.445)	(0.363)	(0.354)	(0.499)	(0.482)	(0.479)	(0.345)	(0.403)	(0.397)	(0.391)	(0.303)	(0.308)

No. of adults	1.882	1.639	1.617	2.535	2.432	2.426	1.282	1.160	1.161	1.813	1.688	1.678
in household	(1.087)	(0.890)	(0.870)	(0.918)	(0.838)	(0.842)	(0.467)	(0.410)	(0.415)	(0.974)	(0.881)	(0.875)
No. of children	1.845	2.125	2.133	2.241	2.602	2.637	0.000	0.000	0.000	0.000	0.000	0.000
in household	(1.034)	(1.149)	(1.146)	(1.230)	(1.319)	(1.326)						
No. of disabled	0.124	0.200	0.208	0.127	0.245	0.261	0.138	0.416	0.429	0.235	0.654	0.678
in household	(0.389)	(0.466)	(0.475)	(0.402)	(0.565)	(0.587)	(0.374)	(0.562)	(0.570)	(0.514)	(0.684)	(0.679)
Age youngest	7.250	5.713	5.705	6.208	4.691	4.706						
in household	(5.334)	(4.916)	(4.899)	(4.929)	(4.264)	(4.273)						
Any elderly	0.071	0.041	0.041	0.065	0.034	0.038	1.000	1.000	1.000	0.107	0.104	0.104
in household	(0.257)	(0.199)	(0.199)	(0.246)	(0.181)	(0.191)				(0.310)	(0.305)	(0.306)
Urban	0.828	0.812	0.807	0.821	0.771	0.768	0.739	0.765	0.760	0.817	0.777	0.771
residence	(0.377)	(0.391)	(0.395)	(0.384)	(0.420)	(0.422)	(0.439)	(0.424)	(0.427)	(0.387)	(0.416)	(0.420)
State unemp.	9.427	9.274	9.246	9.583	9.459	9.440	9.278	9.014	8.989	9.364	9.177	9.163
rate	(1.750)	(1.696)	(1.697)	(1.796)	(1.698)	(1.715)	(1.727)	(1.519)	(1.521)	(1.757)	(1.622)	(1.618)
<u>Economic explanatory variables</u>												
Head	0.588	0.421	0.406	0.604	0.445	0.427	0.100	0.043	0.038	0.489	0.212	0.187
employed	(0.492)	(0.494)	(0.491)	(0.489)	(0.497)	(0.495)	(0.301)	(0.204)	(0.192)	(0.500)	(0.409)	(0.390)
Real total HH	1.611	1.215	1.187	2.107	1.782	1.761	0.997	0.896	0.905	1.022	0.909	0.896
inc. ($0000)	(0.869)	(0.810)	(0.805)	(0.965)	(0.931)	(0.936)	(0.373)	(0.329)	(0.322)	(0.584)	(0.519)	(0.514)
Own home	0.341	0.188	0.187	0.533	0.343	0.341	0.624	0.300	0.306	0.365	0.251	0.246
	(0.474)	(0.391)	(0.390)	(0.499)	(0.475)	(0.474)	(0.484)	(0.458)	(0.461)	(0.481)	(0.434)	(0.431)
Real subjective	116.430	139.683	141.283	134.392	152.152	153.790	53.291	62.534	60.721	77.360	90.319	90.299
food needs	(88.146)	(104.475)	(104.762)	(92.598)	(102.766)	(104.168)	(48.859)	(53.454)	(51.295)	(63.508)	(75.075)	(75.285)
Missing food	0.085	0.054	0.053	0.069	0.040	0.038	0.167	0.097	0.099	0.094	0.070	0.065
needs	(0.279)	(0.227)	(0.224)	(0.253)	(0.196)	(0.190)	(0.373)	(0.296)	(0.299)	(0.291)	(0.256)	(0.247)
<u>Other assistance</u>												
SBP last	0.314	0.589	0.598	0.307	0.597	0.612						
month	(0.464)	(0.492)	(0.490)	(0.461)	(0.491)	(0.488)						
NSLP last	0.396	0.698	0.709	0.399	0.723	0.733						
month	(0.489)	(0.459)	(0.454)	(0.490)	(0.448)	(0.443)						
WIC last	0.135	0.303	0.307	0.157	0.366	0.380						
month	(0.342)	(0.460)	(0.461)	(0.364)	(0.482)	(0.486)						
Food bank	0.098	0.264	0.274	0.086	0.250	0.261	0.054	0.265	0.262	0.097	0.369	0.376

last month	(0.297)	(0.441)	(0.446)	(0.281)	(0.433)	(0.439)	(0.226)	(0.441)	(0.440)	(0.295)	(0.483)	(0.484)
Soup kitchen	0.004	0.023	0.025	0.004	0.013	0.014	0.007	0.022	0.021	0.016	0.078	0.079
last month	(0.062)	(0.150)	(0.157)	(0.063)	(0.113)	(0.117)	(0.086)	(0.146)	(0.143)	(0.126)	(0.268)	(0.270)
Instruments												
Non-citizen	0.185	0.104	0.095	0.305	0.274	0.266	0.038	0.036	0.037	0.113	0.037	0.037
	(0.388)	(0.306)	(0.294)	(0.461)	(0.446)	(0.442)	(0.191)	(0.185)	(0.190)	(0.316)	(0.188)	(0.190)
Median state	9.121	9.170	9.233	9.114	9.021	9.094	9.220	9.268	9.256	9.128	9.227	9.292
cert. interval	(2.987)	(2.979)	(2.975)	(2.982)	(2.984)	(2.982)	(2.980)	(2.981)	(2.985)	(2.987)	(2.977)	(2.971)
Observations	2266	3529	3130	2655	1591	1344	4391	1090	1004	6523	2824	2489

Note: Means and standard deviations (in parentheses) estimated using weighted household data from the 2009-11 CPS-FSS.