How Much Does SNAP Reduce Food Insecurity?

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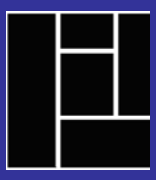

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Abstract

In a country as wealthy and prosperous as the United States, one would think that having enough to eat is not an issue. However, nearly 15 percent of all households and 39 percent of near-poor households were food insecure in 2008. The Supplemental Nutrition Assistance Program (SNAP, formerly called the Food Stamp Program) is the cornerstone of federal food assistance programs and serves as the first line of defense against food-related hardship, such as food insecurity. Using the 1996, 2001, and 2004 Survey of Income and Program Participation (SIPP) panels, this paper measures SNAP's effectiveness in reducing food insecurity using a dummy endogenous variable model with instrumental variables to control for selection bias. Recent changes in state SNAP policies and rules provide exogenous variation, which we use to control for selection into the program. Results from naïve models that do not control for the endogeneity of SNAP receipt show that SNAP receipt is associated with higher food insecurity. However, instrumental variable models that control for the endogeneity of SNAP receipt suggest that SNAP receipt reduces the likelihood of being food insecure by roughly 30 percent and reduces the likelihood of being very food insecure by 20 percent. These findings provide evidence that SNAP is meeting its key goal of reducing food-related hardship.

Keywords: food stamps, SNAP, food insecure, food insufficient, instrumental variables, selection bias

Introduction

In a country as wealthy and prosperous as the United States, one would think that having enough to eat is not an issue. However, nearly 15 percent of all households and 39 percent of near-poor households (below 130 percent of the poverty threshold) were food insecure in 2008 (Nord, Andrews, and Carlson 2009). These numbers are up from 11 percent and 34 percent (respectively) in 2007 and are likely climbing with the current economic downturn marked by double-digit unemployment. Food insecurity has been connected with an array of negative outcomes, including poor health among children, lower academic achievement, and depression (Oberholser and Tuttle 2004).

The Supplemental Nutrition Assistance Program (SNAP, formerly called the Food Stamp Program) is the largest food-assistance program in the United States and is the cornerstone of the federal food-assistance programs. It serves as the first line of defense against hunger (USDA 2007) and is designed to reduce food-related hardship, such as food insecurity. Increasingly, a key policy question is, how effective is SNAP in reducing food insecurity? Understanding the effectiveness of SNAP in meeting its goal is important for SNAP administrators as they make changes to their programs, as states have done to a large degree in recent years.

Identifying the extent to which SNAP reduces food insecurity is complicated by the fact that households that do and do not receive SNAP benefits can differ in systematic ways. Persons in households that are most needy and food insecure are more likely to be eligible for and to take up SNAP benefits, so simple comparisons of food insecurity for those who do and do not receive SNAP benefits are likely to find better outcomes for those who do not receive SNAP benefits. Selection of more needy households into SNAP makes it difficult to identify a causal relationship between SNAP participation and food insecurity.

This paper measures SNAP's effectiveness in reducing food insecurity using a dummy endogenous variable model with instrumental variables to control for selection bias. Recent changes in state SNAP policies and rules provide exogenous variation, which we use to control for selection into the program. The federal government began to give states flexibility to change SNAP policies in the mid- to late-1990s. These changes culminated in the Farm Security and Rural Investment Act of 2002 (the Farm Bill), which provides broader flexibility to states to set SNAP policies (and rules). Additional flexibility has been subsequently provided. This variation

in SNAP policies across states and over time provides the instrumental variables for the analysis. Household level data come from the nationally representative, longitudinal 1996, 2001, and 2004 Survey of Income and Program Participation (SIPP) panels. State-level SNAP data come primarily from the Food Stamp Program State Rules Database.

We examine two measures of food-related hardship. One measure captures whether households are food insecure, while the second captures a higher degree of hardship and identifies households that are very food insecure.[1] Results from models that do not control for the endogeneity of SNAP receipt show that SNAP receipt is associated with higher food insecurity (both measures). This finding is consistent with the self-selection of more needy and food-insecure households into SNAP. However, instrumental variable models that control for the endogeneity of SNAP receipt suggest a different relationship. In these models, the receipt of SNAP benefits is found to reduce the likelihood of being food insecure and very food insecure. These findings provide evidence that SNAP is meeting its key goal of reducing food-related hardship.

Relevant Literature and Contribution

There is a growing body of literature examining SNAP participation and food insecurity. This literature uses a mix of methods and finds a mix of results. A number of studies have found that SNAP participants are more likely than nonparticipants to be food insecure or insufficient (Alaimo et al. 1998; Cohen et al. 1999, Jensen 2002; Ribar and Hamrick 2003; Wilde and Nord 2005).

Other studies have found that SNAP participation has no statistically significant effect on food insecurity or insufficiency (Gibson-Davis and Foster 2006; Gundersen and Oliveira 2001; Huffman and Jensen 2008). These studies acknowledge concerns about selection into SNAP and several take steps to address this selection. For example, Wilde and Nord (2005) use a panel data approach, Gibson-Davis and Foster (2006) use propensity score matching (and caution against it), and Gundersen and Oliveira (2001) use an instrumental variables (IV) approach and simultaneous probit model for SNAP participation and food insufficiency.[2] Gundersen and

[1] The U.S. Department of Agriculture refers to "very food insecure" households as households with "very low food security." We use the terminology very food insecure so that comparisons of the food insecure and very food insecure findings are more straightforward.

[2] For a review of findings by empirical approach see Wilde (2007).

Oliveira, in one of the early studies that address selection, uses a measure of stigma (shop at store where unknown) as the instrument to identify the food-insecurity equation. In their naïve model that does not control for selection, they find that SNAP receipt statistically significantly increases food insufficiency. The coefficient on SNAP receipt remains positive and is larger in their model designed to control for selection, although the large standard error makes the coefficient statistically insignificant at conventional levels.

While numerous studies find no evidence that SNAP reduces food-related hardship, several studies find evidence that SNAP reduces food insecurity or insufficiency (Bartfeld and Dunifon 2006; Borjas 2004; DePolt, Moffitt, and Ribar 2008; Nord and Golla 2009; Yen et al. 2008).[3] These studies examine different populations and use a variety of data and methods.

Bartfeld and Dunifon (2006), Borjas (2004), and Nord and Golla (2009) use the Current Population Survey (CPS) to estimate the relationship between program participation and food insecurity, but the three papers focus on different populations. Borjas focuses on immigrants, Bartfeld and Dunifon examine households with children, and Nord and Golla focus on households shortly before and after beginning to receive SNAP benefits. The analytic approach of these three papers also differs. Bartfeld and Dunifon use hierarchal regression and find that low-income and near-poor families in states with higher SNAP participation rates are less likely to be food insecure. Borjas, on the other hand, uses an IV approach and finds that reductions in immigrants' public assistance participation (cash benefits, SNAP, or Medicaid) leads to increases in immigrants' food insecurity. This IV approach controls for selection into SNAP with an instrument for public assistance participation that captures the generosity of states' immigrant eligibility rules after the 1996 federal welfare reform. Nord and Golla use monthly data to examine household food insecurity before and after SNAP receipt. They find that food insecurity falls by roughly one-third after entry into SNAP.

Yen et al. (2008) and DePolt et al. (2008) use smaller data sets that are not representative of the U.S. population and find results that may be explained in part by their datasets. Yen et al. (2008) use data from the 1996–97 National Food Stamp Program Survey, which is a survey of roughly 2,200 SNAP participants and income-eligible nonparticipants. DePolt et al. use data

[3] Studies have also found that SNAP benefit *amounts* are associated with lower food insecurity among select populations including SNAP participants (Rose, Gundersen, and Oliveira 1998) and households that experienced hunger in the past year (Kabbani and Kmeid 2005).

from the Three-City Study (Boston, Chicago, and San Antonio), which includes roughly 2,500 families with children who had incomes below 200 percent of the federal poverty level at the initial interview (in 1999) and includes two follow-up interviews (in 2000–2001 and 2005).[4] The restriction of these data sets to the low-income population should not be a significant drawback, because low-income households are an appropriate study population and the literature tends to focus on low-income and SNAP-eligible households.

Both of these studies use methods to address the endogeneity of SNAP receipt. Unlike much of the literature, however, the studies find that SNAP participation is associated with lower food hardship in descriptive statistics or models that do not control for the self-selection into SNAP.[5,6] DePolt et al. (2008) explain that this finding could be due to additional control variables in the Three-City Study data that are often not available in other data sets. When DePolt et al. use Chamberlain's quasi-fixed-effect model to control for unobserved family characteristics that may affect both SNAP receipt and food hardship, they find a similar, although generally stronger, negative relationship. Yen et al. (2008) use IV models to control for the endogeneity of SNAP participation and find that SNAP participations lowers the severity of food insecurity.

Our study contributes to the literature on the relationship between SNAP participation and food-related hardship by using the nationally representative SIPP data from the late 1990s to 2005 and taking advantage of recent variation in state SNAP policies to control for selection into SNAP. This analysis shows that state SNAP rules and policies are important determinants of SNAP participation and are strong instrumental variables for estimating the effects of SNAP participation. Our findings provide evidence that SNAP reduces food-related hardship. This research is well-timed, as the USDA and others have considered expensive and difficult-to-implement random-assignment research designs to answer this question (Wilde 2007).

[4] The National Food Stamp Program Survey and Three-City Study data may suffer less from SNAP participation underreporting than national surveys.
[5] Yen et al. (2008) do not present findings from naïve models that do not control for the self-selection into SNAP, but descriptive statistics show less food hardship among SNAP participants than non-SNAP participants.
[6] The primary specification in DePolt et al. (2008) measures SNAP participation as a benefit amount, not a binary indicator of participation.

Conceptual Model

Determinants of Food Insecurity

At the micro level, food insecurity is a function of earned income, public and private transfers, and household composition—each of which is chosen, to some degree, by the household members. Because our primary focus is on the role that SNAP plays in food insecurity, we model food insecurity as a function of SNAP participation and the reduced-form determinants of earned income, public and private transfers, and household composition. The reduced-form determinants and their hypothesized effects are based on human capital theory (Becker 1975) and Becker's (1991) theory of the demand for children. State and year fixed effects and economic variables are included in our empirical model to control for macro-level variables.

Additional children in the household (especially young children) are hypothesized to increase food insecurity through their negative effect on wage labor hours and positive effect on household size. Additional working-age adults in the household are hypothesized to increase household labor supply (and earnings) and decrease food insecurity. However, if these additional adults do not work, then food insecurity can increase with the number of adults. Having a disabled person in the household is hypothesized to decrease labor supply (and earnings) because the individual may be unable (or limited in his or her ability) to work, and because another household member's work hours may be limited by his or her need to care for the disabled individual. Increases in human capital are hypothesized to increase income, and thus, decrease food insecurity. Being young, a minority, a non-citizen, and/or female is hypothesized to lower income through their negative effects on wages, and thus increase food insecurity. Finally, improvements in the state of the economy are hypothesized to increase household income (through their positive effect on wages and the hours household members can choose to work) and reduce food insecurity. These variables provide the reduced-form control variables for our empirical model.

Hypothesized Effect of SNAP Participation on Food Insecurity: SNAP participation can have a direct mechanical effect on household food insecurity, as well as an indirect behavioral effect. These two effects are hypothesized to go in opposite directions. The direct effect is hypothesized to *reduce* household food insecurity, while the indirect effect is hypothesized to *increase* household food insecurity.

SNAP provides direct support to households so that the household can purchase food. Because the program transfers resources to households, we hypothesize that the direct mechanical effect of SNAP participation is to reduce food insecurity. On the other hand, the availability of additional resources to purchase food could lead SNAP-participating households to reduce their labor supply, and thus, earnings. For example, household members might choose to reduce their labor supply in order to receive a larger benefit or become eligible for the program. Ceteris paribus, reduced earnings could lead to reduced food purchases and increased food insecurity. Thus, we hypothesize that the indirect behavioral effect of SNAP participation is to increase food insecurity. Overall, however, we expect the direct effect to dominate the indirect effect, and hypothesize that SNAP participation leads to lower levels of food insecurity.

Determinants of SNAP Participation

Participation in SNAP is affected by demographic and household characteristics and by the rules of the program. These program rules determine whether a family is eligible to participate, as well as the costs and benefits of program participation. Eligibility is a prerequisite for participation in any means-tested program. In some cases, family members can change their behavior to meet eligibility requirements (e.g., reduce earnings below the required threshold), while in other cases this is not possible (e.g., become a nonimmigrant to avoid eligibility restrictions on immigrants). Program rules can also affect the cost (pecuniary and nonpecuniary) of participation. For example, biometric technology (typically fingerprint imaging), which is used by some states to reduce multiple participation fraud, can increase the costs of participation. Program rules that lower the cost of participation are hypothesized to increase program participation, while program rules that increase the cost of participation are hypothesized to decrease program participation.

Instruments for SNAP Participation: Our estimation approach uses state program rules to identify our IV model. A key component of this approach is identifying the instruments—the set of variables that affect SNAP participation, but do not affect food insecurity conditional on participation. Program rules that are strong instruments are those that affect participation, but do not directly lead to different levels of food insecurity across program participants. A potential concern is that these policy changes are endogenous to the processes under investigation. Our model design helps alleviate this problem by including state fixed effects (which control for time-invariant unobservable heterogeneity within states) and year fixed effects (which control for unobservable heterogeneity across years), as well as state-level economic controls.

We identify four SNAP policies that predict SNAP participation but do not independently affect food insecurity. These policies are the use of biometric technology, outreach spending, and partial and full immigrant eligibility. These variables are set at the state level and are not controlled by any given sample member. As discussed above, the use of biometric technology is hypothesized to increase the costs of SNAP participation and thus decrease participation. Higher outreach spending by states is hypothesized to increase participation via an increase in the number of SNAP applicants (due to increased knowledge about SNAP). Finally, more lenient immigrant eligibility rules are hypothesized to increase SNAP participation among immigrants. Each of these policy variables is hypothesized to affect food insecurity only through its effect on SNAP participation. The quality of these instruments in our empirical analysis is discussed below.

Empirical Model

Our empirical model uses an IV approach to control for the endogeneity of SNAP participation. We estimate a bivariate probit model with an endogenous dummy variable, using state SNAP policies as instrumental variables. As discussed in the conceptual model, some SNAP policies are hypothesized to affect food insecurity only through their effect on SNAP participation. The model is identified by these SNAP policies. With this approach, only the effects of SNAP participation that are correlated with these SNAP program rules are included in the causal effect of participation.

We measure the total (direct and indirect) effect of SNAP participation on food insecurity using a dummy endogenous variable model (Heckman 1978) with instrumental variables. Our model consists of two equations: one equation relating food insecurity to SNAP participation and a second reduced-form equation describing SNAP participation as a function of state program rules. The two equations are as follows:

$$Y^{*}_{ist} = \beta \mathrm{SNAP}_{ist} + X_{ist}\gamma_2 + E_{st}\gamma_3 + \mu_s + \tau_t + \varepsilon^{Y}_{ist}$$

$$\text{where } Y_{ist} = 1 \text{ if } Y^{*}_{ist} > 0 \text{ and } Y_{ist} = 0 \text{ otherwise} \qquad (1)$$

$$\mathrm{SNAP}^{*}_{ist} = Z_{st}\delta_1 + X_{ist}\delta_2 + E_{st}\delta_3 + \mu_s + \tau_t + \varepsilon^{S}_{ist}$$

$$\text{where } SNAP_{ist} = 1 \text{ if } SNAP^{*}_{ist} > 0 \text{ and } SNAP_{ist} = 0 \text{ otherwise} \qquad (2)$$

In this model, Y_{ist} is an indicator variable measuring whether household *i* in state *s* at month *t* is food insecure (or very food insecure). $SNAP_{ist}$ is an indicator variable for whether household *i* in state *s* at month *t* participates in SNAP. The coefficient on SNAP participation (β) captures the total effect of participation, including both the direct effect of participation as well as the indirect effect through, for example, changes in labor supply.

The remaining explanatory variables in the equations are drawn from the conceptual framework described above. X_{ist} is a vector of variables controlling for individual-level and household-level characteristics (age, race and ethnicity, noncitizen immigrant, educational attainment, number of children and adults in household, female- and male-headed household, disabled person in household, and metropolitan status).[7] The vector Z_{st} represents the instruments that identify the model and include four specific state SNAP policies (biometric technology, outreach spending per capita, and partial and full immigrant eligibility), as discussed in the conceptual model above.[8] E_{st} is a vector of time-varying variables controlling for economic conditions (monthly state unemployment rate, monthly state employment-population ratio, annual state per capita income, and quarterly gross domestic product [GDP]). Finally, μ_s is the state fixed effect, τ_t is the year fixed effect, and ε_{ist}^{Y} and ε_{ist}^{S} are the error terms. State and year fixed effects are included in all equations to control for state- and year-specific unobservable factors that affect SNAP participation or food insecurity. The state fixed effects control for time-invariant unobservable heterogeneity (differences) across states (e.g., public sentiment toward welfare receipt), while the year fixed effects control for unobservable heterogeneity across years. To account for potential serial correlation in the error term, we cluster our standard errors by state as recommended by Bertrand et al. (2004).

We estimate a bivariate probit model because the dependent variables in equations 1 and 2 are binary—food insecure or very food insecure (yes/no) and SNAP participation (yes/no). We assume the error terms are draws from a bivariate normal distribution with mean zero and variance of one, and estimate the equations simultaneously using a bivariate probit model. The

[7] These characteristics are available monthly except for U.S. citizenship status. U.S. citizenship is available only once in the 1996 and 2001 SIPP panels (topical module 2), but is available monthly in the 2004 SIPP panel.

[8] Biometric technology and partial and full immigrant eligibility rules are available monthly. The outreach spending data are reported annually and quarterly, and these dollars are spread equally over the relevant months. That is, fiscal year outreach dollars are spread equally over months in the fiscal year and quarterly outreach dollars are spread evenly over months in the quarter. To obtain our measure of outreach spending per capita, state outreach spending is divided by the state population below 150 percent of the federal poverty threshold (annual measure) minus the number of state SNAP recipients (monthly measure), which is a measure of the state target outreach population.

correlation coefficient is $\rho = \text{Cov}(\varepsilon_{ist}^{Y}, \varepsilon_{ist}^{S})$. If $\rho \neq 0$, then the error terms are correlated and probit estimation of equation 1 ignoring equation 2 will yield inconsistent estimates of the parameters due to the endogeneity of SNAP participation.[9]

Our reduced-form equation for SNAP participation (equation 2) uses the variation across states and in the timing of state policy changes to identify the model. As described above, states implemented changes to their Supplemental Nutrition Assistance Programs at different times. We use this variation across states and time to identify the effects of program rules on participation.

The ability of our bivariate probit model to correct for the endogeneity of SNAP receipt depends on the explanatory power of the instruments in the SNAP receipt equation (equation 2) and on whether it is appropriate to exclude the instruments from the food-insecurity equation. Our set of instruments (biometric technology, outreach spending, and partial and full immigrant eligibility) has good predictive power in the SNAP receipt equation, indicating that the instruments are strongly correlated with the food insecurity. We also examine the strength of our instruments using the Kleibergen-Papp statistic, which provides evidence that the instrumental variables identify the model; we reject the null hypothesis that the model is underidentified.[10] In addition, we find that the instruments do not independently affect household food insecurity. We test the exogeneity of our instruments using Hansen's J-test and find that we do not reject the null hypothesis that all of the instruments are exogenous.[11] Taken together, these characteristics suggest that the instruments influence food insecurity only through their effect on SNAP participation.

In addition to the bivariate probit model, we estimate a naïve probit model of the effect of SNAP receipt on food insecurity (equation 1). If food-insecure households are more likely to become SNAP participants, the estimated coefficients from this model will be biased. A

[9] As a sensitivity test, we estimate a two-step linear IV model. We find that the marginal effects of SNAP participation (the key variable of interest) from the bivariate and linear models have the same sign and are very similar in magnitude. As expected, the linear IV model produces less efficient estimates than the bivariate probit model.

[10] Our primary specification clusters the standard errors by state, while the Kleibergen-Papp statistics are calculated based on models that cluster the standard errors at the household level. The standard errors from these two sets of models are quite similar and the levels of statistical significance are virtually unchanged across the two models.

[11] These two tests of our instrumental variables are carried out using the linear IV model, since tests to evaluate the quality of instrumental variables are more developed for the linear framework.

comparison of the probit and bivariate probit model results highlights the importance of correcting for this selection.

Study Population

Selection of the study population is an important element of this study, as an inappropriate study population could lead to biased estimates. Because the study focuses on SNAP participation and food insecurity, one might select the study population to include only households eligible for SNAP. Defining the study population this narrowly has a drawback, however. Focusing only on the SNAP-eligible population excludes households that can slightly alter their behavior to become eligible for benefits (i.e., it excludes households at the margin). Ashenfelter (1983), for example, argues that if the elasticity of labor supply does not equal zero, the pool of persons that should be examined as eligible for a program is larger than those who would actually qualify for the program under current income and asset limits. The concern with limiting the sample to the SNAP eligible population is that it results in a sample of households that are disproportionately more likely to alter their behavior to become eligible for SNAP benefits. Carrying out our analysis on a select group of households may produce biased estimates. As a result, we carry out our primary analyses on a more broadly defined study population and then conduct sensitivity tests with a more restricted population.

Our primary study population includes low-income households defined as being below 150 percent of the poverty threshold and having readily available assets of less than or equal to $4,000, or $5,000 if at least one household member is age 60 or older. We also carry out robustness checks on a secondary population that more closely mimics the SNAP-eligible population—households with incomes below 130 percent of the poverty threshold and readily available assets of less than or equal to $2,000, or $3,000 if at least one household member is age 60 or older.[12]

Data

Survey of Income and Program Participation (SIPP): Individual-level data for the analysis come from the 1996, 2001, and 2004 SIPP panels. Each of these SIPP panels contains a nationally

[12] Among other restrictions, households' monthly gross income must be below 130 percent of the federal poverty level to be eligible for SNAP. In addition, households must have no more than $2,000 in countable assets if all household members are under age 60 and no more than $3,000 in countable assets if at least one household member is age 60 or older.

representative (noninstitutional) sample of between 36,000 and 46,000 households whose members are interviewed at four-month intervals (referred to as waves). In addition to collecting monthly data on a host of demographic and economic characteristics, the SIPP includes "topical modules" that ask periodic questions about a variety of topics including material well-being and asset holdings.

A key strength of the SIPP is its monthly data on SNAP participation, income, and household composition. At each interview, data are collected on these and other variables for each of the preceding four months. SNAP benefits are received monthly, not annually, so the monthly SIPP data allow participation to be examined over the same time period that benefits are received. All household-level characteristics identified in the conceptual framework are available in the SIPP.

Variables that measure household food insecurity are created using a series of questions available in the adult well-being topical module. These data are available once in each of the three SIPP panels. Combining the 1996, 2001, and 2004 SIPP panels provides information on whether household are food insecure and very food insecure in three separate years—1998 (April to October), 2003 (February to August), and 2005 (February to August). While the SIPP does not provide this information on a more regular basis (e.g., annually), the SIPP data do provide these food-insecurity measures in years when state SNAP policies were changing and in strong and weak economic times. It is this variation that allows us to identify our empirical model.

Our food-insecurity measures take account of whether households have enough food to eat and whether households are able to afford balanced meals. Five questions in the SIPP topical module are used to generate our two indicators of household food-related hardship:

1. *The food that you bought just didn't last and you didn't have money to get more. Was that [this statement] often, sometimes, or never true for you in the last four months?*
2. *You couldn't afford to eat balanced meals. Was that [this statement] 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?*

These five questions are used in conjunction with the methodology developed by the U.S. Department of Agriculture's Economic Research Service (Nord 2006) to generate our two indicators of food-related hardship.[13] Our first measure identifies households that have low *or* very low food security, while the second is a more severe measure that identifies households that have very low food security.[14] We refer to these levels of food hardship as "food insecure" and "very food insecure," respectively.[15]

These two food-insecurity measures capture households' experiences over the full SIPP wave (i.e., a four-month period), while household characteristics such as SNAP participation, income, and household structure are available each month of the wave. Household characteristics in each month of the wave can influence households' food insecurity, because the outcomes are measured over the four-month period. Thus, households are included in our sample up to four times—once for each month in the wave that food insecurity and food insufficiency are measured.[16]

Potential weaknesses of the SIPP involve concerns about the underreporting of SNAP receipt and attrition bias. Estimates suggest that the SIPP underreports SNAP receipt by 7 percent to 19 percent (Bitler, Currie, and Scholz 2002; Cody and Tuttle 2002). These studies also find that SNAP underreporting is smaller in the SIPP than in the CPS. A recent article by Gundersen and Kreider (2008) suggests that misreported SNAP receipt could explain why earlier studies found no effect of SNAP participation on food-related hardship. While misreporting is an issue in the SIPP, and therefore our analysis, it does not lead us to conclude that SNAP does not affect food insecurity. Adjusting the SIPP data to account for the underreporting might be possible if the root causes of the underreporting were known. However, the source of the underreporting is likely complex and choosing the wrong adjustment strategy could lead to

[13] For more information about the questions and the food insecurity measure, go to http://www.ers.usda.gov/data/FoodSecurity/SIPP/ (accessed December 1, 2009).

[14] Prior to 2006, "low food security" was referred to as "food insecure without hunger" and "very low food security" was referred to as "food insecure with hunger." The new labeling was introduced by USDA based on recommendations from the Committee on National Statistics (CNSTAT), but the content of these measures did not change (Nord 2006).

[15] If respondents do not answer the food insecurity questions, the U.S. Census Bureau imputes values for these households. Our main analysis excludes households with imputed food insecurity or SNAP receipt data. However, we conduct sensitivity tests on the full sample of households (those with and without imputed data) and the model results are very similar (discussed below).

[16] We conduct sensitivity tests to examine whether the results are sensitive to the inclusion of households in multiple months. In models that include households only once per panel, we continue to find that SNAP participation statistically significantly reduces food insecurity (discussed below).

greater biases (Cody and Tuttle 2002, p. 25). Research to investigate the degree of attrition bias measurable in the SIPP suggests that poorer persons are more likely to leave the sample prior to the end of the panel. This analysis uses the SIPP weights to help account for attrition, nonresponse, and a complex sample design.

Among our sample of low-income households, 24.4 percent are food insecure and 10.3 percent are very food insecure (Table 1). Comparisons of these outcomes for households that do and do not participate in SNAP show higher rates of food insecurity among SNAP-recipient households. While 35.6 percent of SNAP-recipient households are food insecure, 19.9 percent of nonparticipating households are food insecure. Similarly, the percent of households that are very food insecure is higher among SNAP-participating than SNAP-nonparticipating households—15.4 percent and 8.3 percent, respectively. The higher rates of food-related hardship among SNAP participants suggest that these households are more needy and are more likely to self-select into SNAP.

SNAP receipt is quite prevalent among low-income households, with roughly one-quarter (28.6 percent) of our sample receiving SNAP benefits. As compared with non-SNAP recipients, SNAP-recipient households tend to be younger, minority, less educated, and female headed, and to have more children and include a disabled member. Food-insecure households have these same tendencies, as compared with households that are food secure. Appendix Table A-1 presents the means of all variables included in the analysis.

Economic Variables: To control for changes in the economy, the SIPP data are supplemented with (1) monthly state unemployment rates, (2) annual state per capita income, (3) the monthly state employment-population ratio, and (4) quarterly gross domestic product from the Bureau of Economic Analysis (2008).

SNAP Rules: Measures of state specific SNAP rules, which are the instrumental variables in the analysis, come largely from USDA's Food Stamp Program State Rules Database.[17] The SNAP rules used in this analysis—biometric technology, outreach spending per capita, and immigrant eligibility—are available in this database. This database only contains data through

[17] For more information about the Food Stamp Program State Rules Database go to: http://www.ers.usda.gov/Briefing/FoodNutritionAssistance/data/#fsdatabase (accessed December 1, 2009).

December 2004, so we used additional documents provided to us by the USDA to update these variables through 2005.

Results

Food Insecure: The naïve probit model results, which do not control for the endogeneity of SNAP receipt, show that SNAP receipt is associated with higher food insecurity. The estimated coefficient on SNAP participation suggests that participating in SNAP is associated with an 8.6 percentage point increase in the probability of being food insecure (Table 2, model 1). This result is consistent with the self-selection of more needy and food-insecure households into SNAP.

Results from the bivariate probit model, which controls for the endogeneity of SNAP receipt, suggest a different relationship. The receipt of SNAP benefits is found to reduce the likelihood of food insecurity by 16.2 percentage points (Table 2, model 2).[18] Nearly one-quarter of our low-income sample is food insecure, so these results suggest that SNAP has a substantial effect on households' food insecurity and is achieving exactly what the program was designed to do—reduce food-related hardship. To further put this number in context, we use the marginal effect along with the SNAP recipients' level of food insecurity to estimate the percent (versus percentage point) decline in food insecurity implied by our model. Our summary statistics show that 35.6 percent of SNAP recipients are food insecure. The bivariate probit model estimates suggest that SNAP recipients' food insecurity would be 16.2 percentage points higher (51.8 percent), if SNAP benefits were not available. The decrease in the likelihood of food insecurity from 0.518 without the SNAP program to 0.356 with the program suggests that SNAP receipt reduces food insecurity by 31.2 percent. The magnitude of this decline is consistent with Nord and Golla (2009), who find that the likelihood of being very food insecure falls by roughly one-third when households begin receiving SNAP benefits.

A comparison of the SNAP receipt coefficients from the probit and bivariate probit models suggests that controlling for selection into SNAP is important for disentangling the effect of SNAP receipt on food insecurity. The model that does not control for the endogeneity of

[18] The marginal effects are calculated as the average difference in the predicted probability of being food insecure for those with and without SNAP receipt. The calculations are based on the estimated parameters from the bivariate probit food insecurity equation (equation 1), which have been corrected for the endogeneity of SNAP receipt. Estimation of the univariate probablities is appropriate because our goal is to understand how SNAP receipt affects food insecurity, not the joint probabilities. We estimate the marginal effects using the Stata marginal effects command, mfx, with the option predict(pmarg1).

SNAP receipt shows that SNAP participation is associated with increased food insecurity, while the model that does control for the endogeneity shows that SNAP participation reduces food insecurity. Further, the correlation coefficient from the bivariate probit model indicates a positive and statistically significant correlation between unobservables that affect SNAP receipt and food insecurity (ρ=0.509 with a standard error of 0.054). Households that are more likely to be food insecure are also more likely to participate in SNAP.

As discussed above, the validity of our IV model depends on the quality of the instruments. Because our model is overidentified, we are able to test the exogeneity of the instruments. Using Hansen's J-test, we conclude that the instruments are indeed exogenous (we do not reject the null hypothesis that all of the instruments are exogenous, p=0.89). Using the Kleibergen-Papp statistic, we test whether the instrumental variables identify the model and reject the null hypothesis that the model is underidentified (p=0.0002). Each of the four instruments has the anticipated sign and statistically significantly ($p<0.1$) affects SNAP receipt (Table 3), and a joint test for significance of the four instruments indicates that they are jointly statistically significant at the one percent level ($\chi^2(4)=15.8$, p=0.003). The coefficients and standard errors of the instruments from the reduced-form SNAP participation equation are presented in Table 3 (column 1).

Many household demographic characteristics are important determinants of food insecurity (Table 3, column 2). Households headed by younger persons are more likely to be food insecure, as are households headed by minorities and persons with limited education. Households with more children are also more likely to be food insecure. Female-headed and male-headed households are more likely than two-adults-headed households to be food insecure. Finally, having a disabled person in the household is associated with a higher likelihood of food insecurity. The state unemployment rate and employment-population ratio do not affect food insecurity, although a stronger economy as measured by quarterly GDP is found to reduce food insecurity.

Very Food Insecure: Findings from our analysis of the relationship between SNAP participation and the likelihood of being very food insecure show a similar pattern. The model that does not control for selection into SNAP finds a positive, statistically significant relationship between SNAP receipt and being very food insecure, while the model that does control for selection finds that SNAP receipt statistically significantly reduces the likelihood of being very

food insecure (Table 2, models 3 and 4). Fewer households are very food insecure than food insecure (10.3 percent versus 24.4 percent, respectively), and the magnitudes of the estimated coefficients are consistent with this lower prevalence. The bivariate probit model results suggest that SNAP benefit receipt reduces the likelihood of being very food secure by 3.9 percentage points. Translating this percentage point decline into a percent decline (as done above for food insecurity), we find that SNAP reduces the likelihood of being very food insecure by 20.2 percent. This is lower than the roughly 30 percent decline found for food insecurity, although is still substantial.

Like our analysis of food insecurity, the correlation coefficient indicates a positive and statistically significant relationship between unobservables that affect SNAP receipt and being very food insecure (ρ=0.284 with a standard error of 0.035). Also, we again find that Hansen's J-test suggests that all of the instruments are exogenous (p=0.53) and the Kleibergen-Papp statistic leads us to reject the null hypothesis that the model is underidentified (p=0.0002). Each of the four instruments has the anticipated sign and statistically significantly (p<0.1) affects SNAP receipt, and a joint test for significance of the four instruments indicates that they are jointly statistically significant at the 1 percent level ($\chi^2(4)$=14.9, p=0.005). Appendix Table A-2 presents the full set of coefficients from this model.

Additional Specifications: As discussed above, we estimate our model on somewhat different samples to test the sensitivity of our results. First, we examine households with incomes below 130 percent of the poverty threshold, which more closely mimics the SNAP eligibility criteria. Analyses based on this more disadvantaged population show very similar results. The naïve models that do not control for selection into SNAP find a positive relationship between SNAP receipt and food insecurity, while models that control for selection find that SNAP receipt reduces food insecurity (Table 4). The bivariate probit results suggest that SNAP receipt reduces the likelihood of being food insecure by 12.8 percentage points and reduces the likelihood of being very food insecure by 3.4 percentage points. These percentage point declines translate into declines of 27.8 percent and 18.2 percent, respectively. These declines are very similar to what was found for the broader population of households with incomes below 150 percent of the poverty threshold.

We also examine whether our findings are sensitive to having each household in the study sample for up to four months, by estimating the model on a sample that includes each

household only once. Results from the bivariate probit model (estimated with this smaller sample) suggest that SNAP receipt statistically significantly (at the 1 percent level) reduces the likelihood of being food insecure by 16.0 percentage points and the likelihood of being very food insecure by 3.9 percentage points (not shown). These estimated effects are nearly identical to those presented in Table 3 (16.2 and 3.9 percentage points, respectively). We also estimate models on a sample that includes households that have imputed food-insecurity or SNAP-receipt data, and again find very similar results. In this case, the bivariate probit model results suggest that SNAP receipt statistically significantly (at the 1 percent level) reduces the likelihood of being food insecure by 16.0 percentage points and being very food insecure by 4.1 percentage points (not shown).

In addition to testing sensitivity to different study populations, we examine another measure of food-related hardship—food insufficiency—which has also been examined in the literature. Food insufficiency captures a relatively severe level of food hardship and is more similar to our very-food-insecure than to our food-insecure measure. Food-insufficient households are those that report sometimes or often not having enough to eat. Food insufficiency is not our primary outcome, because USDA official statistics report on food insecurity, not food insufficiency. Among our sample of households with incomes below 150 percent of the poverty threshold, 6.9 percent are food insufficient (compared with 10.3 percent that are very food insecure). Results from the bivariate probit model suggest that SNAP participation statistically significantly (at the 1 percent level) reduces food insufficiency by 2.7 percentage points, or by 19.4 percent. This is nearly identical to our finding that SNAP reduces the likelihood of being very food insecure by 20.2 percent.

Discussion and Conclusion

Using nationally representative data from the late 1990s and early- to mid-2000s and instrumental variables models, this study provides evidence that SNAP reduces households' food-related hardships. We find that SNAP participation reduces the likelihood of being food insecure, very food insecure, and food insufficient. How much does SNAP reduce food-related hardship? The results suggest that the effect of the program is sizable. Results from our primary specification suggest that participation in SNAP reduces the likelihood of being food insecure by 16.2 percentage points (31.2 percent) and reduces the likelihood of being very food insecure by 3.9 percentage points (20.2 percent). Results from our specification tests show similar declines.

Further, we find that SNAP receipt reduces food insufficiency by about 20 percent. These estimated effects are substantial and provide evidence that SNAP is meeting its key goal of reducing food-related hardship.

Given inherent difficulties in identifying causal effects where individuals self-select into programs (such as SNAP), the conclusions of any single analysis cannot be taken as definitive. This study contributes recent, nationally representative findings from models designed to control for self-selection to a growing body of literature that finds SNAP reduces food insecurity. For example, this study provides results consistent with Nord and Golla's recent study (2009) using CPS data, which finds that food insecurity falls by roughly one-third after entry into SNAP. Our results are also consistent with analyses by DePolt et al. (2008) and Yen et al. (2008) that find SNAP reduces food hardship using data from the National Food Stamp Program Survey and the Three-City Study, respectively.

In the current economic downturn, it is important for policymakers and program administrators to understand the effectiveness of their programs so they can better serve low-income households and those experiencing food-related hardship. The results of this study suggest that program administrators can improve the well-being of households by increasing their enrollment in SNAP. Prior research suggests that this can be accomplished by making SNAP program rules more lenient, for example, and by expanding outreach (e.g., Bartlett, Burstein, and Hamilton 2004; Ratcliffe, McKernan, and Finegold 2008; Yen et al. 2008; Ziliak, Gundersen, and Figlio 2003). In addition, easing SNAP rules is a cost-efficient way for states to increase SNAP participation and improve the well-being of residents, as the federal government pays roughly half of the programs' administrative costs and the full cost of benefits. States, however, should weigh concerns about program fraud and abuse and federal resources in deciding whether and which SNAP policies to ease.

References

Alaimo, K., R.R. Briefel, E.A. Frongillo, Jr., et al. 1998. "Food Insufficiency Exists in the United States: Results from the Third National Health and Nutrition Examination Survey (NHANES-III)." *American Journal of Public Health* 88(3): 419–26.

Ashenfelter, Orley. 1983. "Determining Participation in Income Tested Social Programs." *Journal of the American Statistical Association* 78(383): 517–25.

Bartfeld, Judi, and Rachel Dunifon. 2006. "State-Level Predictors of Food Insecurity among Households with Children." *Journal of Policy Analysis and Management* 25(4): 921–42.

Bartlett, Susan, Nancy Burstein, and William Hamilton. 2004. "Food Stamp Program Access Study: Final Report." Report to the USDA, Economic Research Service (E-FAN-03-013-3). Cambridge, MA: Abt Associates.

Becker, Gary S. 1975. *Human Capital*. New York: Columbia University Press.

———. 1991. *A Treatise on the Family*. Cambridge, MA: Harvard University Press.

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan. 2004. "How Much Should We Trust Differences-in-Differences Estimates?" Quarterly Journal of Economics, 119, no. 1: 249-75.

Bitler, Marianne, Janet Currie, and John Karl Scholz. 2002. "WIC Eligibility and Participation." Discussion Paper No. 1255-02. University of Wisconsin–Madison, Institute for Research on Poverty.

Borjas, George J. 2004. "Food Insecurity and Public Assistance." *Journal of Public Economics* 88(7-8): 1421–43.

Bureau of Economic Analysis, National Economic Accounts. 2008. "Current-Dollar and 'Real' Gross Domestic Product." http://bea.gov/national/xls/gdplev.xls. Accessed October 31, 2008.

Cody, Scott, and Christina Tuttle. 2002. "The Impact of Income Underreporting in CPS and SIPP on Microsimulation Models and Participating Rates." Memorandum No. 8659-013 (July 24). Washington, DC: Mathematica Policy Research.

Cohen, B., J. Ohls, M. Andrews, et al. 1999. *Food Stamp Participants' Food Security and Nutrient Availability: Final Report*. Princeton, NJ: Mathematica Policy Research.

DePolt, Richard A., Robert A. Moffitt, and David C. Ribar. 2008. "Food Stamps, TANF, and Food Hardships in Three American Cities." Washington, DC: USDA, Economic Research Service.

Gibson-Davis, Christina, and E. Michael Foster. 2006. "A Cautionary Tale: Using Propensity Scores to Estimate the Effect of Food Stamps on Food Insecurity." *Social Service Review* 80(1): 93–126.

Gundersen, Craig, and Brent Kreider. 2008. "Food Stamps and Food Insecurity: What Can Be Learned in the Presence of Nonclassical Measurement Error?" *Journal of Human Resources* 43(2): 352–82.

Gundersen, Craig, and Victor Oliveira. 2001. "The Food Stamp Program and Food Insufficiency." *American Journal of Agricultural Economics* 83(4): 875–87.

Heckman, James J. 1978. "Dummy Endogenous Variables in a Simultaneous Equations System." *Econometrica* 46: 931–60.

Huffman, Sonya Kostova, and Helen H. Jensen. 2008. "Food Assistance Programs and Outcomes in the Context of Welfare Reform." *Social Science Quarterly* 89(1): 95–115.

Jensen, Helen H. 2002. "Food Insecurity and the Food Stamp Program." *American Journal of Agricultural Economics* 84(5): 1215–28.

Kabbani, N.S.,and M.Y. Kmeid. 2005. "The Role of Food Assistance in Helping Food Insecure Households Escape Hunger." *Rev. Agr. Econ.* 27: 439–45.

Nord, Mark. 2006. "Survey of Income and Program Participation 2001 Wave 8 Food Security Data File Technical Documentation and User Notes." Washington, DC: USDA, Economic Research Service. http://www.ers.usda.gov/data/FoodSecurity/SIPP/sipp2001w8fs.pdf.

Nord, Mark, and Anne Marie Golla. 2009. "Does SNAP Decrease Food Insecurity? Untangling the Self-Selection Effect. Washington, DC: USDA, Economic Research Service, Economic Research Report Number 85, October.

Nord, Mark, Margaret Andrews, and Steven Carlson. 2009. "Household Food Security in the United States, 2008." Economic Research Report No. 83. Washington, DC: USDA, Economic Research Service.

Oberholser, Cheryl A., and Cynthia Reeves Tuttle. 2004. "Assessment of Household Food Security among Food Stamp Recipient Families in Maryland." *American Journal of Public Health* 94(5): 790–95.

Ratcliffe, Caroline, Signe-Mary McKernan, and Kenneth Finegold. 2008. "Effect of Food Stamp and TANF Policies on Food Stamp Participation." *Social Service Review* 82(2): June.

Ribar, David C., and Karen S. Hamrick. 2003. *Dynamics of Poverty and Food Sufficiency*. Food and Nutrition Research Report No. 36. Washington, DC: USDA, Economic Research Service,.

Rose, D., C. Gundersen, and V. Oliveira. 1998. "Socio-economic Determinants of Food Insecurity in the United States: Evidence from the SIPP and CSFII Data Sets." Tech. Bull. No. 1869. Washington, DC: U.S. Department of Agriculture.

U.S. Department of Agriculture (USDA). 2007. "Food Stamp Program." http://www.fns.usda.gov/fsp/. Washington, DC: USDA. Accessed May 17, 2007.

Wilde, Parke. 2007. "Measuring the Effect of Food Stamps on Food Insecurity and Hunger: Research and Policy Considerations." *Journal of Nutrition* 137: 307–10.

Wilde, Parke, and Mark Nord. 2005. "The Effect of Food Stamps on Food Security: A Panel Data Approach." *Review of Agricultural Economics* 27(3): 425–32.

Yen, Steven T., Margaret Andrews, Zhuo Chen, and David B. Eastwood. 2008. "Food Stamp Program Participation and Food Insecurity: An Instrumental Variables Approach." *American Journal of Agricultural Economics* 90(1): 117–32.

Ziliak, James P., Craig Gundersen, and David N. Figlio. 2003. "Food Stamp Caseloads over the Business Cycle." *Southern Economic Journal* 69(4): 903–19.

Table 1: Low-Income Households' Food-Related Hardship and Supplemental Nutrition Assistance Program (SNAP) Participation, Households with Income below 150% of Poverty Threshold[1]

Variable	All Households	SNAP Participants	SNAP Nonparticipants
Food Insecure	24.4%	35.6%	19.9%
Very Food Insecure	10.3%	15.4%	8.3%
SNAP Receipt	28.6%	100%	0.0%
Number of Observations	65,269	20,197	45,072

[1] Sample includes households with income below 150% of the poverty threshold who have liquid assets below $4,000, or below $5,000 if one member of the household is age 60 or older.

Note: All percentages are weighted.

Table 2: Estimates of the Effects of SNAP Participation on the Likelihood of Being Food Insecure and Very Food Insecure, Households with Income below 150% of Poverty Threshold[1]

Explanatory Variable	Food Insecure				Very Food Insecure			
	Probit (1)		Bivariate Probit (IV) (2)		Probit (3)		Bivariate Probit (IV) (4)	
	Coeff/SE	*Marginal Effect*	*Coeff/SE*	*Marginal Effect*	*Coeff/SE*	*Marginal Effect*	*Coeff/SE*	*Marginal Effect*
SNAP Receipt	0.275 ***	0.086	-0.582 ***	-0.162	0.208 ***	0.034	-0.268 ***	-0.039
	(0.028)		(0.091)		(0.033)		(0.062)	
Rho			0.509 ***				0.284 ***	
			(0.054)				(0.035)	
Number of Observations	65,269		65,269		65,269		65,269	

[1] Sample includes householdes with income below 150% of the poverty threshold who have liquid assets below $4,000, or below $5,000 if one member of the household is age 60 or older.

Notes: The unit of observation is a household-month. Robust standard errors are presented within parentheses. Standard errors are adjusted for clustering by state. All models include controls for age, age squared, noncitizen immigrant, black, Hispanic, other non-white race, no high school degree, high school degree only, number of children in household, number of adults in household, female-headed household, male-headed household, disabled person in household, and metropolitan area; state unemployment rate, state employment-population ratio, state per capita income, and gross domestic product; and state and year fixed effects. Instrumental variables are biometric technology, outreach spending per capita, and immigrant eligibility rules (i.e., all legal immigrants eligible interacted with noncitizen and some legal immigrants eligible interacted with noncitizen). *** p<0.01, ** p<0.05, * p<0.1

Table 3: Bivariate Probit (IV) Estimates of the Effects of SNAP Participation on the Likelihood of Being Food Insecure, Households with Income below 150% of Poverty Threshold[1]

Explanatory Variable	SNAP Participation	Food Insecure
SNAP participation		-0.582***
		(0.091)
Instruments-State Food Stamp Rules[2]		
Biometric technology	-0.269***	
	(0.095)	
Outreach spending per capita	0.402*	
	(0.228)	
All legal immigrants eligible X noncitizen immigrant	0.370**	
	(0.201)	
Some legal immigrants eligible X noncitizen immigrant	0.312*	
	(0.180)	
Demographic Characteristics		
Age	-0.016***	0.021***
	(0.004)	(0.005)
Age squared	0.000**	-0.000***
	(0.000)	(0.000)
Noncitizen immigrant	-0.414**	-0.015
	(0.173)	(0.055)
Race/Ethnicity (Omitted: White, non-Hispanic)		
Black, non-Hispanic	0.383***	0.290***
	(0.028)	(0.033)
Hispanic	0.214*	0.220***
	(0.120)	(0.074)
Other, non-Hispanic	0.294***	0.144**
	(0.078)	(0.072)
Educational Attainment (Omitted: More than high school)		
Less than high school	0.462***	0.282***
	(0.037)	(0.030)
High school only	0.223***	0.115***
	(0.031)	(0.025)
Number of children in household	0.264***	0.088***
	(0.015)	(0.014)
Number of adults in household	-0.045**	0.008
	(0.015)	(0.021)

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Table 3: Bivariate Probit (IV) Estimates of the Effects of SNAP Participation on the Likelihood of Being Food Insecure, Households with Income below 150% of Poverty Threshold[1], continued

Variable	SNAP Participation	Food Insecure
Household Structure (Omitted: Two adult-headed household)		
Female-headed household	0.666***	0.410***
	(0.029)	(0.046)
Male-headed household	0.240***	0.296***
	(0.042)	(0.033)
Disabled person in household	0.793***	0.614***
	(0.036)	(0.032)
Metropolitan area	-0.093**	0.029
	(0.037)	(0.037)
Economic Characteristics		
State monthly unemployment	-0.078	-0.012
	(0.219)	(0.207)
State monthly employment-population ratio	-6.398	-10.76
	(22.07)	(20.15)
State annual per capita income (in $100s)	-0.001	0.003
	(0.002)	(0.002)
Quarterly GDP (in trillions)	-0.069	-0.236**
	(0.095)	(0.096)
Year		
1998	-0.460**	-0.338*
	(0.181)	(0.186)
2003	-0.249***	-0.332***
	(0.080)	(0.096)
Constant	6.584	10.54
	(22.339)	(20.12)
Rho	0.509***	
	(0.054)	
Number of Observations	65,269	

[1] Sample includes householdes with income below 150% of the poverty threshold who have liquid assets below $4,000, or below $5,000 if one member of the household is age 60 or older.

[2] A joint test for significance of the four instruments indicates that they are jointly statistically significant at the one percent level ($\chi^2(4)=15.8$, p=0.003).

Notes: The unit of observation is a household-month. Robust standard errors are presented within parentheses. Standard errors are adjusted for clustering by state. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Estimates of the Effects of SNAP Participation on the Likelihood of Being Food Insecure and Very Food Insecure, Households with Income below 130% of Poverty Threshold[1]

Explanatory Variable	Food Insecure				Very Food Insecure			
	Probit (1)		Bivariate Probit (IV) (2)		Probit (3)		Bivariate Probit (IV) (4)	
	Coeff/SE	*Marginal Effect*	*Coeff/SE*	*Marginal Effect*	*Coeff/SE*	*Marginal Effect*	*Coeff/SE*	*Marginal Effect*
SNAP Receipt	0.251 ***	0.081	-0.424 ***	-0.128	0.157 ***	0.027	-0.211 ***	-0.034
	(0.026)		(0.109)		(0.033)		(0.073)	
Rho			0.403 ***				0.221 ***	
			(0.065)				(0.040)	
Number of Observations	52,029		52,029		52,029		52,029	

[1] Sample includes householdes with income below 130% of the poverty threshold who have liquid assets below $2,000, or below $3,000 if one member of the household is age 60 or older.

Notes: The unit of observation is a household-month. Robust standard errors are presented within parentheses. Standard errors are adjusted for clustering by state. All models include controls for age, age squared, noncitizen immigrant, black, Hispanic, other non-white race, no high school degree, high school degree only, number of children in household, number of adults in household, female-headed household, male-headed household, disabled person in household, and metropolitan area; state unemployment rate, state employment-population ratio, state per capita income, and gross domestic product; state and year fixed effects. Instrumental variables are biometric technology, outreach spending per capita, and immigrant eligibility rules (i.e., all legal immigrants eligible interacted with noncitizen and some legal immigrants eligible interacted with noncitizen). *** p<0.01, ** p<0.05, * p<0.1

Appendix Table A-1: Descriptive Statistics,
Households with Income below 150% of Poverty Threshold[1]

Variable	Mean	Standard Deviation
Program Participation and Food-Related Hardship		
SNAP Receipt	0.286	
Food Insecure	0.244	
Very Food Insecure	0.103	
Demographic Characteristics		
Age	47.982	18.547
Noncitizen immigrant	0.112	
White, non-Hispanic (omitted)	0.537	
Black, non-Hispanic	0.231	
Hispanic	0.189	
Other, non-Hispanic	0.043	
Education less than high school	0.271	
Education high school only	0.354	
Education more than high school (omitted)	0.375	
Number of children in household	1.010	1.385
Number of adults in household	1.544	0.747
Female-headed household	0.518	
Male-headed household	0.198	
Two adult-headed household (omitted)	0.284	
Disabled person in household	0.294	
Metropolitan area	0.747	
Economic Variables		
State monthly unemployment	5.290	1.040
State monthly employment-population ratio	0.947	0.010
State annual per capita income	29,361	4,058
Quarterly GDP (in billions)	10,275	730
Instruments		
Biometric technology	0.257	
Outreach spending per capita	0.024	0.083
All legal immigrants eligible X noncitizen immigrant	0.026	
Some legal immigrants eligible X noncitizen immigrant	0.078	
Number of Observations	65,269	

[1] Sample includes householdes with income below 150% of the poverty threshold who have liquid assets below $4,000, or below $5,000 if one member of the household is age 60 or older.

Appendix Table A-2:

Bivariate Probit (IV) Estimates of the Effects of SNAP Participation on the Likelihood of Being Very Food Insecure, Households with Income below 150% of Poverty Threshold[1]

Explanatory Variable	SNAP Participation	Very Food Insecure
SNAP participation		-0.268***
		(0.062)
Instruments-State Food Stamp Rules[2]		
Biometric technology	-0.261**	
	(0.108)	
Outreach spending per capita	0.384*	
	(0.223)	
All legal immigrants eligible X noncitizen immigrant	0.418**	
	(0.179)	
Some legal immigrants eligible X noncitizen immigrant	0.365**	
	(0.174)	
Demographic Characteristics		
Age	-0.015***	0.031***
	(0.004)	(0.005)
Age squared	0.000**	-0.000***
	(0.000)	(0.000)
Noncitizen immigrant	-0.462***	-0.009
	(0.168)	(0.055)
Race/Ethnicity (Omitted: White, non-Hispanic)		
Black, non-Hispanic	0.380***	0.132***
	(0.028)	(0.043)
Hispanic	0.209*	0.045
	(0.121)	(0.053)
Other, non-Hispanic	0.292***	0.198*
	(0.080)	(0.118)
Educational Attainment (Omitted: More than high school)		
Less than high school	0.461***	0.109**
	(0.038)	(0.045)
High school only	0.221***	0.015
	(0.031)	(0.035)
Number of children in household	0.266***	0.038**
	(0.015)	(0.017)

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Appendix Table A-2
Bivariate Probit (IV) Estimates of the Effects of SNAP Participation on the Likelihood of Being Very Food Insecure, Households with Income below 150% of Poverty Threshold[1], continued

Variable	SNAP Participation	Very Food Insecure
Number of adults in household	-0.045***	-0.044*
	(0.015)	(0.027)
Household Structure (Omitted: Two adult-headed household)		
Female-headed household	0.665***	0.367***
	(0.030)	(0.047)
Male-headed household	0.237***	0.276***
	(0.043)	(0.051)
Disabled person in household	0.791***	0.528***
	(0.036)	(0.038)
Metropolitan area	-0.092**	0.032
	(0.037)	(0.043)
Economic Characteristics		
State monthly unemployment	-0.074	0.112
	(0.216)	(0.253)
State employment-population ratio	-5.883	1.395
	(21.78)	(25.40)
State per capita income (in $100s)	-0.001	0.001
	(0.002)	(0.003)
Quarterly GDP (in trillions)	-0.073	-0.015
	(0.093)	(0.171)
Year Fixed Effects		
1998	-0.470***	-0.028
	(0.178)	(0.308)
2003	-0.255***	-0.206
	(0.078)	(0.143)
Constant	6.197	-3.859
	(20.02)	(26.17)
Rho	0.284***	
	(0.035)	
Number of Observations	65,269	

[1] Sample includes householdes with income below 150% of poverty threshold who have liquid assets below $4,000, or below $5,000 if one member of the household is age 60 or older.

[2] A joint test for significance of the four instruments indicates that they are jointly statistically significant at the one percent level ($\chi^2(4)=14.9$, p=0.005).

Notes: The unit of observation is a household-month. Robust standard errors are presented within parentheses. Standard errors are adjusted for clustering by state. *** p<0.01, ** p<0.05, * p<0.1