The Purchasing-Power Constant Effect of SNAP Benefits for Food Insecurity

Abstract:

We estimate the marginal effect of a per-person SNAP dollar on food insecurity and find that each additional dollar decreases food insecurity by about .9 percent. By including food prices, we control for differences in the purchasing power of benefits. We find that households in high price areas are more likely to be food insecure because SNAP benefits have less purchasing power in these areas.

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1. Introduction

This research investigates whether an additional Supplemental Nutrition Assistance Program (SNAP, formerly known as the Food Stamp program) dollar per person, reduces food insecurity. SNAP provides benefits to qualifying households for purchasing food. Some have suggested that SNAP benefits may be less effective in some areas because of geographic differences in food prices (Leibtag, 2007; Nord and Hopwood, 2007). We include food prices in our analysis to control for these differences. We find that holding food prices constant, an additional SNAP dollar per capita reduces the probability of food insecurity by nearly 1 percent. Furthermore, we find that food prices do not in and of themselves contribute to higher food insecurity. Instead, higher food prices decrease the purchasing power of SNAP benefits, reducing food security.

Food insecure households are more likely to be SNAP participants. Previous research has investigated SNAP's ability to improve food security. Jensen (2002) notes that there is likely a positive correlation between a household's SNAP-participation decision and their food-insecurity status. Using full-information maximum likelihood, she jointly estimates limited-dependent variable equations and finds that expected SNAP benefits reduce the probability of food insecurity. Jensen must estimate "expected SNAP benefits" because her data source, the CPS-FSS, did not capture actual SNAP benefits in the 2000 survey.[1] Gunderson and Oliveira (2001) estimate two equations for SNAP participation and food security using simultaneous probit, but are unable to identify a statistically significant link between the two. Wilde and Nord (2002) exploit the longitudinal nature of the CPS-FSS to control for unobserved household heterogeneity. But, again they are unable to identify a statistically significant causal relationship between SNAP and food insecurity.

Recent research uses instrumental variables to identify SNAP participation effects. Food insecurity status and food stamp participation are separate limited dependent-variable equations.

[1] Jensen did not include food prices in her analysis.

Heterogeneity in participation rules across states exogenously shifts the participation equation allowing the identification of the participation effect in the food insecurity equation (Yen, et al. 2008; Ratcliffe and McKernan, 2010). Another approach uses state-level errors in payments as instruments for benefits (Myzkerezi and Mills, 2010). These studies find a negative relationship between SNAP participation and food insecurity.

This research follows a similar approach, but differs in two ways. First, we use a natural experiment to identify a causal link between SNAP benefits and food insecurity. Recent legislation increased the maximum amount of SNAP benefits and we use this exogenous increase to identify the causal effect of increased SNAP benefits for food insecurity. While recent research finds support for the notion that SNAP participation reduces food insecurity, all prior research has not always found a negative link. This research will contribute to the body of knowledge concerning the efficacy of the program. Second, this research differs in that we identify the marginal effect of an additional SNAP dollar on the probability that a household is food insecure controlling for geographic differences in the purchasing power of SNAP benefits.

2. SNAP and the American Recovery and Reinvestment Act (ARRA)

Food stamp eligibility is determined by a household's income and resources, while the per-person benefit is determined by household income and deductions for certain expenses. Eligibility guidelines require gross monthly income to be equal or less than 130 percent of the poverty level, and net income after allowable expense deductions must be at or below the poverty line. Resource guidelines require households to have assets equal to $2,000 or less, while households with elderly or disabled members may have assets equal to $3,250.[2] And, some persons are typically ineligible for food stamps regardless of income and resources, including undocumented immigrants, persons on

[2] These are 2012 limits, which are adjusted for inflation. Limits in 2008 and 2009 would have been lower.

strike, and some legal immigrants in the US for less than five years. In addition, childless unemployed adults are typically limited to three months of benefits.

Maximum household benefits increase at a decreasing rate with household-size. Households with zero net-income receive the maximum benefit, while benefits are reduced from the maximum by 30 cents for each dollar of net-income. Gross income is reduced by deductions for living expenses, including a standard deduction, and deductions for medical, dependent care, child support, and shelter expenses to arrive at net income.

The American Recovery and Reinvestment Act of 2009 (ARRA) affected federal food assistance in three primary areas. The ARRA expanded SNAP eligibility to jobless households with no children and increased maximum food benefits by 13.6 percent. The ARRA also provided additional funds to states for program administration. The ARRA allotted $500 million to the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) with $400 million devoted to an anticipated increase in demand for services. The ARRA provided $150 million for local agencies to support food banks, soup kitchens, and food pantries. The Act also provided funds to the National School Lunch Program (NSLP) and food distribution programs on Indian Reservations. But the funds, $100 million to the NSLP and $5 million to Indian Reservations, were designated for purchase of equipment and facility upgrades and are unlikely to have an impact of food security.

Beginning in April 2009, the ARRA temporarily increased the maximum SNAP benefit by 13.6 percent. Originally, the benefit increase was set to expire when the regular rate of benefit inflation overtook it, but legislation in 2010 instead terminates the increase in November 2013. The Act also eliminated the three month limit on benefits for childless unemployed adults.

The ARRA may affect food insecurity through two avenues. SNAP participation is likely to increase because of expanded eligibility standards. But, SNAP participation might also increase because of expanded food benefits. Prior to the Act some households may have chosen not to participate, even though they were eligible, because the benefit from participating did not exceed the perceived, perhaps psychic cost, of participating in SNAP. After the Act, the enhanced benefits likely changed the cost-benefit calculation for some households leading them to participate (Nord and Prell, 2011).

3. Conceptual Model

Households receive utility from food (F) and other goods (OG). Households may receive some of their food through SNAP benefits. Let S denote food items bought with SNAP benefits and let f denote food items bought with cash, and so F=f+S. Households may receive disutility from the cost and perhaps stigma of using SNAP benefits denoted D(S). The household's problem is:

$$(1) \qquad Max\ U(F, OG) - D(S)\ s.t.\ I = p_{OG}OG + p_f(F - S)$$

The household's optimization problem results in their demand for SNAP foods, $S = S(p_f, p_g, I) \geq 0$, food, $f = f(p_f, p_{OG}, I)$, and other goods, $OG = OG(p_f, p_{OG}, I)$.

Given an appropriate functional form for household utility, e.g., as in a Linear Expenditure System, it is possible to rewrite demand functions as expenditures that are linear functions of prices and income. In this paper we are interested in the interaction of SNAP benefits and food insecurity and so focus on estimating SNAP demand, and assuming expenditures are linear in prices and income write it as

$$(2) \qquad p_f S_i = \alpha_o + \beta_{f1} p_{fi} + \beta_{OG} p_{OG,i} + \beta_I I_i + \boldsymbol{x_{1i}\beta_1} + \varepsilon_i,$$

where $p_f S$ is the per capita amount of SNAP benefits received by a household, $\boldsymbol{x_{1i}}$ is a vector of demand shift variables, and the β_j are parameters to estimate.

Each household has some minimal level of food required to meet their needs, F_{min}. If $F = S(p_f, p_{OG}, I) + f(p_f, p_{OG}, I) \geq F_{min}$ then the household is food secure. If $F = S(p_f, p_g, I) + f(p_f, p_{OG}, I) < F_{min}$ then the household is food insecure.

We are also interested in the effect of SNAP benefits for food security. Let $F_i^* = F_i - F_{min} = \alpha + \boldsymbol{x_{2i}}\boldsymbol{\beta_2} + \beta_S p_f S_i + \beta_{f2} p_{fi} + e_i$, but F_i^* is unobserved. Instead, we observe $FI_i=0$ if $F_i^*>0$ and $F_i \geq F_{min}$. Alternatively, $FI_i=1$ if $F_i^*<0$ and $F_i<F_{min}$. The equation for food security is

(3) $$FI_i = \alpha + \boldsymbol{x_{2i}}\boldsymbol{\beta_2} + \beta_S p_f S_i + \beta_{f2} p_{fi} + e_i,$$

$\boldsymbol{x_{2i}}$ is a vector of exogenous variables affecting food security, and the β_j are parameters to estimate.

Note that FI does not enter on the right hand side of equation (2). Households get utility from food and optimally choose F=f+S. Food insecurity is a consequence of the inability to purchase sufficient food, even though income may be subsidized with SNAP benefits; food insecurity is not a determinant of SNAP demand. Maximizing utility implies the household will demand a positive amount of SNAP foods so that $\frac{\partial U}{\partial S} = \frac{\partial U}{\partial f} - \frac{\partial D}{\partial S}$. If the disutility from SNAP is too large, the household may optimize at a negative amount of SNAP food. But since SNAP food is bounded at zero, SNAP food demand is determined by the corner solution, S=0 in that case.[3]

Equations (2) and (3) form the basis for estimation. In principle, equation (3) could be estimated in isolation, but previous studies have established that food insecure households are more likely to be SNAP recipients and so SNAP benefits are likely to be endogenous in that $E[e|p_f S] \neq 0$.

We investigate two methods to consistently estimate the parameters in equations 2 and 3. First, we assume (ε_i, e_i) has a mean-zero bivariate normal distribution and estimate equation 3 with a Probit model taking account of the endogeneity of SNAP benefits. The log likelihood for observation i is

(4) $$lnL_i = FI_i ln\Phi(m_i) + (1 - FI_i)\ln[1 - \Phi(m_i)] + ln\phi\left(\frac{p_f S_i - (\alpha_o + \beta_{f1} p_{fi} + \beta_{OG} p_{OG,i} + \beta_I I_i + \boldsymbol{x_{1i}}\boldsymbol{\beta_1})}{\sigma}\right) - ln\sigma$$

where $m_i = \frac{\alpha + \boldsymbol{x_{2i}}\boldsymbol{\beta_2} + \beta_S p_f S_i + \beta_{f2} p_{fi} + \rho(p_f S_i - (\alpha_o + \beta_{f1} p_{fi} + \beta_{OG} p_{OG,i} + \beta_I I_i + \boldsymbol{x_{1i}}\boldsymbol{\beta_1})}{(1-\rho^2)^{1/2}}$,

[3] We prefer a modeling concept that does not treat food insecurity as a determinant of demand. Some studies include food insecurity as a determinant of the probability of SNAP participation (e.g., Gunderson and Oliveira, 2001). The counterpart in our approach would be to include food insecurity as a demand determinant of SNAP. But, unless food insecurity enters the household's utility function or budget constraint, it cannot have a role as a demand determinant.

ρ is the correlation between ε_i and e_i, and Φ and ϕ are the standard normal distribution and density.

This is the so-called Instrumental Variable-Probit estimator (IV-Probit) and can be estimated using maximum likelihood (ML). ML estimation requires an untestable distributional assumption, and the method does not address censored at zero, SNAP benefits. To check robustness, we estimate equations 2 and 3 as a system using generalized method of moments (GMM), and account for non-negative SNAP benefits by estimating equation 2 as an exponential regression as suggested by Silva and Tenreyro (2006). Both ML and GMM give consistent estimates and we expect similar marginal effects, but ML is asymptotically more efficient.

Both methods require there to be at least one exogenous variable in $\boldsymbol{x_1}$ that is not included in $\boldsymbol{x_2}$ to identify β_S in equation (3). In other words, there must be a variable that affects food insecurity only through its effect on SNAP benefits. The ARRA exogenously increased SNAP benefits starting in April 2009. We define a binary variable that takes a value of 1(ARRA) after the Acts implementation and include it as a regressor in equation 3.

The effect of food prices can directly impact food security, through β_{f2}, but also indirectly through their effect on SNAP benefits, β_S. So, $\frac{\partial FI}{\partial p_f} = \beta_S * \beta_{f1} + \beta_{f2}$. We suspect higher food prices to cause higher food insecurity and for the direct effect, β_{f2},to be positive. We expect SNAP benefits to decrease food insecurity and for β_S to be negative.

The sign for β_{f1} is ambiguous; $\beta_{f1} = \frac{\partial (p_f S)}{\partial p_f} = S(1 + \varepsilon^S)$, where $\varepsilon^S = \frac{\partial S}{\partial p_f}\frac{p_f}{S}$. If $\varepsilon^S$is less than negative 1, then $\beta_{f1} < 0$, otherwise $\beta_{f1} \geq 0$. $\varepsilon^S$is a quasi-demand elasticity of SNAP foods and captures the propensity of households to utilize SNAP foods given changes in prices.

4. Data

The Current Population Survey – Food Security Supplement (CPS-FSS) supplies data for household characteristics including household food-security. Data for food prices comes from two separate sources. A first food-price source is compiled by members of the Council for Community and Economic Research (CCER) that are used to create the CCER Cost of Living Index. The second food price source comes from the Quarterly-Food-at-Home Database compiled by the Economic Research Service of USDA.

4.1 **Current Population Survey – Food Security Supplement (CPS-FSS)**

We use observations from the CPS-FSS from 2008 and 2009. The benefit of using this survey is that it includes household information, including whether the household received SNAP benefits and whether the household is food secure. Importantly the survey also includes geographic indicators that can be used to match household data with price data.

In general, households in the CPS are interviewed each month for four consecutive months, then ignored for eight months, then interviewed for the same four months the following year. The FSS of the CPS is conducted in December of each year. Each household is identified by a unique number so there is a subset of CPS households that is interviewed in December 2008 that is again interviewed in December 2009. We use the unique household indicator to identify these households and include only them in the analysis. The ARRA took effect in April of 2009, so its effect for SNAP benefits will be fully implemented by December of that year.

The survey asks a number of detailed questions that are combined into a single overall measure of household food security called the household's food security scale. The scale is a continuous variable that measures the severity of a household's food insecurity and hunger. The scale provides a more thorough way of capturing the complex factors inherent when measuring food security. It is useful to summarize the continuous scale into discrete measure of food security for research purposes. In the CPS-FSS households are categorized as food secure, moderately food secure, low food secure, and very-low food secure.

In this article, we use the survey's "Detailed Food Security Status, 30-Day Recall" to define a household's food security status. The 30-day recall is based on a subset of questions to the questions that are asked to develop the 12-month recall scale. The 30-day recall questions are used to determine whether the household experienced food insecurity during the last 30-days, while the 12-month recall are to determine food insecurity during the last 12-months. We use the 30-day recall because households are asked the amount of SNAP benefit they received in the previous month.

4.2 CCER Food Prices

The Council for Community and Economic Research, CCER (formerly known as the American Chamber of Commerce Research Association, ACCRA), produces a "Cost of Living Index to provide a useful and reasonably accurate measure to compare cost of living differences among urban areas."[4] The approach used in the Cost of Living Index is to divide consumer expenditures into categories, and then select individual items that represent those categories. The items used in the Cost of Living Index thus are surrogates for entire categories of consumer spending.

The Cost of Living Index consists of six major categories: grocery items, housing, utilities, transportation, health care, and miscellaneous goods and services. Prices for each of the surrogates are collected by volunteers that the organization deems reliable. Prices recorded are meant to represent prices paid by a "mid-management" household.

The CCER price data are collected from approximately 300 metropolitan areas in the US. Each urban area is identified by its Core Based Statistical Area code (CBSA). Some households in the CPS-FSS also include a CBSA identifier and we are able to match 5,318 CPS-FSS households in 135 urban areas with CCER price data for 2008 and 2009 providing a total of 10,636 observations.

4.3 Quarterly Food at Home Price Database

[4]We the acronym CCER rather than the more familiar ACCRA acronym to avoid confusion with the acronym we use for the American Recovery and Reinvestment Act, ARRA.

The Quarterly Food-at-Home Price Database (QFAHD) is constructed by the Economic Research Service (ERS) of USDA using Nielsen Homescan data. The Homescan data are from a household panel's purchases of grocery items from a variety of store types. Purchases are of both UPC coded items and random weight products. Households register to become panel members and those chosen receive a hand-held scanner to record their purchases. Households receive a set amount of points for recording their purchases that can be redeemed for merchandise.

Using these data, ERS estimates household-level quarterly prices for 54 food groups that correspond with the 2005 Dietary Guidelines for Americans. Prices are in dollars per 100 grams of food as purchased by consumers, and take into account premiums for processing and convenience.

We use prices in the QFAHPD to construct an index of the cost of the thrifty-food-plan for a family of four, a male adult, a female adult, a child age 6 to 8 and a child age 9 to 11. We calculated the cost of the family thrift-food-plan for each household in the CPS-FSS that is located in a MSA that coincides with the market groups in the QFAHD. We then find the average annual cost of the family thrifty-food-plan, and then divide each household's food-plan cost by the annual average. A household with the average thrifty-food-plan cost would have an index value of 1.

QFAHD price estimates are available for 26 metropolitan areas called market groups. We matched QFAHD observations with CPS-FSS households by assigning each household's CBSA to the appropriate market group. If a household's CBSA could not be matched with a market group, it was eliminated from the data set.

4.4 Summary Statistics

Definitions of variables are given in Table 1, and Tables 2 and 3 include summary statistics for two samples of the data. The first, in table 2, are for households in the CPS-FSS in 2008 and 2009 that we was able to match with the CCER grocery price index. There are 10,636 observations from 5,318 households in this sample. The second, in table 3, are for households in the CPS-FSS in 2008 and 2009 that we were able to match with a thrifty food plan index using prices from the QFAHD. There are 21,342 observations from 10,671 households in this sample.

It is interesting to consider temporal changes in key variables. In both samples, food insecurity (in the 30 days prior to the survey) declined between 2008 and 2009. Using the CCER data, 7.85 percent of households were food insecure in 2008 compared to 7.19 percent in 2009. The QFAHD data show that 7.1 percent of households were food insecure in 2008, but 6.89 percent were food insecure in 2009. The decline in food insecurity is somewhat puzzling in that economic conditions worsened between 2008 and 2009. In these data, average household income declined from $68,800 to $65,770 in CCER data, and from $74,331to 71,225 in the QFAHD data. Similarly, the proportion of households with an unemployed head increased in both samples from 4.11 to 5.16 percent in the QFAHD data, and from 4.12 to 5.11 percent in the CCER data. However, the improvement in food security might be partially explained by the increase in SNAP benefits. Per capita SNAP benefits increased from $4.53 to $5.88 in the CCER sample and from $4.13 to $5.48 in the QFAHD sample. Conditioning on SNAP participation, SNAP benefits per capita increased from $78.82 to $86.89 in the CCER data, and from $77.64 to $89.06 in the QFAHD data.

These changes in mean values hint at the econometric results to come. Although economic conditions worsened for households in the data, food security was not adversely affected. Increases in household SNAP benefits seem to compensate for household's worsening financial situation.

5. Empirical Results

Results from estimating IV-Probit models are in tables 4 through 7. Results in table 4 are for the first-stage SNAP benefits equation (2) using four subsamples of households when the CCER grocery index is available. Results in table 5 are for the reduced-form SNAP benefits equation, equation (2), using three subsamples of households when the thrift-food-plan (TFP) cost index is available. Results in tables 6 and 7 are for the Probit model of food insecurity, equation (3), using the same samples.[5]

5.1 Maximum Likelihood IV-Probit Results

The first sample in all tables includes all households that we were able to match with price data. The second sub-sample includes households that are below 185 percent of the poverty level in either 2008 or 2009. The third sub-sample includes households that are below 185 percent of the poverty in 2008 or 2009, and that never participated in WIC, and that did not visit a food pantry in the 30 days prior to the survey, either in 2008 or 2009. The final sub-sample includes only households that were not below 185 percent of the poverty level in 2008, but were below 185 percent of the poverty level in 2009; these households also were never WIC participants nor did they visit a food pantry.

It appears ARRA is a valid instrument in that there is a strong partial correlation between ARRA and per capita SNAP benefits in the first stage regressions in tables 4 and 5. Results indicate the ARRA increased per capita SNAP benefits about $1.39 when all households are combined, and approximately $3.00 for households that were below 185% of the poverty level in 2008 or 2009, on average, conditioned on the other explanatory variables.

The second condition for a valid instrument is that ARRA is uncorrelated with the error term in equation 3. Presumably, there are unobservable factors that affect food security, but that are not controlled in estimation. As long as these unobservable factors are uncorrelated with the included observables and the ARRA instrument, then coefficients are consistent. But, ARRA is essentially a time dummy and if unobservable factors changed between 2008 and 2009, then ARRA would be correlated with equation 3's error term; ARRA would be endogenous, and the estimated coefficients would be inconsistent. This is not a testable hypothesis given the model is just identified.

[5] Standard errors in all models are corrected for arbitrary correlation within household with cluster robust standard errors.

However, general economic conditions worsened between 2008 and 2009. Real GDP declined about .10% between quarter 4 2008 and quarter 4 2009, which should have increased the likelihood that a household would be food insecure. Indeed, food insecurity increased from 14.6 percent of the population in 2008 to 14.7 percent in 2009 (Nord et. al, 2009, and Nord, Andrews and Carlson, 2009). And as mentioned, incomes and unemployment deteriorated for households in our sample. So, the unobservable factors are likely to have adversely affected food security, thus working in the opposite direction of per capita SNAP benefits. If our results are biased, they should be biased toward a finding of no SNAP effect.

We check for evidence of inconsistent estimates caused by endogenous ARRA by restricting the sample to households that saw their financial conditions worsen in 2009. In the final column of tables 4 and 5, we show results from estimating the model including only households that were not below 185 percent of the poverty level in 2008, but were below that level in 2009. Restricting the sample this way dramatically reduces the number of observations and perhaps not surprisingly few coefficients are statistically significant; although in many instances the sign and magnitude agree with estimates from the other samples. But, ARRA appears to be a relevant instrument because it is statistically significant.

The price-index coefficients are negative, and statistically significant in many cases.[6] A negative coefficient suggests household demand for foods bought with SNAP benefits is elastic. Households in areas with high food prices purchase fewer SNAP foods, and the proportionate decrease in quantity purchased is larger than the proportionate increase in prices, and so total SNAP spending declines.

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[6] The average price index is 1.00. As an example, the coefficient in the first column of table 4 indicates that a doubling of prices is associated with a $12.296 decrease in SNAP benefits per household member.

This is an interesting finding, but it is difficult to fully understand given the current evidence. It might be that the stigma from using SNAP benefits is higher in high price areas. If high food prices reflect a higher cost of living in general (as in a high income area), households might be hesitant to participate in SNAP fearing judgment from their neighbors. On the other hand, it seems likely that food prices affect a household's food spending in general, and SNAP benefits are a portion of overall expenditures. If so, then to fully understand the effect of food prices, it is necessary to simultaneously examine their effect on SNAP benefits, and other out-of-pocket spending. Such an examination is not possible with the current data set.

The results in tables 6 and 7 are the marginal effects of an IV-Probit estimation of equation 3. In all 4 columns of each table the marginal effect of SNAP per capita is statistically significant and negative. In the first results column in table 6 the marginal effect of an additional per capita SNAP dollar suggests a reduction in the probability of being food insecure of .9 percent. SNAP participants received an average monthly benefit of $78.83 in 2008 and yet 36.39% were food insecure. In 2009, the average benefit increased to $86.89, but the proportion of food secure declined to 31.75%. The .9 percent marginal effect predicts the eight dollar increase in average SNAP benefit decreased the proportion of food insecure households by 7.20 percent.

The following two columns in table 6 suggest a slightly smaller negative effect. The second column of results finds a negative effect of about .5 percent. The sample here includes households that were below 185 percent of the poverty level in 2008 or 2009. The third results column suggests a negative .6 percent effect when the sample is restricted to households below 185 percent of the poverty level and that did not receive WIC and that did not visit a food pantry. Because the ARRA may have improved access to WIC and food pantries for some low-income households, the effect of SNAP benefits may be overstated in the first two results columns. But the estimates are nearly identical in the second and third results columns, so it seems unlikely that ARRA is a poor instrument capturing the effect of increased WIC participation and food pantry usage. The smaller effects in the second and third results column might result from a larger proportion of low-income households being SNAP recipients in 2008 and 2009. In the larger sample, a larger proportion of households only became SNAP recipients in 2009 (ARRA increased SNAP participation (Nord and Prell, 2011). The marginal increase in SNAP benefits is likely larger in this sample because it includes more households participating in SNAP for the first time.

The final robustness check is in the last column of table 6. The sample is restricted to households that were above 185 percent of the poverty line in 2008, but below it in 2009. Households were also eliminated if they participated in WIC, or used a food pantry. The goal is to eliminate the possibility that unobservable factors that affect food insecurity changed between 2008 and 2009 in a way that would overstate the effect of SNAP benefits. Even when the sample is restricted to households whose food security is most likely to worsen between 2008 and 2009, SNAP benefits are estimated to have a mitigating effect as the marginal effect is negative and statistically significant. The marginal effect in the last column is negative 1.2 percent, larger in absolute value that any of the previously mentioned.

Although it is likely that differing food prices affect the purchasing power of SNAP benefits, it is difficult to find data sources for geographically discriminated food prices. Even when available, it is questionable how well the prices in the data sets represent the food prices customers actually pay. Our solution is to check whether our results are sensitive to choice of food-price data. In table 7 we show results from estimating the model when food prices are taken from the QFAHD.

The strategy to determine samples is the same in table 7 as in table 6. We are able to match more households with price data, but the price index has less geographic variation. None-the-less, table 7 results are similar to those in table 6. The marginal effect of per-capita SNAP benefits is a negative .6 percent for the largest sample, which is smaller than the corresponding estimate in table 6, but within its 95 percent confidence interval. Effects in the next two columns are smaller in absolute value, but statistically significant. The SNAP benefit marginal effect in the final column is a negative 1.3 percent, again very similar to the corresponding column in table 6.

Other estimates in tables 4 and 5 are consistent with theory and other SNAP studies. Interesting results include that even controlling for income, a household with an unemployed head received more SNAP benefits. Benefits increase with household size, and increase at a decreasing rate with age.

5.1 GMM Estimation

Econometricians are currently debating the merits of various limited-dependent variable models. Angrist and Pishke (2009) voice the argument that linear regression models do well at estimating marginal effects of independent variables and since most studies are primarily interested in marginal effects, linear models are sufficient. In this argument, non-linear models are unnecessarily complex, and their consistency is dependent on choosing the correct nonlinear model, which is not testable since the correct model is unknown. On the other hand, some researchers contend that nonlinear models should not be so easily dismissed. As an example, the linear probability model is biased and likely inconsistent unless the predicted values from the true linear model are within the unit interval (Horrace and Oaxaca, 2006).

Our approach uses a nonlinear IV-Probit estimator. But, this approach may be criticized for the reasons mentioned and because the IV Probit model is appropriate only for continuous endogenous regressors. SNAP per capita is continuous but with an overwhelming majority of zero observations. Some readers may be concerned that it is censored at zero (although it is accurately described as a corner solution). Given these concerns we check the robustness of our IV-Probit results by estimating equations 2 and 3 with system GMM. Equation 3, the binary food insecurity equation, is estimated as a linear relationship (e.g., a linear probability model). But because SNAP per capita is bounded at zero we estimate equation 3 as an exponential regression,

(4) $$p_f S_i = e^{(\alpha_o + \beta_{f1} p_{fi} + \beta_{OG} p_{OG,i} + \beta_I I_i + \boldsymbol{x_{1i}} \boldsymbol{\beta_1} + \varepsilon_i)},$$

so that predicted SNAP benefits are also bounded at zero.

We contend that maximum likelihood, while not without concerns, is an efficient estimator. In contrast, linear probability models (LPM) with endogenous regressors are consistent, but not as efficient. Our strategy is to present results from system GMM as a robustness check to our maximum likelihood estimates. Both maximum likelihood and system GMM are consistent with appropriate instruments, and assuming the correct distribution in ML. Therefore, we expect marginal effects to be similar no matter the estimation method. However, maximum likelihood should provide more efficient standard errors.

Tables 8 shows the equation 4 coefficients when equations 2 and 4 are estimated with system GMM using the CCER data. Coefficients in the exponential regression can be interpreted as semi-elasticities since $\ln(p_f S_i) = \alpha_o + \beta_{f1} p_{fi} + \beta_{OG} p_{OG,i} + \beta_I I_i + \boldsymbol{x_{1i}} \boldsymbol{\beta_1} + \varepsilon_i$ and for example, $\frac{\partial \ln(p_f S_i)}{\partial I} = \beta_I$.

The ARRA dummy is a relevant instrument and suggests that SNAP per capita increased 20.4 to 32.3 percent when using the first three sub-samples, 189 percent with using the fourth subsample. Table 9 includes the corresponding results using the QFADH data. The ARRA dummy coefficients are similar to those in table 8, with the exception of the results for the fourth sub-sample.

Tables 10 and 11 show the counterpart system GMM estimates to the IV-Probit estimates in tables 6 and 7. The system GMM estimates are very similar to the IV-Probit estimates. Again, the estimates in the fourth subsample diverge, but this is likely attributed to the small sample size. The system GMM results are usually less efficient than the IV-Probit results, but that is expected since IV-Probit maximum likelihood is the more efficient estimator.

Overall, the system GMM estimates support our conclusions based on the IV-Probit estimates. Increases in per capita SNAP benefits decrease food insecurity. We prefer the ML estimates in tables 6 and 7 because they are consistent and efficient, given correct specification of the data generating distribution. Estimates in tables 10 and 11 are also consistent, but not as efficient. Our concern is that assuming an inappropriate distribution may lead to biased and/or inconsistent ML estimates. Comparing corresponding estimates quells these concerns. For example, in table 6 the marginal effect of a $1 increase in SNAP per capita is -.9 percent, with a 95 percent confidence interval ranging from -.3 to -1.5. We conclude, with a 5 percent chance of a type 1 error, the true marginal effect is in that range. The corresponding marginal effect in table 10 from the GMM estimate is -.7 percent, which is within the 95 percent confidence interval for the IV-Probit estimate. This relationship holds true for each of the IV-Probit estimates and their corresponding system GMM estimate.

5.2 The Effect of Food Prices for Food Insecurity

It's interesting to note that the food price-index coefficient is not statistically significant in any of the food insecurity equations estimated. But, food prices are negatively related to SNAP per capita in many of the benefit equations. Thus, these results suggest that higher food prices affect food insecurity through the purchasing power of SNAP benefits.

Table 12 shows the effects of food prices on food insecurity as $\frac{\partial FI}{\partial p_f} = \beta_S {*} \beta_{f1}$, where β_S is the appropriate marginal effect from estimating equation 3. Estimates in table 12 can be interpreted as elasticities; and, for example, the IV-Probit estimate from the large CCER sample suggests a 1 percent increase in food prices increases food insecurity .116 percent.

We experimented by including a general cost of living index in the CCER models. The CCER calculates a composite index from all recorded prices that is meant to measure overall geographic purchasing power variation. When included, the composite index dominated the grocery price index in that the composite coefficient was negative and significant in the benefits equation, but the grocery index was not. The grocery index and composite index are highly correlated and we speculate there is insufficient information to uniquely identify separate coefficients. We chose to include the grocery index because it seems most appropriate when examining food purchases and food insecurity. But, the food price index coefficient is likely best interpreted as a general cost of living effect.

We are somewhat surprised that the price index is not significant in the food insecurity equation. If a higher cost of living decreases the purchasing power of SNAP benefits, then we expect it would also affect a household's ability to purchase other food. If so, then a higher cost of living should be associated with more food insecurity independent of its effect through SNAP benefits.

Because we do not observe a direct effect of cost of living on food insecurity, we speculate that households in high cost areas substitute away from other goods toward food. That is, food purchases may be more price insensitive than other goods. If so, a complete model of household purchases is necessary to better understand household allocation decisions. The current data do not allow for this type of examination and we leave it for future research.

Conclusion

We believe the results build a convincing case that additional SNAP spending decreases food insecurity and confirm earlier studies (e.g., Mykerezi, Elton and Bradford Mills, 2010; Ratcliffe, and McKernan 2010; Yen et al, 2008). Our approach differs from previous studies in that we model food insecurity as a function of SNAP benefits received; earlier studies modeled food insecurity as a function of SNAP participation. Our concern was that earlier studies did not control for differences in the purchasing power of SNAP benefits because of differences in cost-of-living and may have underestimated the effect of SNAP.

To control for differences in purchasing power we include spatially varying food-price indexes in our regressions. Interestingly, our findings suggest that households that live in areas with high food prices have a higher probability of being food insecure, but this price effect runs only through the purchasing power of SNAP benefits. That is to say, we don't find any negative consequences of high prices for insecurity, except because SNAP benefits purchase less food where prices are high. Part of the explanation is that our results suggest the demand for SNAP foods is elastic; when prices are high households don't utilize SNAP foods enough to offset the effect of the higher prices.

We hope our results will contribute to ongoing policy debates in two respects. First, the ARRA increase in SNAP benefits is set to expire on November 1, 2013. Our results provide an estimate of the likely consequences for food security. The Center on Budget and Policy Priorities has estimated per participant benefits will decline about $10 (Dean and Rosenbaum, 2013). Using our estimate of -.009, food insecurity among SNAP eligible households is expected to increase about 9 percent as a result.

Second, SNAP benefits are not indexed for differences in purchasing power in the continental United States. Our results suggest SNAP participating households in higher cost areas are more susceptible to food insecurity than identical households in the lower cost areas. This discrepancy could be alleviated if SNAP benefits were geographically indexed.

Table 1. Variable Names and Definitions

Variable Name	**Definition**
Food Insecure	A binary variable for whether the household was food insecure in the last 30 days
SNAP per Capita	Nominal food stamp dollars received in the most recent month, divided by the number of persons in the household
Household Income	A continuous measure of income. The mid-point of upper and lower values of the categorical income values in the CPS-FSS
Age	The age of the person answering the survey in the CPS-FSS
Age Squared	Age x age
Married	Binary variable = 1 if the household is made of a married couple.
Own Home	Binary variable = 1 if the household owns their home
High School Grad	Binary variable for whether the person answering the survey graduated high-school. Not a high school graduate is the base
College Grad	Binary variable for whether the person answering the survey graduated college. Not a high school graduate is the base
Non-white	Binary variable for whether the person answering the survey identified themselves as non-caucasian
No-children	Binary variable = 0 if the household includes children less than 18 years old
Unemployed	Binary variable = 1 if the person answering the survey is unemployed.
ARRA	Binary variable = 1 in 2009
HH Size	The number of person in the household
Grocery Index	Continuous grocery price index from CCER
Thrifty Food Plan Index	Continuous composite thrifty food plan cost index constructed using QFAHD

Table 2. Summary Statistics when CCER Grocery Index is Available

Variable	Obs	Mean	Std. Dev.
Food Insecure	10,636	0.076	0.265
Household Income	10,636	6.719	6.090
Age	10,636	50.665	16.088
Age Squared	10,636	2825.790	1704.478
Married	10,636	0.528	0.499
Own Home	10,636	0.760	0.427
HS Graduate	10,636	0.561	0.496
College Graduate	10,636	0.336	0.472
Non-white	10,636	0.166	0.372
HH Head Unemployed	10,636	0.046	0.210
Childless	10,636	0.310	0.462
Grocery Index	10,636	1.005	0.121
HH Size	10,636	2.527	1.429
Snap per Capita	10,636	5.519	25.099
ARRA	10,636	0.500	0.500

Table 3. Summary Statistics when QFAHD TFP Index is Available

Variable	Obs	Mean	Std. Dev.
Food Insecure	21,342	0.070	0.256
Household Income	21,342	7.231	6.546
Age	21,342	50.962	15.897
Age Squared	21,342	2849.825	1692.477
Married	21,342	0.535	0.499
Own Home	21,342	0.748	0.434
HS Graduate	21,342	0.543	0.498
College Graduate	21,342	0.353	0.478
Non-white	21,342	0.161	0.368
HH Head Unemployed	21,342	0.047	0.211
Childless	21,342	2.557	1.443
Grocery Index	21,342	0.309	0.462
HH Size	21,342	0.998	0.063
Snap per Capita	21,342	5.154	24.587
ARRA	21,342	0.500	0.500

Table 4. First-Stage Snap Per Capita Dependent Variable, CCER Sample

	Sample 1	Sample 2	Sample 3	Sample 4
Household Income	-0.385***	-2.983***	-2.048***	-0.009
	(0.04)	(0.39)	(0.32)	(0.06)
Age	0.299*	0.488*	0.49	0.09
	(0.12)	(0.24)	(0.26)	(0.28)
Age Squared	-0.003**	-0.006**	-0.006**	-0.001
	(0.001)	(0.002)	(0.002)	(0.003)
Married	-8.090***	-13.054***	-9.155***	1.46
	(1.00)	(1.78)	(1.80)	(1.90)
Own Home	-9.034***	-9.409***	-8.481***	-1.26
	(0.93)	(1.54)	(1.61)	(2.47)
HS Graduate	-3.694**	(0.59)	(0.20)	-2.91
	(1.25)	(1.71)	(1.75)	(3.45)
College Graduate	-5.473***	-6.660**	-5.225*	-5.70
	(1.22)	(2.12)	(2.09)	(3.30)
Non-white	5.665***	10.180***	6.891**	0.77
	(1.11)	(2.11)	(2.21)	(2.40)
HH Head Unemployed	10.637***	10.965***	8.255*	-0.63
	(2.05)	(2.98)	(3.44)	(3.17)
No Children	-6.290***	-9.776***	-6.027*	3.63
	(1.28)	(2.36)	(2.41)	(2.36)
Grocery Index	-12.296***	-21.873***	-16.447**	-0.56
	(2.09)	(5.56)	(5.10)	(4.16)
HH Size	0.862***	1.249*	0.60	-0.13
	(0.24)	(0.49)	(0.50)	(0.59)
ARRA	1.390***	3.562***	3.413***	4.226**
	(0.33)	(0.89)	(0.90)	(1.49)
Constant	27.589***	45.338***	32.279***	2.52
	(4.53)	(9.52)	(9.67)	(7.35)
athrho	1.372***	0.964**	1.067**	1.034*
	(0.34)	(0.33)	(0.36)	(0.48)
lnsigma	3.163***	3.589***	3.515***	2.852***
	(0.04)	(0.04)	(0.05)	(0.18)
Log-likl	-5.10E+04	-2.12E+04	-1.74E+04	-2.79E+03
N	10636	3928	3294	610

* p<0.10, ** p<0.05, *** p<0.01
Standard Errors in () robust to arbitrary heteroskedasticity and correlation within households.

Table 5. First-Stage Snap Per Capita Dependent Variable, QFAHD Sample

	Sample 1	Sample 2	Sample 3	Sample 4
Household Income	-0.308***	-2.554***	-1.934***	-0.198*
	(0.022)	(0.262)	(0.202)	(0.087)
Age	0.286**	0.498**	0.708***	-0.012
	(0.088)	(0.179)	(0.180)	(0.213)
Age Squared	-0.003***	-0.006***	-0.008***	0.000
	(0.001)	(0.002)	(0.002)	(0.002)
Married	-7.918***	-13.211***	-9.951***	-2.653
	(0.685)	(1.265)	(1.300)	(1.887)
Own Home	-8.943***	-10.726***	-9.335***	-0.375
	(0.646)	(1.126)	(1.143)	(1.446)
HS Graduate	-6.092***	-3.591**	(2.493)	-0.578
	(0.990)	(1.353)	(1.349)	(2.038)
College Graduate	-7.633***	-8.721***	-6.857***	-2.290
	(0.973)	(1.616)	(1.552)	(2.141)
Non-white	3.541***	6.781***	4.880**	3.655
	(0.739)	(1.535)	(1.598)	(2.107)
HH Head Unemployed	8.191***	8.467***	5.864**	0.794
	(1.370)	(2.096)	(2.256)	(2.411)
No Children	-5.840***	-9.929***	-7.097***	-2.652
	(0.896)	(1.727)	(1.761)	(2.555)
Thrifty Food Plan Index	-13.582***	-22.215**	-7.384	-8.268
	(3.044)	(8.238)	(8.178)	(8.762)
HH Size	0.705***	0.708	0.352	-0.565
	(0.161)	(0.362)	(0.379)	(0.497)
ARRA	1.393***	3.703***	3.385***	2.834**
	(0.227)	(0.626)	(0.623)	(1.062)
Constant	30.367***	48.270***	20.094*	16.568*
	(4.062)	(9.801)	(9.931)	(8.061)
athrho	0.940**	0.666*	0.868**	1.143*
	(0.303)	(0.264)	(0.283)	(0.58)
lnsigma	3.148***	3.605***	3.505***	2.919***
	(0.027)	(0.027)	(0.034)	(0.119)
Log-likl	-1.02E+05	-4.12E+04	-3.36E+04	-5.51E+03
N	21,342	7,606	6,384	1,184

* p<0.10, ** p<0.05, *** p<0.01

Standard Errors in () robust to arbitrary heteroskedasticity and correlation within households.

Table 6. Second-Stage Food Insecurity IV-Probit Marginal Effects, CCER Sample

	Sample 1	Sample 2	Sample 3	Sample 4
Snap per Capita	-0.009***	-0.005***	-0.006***	-0.012*
	(0.003)	(0.002)	(0.002)	(0.007)
Household Income	-0.022***	-0.040***	-0.033***	-0.019***
	(0.002)	(0.005)	(0.004)	(0.006)
Age	0.013***	0.020***	0.017***	0.015*
	(0.002)	(0.003)	(0.003)	(0.008)
Age Squared	-0.0001***	-0.0002***	-0.0002***	-0.0002**
	(0.00002)	(0.00003)	(0.00003)	(0.0001)
Married	-0.103***	-0.088***	-0.085***	0.023
	(0.021)	(0.028)	(0.025)	(0.045)
Own Home	-0.102***	-0.069***	-0.065***	-0.008
	(0.023)	(0.020)	(0.023)	(0.046)
HS Graduate	-0.049***	-0.022	-0.028	-0.001
	(0.017)	(0.017)	(0.019)	(0.061)
College Graduate	-0.095***	-0.093***	-0.087***	-0.063
	(0.018)	(0.024)	(0.025)	(0.067)
Non-white	0.058***	0.061***	0.048**	-0.039
	(0.019)	(0.025)	(0.025)	(0.056)
HH Head Unemployed	0.153***	0.116***	0.104***	0.080
	(0.028)	(0.025)	(0.030)	(0.057)
No Children	-0.065***	-0.062**	-0.04	0.053
	(0.021)	(0.027)	(0.026)	(0.056)
Grocery Index	-0.044	-0.023	-0.004	0.007
	(0.053)	(0.083)	(0.081)	(0.181)
HH Size	0.025***	0.023***	0.022***	0.017
	(0.003)	(0.005)	(0.006)	(0.014)

* p<0.10, ** p<0.05, *** p<0.01

Standard Errors in () robust to arbitrary heteroskedasticity and correlation within households.

Table 7. Second-Stage Food Insecurity IV Probit Marginal Effects, QFAHD Sample

	Sample 1	Sample 2	Sample 3	Sample 4
Snap per Capita	-0.006***	-0.004**	-0.005***	-0.013*
	(0.003)	(0.002)	(0.002)	(0.007)
Household Income	-0.019***	-0.032***	-0.030***	-0.018***
	(0.002)	(0.005)	(0.004)	(0.005)
Age	0.012***	0.019***	0.019***	0.014**
	(0.001)	(0.002)	(0.002)	(0.007)
Age Squared	-0.0001***	-0.0002***	-0.0002***	-.0002**
	(0.00001)	(0.00002)	(0.00002)	(0.0001)
Married	-0.075***	-0.075***	-0.078***	-0.054
	(0.023)	(0.024)	(0.022)	(0.041)
Own Home	-0.070***	-0.054***	-0.057***	0.008
	(0.025)	(0.020)	(0.021)	(0.031)
HS Graduate	-0.051***	-0.029**	-0.030**	0.011
	(0.019)	(0.013)	(0.014)	(0.041)
College Graduate	-0.092***	-0.089***	-0.089***	-0.052
	(0.023)	(0.021)	(0.021)	(0.049)
Non-white	0.031***	0.038**	0.033**	0.029
	(0.012)	(0.016)	(0.017)	(0.049)
HH Head Unemployed	0.102***	0.090***	0.090***	0.099**
	(0.025)	(0.018)	(0.019)	(0.042)
No Children	-0.040**	-0.047**	-0.042**	-0.037
	(0.018)	(0.022)	(0.021)	(0.048)
Thrifty Food Plan Index	-0.065	-0.057	-0.030	-0.152
	(0.056)	(0.090)	(0.090)	(0.216)
HH Size	0.020***	0.017***	0.016***	0.005
	(0.003)	(0.004)	(0.004)	(0.011)

* p<0.10, ** p<0.05, *** p<0.01

Standard Errors in () robust to arbitrary heteroskedasticity and correlation within households.

Table 8. GMM SNAP Per Capita Exponential Regression, CCER Sample

	Sample 1	Sample 2	Sample 3	Sample 4
ARRA	0.204***	0.239***	0.323***	1.890***
	(0.061)	(0.061)	(0.086)	(0.712)
Household Income	-0.706***	-0.609***	-0.654***	-0.148
	-0.045	-0.052	-0.077	-0.223
Age	0.067***	0.065***	0.071***	0.017
	(0.02)	(0.02)	(0.02)	(0.09)
Age Squared	-0.001***	-0.001***	-0.001***	0.000
	0.000	0.000	0.000	(0.001)
Married	-0.571***	-0.551***	-0.532***	0.680
	(0.116)	(0.114)	(0.166)	(0.968)
Own Home	-0.471***	-0.436***	-0.551***	(0.485)
	(0.108)	(0.107)	(0.152)	(0.762)
HS Graduate	0.058	0.037	0.091	(0.657)
	(0.101)	(0.098)	(0.142)	(0.690)
College Graduate	-0.567***	-0.563**	-0.495*	-2.792**
	(0.217)	(0.231)	(0.288)	(1.132)
Non-white	0.371***	0.403***	0.348**	0.327
	(0.098)	(0.096)	(0.137)	(0.718)
HH Head Unemployed	0.318***	0.227**	0.295*	(0.136)
	(0.116)	(0.108)	(0.160)	(1.097)
No Children	-0.350***	-0.322**	(0.264)	1.382
	(0.134)	(0.135)	(0.174)	(0.966)
Grocery Index	-0.959**	-1.004**	-1.116*	-0.326
	(0.432)	(0.438)	(0.573)	(1.941)
HH Size	0.158***	0.134***	0.124***	0.028
	(0.031)	(0.030)	(0.041)	(0.270)

* p<0.10, ** p<0.05, *** p<0.01

Standard Errors in () robust to arbitrary heteroskedasticity and correlation within households.

Table 9. GMM SNAP Per Capita Exponential Regression QFAHD Sample

	Sample 1	Sample 2	Sample 3	Sample 4
ARRA	0.254***	0.257***	0.317***	0.224
	(0.045)	(0.044)	(0.059)	(0.384)
Household Income	-0.684***	-0.564***	-0.646***	-0.492***
	-0.039	-0.052	-0.052	-0.163
Age	0.054***	0.060***	0.077***	0.014
	(0.01)	(0.01)	(0.02)	(0.06)
Age Squared	-0.001***	-0.001***	-0.001***	0.000
	0.000	0.000	0.000	(0.001)
Married	-0.666***	-0.684***	-0.724***	-0.800
	(0.090)	(0.092)	(0.132)	(0.594)
Own Home	-0.643***	-0.552***	-0.682***	-0.059
	(0.088)	(0.092)	(0.125)	(0.415)
HS Graduate	-0.106	-0.094	-0.039	-0.317
	(0.079)	(0.082)	(0.113)	(0.457)
College Graduate	-0.700***	-0.707***	-0.690***	-1.176
	(0.167)	(0.189)	(0.239)	(0.740)
Non-white	0.246***	0.318***	0.256**	0.909**
	(0.076)	(0.078)	(0.110)	(0.432)
HH Head Unemployed	0.277***	0.221***	0.231*	0.123
	(0.085)	(0.084)	(0.123)	(0.503)
No Children	-0.410***	-0.456***	-0.450***	-0.770
	(0.096)	(0.102)	(0.133)	(0.507)
TFP Index	-1.825***	-1.913***	-1.587**	-4.208
	(0.537)	(0.573)	(0.780)	(3.598)
HH Size	0.130***	0.107***	0.108***	-0.004
	(0.023)	(0.023)	(0.034)	(0.165)

* p<0.10, ** p<0.05, *** p<0.01

Standard Errors in () robust to arbitrary heteroskedasticity and correlation within households.

Table 10. GMM Food Insecurity Linear Model, CCER Sample

	Sample 1	Sample 2	Sample 3	Sample 4
Snap per Capita	-0.007**	-0.005*	-0.008*	-0.005
	(0.003)	(0.003)	(0.004)	(0.006)
Household Income	-0.009***	-0.036***	-0.036***	-0.008***
	(0.001)	(0.010)	(0.010)	(0.003)
Age	0.011***	0.018***	0.019***	0.007
	(0.002)	(0.003)	(0.004)	(0.006)
Age Squared	-0.000***	-0.000***	-0.000***	0.000
	0.00	0.00	0.00	0.00
Married	-0.102***	-0.103**	-0.113**	0.007
	(0.030)	(0.046)	(0.048)	(0.039)
Own Home	-0.116***	-0.087***	-0.117***	0.000
	(0.032)	(0.033)	(0.042)	(0.040)
HS Graduate	-0.066***	(0.026)	-0.045*	0.005
	(0.020)	(0.020)	(0.026)	(0.044)
College Graduate	-0.104***	-0.107***	-0.133***	-0.045
	(0.024)	(0.031)	(0.038)	(0.054)
Non-white	0.048**	0.060	0.075*	-0.038
	(0.023)	(0.038)	(0.040)	(0.040)
HH Head Unemployed	0.179***	0.155***	0.136**	0.127**
	(0.042)	(0.046)	(0.055)	(0.064)
No Children	-0.061**	-0.070*	(0.033)	0.018
	(0.026)	(0.039)	(0.040)	(0.048)
Grocery Index	-0.051	-0.003	-0.021	0.042
	(0.052)	(0.101)	(0.115)	(0.194)
HH Size	0.025***	0.026***	0.036***	0.012
	(0.005)	(0.008)	(0.009)	(0.015)

* p<0.10, ** p<0.05, *** p<0.01

Standard Errors in () robust to arbitrary heteroskedasticity and correlation within households.

Table 11. GMM Food Insecurity Linear Model, QFAHD Sample

	Sample 1	Sample 2	Sample 3	Sample 4
Snap per Capita	-0.003	-0.005***	-0.007***	-0.004
	(0.002)	(0.001)	(0.002)	(0.006)
Household Income	-0.006***	-0.032***	-0.028***	-0.009***
	(0.001)	(0.004)	(0.004)	(0.003)
Age	0.008***	0.016***	0.015***	0.008**
	(0.001)	(0.002)	(0.002)	(0.004)
Age Squared	-0.000***	-0.000***	-0.000***	-0.000***
	0.00	0.00	0.00	0.00
Married	-0.073***	-0.112***	-0.112***	-0.031
	(0.018)	(0.022)	(0.023)	(0.038)
Own Home	-0.074***	-0.078***	-0.080***	0.003
	(0.020)	(0.018)	(0.020)	(0.027)
HS Graduate	-0.059***	-0.036**	-0.038**	0.011
	(0.016)	(0.015)	(0.016)	(0.029)
College Graduate	-0.088***	-0.106***	-0.106***	(0.045)
	(0.018)	(0.021)	(0.022)	(0.034)
Non-white	0.025**	0.051***	0.039**	(0.019)
	(0.010)	(0.018)	(0.019)	(0.036)
HH Head Unemployed	0.123***	0.138***	0.134***	0.134***
	(0.022)	(0.024)	(0.027)	(0.042)
No Children	-0.038**	-0.074***	-0.065***	-0.002
	(0.015)	(0.021)	(0.022)	(0.039)
TFP Index	-0.080	-0.167*	-0.143	-0.091
	(0.049)	(0.099)	(0.103)	(0.188)
HH Size	0.018***	0.022***	0.019***	0.008
	(0.003)	(0.005)	(0.006)	(0.010)

* p<0.10, ** p<0.05, *** p<0.01

Standard Errors in () robust to arbitrary heteroskedasticity and correlation within households.

Table 12. The Marginal Effect of Food Prices on Food Insecurity

	Sample 1	Sample 2	Sample 3	Sample 4
IV-Probit Estimates				
CCER Index	.1165***	.0506***	.0434***	0.003
	(0.023)	(0.018)	(0.016)	(0.022)
QFAHD Index	.0494***	.0376*	0.0175	0.0434
	(0.016)	(0.020)	(0.020)	(0.045)
System GMM Estimates				
CCER Index	0.0343	0.0768	0.0875	0.0038
	(0.024)	(0.056)	(0.068)	(0.024)
QFAHD Index	0.0219	0.0493	0.0242	0.0577
	(0.017)	(0.040)	(0.035)	(0.088)

* p<0.10, ** p<0.05, *** p<0.01

References

Angrist, Joshua D., and Jorn-Steffen Pischke, *Mostly Harmless Econometrics: An Empiricist's Companion*, Princeton University Press, Princeton, NJ, 2009.

Dean, Stacy and Dorothy Rosenbaum, "SNAP Benefits Will Be Cut for All Participants In November 2013," Center on Budget and Policy Priorities, August 2013.

Nord, Mark, Alisha Coleman-Jensen, Margaret Andrews, and Steven Carlson, "Household Food Security in the United States," 2009 Economic Research Report No. (ERR-108), November 2010.

Nord, Mark, Margaret Andrews, and Steven Carlson, Household Food Security in the United States, 2008, Economic Research Report No. (ERR-83) 66 pp, November 2009.

Mykerezi, Elton and Bradford Mills, "The Impact of Food Stamp Participation of Household Food Insecurity," *American Journal of Agricultural Economics*, 2010, 92(5): 1379-1391.

Ratcliffe, Caroline and Signe-Mary McKernan, "How Much Does SNAP Reduce Food Insecurity?" The Urban Institute, Washington D.C. March 2010.

Jensen, Helen, "Food Insecurity and The Food Stamp Program," *American Journal of Agricultural Economics*, 2002, 84(5): 1215-1228.

Gunderson, Craig and Victor Oliveira, "The Food Stamp Program and Food Insufficiency," *American Journal of Agricultural Economics*, 2001, 83(4): 875-887.

Leibtag, Ephraim, "Stretching the Food Stamp Dollar Regional Price Differences Affect Affordability of Food, Economic Research Service Electronic Information Bulletin 29-2. September, 2007.

Nord, Mark and Heather Hopwood," Higher Cost of Food in Some Areas May Affect Food Stamp Households' Ability To Make Healthy Food Choices," Economics Research Service, Economic Information Bulletin Number 29-3 September 2007.

Nord, Mark and Mark Prell, "Food Security Improved Following the 2009 ARRA Increase in SNAP Benefits, by, ERR-116, USDA, Economic Research Service, April 2011.

Silva, J. M. C. Santos and Silvana Tenreyro, "The Log of Gravity," *The Review of Economics and Statistics*, November 2006, 88(4): 641–658

Wilde, Parke, and Mark Nord, "The Effect of Food Stamps on Food Security: A Panel Data Approach" *Review of Agricultural Economics*, 2005, 27(3) 425-432.

Yen, Steven T., Margaret Andrews, Zhuo Chen, and David B. Eastwood, "Food Stamp Program Participation and Food Insecurity: An Instrumental Approach," *American Journal of Agricultural Economics*, 90(1) (February 2008): 117–132.