The Supplemental Nutrition Assistance Program and Nutrient Intakes

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April 2009

Abstract

The socioeconomic determinants of Food Stamp Program participation and the effects of program participation on nutrient intakes are investigated, using data from the 2003–04 and 2005–06 National Health and Nutrition Examination Survey (NHANES). An endogenous switching regression system of equations is estimated, which includes protein, vitamin A, vitamin C, calcium and iron. Participation in the FSP is found to play an important role in nutrient intakes. Socio-demographic variables such as income, household size and presence of children are also found to affect individuals' decisions on program participation and nutrient intakes.

Selected Paper prepared for presentation at the Agricultural and Applied Economics Association's Annual Meeting, Milwaukee, July 26–28, 2009. The paper is based on a very preliminary draft of Liu's M.S. thesis at the University of Tennessee.

The Supplemental Nutrition Assistance Program (SNAP), formerly the Food Stamp Program until October 1, 2008, is the largest food and nutrition programs monitored by the U.S. Department of Agriculture (USDA, 2009). It has grown from a modest effort to distribute excess farm commodities during the Great Depression to the largest among 16 food nutrition assistance programs sponsored by Federal government today. The program expanded during the 1960s and became a national program in 1975. The SNAP budget for Fiscal Year 2008 was $39.8 billion, supporting 26.2 million people. Major purpose of the SNAP is to help low-income households obtain adequate and nutritious diets by providing electronic debit cards that can be redeemed for food with few restrictions. The program is based on the assumption that without it, low-income households would cut their diet and become nutritiously insufficient.

To be eligible for SNAP, a household must meet certain financial, work-related, and categorical requirements. Financial requirements include a gross income limit of 130 percent of Federal poverty level. Work related eligibility conditions require certain household members to register for work, accept suitable job offers, and comply with State welfare agency work or training programs. Finally, a few groups are ineligible for SNAP, including strikers, non-citizen, non-permanent residents, postsecondary students, and people living in institutional settings (Fox, Hamilton, and Lin, 2004). In recent years, the 2002 Act[1] removed the prohibition on benefits for several categories of legally resident aliens, including children, elderly or disabled people, and others who have legally resided for 5 years. This move opens a wider door for the public to access SNAP, even for those who are neither U.S. citizens or permanent residents.

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[1] The Food Stamp Reauthorization Act of 2002 ("Food Stamp Reauthorization Act"), signed into law on May 13, 2002, includes a number of provisions that could enhance the program's effectiveness for these groups, by broadening eligibility, increasing benefits and improving access.

SNAP is a mature program, having been in place for more than four decades. Although previous studies have found that participation in the program increases food expenditures (Fox, Hamilton, and Lin, 2004), the link between a rise in food expenditure and a rise in nutrient intake is not a direct one. Food may be purchased for many reasons – convenience, pleasing tastes, etc. (Butler, Ohls, and Posner, 1985). According to Rossi (1998), the program results in substantial increases in food purchases and does appear to put more food on the tables of the poor. The issue of whether these added food purchases translate into improved nutrition is, however, a complex matter. Measurement of nutrients requires translating each food item consumed to its nutritional equivalent using standard tables of nutritional equivalents. However, research evidence on the nutritional effects of SNAP does not lead to the firm conclusion that SNAP improves the nutritional intake of recipient households, on average. A study by Currie (2000) shows that although on average the levels of nutrients available to respondents exceeds the recommended daily allowances (RDAs), substantial numbers of SNAP recipients failed to meet the RDAs for some nutrients. For example, 31 percent of SNAP households did not meet the RDA for iron, and 21 percent did not meet the RDA for folate. The questions for policy makers have therefore been: what determines participation in SNAP, and how effective is it in improving nutritional well being of the nation's poor? This paper will address these important policy issues, using the 2003–2004 and 2005–2006 National Health and Nutrition Examination Survey (NHANES), conducted by the U.S. Centers for Disease Control and Prevention (CDC, 2004a, 2004b). The objectives are accomplished by estimating a system of nutrient equations with endogenous switching (SNAP participation), henceforth the switching regression system (SRS).

The Nutrient Equation System

According to the neoclassical theory of consumption, a rational consumer chooses the levels of commodities (food and non-food) to maximize utility subject to a fixed budget. The nutrient intake equations estimated in this paper are motivated by a theoretical framework in which consumer preference is defined over utility-generating attributes (nutrients) which are produced with market goods (food items). Maximization of utility subject to the nutrient-producing technology and fixed budget yields the nutrient demand equations (e.g., Lancaster, 1971).

To investigate the effects of SNAP participation on nutrient intakes, a system of nutrient equations is estimated as an SRS. A series of hypotheses will be tested, including endogeneity of SNAP participation, and simultaneity among nutrition intakes. The estimated equation system allows investigation of (i) effects of income and other explanatory variables on SNAP participation; and (ii) effects of SNAP and other explanatory variables on nutrient intakes.

Statistical Model: The Switching Regression System

Switching regression models (SRMs) date back to Roy (1951) who was concerned with an individual's decision between earning income as a fisher or hunter, and have been used extensively in economics. Important contributions of SRMs include Heckman (1990) and Heckman and Honoré (1990). Vijverberg (1993) reviews their applications in labor economics. Important applications in food and health include investigation of shopping frequencies and food intake decisions (Wilde, McNamara, and Ranney, 1999), effect of food label use on nutrient intakes (Kim, Nayga, and Capps, 2000), use of preventive care among the immigrant population (Pylypchuk and Hudson, 2008), and body weight determination with endogenous weight categories (Yen, Chen, and Eastwood, 2009). All existing SRM applications feature regression functions for one outcome variable, most of which governed by a binary probit switching mechanism (Amemiya, 1985, pp. 399−400; Maddala 1983, p. 223). We extended the SRM from a single outcome variable to one with multiple outcome variables, that is, the SRS.

The SRS pertains to the situation where, for individual t, the dependent variables (nutrient intakes) y_{it} (i = 1,…, m) take one set of values when outcome for the switching variable (SNAP participation) $d_t = 0$, and take another set of values when $d_t = 0$. In this case, the decision for individual t to participate in the SNAP or not is observed and determined by individual and household characteristics according to the probit mechanism

$$\begin{aligned} d_{it} &= 1 \quad \text{if} \quad z_t'\gamma + \varepsilon_t > 0 \\ &= 0 \quad \text{if} \quad z_t'\gamma + \varepsilon_t \le 0, \; t = 1,\ldots,T. \end{aligned} \tag{1}$$

The outcomes for nutrient intakes are governed by the switching mechanism (1) such that

$$\begin{aligned} \log y_{it} &= x_t'\beta_{0i} + u_{it} \quad \text{if} \quad d_t = 0 \\ &= x_t'\beta_{1i} + v_{it} \quad \text{if} \quad d_t = 1, \; i = 1,\ldots,m, \; t = 1,\ldots,T. \end{aligned} \tag{2}$$

In Equations (1) and (2), z_t and x_t are vectors of explanatory variables, γ, β_{0i} and β_{1i} are conformable parameter vectors, and the error vector $e = [\varepsilon_t, u_{1t}, \ldots, u_{mt}, v_{1t}, \ldots, v_{mt}]'$ is normally distributed as $e \sim \mathcal{N}(0, \Sigma)$, where

$$\Sigma = \begin{bmatrix} 1 & \Sigma_{\varepsilon u} & \Sigma_{\varepsilon v} \\ \Sigma_{u\varepsilon} & \Sigma_{uu} & \Sigma_{uv} \\ \Sigma_{v\varepsilon} & \Sigma_{vu} & \Sigma_{vv} \end{bmatrix}, \tag{3}$$

such that Σ_{uu}, Σ_{vu}, and Σ_{vv} are $m \times m$, and $\Sigma_{u\varepsilon}$, and $\Sigma_{v\varepsilon}$ are $m \times 1$. This paper focuses on the form of nutrient equations in (2) in which each dependent variable is logarithmically transformed (Yen and Rosinski, 2008). Because the participant and non-participant regimes are mutually exclusive, similar to conventional SRMs with one outcome variable, elements of Σ_{uv} and Σ_{vu} are not identifiable and are not estimated. The SRS, consisting of Equations (1) and (2), is estimated by the method of maximum likelihood. Details on development of the likelihood function are available in an appendix upon request. The model nests several interesting models—the most notable of which is a treatment effect system (TES) which contains a system of outcome equations with a binary endogenous treatment variable (SNAP participation) on the right-hand side of each outcome equation.

Marginal Effects and Treatment Effects

The effects of SNAP participation on nutrient intakes can be examined by calculating treatment effects, and the roles of explanatory variables on SNAP participation and nutrient intakes by marginal effects. Both sets of measures are based on the conditional mean of the dependent variables y_{it}. Using Equation (1) and based on normality of the error term ε_t, the probability of participation in SNAP is

$$\Pr(d_t = 1) = \Pr(\varepsilon_t > -z_t'\gamma) = \Phi(z_t'\gamma), \tag{4}$$

where $\Phi(\cdot)$ is the cumulative distribution function (cdf) of the univariate standard normal distribution. Using Equations (1) and (2) and based on bivariate normality of (ε_t, u_{it}) with standard deviations $(1, \sigma_i)$ and correlation $\rho_{\varepsilon i}$ and of (ε_t, v_{it}) with standard deviations $(1, \theta_i)$ and correlation $\tau_{\varepsilon i}$ for all $i = 1,\ldots,m$, the conditional means of y_{it} are (Yen and Rosinski, 2008)

$$\begin{aligned} \mathrm{E}(y_{it} \mid d_t = 0) &= \exp(x_t'\beta_{0i})\,\mathrm{E}(e^{u_{it}} \mid \varepsilon_t \le -z_t'\gamma) \\ &= \exp(x_t'\beta_{0i} + \sigma_i^2/2)\,\frac{\Phi(-z_t'\gamma - \sigma_i\rho_{\varepsilon i})}{\Phi(-z_t'\gamma)} \end{aligned} \tag{5}$$

$$\begin{aligned} \mathrm{E}(y_{it} \mid d_t = 1) &= \exp(x_t'\beta_{1i})\,\mathrm{E}(e^{u_{it}} \mid \varepsilon_t > -z_t'\gamma) \\ &= \exp(x_t'\beta_{1i} + \theta_i^2/2)\,\frac{\Phi(z_t'\gamma + \theta_i\tau_{\varepsilon i})}{\Phi(z_t'\gamma)}. \end{aligned} \tag{6}$$

Marginal effects of explanatory variables can be derived by differentiating (and differencing, in the case of a discrete explanatory variable) equations (4), (5) and (6).

We draw on the results for a similar model, specifically SRM with a single outcome variable, by Heckman, Tobias, and Vytlacil (2001) in calculating alternative treatment effects. First, using Equations (5) and (6), the treatment effect (TE) for nutrient *i* and observation *t* is

$$TE_{it} = E(y_{it}^{(1)} \mid d_t = 1) - E(y_{it}^{(0)} \mid d_t = 0) \tag{7}$$
$$= \exp(x_t'\beta_{1i} + \theta_i^2/2)\frac{\Phi(z_t'\gamma + \theta_i\tau_{\varepsilon i})}{\Phi(z_t'\gamma)}$$
$$-\exp(x_t'\beta_{0i} + \sigma_i^2/2)\frac{\Phi(-z_t'\gamma - \sigma_i\rho_{\varepsilon i})}{\Phi(-z_t'\gamma)}.$$

The treatment effect on the treated (TT) is

$$TT_{it} = E(y_{it}^{(1)} \mid d_{it} = 1) - E(y_{it}^{(0)} \mid d_{it} = 1) \tag{8}$$
$$= \exp(x_t'\beta_{1i} + \theta_i^2/2)\left(\frac{\Phi(z_t'\gamma + \tau_{\varepsilon i}\theta_i)}{\Phi(z_t'\gamma)}\right)$$
$$-\exp(x_t'\beta_{0i} + \sigma_i^2/2)\left(\frac{\Phi(z_t'\gamma + \rho_{\varepsilon i}\sigma_i)}{\Phi(z_t'\gamma)}\right).$$

In Equations (7) and (8), $y_{it}^{(1)}$ is realized value of y_{it} for the participants regime and $y_{it}^{(0)}$ for the non-participant regime. Finally, the average treatment effect (ATE) is

$$ATE_{it} = \exp(x_t'\beta_{1i} + \theta_i^2/2)$$
$$- \exp(x_t'\beta_{0i} + \sigma_i^2/2)$$
$$= \exp(x_t'\beta_{1i} + \theta_i^2/2)\left(\left.\frac{\Phi[\kappa_t(z_t'\gamma + \theta_i\tau_{\varepsilon i})]}{\Phi[\kappa_t z_t'\gamma]}\right|_{\kappa_t=1,\tau_{\varepsilon i}=0}\right) \tag{9}$$
$$- \exp(x_t'\beta_{0i} + \sigma_i^2/2)\left(\left.\frac{\Phi[\kappa_t(z_t'\gamma + \sigma_i\rho_{\varepsilon i})]}{\Phi[\kappa_t z_t'\gamma]}\right|_{\kappa_t=1,\rho_{\varepsilon i}=0}\right).$$

All treatment effects are calculated for each individual observation and average over the sample, weighted by the sample weight. For statistical inference, standard errors of marginal effects and of the ATE can be calculated by the delta method (Spanos, 1999, p. 493)

Data and Sample

Our sample is drawn from the 2003–04 and 2005–06 NHANES, conducted by the U.S. Center for Disease Control and Prevention (CDC, 2004a, 2004b), which provide critical information on the health and nutritional status of the U.S. population. Its target population is the civilian, noninstitutionalized population in the U.S. Data collected in NHANES came from interviews, examinations, and laboratory tests such as blood and urine samples. For the interview part, NHANES includes demographic, socioeconomic, dietary, health, and physiological questions. For the examination part, a majority of the physical examinations were conducted at mobile examination centers (MECs) while a small number of survey participants received an abbreviated health examination in their homes. Data used in this study came from both interview and examination.

Two dietary interviews were administered to all interviewees. The primary dietary interview was administered in person in the MEC (the MEC in-person interview). In MEC, interviewee's blood and urine samples were taken for examination. A follow-up dietary interview is conducted by telephone from the home office and is called "the Phone Follow-up (PFU) interview." Since PFU interview data were subject to non-sampling errors such as recall problems, misunderstanding of the question, and a variety of other factors, only MEC interview data are used in this analysis. Total nutrient intakes from food and dietary supplements are calculated by combining dietary recall data with household interview dietary supplement information (CDC, 2002).

Selection of Sample

One focus of this study is on participation in SNAP, and therefore, use of a SNAP eligible sample is important. The eligibility to participate in the SNAP is determined as having a gross annual income below 130% of the Federal poverty level adjusted for household size. The Federal poverty level is set by number of family size. For example, for family with 2 people, the Federal poverty line is $14,570 annual gross income per year. The SNAP participation variable used in this study is a binary indicator indicating whether the respondent received SNAP benefits when the survey and examination take place. Since nutrients examined in this paper absorbable during a short time period, program participation is the current status at the individual level. Women who were pregnant or lactating are excluded from the sample because these women might have special needs for nutrients. In order to focus on adults, observations age < 20 were excluded as well. Individuals were classified into four age groups according to Recommended Dietary Allowance (RDA) table by USDA.

Five nutrients are included in this study: protein, vitamin A, vitamin C, iron, and calcium. These nutrients were targeted by the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) — another important Federal food program (Yen, 2009a). Each dependent (outcome) variable is nutrient intake expressed as a percent of Dietary Reference Intake (DRI) (USDA, 2002). The explanatory variables include household characteristics such as household income (expressed as a percentage of Federal poverty level), household size, interviewee's education, age and dummy variables characterizing country or origin, marital status, race, experience of receiving emergency food, health insurance condition, household ownership, physical activity, presence of child(ren), household food insecurity measures such as indicators indicating whether child(ren) has balanced food and whether household food didn't last long, dietary supplement taken, health condition (body mass index, BMI; see table 1), psychological factor (whether consider oneself less food security situation and interviewee worry about running out of food), and risky behavior (smoking). Detailed definitions of all variables and the sample statistics are presented in table 1. All estimation and sample statistics calculation are weighted, suing a combined sample weight suggested by the USDA.

Results

The SRS is estimated by the method of maximum likelihood, using two-step estimates of the nutrient-by-nutrient SRMs (Maddala, 1983, pp. 223–228) as initial values. As in other sample selection and switching regression models, use of exclusion restriction is important in identifying the model parameters. The empirical strategy is, besides a common set of variables used in all equations, a unique set of variables are included in the SNAP participation equation and another unique set in the nutrient equations. Unique variables in the SNAP participation equation include: whether the household worry about running out of food, can provide children a balanced diet, and can have a balanced diet for adults; these variables are related to household food security and can have more direct effects on SNAP participation than can on nutrient intakes. Also unique in the SNAP participation equation are home ownership, household size and three age dummy variables (age 18–29, age 30–43, age 44–63).

Unique variables in the nutrient equations include lifestyle variables indicating whether the individual smokes cigarettes or actively participates in physical activity, BMI which reflects personal physiques, whether the individual has been diagnosed with problems with blood pressure, and whether the individual was taking dietary supplement(s). While age category dummy variables are used in the SNAP participation equation, another set of age-related variables, age and age^2, are included in the nutrient equation, with age^2 capturing potential nonlinearity in the effect of age on nutrient intake. In addition, education, smoking, BMI, and physical active are interacted with the gender dummy variable female (see discussion on gender differences below). Use of these unique variables in the nutrient equations guarantee that the model parameters are identified.

Tests for Gender Differences and Specifications

The first empirical issue relates to gender differences. Due to the large system (and resulting large number of parameters) and relatively small sample size, it is not possible to allow for gender differences in the whole set of parameters.[2] Therefore, gender effects are accommodated by including interaction terms of the gender dummy (female) with a sub-set of regressors, selected as a results of an extensive search in preliminary analysis with separate nutrient SRMs. Based on results of the likelihood-ratio (LR) test (table 2), the hypothesis of gender equality in all parameters (against the alternative that parameters for the selected set of variables interacted with gender differ) was rejected (LR = 1101.861, df = 20, *p*-value < 0.0001), justifying inclusion of the gender-augmented interaction terms in the nutrient equations.

Table 2 also presents results of the LR tests among the different models, with the hypothesis of gender differences maintained. Besides the TES, two additional restricted models are considered: (1) SRS with exogenous switching, and (2) nutrient system with exogenous SNAP variable. The first system is estimated by imposing zero restrictions on the error correlation between each nutrient equation and the SNAP participation equation, for both participant and non-participant regimes. Due to the lack of cross-equation restrictions, the first exogenous system is equivalent to equation-by-equation OLS, separately using the participant and non-participant sample. Likewise, the second exogenous system is equivalent to equation-by-equation OLS using the pooled sample.

First, the hypothesis that the SRS performs as well as the TES was rejected (LR = 286.14, df = 140, *p*-value < 0.0001), favoring the former. Further, the hypothesis of zero restrictions on the error correlation between the SNAP participation equation and each nutrient equation in the

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2 Test for such gender differences can be carried out with a LR test, using likelihood values from the pooled and segmented (male and female) sample estimation. Separate estimation of the model by gender proved to be difficult due to the small sample sizes.

participant and non-participant samples (exogenous system 1, $\rho_{\varepsilon i} = \tau_{\varepsilon i} = 0\ (i = 1,...,m)$) was rejected (LR = 4365.960, df = 10, p-value < 0.0001), which is consistent with significance of these error correlations in the SRS. Likewise, the hypothesis of zero restrictions on the error correlation between each nutrient equation and the SNAP participation equation for the pooled sample (exogenous system 2; $\rho_{\varepsilon i} = 0\ (i = 1,...,m)$) was rejected (LR = 4573.018, df = 5, p-value < 0.0001), which is also consistent with significance of the error correlation in the TES.

These two tests mean that system SRS is necessary, and it will gain statistical efficiency. The SRS was also compared with the treatment effect system, with LR test result (LR=286.138, p-value < 0.0001) supporting the former. In sum, SRS performs better than the TES, and both system perform better than the corresponding exogenous switching or treatment system.

Treatment Effects

Treatment effects are calculated separately in pooled sample (male and female), female group, and male group. Detailed treatment effect is presented in table 3. Three different treatment effects are presented. Most of Treatment effect (TE)s are positive but not significant. The problem with this measure is that it refers to different people, but in fact no one can be in both states. So for an individual selected at random from the entire population, the average treatment effect (ATE) is calculated. The average treatment effects (ATE) and treatment effects on the treated (ATTs) both suggest a positive effect of SNAP participation on the intake of iron, for both males and female. The ATT also suggests that negative effect of SNAP participation on protein intake. For the pooled sample, all measures of treatment effects suggest a negative effect of SNAP participation in the intake of iron. The insignificant effect of SNAP participation on calcium is similar to result reported by Butler and Raymond (1996), who states that SNAP has a negative and insignificant effect on intake of calcium among elderly, and similar results are found by Fraker (1990) among women, and Dixon (2002) among adults. The negative effect of SNAP participation on iron intake is similar to finding reported by Butler and Raymond (1996).

Marginal Effect of Explanatory Variables on SNAP Participation

Marginal effects of pooled sample are presented in Table 4. Half (12) of the 24 variables used in the SNAP equation are significant at the 5% level of significance or lower. Variables contributing negatively to SNAP participation are income, household size, being born in Mexico, being born in other countries, married or cohabitating, and being of other race. As expected, income has a negative effect on program participation. This finding is similar to findings by Butler and Raymond (1996), Gunderson and Oliveira (2001), and Yen (2009a), all of whom reported a negative effect of household income on SNAP.

Being married or living with a partner is 7.1 per cent less likely to participate in SNAP, which may be due to the multiple income sources in such households. This finding differs from that reported by Butler and Raymond (1996), that the probability of participation is lower among those who live alone.

Variables contributing positive to SNAP participation are being female, being a renter, and age 20-50. Presence of children increases the probability of SNAP participation. This is similar to findings by Butler and Raymond (1996) that the decision to participate in the SNAP is significantly increased by the number of children and decreased by the number of adults in the household, and to the finding by Gunderson and Oliveira (2001) that household without children are less likely to participate in SNAP.

Marginal Effect of Explanatory Variables on Nutrient Intakes

Table 5 presents the marginal effects of explanatory variables on the nutrient intakes, conditional on program participation and non-participation. For intake of protein, 12 out of 30 variables are significant at 10% level or lower for males, while 10 out of 30 are significant at 10% level or lower for females. As for intake of vitamin A, 7 variables are significant at 10% level or lower in male sample, and 9 variables are significant at 10% level or lower in female sample. The numbers of significant variables for vitamin C, calcium and iron for men are 6, 13, and 17 respectively.

Marginal Effects between Participants and Non-Participants

The SRS produces notably different marginal effects of some variables, in both signs and magnitudes, between participants and non-participants. Sign differences are seen in variables like being born in other countries, being divorced, separated or widowed, home ownership, age, and cigarette smoking. For example, conditional on participation in SNAP, individuals who are divorced, separated or widowed have 11.44 per cent more intake of protein and 17.46 per cent more intake of iron, than individuals who are single. The positive effects of this marital status are absent among the SNAP participants. These findings are similar to those reported by Butler and Raymond (1996) that living alone often has large negative effects on protein and iron intake.

Differences in marginal effects between participants and non-participants are most notable in variables like household income, good (self-accessed) health, being female, being physically active, and BMI. For example, household income has positive effects on the intakes of protein, vitamin C, calcium, and iron among the non-participants, while such effects are absent among the SNAP participants. These positive effects on income differ from the negative effect of income on protein reported by Butler and Raymond (1996), and negative effects of income on protein and iron intakes among children reported by Yen (2009a).

Marginal Effects between Males and Females

Marginal effects are calculated separately for males, females, and both genders combined. Few qualitative differences are between males and females; though magnitudes of marginal effects do differ for most variables. Among the SNAP non-participants, for example, income increases protein intake by 11.49 per cent for males, and by 12.09 per cent for females. Having a college degree increase vitamin A intake 27.39 for men and 22.49 per cent for women, conditional on non-participation in SNAP. These positive effects of college education are similar to those reported by Butler and Raymond (1996).

Among the SNAP participants, having poor health decreases the intake of protein by 39.86 per cent for men and 46.28 per cent for women, both are significant at the 5% level. Cigarette smoking increases protein intake by as high as 47.11 per cent among the female participants, whereas the effect is not significant among the male participants.

Concluding Remarks

SNAP is an important food and nutrition assistance program administered by USDA to improve nutritional well being of the low-income individuals, and there is continued interest in investigating the roles of these programs in achieving their goals. Although precious studies show that SNAP increases participants' food expenditure, it is not necessarily improve their nutrient intake, because the link between increases in food expenditure and increased nutrient intake is not a direct one, according to Butler, Ohls and Posner.

This paper focuses on nutrient intakes among the SNAP- eligible individuals, by investigating the factors contributing to SNAP participation, and the effects of such participation on nutrient intakes among the SNAP-eligible individuals. Since participation in programs and intakes of nutrients are likely to be joint decisions and consumers typically make food and nutrition choices from a bundle of commodities, there are behavioral reasons to model these decisions in a system. Estimation of the nutrient equations in a system also improves statistical efficiency, and endogenization of SNAP, either in the TES or the SRS, also avoids simultaneous-equation and sample selection biases in the parameter estimates.

This paper focuses on the effects of SNAP on the level of nutrient intakes. The effects of SNAP participation are insignificant for most nutrients except iron.

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Table1. Variable Definitions and Sample Statistics

Variable	Definition	Mean
Nutrients (% of dietary recommended intakes, DRIs)		
Protein		152.91
Vitamin C		109.87
Vitamin A		67.67
Calcium		76.91
Iron		161.52
Continuous variables		
Income	Household income as a percentage of Federal poverty level	0.83
BMI	Body mass index: (weight in kg) / (height in *m*)^2	2.87
Household size	Number of members in household (HH)	3.23
Age	Age in years	5.02
Binary variables (yes = 1; no = 0)		
Age 20-30	Between 20 and 30 years of age	0.21
Age 31-50	Between 31 and 50 years of age	0.31
Age 51-70	Between 51 and 70 years of age	0.26
Age >70	Over 70 years of age (reference)	0.21
SNAP	Individual currently participating in SNAP	0.17
U.S. born	Reference person born in the U.S. (reference)	0.72
Mexico born	Reference person born in Mexico	0.20
Other	Reference person born in other countries	0.08
Single	Never married (reference)	0.19
Married	Married or live with a partner	0.50
Divorced	Divorced, widowed or separated	0.31
High school	Has high school education (reference)	0.73
College	Has college or higher education	0.27
White	White non-Hispanic (reference)	0.40
Hispanic	Race is Hispanic	0.34
Black	Black non-Hispanic	0.23
Other	Other race	0.03
Food worry	Worried about running out of food	0.40
Food last	Food does not last long	0.35
Balanced food	Could not afford balanced food	0.30
Child(ren)	Presence of child(ren) (under 17 years of age)	0.46
Child food	HH can provide child(ren) with balanced food	0.87
Food insecure	Considered oneself low food secure	0.31

Fair health	Self-assessed health is good or fair (reference)	0.68
Good heath	Self-assessed health is excellent or very good	0.25
Poor health	Self-assessed health is poor	0.07
Insurance	Individual has health insurance	0.67
Rent	Current residence is rented	0.54
Diet. supp.	Taking dietary supplement(s)	0.39
Smoking	Has smoked more than 100 cigarettes in life	0.52
Blood pressure	Has been diagnosed with high blood pressure	0.37
Active	Has physical activity in the past 30 days	0.29

Note: Standard deviations in parentheses.

Table 2. LR Tests of the SRS against Nested Specifications

		LR Statistics: Model Tested Against			
Model	Log likelihood	SRS without Gender Effects	TES	Exog. Systems 1	Exog. System 2
SRS	–50499.131	101.81	286.14	4365.96	4573.02
SRS without gender effects	–50550.035				
TES	–50642.200			4079.82	4286.88
Exogenous systems 1	–52682.111				207.06
Exogenous system 2	–52785.640				

Note: Exogenous systems 1 refer to nutrient systems with exogenous switching and was estimated by separate seemingly unrelated regressions (which amount to separate single equation OLS) for SNAP participants and non-participants. Exogenous system 2 refers to nutrient equation system with an exogenous dummy variable for SNAP participation. Both exogenous systems are estimated with gender effects.

Table 3. Average Treatment Effect of SNAP Participation on Nutrient Intakes

Nutrient	Male	Female	Pooled
		Treatment Effects (Individual)	
Protein	29.743	5.377	3.381
Vitamin C	–33.923	2.510	–8.973
Vitamin A	12.277	–9.023	–1.873
Calcium	9.911	0.499	–3.519
Iron	11.311	–4.548	–31.652***
		Treatment Effects (Sample Mean)	
Protein	14.988	–3.163	–11.019
Vitamin C	–35.729*	8.013	–12.135
Vitamin A	11.906	–6.474	–2.314
Calcium	6.054	0.372	–6.162
Iron	–5.824	–7.844	–38.838***
		ATT	
Protein	–30.452	–42.114**	–36.849
Vitamin C	–40.309	–12.987	–25.321
Vitamin A	5.848	–11.600	–3.723
Calcium	20.970	–0.945	8.948
Iron	–312.550***	–107.012***	–199.798***
		ATE	
Protein	38.152	–2.869	15.649
Vitamin C	35.502	49.862	43.379
Vitamin A	48.423	16.508	30.916
Calcium	16.126	–3.324	5.456
Iron	–147.398***	–59.155***	–98.991***

Note: Asterisks indicate level of significance: ***=1%, **=5%, *=10%.

Table 4. Marginal Effects of Explanatory Variables on SNAP Participation and Nutrient Intakes: Switching Regression System (Both Genders)

	SNAP	Protein		Vitamin A		Vitamin C	
Variable	Participation	Participants	Non-Participants	Participants	Non-Participants	Participants	Non-Participants
Income	–0.084***	19.776	12.902*	–9.593	15.333	5.782	14.620
Mexico born	–0.088***	29.187	18.244	55.076	48.505*	34.717	–4.909
Other born	–0.048**	2.040	–20.159***	20.479	41.529**	–14.501	–1.105
Married	–0.071***	–12.194	9.034	–20.411	7.962	–16.491	3.073
Divorced	0.016	–26.760	15.178*	–9.609	–17.278	–14.039	4.297
College	–0.014	17.675	6.564	84.224	15.955	27.678	14.694***
Hispanic	0.024	–3.977	–9.025	–24.892	16.636	–22.430	–8.961
Black	0.034	33.143	–5.442	–18.956	28.843**	–9.070	–16.424***
Other	–0.042*	103.399	5.425	–23.038	–2.186	7.967	–3.587
Year	–0.041***	–5.750	4.025	–23.058	17.439**	5.077	7.583**
Child	0.064***	17.180	–3.150	54.066	–19.200**	10.499	–10.458***
Good health	–0.018	–16.364	3.776	4.722	15.197	1.223	5.641
Poor health	0.023	–59.084**	–40.011***	–6.648	–25.419	–24.461	–16.575***
Female	0.075***	–55.884*	–37.838***	1.492	5.219	–15.952	2.665
Food worry	0.030	1.184	–1.321	3.115	–0.396	2.198	–0.152
Food last	–0.001	–0.025	0.028	–0.067	0.008	–0.047	0.003
Balanced food	0.011	0.436	–0.484	1.147	–0.145	0.809	–0.056
Child food	–0.019	–0.731	0.835	–1.931	0.251	–1.361	0.096
Food security	–0.021	–0.872	0.932	–2.278	0.279	–1.610	0.107

Rent	0.034***	1.427	–1.536*	3.734	–0.460	2.637	–0.176
Age20-30	0.067***	3.836	–3.269**	9.696	–0.970	6.894	–0.371
Age31-50	0.113***	5.364	–5.217**	13.807	–1.559	9.782	–0.597
Age51-70	0.011	0.899	–0.579	2.194	–0.170	1.570	–0.065
Household size	–0.017***	–0.694	0.760	–1.821	0.228	–1.286	0.087
Diet. supp.		–9.596	0.680	32.929	4.008	4.461	1.298
Smoke		88.924*	9.816	–21.412	–24.951**	15.083	–14.058***
Blood pressure		–19.301	5.739	8.832	10.321	5.332	4.818
Activity		36.205	3.678	15.416	19.896*	7.158	4.677
BMI		–34.214	4.928	–48.309	–15.344	–29.600	–4.482
Age		–2.395	–12.559***	9.125	–2.495	11.498	–0.280

Table 4 continued

	Calcium		Iron	
Variable	Participants	Non-Participants	Participants	Non-Pparticipants
Income	3.673	3.673	48.984	20.371**
Mexico born	25.022	25.022	23.236	5.436
Other born	–11.659	–11.659	27.759	–21.498
Married	–4.721	–4.721	–9.952	10.989
Divorced	–0.997	–0.997	–26.695	49.055***
College	29.826	29.826	52.683	33.569***
Hispanic	–24.675	–24.675	–12.136	–5.786
Black	–22.043	–22.043	19.758	–16.683*
Other	70.965	70.965	222.154	3.762
Year	11.028	11.028	–3.310	15.185**
Child	14.660	14.660	–44.642	–7.453
Good health	–0.021	–0.021	–16.720	23.944***
Poor health	–23.613	–23.613	–58.257	–27.573**
Female	–41.515***	–41.515***	–150.321***	–152.799***
Food worry	–0.168	–0.168	–15.589	–6.432
Food last	0.004	0.004	0.337	0.136
Balanced food	–0.062	–0.062	–5.756	–2.359
Child food	0.104	0.104	9.532	4.043
Food security	0.124	0.124	11.692	4.582
Rent	–0.203	–0.203	–19.092	–7.539***
Age20-30	–0.551	–0.551	–56.616	–16.760***
Age31-50	–0.767	–0.767	–75.566	–25.944***

Age51-70	–0.131	–0.131	–14.538	–3.134
Household size	0.099	0.099	9.214	3.717***
Diet. supp.	1.977	1.977	–9.212	14.126*
Smoke	25.204	25.204	64.588	–31.459***
Blood pressure	–10.584	–10.584	2.480	16.205*
Activity	19.022	19.022	25.893	24.589**
BMI	–37.414	–37.414	–84.252	–12.298
Age	–6.682	–6.682	10.232	6.545*

Note: Asterisks indicate levels of significance: *** = 1%, ** = 5%, * = 10%.

Table 5. Marginal Effects of Explanatory Variables on Nutrient Intakes: Switching Regression System (Male Sample)

	Protein		Vitamin A		Vitamin C	
Variable	Participants	Non-Participants	Participants	Non-participants	Participants	Non-Participants
Income	13.463	11.486**	–11.119	14.878	5.244	15.620***
Mexico born	20.021	16.210	71.417	47.445*	30.584	–4.855
Other born	1.468	–14.944**	26.542	40.212**	–12.401	–1.026
Married	–8.269	7.884	–24.186	8.231	–13.702	3.371
Divorced	–18.394	11.438*	–11.677	–17.029	–11.890	4.462
College	8.578	–5.468	23.287	27.393**	23.827	8.457
Hispanic	–2.696	–7.377	–30.570	15.344	–18.787	–9.520
Black	22.056	–4.767	–23.405	26.642**	–7.697	–17.409***
Other	69.170	5.256	–27.772	–1.693	6.890	–3.616
Year	–3.788	3.848	–27.862	16.639**	4.477	8.125**
Child	11.426	–3.563	65.708	–18.377**	8.608	–11.200***
Good health	–10.999	3.277	6.003	14.477*	1.121	6.046
Poor health	–39.861**	–31.400***	–8.397	–24.089	–20.920	–17.638***
Female	–34.586	–34.005***	18.772	2.096	–9. 499	2.142
Food worry	0.741	–1.540	3.590	–0.565	1.737	–0.245
Food last	–0.016	0.033	–0.077	0.012	–0.037	0.005
Balanced food	0.273	–0.566	1.322	–0.207	0.640	–0.090
Child food	–0.457	0.965	–2.222	0.354	–1.074	0.154
Food security	–0.547	1.103	–2.633	0.403	–1.276	0.175
Rent	0.894	–1.817*	4.314	–0.665	2.089	–0.288

Age20-30	2.418	–4.339**	11.370	–1.576	5.533	–0.681
Age31-50	3.356	–6.568**	16.056	–2.402	7.788	–1.041
Age51-70	0.573	–0.855	2.606	–0.307	1.276	–0.132
Household size	–0.435	0.893	–2.101	0.327	–1.017	0.142
Diet. supp.	–6.497	0.526	39.003	3.726	3.750	1.362
Smoke	22.809	–12.124**	–43.362	15.899	10.970	–4.299
Blood pressure	–13.068	4.431	10.832	9.584	4.495	5.044
Activity	3.029	22.496***	–26.770	12.975	10.849	12.148**
BMI	14.668*	6.722*	18.018	2.020	7.182	2.224
Age	0.399	–9.707***	11.262	0.432	9.425	0.434

Table 5 continued

	Calcium		Iron	
Variable	Participants	Non-Participants	Participants	Non-Participants
Income	2.121	9.187***	17.237	10.828***
Mexico born	14.750	7.382	7.245	6.114
Other born	–6.894	–16.263***	9.860	–6.624
Married	–2.746	2.945	–4.847	5.910
Divorced	–0.575	5.637	–10.239	17.464***
College	5.876	1.512	13.066	–7.550**
Hispanic	–14.314	–10.174**	–4.226	–3.056
Black	–12.785	–18.223***	8.101	–7.471**
Other	41.161	–17.345***	82.655	3.677
Year	6.441	7.600***	–1.972	7.290***
Child	8.549	–1.547	–15.974	–5.140
Good health	–0.016	5.744**	–6.700	9.886***
Poor health	–13.823	–3.493	–21.984	–11.173**
Female	–29.609*	–24.374***	–124.445***	–161.072***
Food worry	–0.091	0.072	–5.450	–3.500
Food last	0.002	–0.002	0.118	0.074
Balanced food	–0.034	0.027	–2.012	–1.287
Child food	0.056	–0.045	3.330	2.182
Food security	0.067	–0.052	4.094	2.533
Rent	–0.110	0.085	–6.669	–4.162***
Age20-30	–0.300	0.200	–19.365	–10.291***
Age31-50	–0.414	0.307	–25.729	–15.119***

Age51-70	–0.072	0.038	–5.009	–2.140
Household size	0.053	–0.042	3.221	2.038***
Diet. supp.	1.150	3.744*	–3.534	5.327*
Smoke	11.385	–7.027**	15.732	–15.125***
Blood pressure	–6.208	4.202	0.946	6.130*
Activity	4.844	8.366**	–7.461	5.505
BMI	8.318*	0.455	13.053*	1.374
Age	–3.429	–6.951***	4.942	3.135**

Note: Asterisks indicate levels of significance: *** = 1%, ** = 5%, * = 10%.

Table 6. Marginal Effects of Explanatory Variables on Nutrient Intakes: Switching Regression System (Female Sample)

	Protein		Vitamin A		Vitamin C	
Variable	Participants	Non-Participants	Participants	Non-participants	Participants	Non-participants
Income	15.559	12.091**	–10.036	15.157	5.347	15.186
Mexico born	23.062	17.039	61.037	48.135*	31.649	–4.893
Other born	1.652	–17.046**	22.690	40.993**	–13.021	–1.065
Married	–9.582	8.366	–21.555	8.147	–14.576	3.238
Divorced	–21.175	12.941*	–10.279	–17.220	–12.531	4.393
College	11.704	–0.827	50.041	22.490***	24.932	11.341***
Hispanic	–3.121	–8.055	–26.789	15.992	–19.900	–9.278
Black	25.770	–5.054	–20.456	27.748**	–8.101	–16.985***
Other	80.608	5.331	–24.563	–1.923	7.185	–3.612
Year	–4.449	3.934	–24.615	17.078**	4.627	7.889**
Child	13.358	–3.418	57.890	–18.836**	9.221	–10.876***
Good health	–12.794	3.485	5.175	14.869*	1.137	5.870
Poor health	–46.278**	–34.903***	–7.261	–24.800*	–21.953	–17.178***
Female	–43.674	–35.717***	10.491	3.428	–12.431	2.378
Food worry	0.893	–1.462	3.250	–0.494	1.896	–0.202
Food last	–0.019	0.031	–0.069	0.010	–0.041	0.004
Balanced food	0.329	–0.536	1.196	–0.181	0.698	–0.074
Child food	–0.551	0.919	–2.013	0.311	–1.174	0.127
Food security	–0.658	1.041	–2.380	0.351	–1.391	0.143
Rent	1.078	–1.715*	3.900	–0.579	2.278	–0.237

Age20-30	2.906	–3.916**	10.214	–1.310	5.998	–0.534
Age31-50	4.049	–6.056**	14.485	–2.040	8.478	–0.833
Age51-70	0.685	–0.739	2.326	–0.244	1.375	–0.099
Household size	–0.524	0.845	–1.901	0.285	–1.110	0.117
Diet. supp.	–7.531	0.588	34.751	3.869	3.966	1.335
Smoke	47.114**	–3.596	–31.542	–1.594	12.453	–8.719***
Blood pressure	–15.148	4.961	9.500	9.958	4.749	4.949
Activity	14.541	15.045***	–6.182	16.068*	9.130	8.646**
BMI	–2.725	6.051*	–14.883	–5.554	–7.773	–0.889
Age	–0.591	–10.864***	9.850	–0.844	10.085	0.103

Table 5 continued

Variable	Calcium Participants	Calcium Non-Participants	Iron Participants	Iron Non-Participants
Income	2.649	10.830***	26.884	14.627***
Mexico born	18.241	8.709	12.046	6.568
Other born	–8.513	–19.046***	15.310	–11.306
Married	–3.416	3.502	–6.494	7.956
Divorced	–0.718	6.648	–15.311	27.766***
College	13.644	5.741**	24.297	2.219
Hispanic	–17.829	–11.948**	–6.625	–4.139
Black	–15.926	–21.395***	11.711	–10.781*
Other	51.273	–20.329***	125.282	4.092
Year	7.999	8.931***	–2.429	10.227***
Child	10.622	–1.846	–24.704	–6.364
Good health	–0.018	6.739**	–9.795	14.742***
Poor health	–17.147	–4.102	–33.099	–16.803**
Female	–34.710**	–25.239***	–135.679***	–157.282***
Food worry	–0.117	0.071	–8.529	–4.689
Food last	0.003	–0.002	0.184	0.099
Balanced food	–0.043	0.026	–3.149	–1.723
Child food	0.072	–0.045	5.213	2.934
Food security	0.087	–0.051	6.401	3.372
Rent	–0.142	0.083	–10.440	–5.544***
Age20-30	–0.386	0.187	–30.603	–13.164***
Age31-50	–0.535	0.293	–40.758	–19.753***

Age51-70	–0.092	0.034	–7.885	–2.620
Household size	0.069	–0.041	5.041	2.722***
Diet. supp.	1.431	4.411*	–5.278	8.267*
Smoke	16.080	–6.517**	29.825	–21.236***
Blood pressure	–7.694	4.944	1.416	9.500*
Activity	9.500	8.389***	0.304	11.189**
BMI	–6.565	–0.521	–11.016	–2.096
Age	–4.523	–8.417***	6.697	4.397**

Note: Asterisks indicate levels of significance: *** = 1%, ** = 5%, * = 10%.