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Effects of Supplemental Nutrition Assistance Program on Nutrient Intakes

Xiaowen Liu

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To the Graduate Council:

I am submitting herewith a thesis written by Xiaowen Liu entitled "Effects of Supplemental Nutrition Assistance Program on Nutrient Intakes." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Steven T. Yen, Major Professor

We have read this thesis and recommend its acceptance:

Christopher Clark, Mary F. Evans, Kimberly L. Jensen

Accepted for the Council:
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Vice Provost and Dean of the Graduate School

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EFFECTS OF SUPPLEMENTAL NUTRITION ASSISTANCE PROGRAM PARTICIPATION ON NUTRIENT INTAKES

A Thesis Presented for
the Master of Science Degree
The University of Tennessee, Knoxville

Xiaowen Liu

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Abstract

The socioeconomic determinants of participant in the Supplemental Nutrition Assistance Program (SNAP) and effects of the program on nutrient intakes are investigated. The dependent variable is transformed by logarithm which facilitates estimation of the model. Marginal effects of explanatory variables are calculated which make interpretation of the effects of explanatory variables easier. The result suggests SNAP plays a significant role in nutrient intakes. The effects of participation in SNAP are negative on vitamin C and positive on all other nutrients (protein, vitamin A, vitamin C, calcium, and iron), for males, females, and both genders combined. Income, household size, presence of children, and other socio-demographic variables all affect individuals' decisions on program participation and nutrient intakes. Results suggest the effects of socio-demographic variables are very different, in signs and magnitudes, between the participants and non-participants. These differentiated effects of socio-demographic variables are likely to be masked by the use of a more conventional model (such as the single or multiple equation treatment effect models) and highlight the importance of using the Switching System Regression.

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Chapter 1

Introduction

The Supplemental Nutrition Assistance Program (SNAP), formerly known as the Food Stamp Program (FSP) until October 1, 2008, is one of the largest food and nutrition programs monitored by the U.S. Department of Agriculture (USDA). It has grown from a modest effort to distribute excess farm commodities during the Great Depression to the largest food assistance and nutrition program in the United States (U.S.). The program expanded during the 1960s and became a national program in 1975. SNAP budget for Fiscal Year (YF) 2008 was $39.8 billion, supporting 26.2 million people. It is one of the largest among 15 food nutrition assistance programs sponsored by Federal government (USDA 2009b). Major purpose of 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 diets and become nutritiously insufficient.

According to Fox, Hamilton, and Lin (2004), SNAP stands at the intersection of two sets of Federal programs: those for whom the primary goal is improving access to adequate nutrition and those for whom it is income maintenance. It has been described as the safeguard of the health and well-being of the Nation. Compared to other food assistance and nutrition programs, SNAP is unique in that it has the least limitations. Anyone who meets eligibility guidelines based entirely on financial need can receive benefits. Other food assistance and nutrition programs are targeted at specific populations. For example, the National School Lunch Program includes only school-age children (Fox, Hamilton, and Lin 2004). The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) has a strict nutritious food requirement and is limited to infants and children younger than 5 years of age and pre- and postpartum women (USDA 2009c).

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 in the U.S. for 5 years. This move opens a wider door for the public to access SNAP, even for those who are neither U.S. citizens nor permanent residents. USDA provides a program pre-screening eligibility tool online, which can be used to determine whether an individual is eligible to receive program benefits. In addition, information in languages other than English is also provided online.

SNAP specifies the household as the program participant. A household includes all of the people living together in a dwelling who normally purchase food and prepare food as a unit (Fox, Hamilton, and Lin 2004). The amount of benefits the household can receive is called an allotment. Allotments are determined by a schedule of maximum allotments per household, which are based on the number of individuals in the household. Multiplying the monthly net income of the household by 0.3 and subtracting it from the maximum allotment for the household gives the household's allotment. The reason for subtraction of 30% of the household net income is that SNAP households are expected to spend about 30 percent of their resources on

[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.

food (USDA 2009a). Currently, maximum allotments range from $176 per month for single-person households, to $1,058 for households comprising eight individuals (USDA 2009a).

SNAP originally issued benefits in the form of paper coupons of various denominations. Recipients redeemed these coupons for food at authorized stores. In 1996, an electronic benefit transfer (EBT) system was initiated, in which the recipient receives a credit on a computerized account for their household's monthly allotment. The recipient presents his EBT card and enters a personal identification number (PIN) on a point-of-sale (POS) terminal. Currently, all states use an online EBT system except Ohio and Wyoming. The online EBT system allows POS terminals to connect to a central computer to obtain authorization for each transaction. The nationwide changeover from paper coupons to EBT card was completed in June 2004 (USDA 2004).

Because SNAP is available to most people who meet income and resource requirements, households that participate in the program are diverse and represent a broad spectrum of the needy population (Rosso 2003). Nationwide, the household average income for participants is 71% of the Federal poverty line, which is consistent with report by USDA that almost all participants lived in poverty (USDA 2009a). More than half (51 percent) of all SNAP households have children. SNAP has a wide range of eligible food items compared to other food aid programs. Eligible food items include: breads and cereals, fruits and vegetables, meats, fish and poultry, dairy products, and all other seeds and plants which produce food for households to eat (USDA 2009a).

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 (Butler and Raymond 1996), the link between a rise in food expenditure and a rise in nutrient intakes is not a direct one. Food may be purchased for many reasons — convenience, pleasing tastes, etc. (Butler, Ohls, and Posner 1985). An important goal of SNAP is to improve the nutritional quality of recipients' diets. Nutritional quality is more difficult to assess than food quantity. 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 into its nutritional equivalent using standard tables of nutritional equivalents. Prior research on the nutritional effects of SNAP does not lead to a firm conclusion that SNAP improves the nutritional intakes of recipient households, on average. A study by Currie (2000) shows that although, on average, the levels of nutrients available to respondents exceed 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 the program in improving nutritional well being of the nation's poor? This paper will address these important policy issues, using data from the 2003–04 and 2005–06 National Health and Nutrition Examination Survey (NHANES 2003–04, 2005–06), conducted by the U.S. Centers for Disease Control and Prevention (CDC 2004a, 2004b).

The objectives of the study are threefold:

(1) Identify the factors that determine participation by eligible individuals in SNAP;

(2) Determine the effectiveness of SNAP in increasing the nutrient intakes of its participants; and

(3) Determine the effects of socio-demographic factors on nutrient intakes by SNAP eligible individuals (participants and non-participants).

These objectives will be accomplished by estimating a system of nutrient equations with endogenous regime switching (SNAP participation), henceforth the switching regression system (SRS), using the 2003–04 and 2005–06 NHANES data.

This thesis illustrates how SNAP participation affects nutrient intakes of eligible individuals and what affects individuals' decisions on program participation, using a SRS. It also compares the results with those produced by the treatment effect system (a nested model of the SRS, as demonstrated below). Chapter 2 briefly describes the literature on the effects of SNAP participation on nutrient and food intakes and endogenous switching regression models. Chapter 3 presents the econometric model and describes the data used. Chapter 4 presents and interprets the empirical results. Chapter 5 presents a summary and conclusions.

Chapter 2

Literature Review

Previous research on impact assessment of SNAP addressed two broad categories of outcomes: nutrient intakes and food intakes. These two outcomes are logically sequential. Food intake is different from nutrient intake. The American Dietetic Association maintains that "the best nutrition strategy for promoting optimal health and reducing the risk of chronic disease is to obtain adequate nutrients from a wide variety of foods" (Hunt 1996, p. 73).

Findings of program effects on food intakes also vary. Early studies presented an early call for attention to simultaneity in food intakes and program participation, which has obviously not received proper attention as subsequent researchers have continued to investigate program effects ignoring the potential endogeneity of program participation. Using regional data from Tulsa, Okalahoma, Whitfield (1982) found that the effects of food stamps were neither uniformly positive nor similar to the effects which could be expected under a less expensive system of direct cash payment. Wilde, McNamara, and Ranney (1999) found that participation in SNAP is associated with higher intakes of meats, added sugars, and total fats. They also found significant positive effects of SNAP benefits on nutrient intakes and dietary quality.

In an exhaustive literature review about the effects of food assistance and nutrition programs on nutrition and health, Fox, Hamilton, and Lin (2004) cited nearly 100 studies about the FSP that were published between 1978 and 2003. Most studies were based on analysis of data from large national surveys such as the 1994–96 Continuing Survey of Food Intakes by Individuals (CSFII). In summarizing the literature, Fox, Hamilton, and Lin (2004) concluded that participants in the FSP consistently had greater household food expenditures than non-participants of similar income levels; the FSP increased availability of protein and energy to households, but there was little consistent evidence that participants' dietary intakes were affected.

As to nutrient intakes, Devaney and Moffit (1991) found that SNAP significantly increased household availability of a broad array of vitamins and minerals: vitamins A, C, calcium, and iron, etc. They estimated that SNAP increased the amount of these nutrients available to the household by between 20 and 40 percent of the RDA.

There are two categories of nutrient intakes: household and individual. The hypothesis is that the FSP benefit leads to increased household nutrient availability, which, in turn, leads to increased intakes by individual household members (Fox, Hamilton, and Lin 2004). However, there is no such positive and significant effect found in individual nutrient intakes. In fact, there is a difference between household level and individual level of nutrient intakes. The food eaten by individuals is primarily determined by the food available in the households to which they belong. However, the relationship between nutrient availability at the household level and nutrient intakes at the individual level is weakened by several considerations (Fox, Hamilton, and Lin 2004). The first is that household members may unequally consume nutrients from the food supplies, relative to their needs. Second, some household food supplies are consumed by guests. Third is that some household members may consume food from other sources, including restaurants, school cafeterias, etc. Fourth, some food may be wasted during food preparation process. For this reason, it is important to carry out nutrient education, at least to avoid nutrient loss in food preparation. Moreover, as stated in the previous Chapter, the path between food intakes and nutrient intakes is not necessarily a direct way. Increased availability of food intakes does not necessarily mean the individual will take in more nutrients. For example, fruits and vegetables contain more nutrients like vitamin C and vitamin A than other food, while others may contain more saturated fat or cholesterol, etc. It is crucial to choose the right food instead of just any food. For these reasons, one must examine the dietary intakes of individual household members to adequately assess nutrition-related impacts of SNAP (Fox, Hamilton, and Lin 2004).

Using data from the Food Stamp Cash Out Project, Butler, Ohls, and Posner (1985) found that the effects of SNAP on nutrient intakes were negligible individually, and that controlling for endogeneity of participation with a selection-bias technique did not affect the results. Generally, small and positive effects, usually insignificant, were found. Devaney and Moffitt (1991) used data from the 1979–1980 Survey of Food Consumption in Low-Income Households and found that the dietary effects of SNAP benefit on nutrient availability were considerably larger than those of cash income. They also found that SNAP had significant and positive effects on the availability of food energy, protein, and nine micronutrients.

In recent years, more and more statistical techniques have been applied to the evaluation of SNAP. Multivariate regression analysis has been used to control for observed differences between SNAP participants and eligible non-participants (Devaney and Moffit 1991; Rush 1986). Using data from the 1980–81 Food and Nutrition Service Supplementary Security Income/ Elderly Cashout Demonstration (FNS SSI/ECD) and the 1969–73 Rural Income Maintenance Experiment (RIME), Butler and Raymond (1996) presented one of the few exceptions to the existing literature by considering a system of nutrient equations with a single endogenous SNAP variable. They argued that the previous findings of positive program effects on nutrient intakes could be the result of self-selection into the program by individuals who were more interested in maintaining good nutrition. Using a sample of elderly people and a two-step procedure, they estimate an SRS with endogenous SNAP participation which, after imposing parametric restrictions to avoid overparameterizing the system, reduces to a treatment effect system (discussed below). They found that nutrition was negatively, though not notably, affected by food stamp income. To date, findings on the effect of sample selection bias have been mixed. Fraker (1990) conducted a review of six early studies, which examined the effects of food stamp benefits on nutrient intakes of participants. The studies in his review were inconsistent and showed little relation between food stamp benefits and nutrient intakes; only a small proportion of the food stamp effects were statistically significant. Weimer (1998) found no significant relationship between food stamp participation and nutrient intakes among the elderly. Rose, Habicht, and Devaney (1998) found that the marginal effects of food stamp benefits on iron and zinc intakes were positive, statistically significant, and much greater than the corresponding marginal effects for cash income. Cason et. al. (2002) suggested that there were relatively few differences in intakes of food groups and selected nutrients between SNAP and non-SNAP households. Gleason et. al. (2000) used data from 1994–96 CSFII to compare regressions on adjusted means for low-income individuals, and concluded that SNAP had a positive but insignificant effect on participants' nutrient intakes. Using a system of nutrient equations with dual endogenous programs (SNAP and WIC), estimated by the maximum-likelihood procedure, Yen (2009a) found that participation in SNAP greatly increased the intakes of protein among nutritionally deprived children. The paper by Yen (2009a) was one of the rare applications of equation systems with dual treatment effects, but the 1994–96 CSFII data used were very old, calling for reconfirmation of the results with more recent data. Cason et. al. 2002 compared dietary changes after Expanded Food and Nutrition Education Program (EFNEP)[2] training in 2,182 and 1,939 Food Stamp Program and non-Food Stamp Program participants, respectively. Both groups increased intakes (in servings) of protein, dairy, vegetables, fruits, grains, and the fats and sweets groups. Intakes of iron, calcium, vitamin A, vitamin C, and dietary fiber also increased. The only significant difference between FSP non-participants and participants was that the former consumed more grains while the latter consumed a greater amount of vitamin C.

[2] The Expanded Food and Nutrition Education Program (EFNEP) is designed to assist limited resource audiences in acquiring the knowledge, skills, attitudes, and behavior changes necessary for nutritionally sound diets (USDA 2009).

Overall, the aforementioned empirical literature suggested that SNAP had little to no impact on individuals' nutrient intakes. A few reasons are possible. With more money available, a recipient household may choose to buy convenient food which contains less nutrition; or it may choose to buy a high-end brand at a higher price for the same food which contains the same amount of nutrition; or it may choose to eat out, clearly at a higher price for the same nutrition. In contrast, non-recipients may choose to prepare food from fresh products which are nutritious, or they may eat at friends' house, church, or other places providing free meals. Under the above circumstances, it is not difficult to find non-recipients with better nutrient intakes than recipients. It is also worth noting that data used in most of the existing studies are more than ten years old. During that time, nutrition education has not been widely carried out among recipients. In fact, in 1992, only five states applied for and received optional funding for nutrition education activities in SNAP, with a Federal share of total expenditure of only $661,000. However, by 2007, 52 states had approved nutrition education plans, with Federal expenses reaching $270 million (USDA/FNS 2006). Without nutrition education, SNAP does not seem to have accomplished its stated goal of improving nutrient intakes among the low-income individuals.

Despite a host of empirical studies analyzing the dietary status of the U.S. population and various subgroups, several factors suggest the need for an updated research (Devaney et. al. 2005). One of them is the new dietary reference standard called the Dietary Reference Intakes (DRIs) (Institute of Medicine 1997). "DRI refers to a set of at least four nutrient-based reference values that can be used for planning and assessing diets and for many other purposes" (Institute of Medicine 1997, p.21).

The above empirical literature on nutrient and food intakes suggests that estimates of program effects differ. This thesis is an attempt to investigate the effects of SNAP with an improved methodology—by estimating nutrient intakes equations in a system and by treating SNAP participation as endogenous.

Besides SNAP and nutrient intakes, the more recent literature has focused more on the relationship between SNAP participation and other outcomes such as obesity (Gundersen, Garasky, and Lohman 2009). Meyerhoefer and Pylypchuk (2008) suggested that program participation by women increased their likelihood of overweight and obesity. Webb et. al. (2008) also found that program participation was associated with higher BMI in low-income household. Another intriguing topic is SNAP and food security. Wilde and Nord (2005) found negative impact of SNAP participation on food security. However, using data from 1996–97 National Food Stamp Program Survey, Yen et. al. (2008) found that participation in SNAP reduced the severity of food insecurity.

Chapter 3

Methodology

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 intakes 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; Yen 2009a).

To investigate the effects of SNAP participation on nutrient intakes, a set of nutrient equations is estimated as a switching regression system. A series of hypotheses will be tested, including: endogeneity of SNAP participation and simultaneity among nutrition intakes. The estimated nutrient equation system allows investigation of (i) the effects of income and other explanatory variables on SNAP participation; and (ii) the effects of SNAP participation and other explanatory variables on nutrient intakes. The econometric model is presented below, along with tests of the proposed model against a number of its restricted forms.

3.1 The Switching Regression System

This chapter presents the primary econometric model—an equation system with binary endogenous switching or a SRS. Switching regression models (SRMs) dated back to Roy (1951) who was concerned with an individual's decision between earning income as a fisher or hunter, and they have been used extensively in economics. Important contributions of SRMs include Heckman (1990) and Heckman and Honoré (1990). Vijverberg (1993) reviewed their applications in labor economics which estimate earning differentials by union/nonunion status, public/private sector, occupational status, migrant/stayer distinction, formal/informal sector, and level of education; and in housing demand by renter/owner status and household credit by demand/supply constraint. Important applications in food, nutrition and health include investigation of shopping frequencies and food intakes decisions (Wilde and Ranney 2000), effects of food label use on nutrient intakes (Kim, Nayga, and Capps 2001), use of preventive care among the immigrant population (Pylypchuk and Hudson 2009), body weight determination with endogenous weight categories (Yen, Chen, and Eastwood 2009), and effect of physical activity on body weight (Yen 2009b). All existing SRM applications feature regression functions for one outcome variable, most of which are governed by a binary probit switching mechanism (Amemiya 1985, pp. 399−400; Maddala 1983, p. 223). Lee (1976) extended the SRM for a single outcome variable to one with multiple outcome variables, that is, an SRS which, to our knowledge, has not been used in empirical applications.

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 = 1, and take another set of values when d_t = 0. In this case, the decision for individual t to participate in SNAP or not is observed and determined by individual and household characteristics according to the probit mechanism

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

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

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

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

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

This thesis focuses on the form of SRS in (2) in which each dependent variable is logarithmically transformed (Yen and Rosinski 2008). Because SNAP participation outcome is binary, parameters in the program participation equation (1) are identified only up to a scale and therefore, the variance of error terms ε_t is set to unity. In addition, because the participant and non-participant regimes are mutually exclusive, as in conventional SRMs with one outcome variable, elements of Σ_{uv} and Σ_{vu} are not identifiable (do not appear in the likelihood function below) and are not estimated.

Development of the likelihood function is based on the following sub-matrices of the covariance matrix Σ:

$$\Sigma^{(0)} = \begin{bmatrix} \Sigma_{\varepsilon\varepsilon} & \Sigma_{\varepsilon u} \\ \Sigma_{u\varepsilon} & \Sigma_{uu} \end{bmatrix} = \begin{bmatrix} 1 & \Sigma_{\varepsilon u} \\ \Sigma_{u\varepsilon} & \Sigma_{uu} \end{bmatrix} = \begin{bmatrix} 1 & \sigma_1\rho_{\varepsilon 1} & \cdots & \sigma_m\rho_{\varepsilon m} \\ \sigma_1\rho_{1\varepsilon} & \sigma_1 & \cdots & \sigma_1\rho_{1m} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_m\rho_{m\varepsilon} & \sigma_m\rho_{m1} & \cdots & \sigma_m^2 \end{bmatrix} \tag{4}$$

$$\Sigma^{(1)} = \begin{bmatrix} \Sigma_{\varepsilon\varepsilon} & \Sigma_{\varepsilon v} \\ \Sigma_{v\varepsilon} & \Sigma_{vv} \end{bmatrix} = \begin{bmatrix} 1 & \Sigma_{\varepsilon v} \\ \Sigma_{v\varepsilon} & \Sigma_{vv} \end{bmatrix} = \begin{bmatrix} 1 & \theta_1\tau_{\varepsilon 1} & \cdots & \theta_m\tau_{\varepsilon m} \\ \theta_1\tau_{1\varepsilon} & \theta_1 & \cdots & \theta_1\tau_{1m} \\ \vdots & \vdots & \ddots & \vdots \\ \theta_m\tau_{m\varepsilon} & \theta_m\tau_{m1} & \cdots & \theta_m^2 \end{bmatrix} \tag{5}$$

Let $g(u_{1t},...,u_{mt};\Sigma_{uu})$ be the *m*-variate marginal probability density function (pdf) of $u_t \equiv [u_{1t},..,u_{mt}]' \sim \text{N}(0,\Sigma_{uu})$ and $h(\varepsilon_t \mid u_t) \equiv h(\varepsilon_t \mid u_{1t},...,u_{mt};\xi_0,\omega_0^2)$ the univariate conditional pdf of $\varepsilon_t \mid u_t \sim \text{N}(\xi_0,\omega_0^2)$, where, using properties of the multivariate normal distribution (Kotz, Balakrishnan, and Johnson 2000),

$$\xi_0 = \Sigma_{\varepsilon u}\Sigma_{uu}^{-1}u_t \tag{6}$$

$$\omega_0^2 = \Sigma_{\varepsilon\varepsilon} - \Sigma_{\varepsilon u}\Sigma_{uu}^{-1}\Sigma_{u\varepsilon} \tag{7}$$

which are both scalars. Likewise, let $g(v_{1t},\dots,v_{mt};\Sigma_{vv})$ be the *m*-variate marginal probability density function (pdf) of $v_t \sim \mathrm{N}\,(0,\Sigma_{vv})$ and $h(\varepsilon_t \mid v_{1t},\cdots,v_{mt};\xi_1,\omega_1^2)$ the univariate conditional pdf of $\varepsilon_t \mid v_t \sim \mathrm{N}\,(\xi_1,\omega_1^2)$, such that

$$\xi_1 = \Sigma_{\varepsilon v}\Sigma_{vv}^{-1} v_t \tag{8}$$

$$\omega_1^2 = \Sigma_{\varepsilon\varepsilon} - \Sigma_{\varepsilon v}\Sigma_{vv}^{-1}\Sigma_{v\varepsilon}. \tag{9}$$

Then, the likelihood function for an independent sample of size *n* is

$$L = \prod_{t=1}^{T}\left(\prod_{j=1}^{m} y_{jt}^{-1}\right)\left[g(u_{1t},\dots,u_{mt})\Phi\left(-\frac{z_t'\gamma+\xi_0}{\omega_0}\right)\right]^{(1-d_t)} \times \left[g(v_{1t},\dots,v_{mt})\Phi\left(\frac{z_t'\gamma+\xi_1}{\omega_1}\right)\right]^{d_t} \tag{10}$$

where Φ is the univariate standard normal cumulative distribution function (cdf), $u_{it} = \log y_{it} - x_t'\beta_{0i}$, $v_{it} = \log y_{it} - x_t'\beta_{1i}$, and $\Pi_{j=t}^{m} y_{jt}^{-1}$ is the Jacobain of the transformation from $(u_{1t},\dots,u_{mt})$ to $(\log y_{1t},\dots,\log y_{mt})$ for the non-participant sample and from $(v_{1t},\dots,v_{mt})$ to $(\log y_{1t},\dots,\log y_{mt})$ for the participant sample. Maximum-likelihood (ML) estimation is carried out by maximizing the likelihood function(10). The SRS nests several restricted models, which are discussed below.

3.1.1 *Treatment Effects System (TES)*

By imposing the following parametric restrictions, the SRS reduces to the TES:

$$\Sigma^{(0)} = \Sigma^{(1)};\ \ \overleftarrow{\beta}_{0i} = \overleftarrow{\beta}_{1i} \quad (i = 1,\dots m) \tag{11}$$

where, for each *i*, $\overleftarrow{\beta}_{0i}$ and $\overleftarrow{\beta}_{1i}$ are both (*k*–1)-vectors with the first element of β_{0i} and β_{1i} removed, respectively. In other words, all elements of the pair of parameter vectors β_{0i} and β_{1i} for each (the *i*th) outcome are set to equal between non-participants and participants except the intercept terms. The TES is an interesting model in itself, which is characterized by SNAP participation equation (1) and the system of nutrient equations

$$\log y_{it} = x_t'\beta_i + \gamma d_t + u_{it},\ i = 1,\dots,m;\ t = 1,\dots,T, \tag{12}$$

in which the participation variable d_t appears as a binary endogenous regressor on the RHS. The error vector $[\varepsilon_t, u_{1t},\dots,u_{mt}]'$ is distributed as $(m+1)$-variate normal with zero means and covariance matrix $\Sigma^{(0)}$ as in Equation (4). Define a dichotomous indicator

$$\kappa_t = 2d_t - 1 \tag{13}$$

such that $\kappa_t = 1$ if $d_t = 1$ and $\kappa_t = -1$ if $d_t = 0.$. Then, the sample likelihood function for the TES is

$$L = \prod_{t=1}^{T} \left(\prod_{j=1}^{m} y_{jt}^{-1} \right) g(u_{1t},\dots,u_{mt}) \Phi \left\{ \kappa_t \left(\frac{z_t'\alpha + \xi_0}{\omega_0} \right) \right\}. \tag{14}$$

The TES can be estimated by maximizing the likelihood function (14), or by imposing the parametric restrictions (11) on the likelihood function (10) of the SRS. Thus, by subjecting only the constant term of each outcome equation to endogenous switching, the SRS reduces to the TES. This is the equation system considered by Butler and Raymond (1996), who also investigate the effect of FSP participation on nutrient intakes, which was estimated with a less efficient two-step procedure. Test of the SRS against the TES can be done by the likelihood-ration (LR) test for the restrictions in Equation (11). Specifically, denote the maximum log-likelihood of the two models as $\log L_{SRS}$ and $\log L_{TES}$. Then, the test statistic $LR = 2(\log L_{SRS} - \log L_{TES})$ is χ^2-distributed with $m(k-1) + (m+1)(m+2)/2 - 1$ degrees of freedom, where k is the dimension of x_t. The SRS also nested a number of other restricted models, which are presented below.

3.1.2 *Exogenous Switching System*

Imposing restrictions that error correlations between SNAP and the nutrient equations are uncorrelated (for both participants and non-participants):

$$\rho_{1\varepsilon} = \ldots = \rho_{m\varepsilon} = 0;\ \tau_{1\varepsilon} = \ldots = \tau_{m\varepsilon} = 0 \tag{15}$$

reduces the SRS to an exogenous switching equation system, which can be estimated by separate probit using the full sample, and the nutrient equation systems (2) separately for the participant and non-participant samples. Test for the restrictions in (15) amounts to a test for endogeneity of switching.

3.1.3 *Exogenous Switching Single Equations*

Imposing the further restrictions that all error correlations among the nutrient equations are uncorrelated, the SRS reduces to one with exogenous switching single outcome equations. The parametric restrictions are

$$\begin{aligned} &\rho_{1\varepsilon} = \ldots = \rho_{m\varepsilon} = 0;\ \rho_{ij} = 0\ (\forall\ i, j = 1,\ldots,m; i > j); \\ &\tau_{1\varepsilon} = \ldots = \tau_{m\varepsilon} = 0;\ \tau_{ij} = 0\ (\forall\ i, j = 1,\ldots,m; i > j). \end{aligned} \tag{16}$$

This restricted model can be estimated by separate probit using the full sample, and all nutrient equations (2) separately by ordinary least-squares (OLS), equation-by-equation, for the participant and non-participant samples. Note that in the absence of cross-equation restrictions, seemingly unrelated regression (SUR) of the exogenous switching system (Section 3.1.2) and OLS estimation of the exogenous switching single equations (Section 3.1.3) produce identical estimates.

3.1.4 *Nutrient Equation System with Exogenous Treatments*

Exogeneity of the treatments (variable d_t) in the nutrient equation system amounts to imposing the restrictions to the TES (12):

$$\rho_{1\varepsilon} = \ldots = \rho_{m\varepsilon} = 0. \tag{17}$$

This model can be estimated by separate estimation for the probit equation for SNAP participation and the nutrient equation system (with an exogenous dummy variable d_{it} in each nutrient equation), both with the full sample.

3.1.5 *Single Nutrient Equations with Exogenous Treatments*

Exogeneity of the treatments (variable d_t) in each (single) nutrient equation amounts to imposing the restrictions to the TES:

$$\rho_{1\varepsilon} = \ldots = \rho_{m\varepsilon} = 0;\ \rho_{ij} = 0\ (\forall\ i, j = 1,\ldots,m; i > j) \tag{18}$$

This model can be estimated by separate estimation for the probit equation for SNAP participation and each of the nutrient equations separately, equation-by-equation with ordinary least-squares (OLS), with an exogenous dummy variable d_{it} for SNAP participation, all with the full sample. As in the exogenous switching system case, due to the lack of cross-equation restrictions, SUR estimation of the exogenous nutrient equation system (Section 3.1.4) and OLS estimation of the single nutrient equations (Section 3.1.5) would produce identical estimates.

3.2 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 in SNAP participation and nutrient intakes by calculating marginal effects. Both sets of measures are based on the conditional means 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

$$\Pr(d_t = 1) = \Pr(\varepsilon_t > -z_t'\gamma) = \Phi(z_t'\gamma). \tag{19}$$

Based on (pairwise) bivariate normality of (ε_t, u_{it}) and (ε_t, v_{it}) for all $i = 1,\ldots,m$, the conditional means of y_{it} are (Yen and Rosinski 2008)

$$
\begin{aligned}
\mathrm{E}(y_{it} \mid d_t = 0) &= \exp(x_t'\beta_{0i})\,\mathrm{E}(e^{u_{it}} \mid \varepsilon_t \le -z_t'\gamma) \\
&= \exp(x_t'\beta_{0i} + \sigma_i^2/2)\,\frac{\Phi(-z_t'\gamma - \sigma_i\rho_{i\varepsilon})}{\Phi(-z_t'\gamma)}
\end{aligned} \tag{20}
$$

$$
\begin{aligned}
\mathrm{E}(y_{it} \mid d_t = 1) &= \exp(x_t'\beta_{1i})\,\mathrm{E}(e^{u_{it}} \mid \varepsilon_t > -z_t'\gamma) \\
&= \exp(x_t'\beta_{1i} + \theta_i^2/2)\,\frac{\Phi(z_t'\gamma + \theta_i\tau_{i\varepsilon})}{\Phi(z_t'\gamma)}.
\end{aligned} \tag{21}
$$

Marginal effects of explanatory variables can be derived by differentiating (and differencing, in the case of a discrete explanatory variable) equations (19), (20) and (21).

We draw on the results for a similar model, specifically SRM with a single outcome variable, by Heckman, Tobias, and Vytlacil (2001) and calculate alternative treatment effects. First, using Equations (20) and (21), the treatment effect (TE) for nutrient *i* and observation *t* is

$$
\begin{aligned}
TE_{it} &= E(y_{it}^{(1)} \mid d_t = 1) - E(y_{it}^{(0)} \mid d_t = 0) \\
&= \exp(x_t'\beta_{1i} + \theta_i^2/2)\,\frac{\Phi(z_t'\gamma + \theta_i\tau_{i\varepsilon})}{\Phi(z_t'\gamma)} \\
&\quad - \exp(x_t'\beta_{0i} + \sigma_i^2/2)\,\frac{\Phi(-z_t'\gamma - \sigma_i\rho_{i\varepsilon})}{\Phi(-z_t'\gamma)}.
\end{aligned} \tag{22}
$$

The treatment effect on the treated (TT), a conceptually different parameter, is the average gain from treatment for those who actually selected into the treatment. It can be calculated as

$$
\begin{aligned}
TT_{it} &= E(y_{it}^{(1)} \mid d_{it} = 1) - E(y_{it}^{(0)} \mid d_{it} = 1) \\
&= \exp(x_t'\beta_{1i} + \theta_i^2/2)\left(\frac{\Phi(z_t'\gamma + \tau_{i\varepsilon}\theta_i)}{\Phi(z_t'\gamma)}\right) \\
&\quad - \exp(x_t'\beta_{0i} + \sigma_i^2/2)\left(\frac{\Phi(z_t'\gamma + \rho_{i\varepsilon}\sigma_i)}{\Phi(z_t'\gamma)}\right)
\end{aligned} \tag{23}
$$

In Equations (22) and (23), $y_{it}^{(1)}$ 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 defined as the expected gain from participating in the program for a randomly chosen individual, and can be calculated as

$$
ATE_{it} = \exp(x_t'\beta_{1i} + \theta_i^2/2) - \exp(x_t'\beta_{0i} + \sigma_i^2/2). \tag{24}
$$

All treatment effects are calculated for each individual observation and average over the sample, weighted by the sample weight. Treatment effects for the TES can be calculated by imposing restrictions (11) to Equations (22), (23) and (24). For statistical inference, standard errors of marginal effects and of the treatment effects can be calculated by mathematical approximation (the delta method) (Spanos 1999, p. 493)

3.3 National Health and Nutrition Examination Survey (NHANES)

Data in this study come from the National Health and Nutrition Examination Survey (NHANES 2003–04, 2005–06), conducted by the U.S. Center for Disease Control and Prevention (CDC 2004a, 2004b), which provides critical information on the health and nutritional status of the U.S. population. Its target population is the civilian, non-institutionalized population in the U.S.

The NHANES began in the early 1960s and has been conducted on a periodic basis from 1971 to 1994, which were released as single, multiyear data sets. The survey has become a continuous program since 1999. Data collected in the 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.

Total nutrient data came from first-day dietary interviews, collected in person in a private room of the MEC, and the second interview is collected by phone three to seven days after the first interview. The data collected in dietary interviews are used to estimate the types and amounts of foods and beverages consumed during the 24-hour period prior to the interview (midnight to midnight), and to estimate intakes of energy, nutrients, and other food components from those foods and beverages. In the first interview, the participants use measuring guides such as different sizes of glasses, bowls or other measurement instruments to give description of food intakes, under professional instruction. After the first interview, the participants are given a set of measurement instruments including measuring cups, spoons, a ruler, and a food model booklet, in order to report food amount in the follow-up phone interview.

In the 2005–06 NHANES, 9950 individuals came to MEC for a first-day interview. Among those, 9349 persons provided complete dietary intakes information for day one. Of all the people who provided complete day one information, only 8429 persons provided complete information for follow-up phone interview. In 2003–04, it is reported that 87 per cent of the participants have 2 days of complete nutrient intakes. Considering follow-up phone interview data were subject to non-sampling errors such as recall problems, misunderstanding of the questions, and a variety of other factors, only MEC interview data are used in this analysis. Interview data files for 2005–06 were analyzed following USDA's Food and Nutrient Database for Dietary Studies 3.0 (FNDDS 3.0). Interview data files for 2003–04 were analyzed following USDA's Food and Nutrient Database for Dietary Studies 2.0 (FNDDS 2.0). Besides total nutrient data, other data were collected at in-home interviews. In-home interview is a face-to-face interview conducted by trained interviewers at interviewee's residence.

3.4 Sample Selection Process

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 SNAP is based on a cut-off point for gross annual income—below 130% of the Federal poverty level adjusted for household size. The Federal poverty level is set by the number of family size. For example, the 2009 poverty guidelines for the 48 contiguous states and the District of Columbia specify that the Federal poverty line is $14,570 annual gross income per year for a family with two people, $18,310 for a family with three people, and $22,050 for a family with four people, and so on. The SNAP participation variable used in this study is a binary indicator indicating whether the respondent was receiving SNAP benefits at the time of the survey and examination. Since the nutrients examined in this study are absorbable within a short time, program participation is defined as current participation status.[3]

Women who are pregnant or lactating are excluded from the sample because they have unique levels of DRIs compared to other women. Many physiological changes and changes in nutrient needs occur during these life stages, such as increased absorption and greater conservation of many nutrients. Moreover, there may be net losses of some nutrients that occur physiologically regardless of the nutrient intakes (IOM 1997). In order to focus on adults and be consistent with age division of DRI table announced by the USDA, individuals under 20 years of age were also excluded from the sample. The remaining individuals were classified into four age groups according to the DRI table provided by the USDA: 20–30, 31–50, 51–70, and > 70. After excluding observations with missing information on important variables, a final sample of 1892 SNAP eligible individuals is used in the analysis.

Of the final sample used, only 17 percent of SNAP eligibles had actually applied for and received SNAP benefits. The reason might be those who care more about nutrition are at the same time more likely to apply for and receive SNAP and more likely to maintain a nutritionally adequate diet (Butler and Raymond 1996, p. 781). The possible self-selection problem is reflected in program participation equation. The reasons for the low participation rate might include socio-psychological and social stigma factors, that is, "disutility arising from participation in a welfare program per se" (Moffitt 1983, p. 1023). For instance, a person might feel embarrassed or concerned about receiving discriminatory treatment while buying groceries with an EBT card.

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[3] The level of vitamin A in one's body, for instance, reflects her current food and nutrient conditions in recent days. Therefore, whether she participated in SNAP in the past 12 months has little connection with her current nutrient intake. What matters is whether she is currently participating in SNAP.

Five nutrients are included in this study: protein, vitamin A, vitamin C, iron, and calcium. Vitamin A is important for normal vision, gene expression, reproduction, embryonic development, growth, and immune function. The hepatic vitamin A concentration can vary markedly depending on dietary intakes. Iron functions as a component of a number of proteins, including enzymes and hemoglobin, the latter being important for the transport of oxygen to tissues throughout the body for metabolism. The iron content of vegetables, fruits, breads, and pasta varies from 0.1 to 1.4 mg/serving. Because most grain products are fortified with iron, approximately one-half of ingested iron comes from bread and other grain products such as cereal and breakfast bars (IOM 2001). Calcium plays a key role in the development and maintenance of bone and other calcified tissues. It accounts for 1 to 2 percent of adult human body weight, and 99 percent of body calcium is found in bone or other calcified tissues. The remainder is present in blood (IOM 1997). Food sources of calcium vary, and its absorption efficiency is fairly similar for most foods, including milk, milk products, and grains (major food sources of calcium in North American diets). According to data from 1994, 73 percent of calcium in the U.S. food supply is from milk products, 9 percent from fruits and vegetables, 5 percent from grain products, and the remaining 12 percent from all other sources (USDA-CNPP 1996).

Each outcome (dependent) variables is nutrient intakes expressed as a percent of nutrient DRI. The DRI differs from previous Recommended Dietary Allowance (RDA). According to a report by the Institute of Medicine (IOM 2000, pp. 2–3), the differences are: (1) where specific data on safety and efficacy exist, reduction in the risk of chronic degenerative discase is included in the formulation of the recommendation rather than just the absence of signs of deficiency; (2) upper levels of intakes are established where data exist regarding risk of adverse health effects; and (3) components of food that may not meet the traditional concept of a nutrient but are of possible benefit to health will be reviewed, and if sufficient data exist, reference intakes will be established.

Following the new DRI standard, for male adults, vitamin A (in mcg) is divided by 900, vitamin C (mcg) by 90, iron (mcg) by 8, and protein (mg) by 46. For female adults, vitamin A is divided by 700, vitamin C by 75, and protein by 38. For both males and females, calcium (mcg) is divided by 1000 for the 20–50 age group and by 1200 for the age > 51 group; iron is divided by 18 for those age 20–50, and by 8 for those age > 50 (IOM 1997, pp. 109–117; IOM 2000, pp. 147–149; IOM 2001, p.115, p.344; IOM 2002, pp.645–649).

Sample statistics of nutrient intakes as percentages of DRIs are presented in table 1. Mean intakes of protein, vitamin C and iron are over 100%DRI, suggesting that SNAP-eligible group are not, on average, deficient for these three nutrients. In contrast, mean intakes of vitamin A and calcium are under 100% of the DRI, which means individuals in the sample are, on average, deficient in the two nutrients. These sample means different from those presented by Currie (2000), who stated that both food stamp recipients and non recipients had food available for consumption in the home that exceeded the DRIs for major nutrients. Protein available in food, for example, averaged 232 percent of DRI for recipients and 203 percent for non-recipients; for vitamin C, the respective percentages were 290 percent and 264 percent (Currie 2000).

The explanatory variables include household characteristics such as household income (expressed as a percentage of Federal poverty level), household size, respondent’s education, age and dummy variables characterizing country of origin, marital status, race, experience of receiving emergency food, health insurance condition, home ownership, physical activity, presence of child(ren), use of dietary supplement(s), self-assessed health condition, body mass index (BMI; see table 1), and risky behavior (smoking). All estimation and sample statistics calculations are weighted, using a combined sample weight suggested by the CDC (2006).

During preliminary analysis, a number of food insecurity variables were also considered. These variables indicate whether child(ren) has balanced food, whether household food did not last long, and whether the interviewee considered oneself less food secure or worried about running out of food. These variables were expected to be good instruments of SNAP participation but, surprisingly, none were found to affect SNAP participation (or nutrient intakes) so they were not included in the analysis.

Income is expressed as a percentage of Federal poverty level (which, by construction, is under or equal to 1.3). Education level is presented by a dummy variable: college and higher degree. A dummy variable is also used to indicate the country of origin (i.e., where the individual was born). Household ownership means if respondent's current residence is self-owned or rented, which would be another good indicator of the respondent's financial status besides income. Marital status reflects one's social status and life style, and it is divided into three categories considering the impacts of the status on food preparation practices in the household: married or cohabitated, divorced or widowed, and single. Single individuals are more likely to prepare easily accessed food or to eat out. In contrast, individuals who are married or cohabitating with a partner tend to prepare nutritious food because of the possibility of the existence of children. Likewise, divorced, separated or widowed individuals have higher possibility of having children than single individuals. The food preparation practice in these households may be quite different from households with individuals living alone.

Besides socio-demographic factors, an individual's thoughts or beliefs can affect food and nutrient intakes in a significant and subtle way. Self-assessed health is one of the interesting elements of this paper because it reflects respondent's psychological status. Finally, because the data came from two waves of the NHANES, a dummy is used to indicate the year 2005–06.

Detailed definitions and sample statistics of all explanatory variables are presented in table 1. The average age is 50.2, and 21% of the sample are between ages 20–30, 31% between

31–50, 26% between 51–70, and 21% are over 70 of age. About 34% are Hispanic, 40% Caucasian, 23% African-American, and 3% are of other races. About 27% of the sample have a college degree.

Nineteen percent of the sample are single, 50% are married or cohabitating with a partner, and 31% are divorced, widowed or separated. Fourty-six percent have children. Twenty-five percent of the sample consider themselves in excellent or very good health, 68% in good or fair health, and only 7% in poor health. Sixty-seven percent of the sample have health insurance coverage, and 39% were taking a dietary supplement regularly.

When analyzing the combined NHANES data, it is suggested by USDA that the corrected sampling weights must be used to produce unbiased estimates (CDC, 2006). The NAHNES includes over-sampling of low-income individuals, adolescents age 12–19, individuals age ≥ 60, African Americans, and Mexican Americans (Devaney et. al. 2005). Sample weight is used in all computations (sample statistics and estimation) in this study.

Data collected in NHANES came from varied sources. The source of a data item (interview, MEC, etc.) is important for both assessment of quality of information and for determination of the appropriate sampling weight for use in statistical estimation. The proper sampling weight must be used. Since data for the dependent variables (nutrient intakes) came from the MEC examinations, the sample weight for MEC is used in this paper.

Since data from two different two year cycles of the NHANES were combined to form the data set used in the analysis, the sample weights provided by USDA for each two-year cycle had to be modified to create a single four-year sample weight. In combining the two waves of the NHANES (2003–04 and 2005–06), if the person is sampled in 2003–04, the proper weight for the merged sample equals to the 2003–04 weight times 0.5; if the person was sampled in 2005–06, the proper weight is the 2005–06 weight times 0.5.

Chapter 4

Results

The empirical analysis includes estimation of and comparisons between the SRS and TES. The SRS is estimated by programming the likelihood function (Equation (10)) in GAUSS, using two-step estimates of the nutrient-by-nutrient SRMs (Maddala 1983, pp. 223–228) as initial values. The TES is estimated both by imposing parametric restrictions on the SRS and by programming its likelihood function (Equation (14)), which produces identical results. These models are tested against a number of further restricted specifications. Tables of sample statistics, estimation results and model specification tests are presented in Tables and Appendix.

One important empirical issue was the choice of regressors to explain program participation and nutrient intakes. Unlike a linear system or in instrumental variable estimation for which exclusion conditions are needed for identification (e.g., Currie and Cole 1993; Butler and Raymond 1996), the nonlinear identification criteria are met due to the functional form and distributional assumptions for ML estimation of the current system. However, to avoid overburdening functional form and distributional assumptions for parameter identification in the absence of exclusion restrictions, some exclusion restrictions are imposed. The empirical strategy is, besides a common set of variables used in all equations, a unique set of variables are included in SNAP participation equation and another unique set in the nutrient equations. Variables unique in SNAP participation equation are home ownership (renter), household size and three age dummy variables (age 20–30, age 31–50, and age 51–70).[4]

---

[4] Three dummy variables were included in the SNAP participation equation in preliminary analysis: whether the household worries about running out of food, can provide children balanced food, and can have balanced food for adults. These food security variables can have

Variables used uniquely in the nutrient equations include dummy variables indicating whether the individual was taking dietary supplement(s), or had been diagnosed with problems with blood pressure; lifestyle variables indicating whether the individual actively participates in physical activity; BMI which reflects personal physiques. In addition, 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 equations, with age^2 capturing potentially nonlinear effect of age on nutrient intakes. Importantly, to accommodate gender differences, college education, physical activity, and BMI are interacted with the gender dummy variable female. Use of these unique variables in the nutrient equations, in addition to the exclusion restrictions discussed above, guarantees that the model parameters are identified.

Admittedly, BMI and high blood pressure might be potentially endogenous, which can cause simultaneous equation biases. Accommodating endogeneity of these variables would be difficult for current econometric frame work, especially in the absence of useful instruments to explain variations in these variables. However, a parsimonial approach is to estimate the model with these potentially endogenous variables excluded. The result of this estimation, carried out during preliminary analysis, shows not only similar treatment effects of program, but also similar marginal effects of explanatory variables. Also during preliminary analysis, the same set of age variables (Age and Age^2; and alternatively the age dummy variables) are included in both the SNAP participation equation and the nutrient equations, which also produced similar parameter estimates, treatment effects, and marginal effects. In sum, the empirical results are robust with respect to the exclusion restrictions. The rest of this chapter discusses model specification tests to

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more direct effects on SNAP participation than they can on nutrient intakes and therefore can be good instruments for the SNAP participation equation. Unfortunately, these variables were found insignificant and therefore are not included in the SNAP participation equation.

distinguish among the SRS, TES, and two additional restricted models, ML estimates of the SRS, effects of treatment (SNAP participant) on nutrient intakes, marginal effects of explanatory variables on SNAP participation, and marginal effects of explanatory variables on nutrient intakes.

4.1 Model Specification Tests

The next important empirical issue relates to gender differences. Due to the large system (and large number of parameters) and relatively small sample size, it is not possible to allow for gender differences in the whole set of parameters.[5] Therefore, gender effects are accommodated by interacting the gender dummy (female) with a sub-set of regressors (table 3), selected by an extensive search in preliminary analysis with separate nutrient SRMs in which many other gender-interacted variables were found insignificant. Based on results of the LR test (table 2), the hypothesis of gender equality (in the selected set of parameters) is rejected (LR = 112.182, *p*-value < 0.0001), justifying inclusion of the gender-interacted variables in the nutrient equations.

Table 2 presents results of the LR tests among the different models, with the hypothesis of gender differences maintained. Besides the TES (Section 3.1.1), four additional restricted models are considered (see Sections 3.1.2–3.1.5): (1) exogenous switching system, (2) exogenous switching single equations, (3) nutrient equation system with exogenous treatment, and (4) single nutrient equations with exogenous treatments. Due to the lack of cross-equation restrictions, the first exogenous switching system produces identical estimates to the exogenous switching single eqs, separately using the participant and non-participant samples. Likewise, the

[5] Test for such gender differences can be carried out with a LR test, using maximum log-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.

exogenous treatment system produces identical estimates to the exogenous single nutrient equations.

First, the hypothesis that the TES performs as well as the SRS is rejected (LR = 301.25, df = 155, *p*-value < 0.0001), favoring the latter. Further, the hypothesis of zero restrictions on the error correlation between the SNAP participation equation and each nutrient equation in the participant and non-participant samples (see Section 3.1.2, Exogenous Switching System) was rejected (LR = 14.58, 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 SNAP participation equation for the pooled sample (see Section 3.1.4, Exogenous Treatment System) was rejected (LR = 337.73, df = 150, *p*-value < 0.0001), which is also consistent with significance of the error correlation in the TES. Results in table 2 also suggest that both the exogenous switching system and the exogenous treatment system "perform better" than their single-equation counterparts, despite the fact that SUR and OLS produce identical estimates in the absence of cross-equation restrictions. In sum, SRS performs better than TES, and all models perform better than their further restricted specifications.

4.2 ML Estimates of the SRS

ML estimates of the SRS are presented in table 3 (SNAP participation and nutrient equation estimates) and table 4 (error correlations). Over two thirds (13) of the variables in the SNAP equation are significant at the 10% level of significance or lower, and about half of the variables are significant in each of the nutrient equations. All error correlations between SNAP participation and the nutrient intake equations are significant at the 5% level or lower for the participant regimes, while two are significant (protein and iron) for the non-participant regime.

Statistical significance of these error correlations confirms results of model specification tests from the previous section, which suggests endogeneity of SNAP participation. All error correlations among the nutrient equations are significant at the 1% level for the non-participant regime and all but four are significant at the 5% level or lower for the participant regime, which justifies estimation of the nutrient equations in a system (vis-à-vis a separate SRM for each nutrient) in improving statistical efficiency.

The variable Age^2 is significant in the vitamin C, vitamin A and iron equations for the non-participants, which provides evidence of nonlinear effects of age on the intakes of these nutrients. Each of the gender-interacted variables is significant in at least one equation, suggesting gender differences in the effects of college education, physical activity and BMI on nutrient intakes.

Because many of the explanatory variables are used in both SNAP participation equation and nutrient intake equations, and because of the use of quadratic (Age^2) and gender-interacted terms, the effects of explanatory variables on nutrient intake are non-trivial (see Equations (20) and (21)). Further discussion of such effects will be presented below, in terms of treatment and marginal effects.

4.3 Treatment Effect Results

Three different sets of treatment effect measures, average treatment effects on the treated (ATTs), average treatment effects (ATEs), and the treatment effects (TEs), are calculated (see Section 3.2). These treatment effects for the SRS, along with their standard errors calculated with the delta method (Spanos 1999), are presented in table 5.

4.3.1 *Average Treatment Effects on the Treated (ATTs)*

As stated above, the ATT is the average gain from participation in SNAP for those that actually select into the program. The results, presented in table 5, suggest negative effects of SNAP participation on protein and iron, while the effects on other nutrients are not significant. Specifically, participation in SNAP decreases the intake of protein by 73.16% (of DRI) among the female participants and by 70.06% among females and male combined.[6] The effects on iron are also negative and more notable, with participation in SNAP decreasing the intake by 306.32% among males, 113.87% among females, and 200.75% among males and females combined.

4.3.2 *Average Treatment Effects (ATEs)*

The ATEs, defined as the expected gains from participating in the program for a randomly chosen individual, tell a different story (table 5). According to these ATEs, the effects of participation in SNAP are negative on vitamin C and positive on all other nutrients (protein, vitamin A, vitamin C, calcium, and iron), for males, females, and both genders combined. The positive effects of SNAP participation on protein are similar to findings reported by Yen (2009a) for nutritionally deprived children, but differ from findings reported by Butler and Raymond (1996) for the elderly, that protein is negatively affected by SNAP income. The effects of participation in SNAP on vitamin C are only moderate and negative, decreasing intake by 60.22% among males, 47.19% among females, and 53.07% among males and females combined. Whitfield (1982) and Yen (2009a) also report negative effect of SNAP on intake of vitamin C. Devaney et. al. (2005) report that inadequate usual intakes of vitamin C is higher for most of the adolescent and adult SNAP participants groups than for income-eligible non-participants. The

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[6] Despite the units of measurements (i.e., percentages of DRIs), all treatment and marginal effects presented here and henceforth are in absolute and not relative terms.

effects on all other nutrients are positive and very large. For instance, participation in SNAP increases the intake of vitamin A by 508.86% among females and as high as 1012.48% among males — a tenfold increase. Rose, Habicht, and Devaney (1998) also find that participants in SNAP consume more vitamin A than non-participants, while Gleason (2000) reports a negative and insignificant effect of SNAP on vitamin A intake among adults. The smallest positive effect of SNAP participation is seen in calcium among females — an increase of 86.26%, whereas the corresponding effect is 251.75% among males. These positive effects of SNAP participation on calcium among women differ from the negative results reported by Fraker (1990) for women, Dixon (2002) for adults, and Devaney et. al. (2005) for low income individuals, and insignificant results by Butler and Raymond (1996) and Weimer (1998) for the elderly.

Overall, the current results differ from finding in several of the previous studies that participation in SNAP is not significantly related to the intake of most nutrients (Cason et. al. 2002). Butler and Raymond (1996) find that SNAP has negative effect on intakes of several nutrients. Butler, Ohls and Posner (1985) compare raw means between participants and non-participants, and found that non-participants have higher nutrient intake than participants.

4.3.3 *Treatment Effects (TEs)*

Treatment effects (TEs) are calculated with both SRS (table 5) and TES (table A3) results. These TEs are consistent in signs between the two models, although the magnitudes do differ. For instance, SNAP decreases men's vitamin C intake by 36.84% according to the SRS at sample means level. In comparison, it decreases men's vitamin C intake by 28.17% according to the TES at sample mean level. Another example is that SNAP decreases women's vitamin A intake by 13.00% according to the SRS at individual level. It decreases women's vitamin A intake by 6.76% according to the TES at individual level. The significance of TEs calculated with the SRS estimates is relatively scant, compared with results of the TES. For instance, whereas SNAP decreases protein intake by 8.23% for the pooled sample according to the TES, the effect is not significant according to the SRS.

Overall, TEs tend to be negative, which is not the case in ATE. Use of TE has its limitations, because no individual can be in both situations: treated and untreated. Therefore, ATE is more logically suited, and it has been discussed in the previous section.

4.4 Marginal Effects of Explanatory Variables on SNAP Participation

Marginal effects of explanatory variables on the probability of SNAP participation and their standard errors, also calculated with the delta method, are presented in table 6. Of the 25 variables used in SNAP equation, over half (14) are significant at the 5% level of significance or lower. Income plays a negative role in program participation. As income increases (decreases) by 1%, all else equal, the probability of participating in SNAP decreases (increases) by 13.6%. This finding is similar to results reported by Butler and Raymond (1996) that the probability of participation is lower among households with higher income, and by Gundersen and Oliveira (2001) and Yen (2009a) that total household income contributes negatively to participation in SNAP. Households with higher income have less need to participate and may also be less willing to tolerate the stigma factors attached to participation or to incur other non-monetary costs (e.g. time) of participation.

Being born in Mexico and in other countries both have negative effects on program participation. Compared to those born in the U.S., individuals born in Mexico and in other countries are 14.5% and 8.6% less likely, respectively, to participate in SNAP. Compared with individuals who have never been married, being married or residing with a partner is 10.3% less likely to participate in SNAP, which may be due to the potentially multiple income sources in such a household. Unlike single or divorced individuals, which may have only one source of income or bread feeder, married or cohabitating individuals may have more than one person who can go to work. This negative effect of marriage on SNAP participation differs from finding by Butler and Raymond (1996) that the probability of participation in SNAP is lower among individuals who live alone.

Year 05–06 has a negative effect on SNAP participation, suggesting that the probability of participating in the program decreased over time, all else equal. This result contradicts administrative data released by the USDA, which indicates that in FY 2005, participation in SNAP increased 7.8 percent from 23.9 million people the previous year, and issuance increased by 16.03 percent from $24.6 billion in FY 2004 to $28.6 billion in FY 2005. All 53 state agencies (including the District of Columbia, Virgin Islands, and Guam) reported an increase in participation in FY 2005 (USDA 2009a).

Presence of children increases the probability of program participation. This result is similar to the finding reported by Butler and Raymond (1996), who find that the decision to participate in SNAP is significantly increased by the number of children and decreased by the number of adults in the household. Gundersen and Oliveira (2001) also find that households without children are less likely to participate in SNAP. Presence of children may cost the household tuition, clothing, and food etc., causing these households to spend more on these items than households without child(ren) present.

Compared to their cohorts over age 70, younger individuals (age 20–30 and age 31–50) are more likely to participate in SNAP. This negative effect of age is similar to the finding reported by Gundersen and Oliveira (2001) that seniors are less likely to participate in SNAP.

The reason may be that older people have their life savings and are likely free of the burden of child support, and therefore have less need to participate in SNAP for supplemental income.

Compare to White individuals, Hispanics and Blacks are more likely to participate in SNAP, whereas individuals of other races are less likely to participate. Gundersen and Oliveira (2001) report similar findings on race. Renters are more likely to participate in SNAP than home owners, and females more likely to participate than males. Yen (2009a) also finds home owners less likely to participate in SNAP.

4.5 Marginal Effect of Explanatory Variables on Nutrient Intakes

Because we find evidence of gender difference, marginal effects on intakes of nutrients are calculated separately for males and females. Tables 7 and 8 present the marginal effects of explanatory variables on the levels of nutrient intakes, conditional on program participation status. These marginal effects are calculated by differentiating the conditional means presented above (Equations (20) and (21)), using ML estimates and the weighted sample means of all explanatory variables.

For protein intake by men, 10 of the 23 explanatory variables are significant among the non-participants, and 8 out of 23 are significant among the participants, all at the 10% level of significance or lower. For vitamin C intake by men, 7 out of 23 explanatory variables are significant among the non-participants, and 6 out of 23 are significant among the participants, at the 10 level of significance or lower. For vitamin A, calcium and iron, the number of significant explanatory variables among the non-participants are 7, 10 and 13, and the numbers of significant explanatory variables for participants are 7, 9 and 7 respectively.

Explanatory variables have different effects on different nutrients. For example, income has positive and significant effects on protein, calcium, iron, and vitamin A intakes among male non-participants, but no significant effect among male participants. on the marginal effects of many variables are different across nutrient, between participants and non-participant, and between males and females. Further details on marginal effects are presented below, nutrient by nutrient.

4.5.1 *Marginal Effects for Protein Intake*

Factors contributing negatively to protein intake are being born in other countries, age, poor health, being a woman, and high blood pressure. Factors positively contributing to protein intake are household income, divorce, being an African American, presence of children in household and physical activity. Factors with mixed influence in participants and non-participants are household size, home ownership (renter), age group 20–30, and age group 31–50.

Among males, household income has a positive effect on protein intake among the participants but insignificant effects among the participants. As income increases by 1% (of Federal poverty level), intake of protein increases by 12.39% of DRI among the non-participants. The positive effect of income on protein is also seen among female non-participants. These results differ from finding reported by Yen (2009a) that income decreases protein intake among young children (2009a).

For both men and women, household size plays differentiated roles in protein intake between participants and non-participants. Specifically, as household size increases by 1, all else equal, protein intake decreases by 9.89% among participating men but increases by 0.98% among non-participating men. Negative effect of household size on protein was also reported by Butler and Raymond (1996) find. The effects of household size on protein intake are different among women, with each additional household member decreasing intake by 5.79% among the participants and increasing intake by 1.10% among the non-participants. As for the difference in magnitude between women and men, the difference (e.g. –9.89 and –5.79) appears relatively small in reference to their standard errors (being 3.44 and 1.53, respectively).

Personal physique plays a role among SNAP-participating women, with each additional BMI increasing protein intake by 16.19%. BMI does not affect protein intake among men or non-participating women.

A one-year increase in age decreases protein intake by 9.27% among the non-participating women. Similar results are found among males, with one-year increase in age decreasing protein intake by 11.82% among non-participating men. However, no significant effect is found among participants. These negative effects of age differ from result reported by Butler and Raymond (1996) that age is positively related to protein intake.

Women born in Mexico and not participating in SNAP have a 16.04% higher protein intake than those born in U.S. Non-participating women born in other countries (besides U.S. and Mexico) have a 12.75% lower intake of protein than other women. Men born in other countries and not participating in SNAP have 18.22% lower intake of protein than others.

Conditional on non-participation in SNAP, married women have 9.86% higher intake of protein than single women. This positive result of marriage is not seen in men. However, divorced men have 14.36% higher intake of protein than single men. Divorced women also have 10.86% higher intake of protein than single women. These results differ from finding by Butler and Raymond (1996) that living alone often has a large negative effect, at least among the elderly people.

Ethnicity and race also play a role in protein intake, with African American women having higher intake of protein than White women, and African American men having higher intake of protein than other men, conditional on participation in SNAP.

Presence of children has no effect on women's protein intake, but it increases male participants' intake by 30.92%. This positive effect is not seen among non-participating men. This positive effect of children on protein intake may be due to the fact that households with children may pay more attention to nutrition. SNAP provides nutrition education to program participants, and households with children are more likely to participate in this educational activity and therefore have better nutrition knowledge than households without children. When preparing food, households with children might have less nutrition waste.

Compared to individuals with fair self-assessed health, those who consider themselves in poor health have lower protein intake, both for men and women. Woman not owning a home who participate in SNAP have 10.80% higher intake of protein than other women. The corresponding number is slightly higher for men, with men renting a home and participating in SNAP having 18.41% higher intake of protein than other men. In contrast, women renting their current residence and not participating in SNAP have 2.05% lower intake of protein. For male non-participants, the negative effect is –1.82%. This negative effect of renting on protein intake may be due to the fact that participants renting their homes may have less housing expenses than those who owns a home. But since renters can get assistance from outside (SNAP), especially when such assistance benefits are limited to food purchases, they are more likely to have higher nutrient intakes. However, non-participants who rent may have lower income. The effect of home ownership (renting) may therefore appear negative on nutrient intake for non-participates and positive for participants.

Compared to the elderly (age >70), females age 20–30 have 29.73% higher intake of protein, conditional on participation in SNAP, and 5.58% lower intake conditional on non-participation. Similar results are found among males. Specifically, men age 20–30 have 49.09%

higher protein intake conditional on SNAP participation, but 4.56% lower intake conditional on non-participation, than men age > 70.

Similar results are found among women and men between 31 and 50 years old. In fact, the effects of age category variables in binary form (group) have opposite effects in both males and females. Compared to older participants (age >70), younger participants have higher protein intake conditional on SNAP participation but slightly lower intake conditional on non-participation.

SNAP participating men and women diagnosed with high blood pressure have lower protein intake, and such effect is not seen among the anon-participants. Physical activity contributes to protein intake among both males and females (by 16.19% and 33.44% respectively) who participate in SNAP but not among the non-participants.

4.5.2 *Marginal Effects for Vitamin C Intake*

For men, variables contributing negatively to vitamin C intake are BMI, poor health, renting, and age 31–50. Variables contributing positively to vitamin C intake are household size, being born in Mexico, being born in other countries, college education, being African American, and year 2005–06.

Women residing in larger household have higher vitamin C intake, with one additional household member increasing intake by 2.61%, conditional on participation in SNAP. For male participants, an additional member in the household increases vitamin C intake by 2.76%. This result differs from the findings by Yen (2009a) that household size has a negative effect on the intake of vitamin C. Household size does not affect vitamin C intake among non-participating men or women.

Mexican-born women not participating in SNAP have 42.57% higher vitamin C intake than non-participating women born in the U.S. This positive effect is also seen for non-participating men born in Mexico. Men and women born in other countries both have high intake of vitamin C than native born Americans, conditional on non-participation.

Men who attended college have 131.24% higher vitamin C intake than men with only high school, conditional on participation in SNAP. Women with college education have 25.19% higher vitamin C intake than women without college education, conditional on non-participation, whereas the effect of college education is not significant among female participants. The positive effects of college education on vitamin C intake among males are similar to finding by Butler and Raymond (1996) that an increase in education by four years substantially increases vitamin C intake.

African American women have 23.73% higher vitamin C intake, while African American men have 26.18% higher vitamin C intake compared to their white counterparts, conditional on non-participation.

The effects of year 2005–06 are positive for both males and females, conditional on non-participation. Specifically, female non-participants sampled in NHANES 2005–06 have 16.37% higher vitamin C intake than those sampled in 2003–04. The corresponding number for men is 17.94%.

Presence of children has mixed effects between participants and non-participants. Women (men) residing in households with children have 59.09% (56.71%) higher vitamin C intake, conditional on participation in SNAP. These positive effects of presence of children among both participating males and females may be due to the fact that SNAP participants might have also participated in other programs such was WIC which provides nutrition education.

A woman (man) reporting good health has 14.62% (15.93%) higher vitamin C intake, conditional on non-participation in SNAP. Poor health has the opposite effects among non-participating men and women.

Renters who participate in SNAP have lower vitamin C intake, and this is seen in both males and females. This negative effect of renting is similar to findings by Yen (2009a) that home ownership has a positive effect on vitamin C intake.

Compared to elderly women (age >70), women age 20–30 have 15.49% lower intake, while women age 31–50 have 20.00% lower intake of vitamin C, conditional on participation. For men, the only significant effect is seen in age 31–50, with 21.49% lower intake, conditional on participation.

Women who take dietary supplements have 40.23% higher vitamin C intake than women who do not take dietary supplements, conditional on participation in SNAP. This is expected as the purpose of dietary supplements is to enhance nutrient intakes. Besides, the use of supplements is a growing trend, which suggests that Americans are becoming more receptive to non-food sources of nutrition for health promotion (Kraak, Pelletier, and Dollahite 2002).

Similar to the effect on protein intake, female participants with high blood pressure have lower vitamin C intake, while female non-participants who exercise regularly have higher vitamin C intake.

4.5.3 *Marginal Effects for Vitamin A Intake*

Factors negatively affecting vitamin A intake among men are household size, BMI, being African American, presence of children, and poor health. Positive factors are household income, age, college education, year 2005–06, renting, age 20–30, age 31–50, and physical activity.

A 1% increase in income increases vitamin A intake by 15.23% for men, conditional on non-participation in SNAP. The corresponding figure for non-participating women is 16.20%. These positive effects of income on vitamin A intake for both men and women stand in sharp contrast to finding by Yen (2009a) that household income plays a negative role in vitamin A intake among young children. In reference to the small standard errors (4.48% for men and 4.61% for women), these positive effects of income are large, which contradict the finding by Butler and Raymond (1996) that income has only small effects.

Conditional on SNAP participation, men residing in larger households have lower vitamin intake than men in smaller households, with each additional member decreasing vitamin A intake by 5.55%. This negative effect of household size on vitamin A intake is also seen in female participants (–4.47%). Butler and Raymond (1996) also find that increasing the number of people reduces the level of vitamin A intake.

BMI has a positive effect on vitamin A intake for participating women but a negative effect for participating men. A one-point increase in BMI increases vitamin A intake by 8.65% for women but decreases vitamin A intake by 18.40% for men, conditional on SNAP participation.

The marginal effects of age on vitamin A are positive for male and female participants, which means that an individual would have higher vitamin A as he/she grows older.

Male non-participants with a college education have 16.06% higher vitamin A intake than their less educated counterparts. The effect of college is also positive (9.69%) for non-participating women.

As to race, African American men and women have lower (15.41% and 16.16%, respectively) vitamin A intakes than their white counterparts. These results differ from finding reported by Yen (2009a), that being African American does not affect intakes of vitamin A.

Year 2005–06 has a positive effect on both male and female non-participants, with participating men (women) sampled in 2005–06 having 7.42% (7.91%) higher vitamin A intake than those sampled in 2003–04, conditional on non-participation. Presence of children decreases vitamin A intake for both men and women who do not participate in SNAP, but does not affect men and women who participate. Conditional on non-participation in SNAP, men (women) residing in households with children present have 10.83% (11.54%) lower vitamin A intake.

Compared to women in fair health, women reporting good health have higher vitamin A intake, conditional on non-participation. Women with poor health, on the other hand, have lower vitamin A intake, conditional on both SNAP participation (15.02%) and non-participation (17.52%). The corresponding figures for participating and non-participating men are also negative (17.33% and 16.68%, respectively). These positive effects of health differ from finding by Yen (2009a) that the intake of vitamin C is lower among children reported as healthy.

Home ownership affects vitamin A intake among both men and women. Specifically, male (female) participants who rent have 10.29% (8.32%) higher vitamin A intake than their home-owning cohorts, conditional on SNAP participation. Compared to the elderly (age >70), men and women age 20–50 (two categories) have higher vitamin A intake, conditional on participation in SNAP.

Both men and women who exercise regularly have higher vitamin A intake than those who do not exercise regularly, conditional on non-participation in SNAP.

4.5.4 *Marginal Effects for Calcium Intake*

Variables negatively affecting men's calcium intake are household size, BMI, age, being born in other countries, being a Hispanic, being an African American, being other race, poor health, and high blood pressure. Variables positively affecting calcium intake are household income, college education, year 2005–06, presence of children, good health, renting, age 20–30, age 31–50, and physical activity.

Income increases calcium intake among the participating men and women. A 1% increase in income increases calcium intake by 13.38% for men and 9.37% for women, conditional on non-participation. Household size decreases calcium intake among both men and women who participate in SNAP, with each additional household member decreasing calcium intake by 3.88% among men and 2.00% among women. BMI has different effects for men and women who participate in SNAP. Specifically, conditional on participation, a one-point increase in BMI decreases calcium intake by 27.41% for men, but increases calcium intake by 8.26% for women. Age decreases calcium intake by both men and women (by 10.79% and 6.89%, respectively) who do not participate in SNAP but do not affect intake among those who participate. Both non-participating men and women born in other countries have lower calcium intake (22.23% and 15.27%, respectively), compared to their native born counterparts.

College education has a positive effect on calcium intake among men but not women. Compared to men with only high school education, men with a college education have 13.63% higher calcium intake, conditional on non-participation. This positive effect of college education on calcium intake by men is similar to findings by Butler and Raymond (1996) that education substantially increases calcium intake among the elderly.

Hispanics, Blacks and individuals of other races, both men and women, generally have lower intakes of calcium, conditional on both participation and non-participation in SNAP.

Racial differences in calcium metabolism have been noted in children and adults (IOM 1997). Bell and colleagues (1993) find that African Americans age 9–18 had similar calcium absorption efficiency but lower urinary calcium excretion than white people.

Year 05–06 has a positive effect on calcium intake among both non-participating men and women. Presence of children has a positive effect on calcium intake among both participating men (21.16%) and women (10.91%). This positive effect of children may be due to the fact that households with children may pay more attention to nutrition while purchasing and preparing food.

Good health has a positive effect on calcium intake among men who do not participate in SNAP, while poor health has a negative effect on calcium intake by both participating men (22.41%) and women (12.48%).

Home ownership affects calcium intake among SNAP participating men and women. Specifically, compared to individuals who own a home, men (women) who rent have 7.24% (10.82%) lower calcium intake conditional on SNAP participation.

Having a younger age has a positive effect on calcium intake for both participating men and women. Specifically, conditional on SNAP participation, both men and women age 20–50 (two categories) have higher calcium intake than their elderly cohorts (age > 70).

Individual with high blood pressure have lower calcium intake, conditional on participation in SNAP. Physical activities promote one's calcium intake substantially, with men and women who exercise regularly having higher calcium intakes than those who do not exercise, conditional on non-participation in SNAP.

4.5.5 *Marginal Effects for Iron Intake*

Factors negatively influencing men's iron intake are poor health and high blood pressure. Factors contributing to iron intake are household income, household size, age, divorce, college education, being of other race, year 2005–06, good health, and physical activity. Factors having mixed effect on iron intake are renting, age 20–30, and age 31–50.

Income increases iron intake for both men and women, with an additional 1% increase in income increasing intake by 23.37% for men and 12.13% for women, conditional on non-participation in SNAP. This positive effect of income on iron intake differs from finding by Yen (2009a) that household income has a negative effect on iron intake by children. Evidence on the relationship between household income and nutrient intake levels is mixed (Devaney et. al. 2005). The third Nutrition Monitoring Report in the United States concludes that low-income adolescents and adults have lower mean intakes of the vitamins and minerals. Four of the five nutrients analyzed in this paper are included in the list: vitamin A, vitamin C, calcium, and iron (Life Sciences Research Office 1995).

We find no significant effect of income on non-participants' nutrient intakes, a strong evidence that SNAP has taken the income factor out of recipients' nutrient intakes.

Household size has a negative effect on iron intake conditional on participant but negative effect conditional on non-participant, although the magnitudes are fairly small, with one additional member decreasing iron intake by 2.97% among participating women and increasing intake by 1.55% among non-participating women. Household size also has a positive, though small, effect (2.94%) on iron intake by non-participating men.

BMI has a positive effect (12.10%) on iron intake among participating women, but does not affect intake among men. Age has definitive effects on iron intake by men, with an additional year increasing iron intake by 27.51% conditional on participant and 6.65% conditional on non-participant. The corresponding numbers for women are smaller: 11.47% among participants and 3.31% among non-participants. Marital status also affect iron intake, with divorced men (women) having 42.19% (15.15%) higher intake than their single counterparts, conditional on non-participation. These positive effects of divorce differ from findings by Raymond and Butler (1996) that living alone often has large negative effects on iron intake.

College education increases iron intake by 38.55% among non-participating men, while its effect on women is insignificant. Butler and Raymond (1996) also find positive effect of college education on iron intake among the elderly.

Race has barely noticeable effects on iron intake, with non-participating Black women having lower intake of iron (–6.11%), and men (women) of other races having 126.37% (43.43%) higher iron intake conditional on participation, than their White counterparts.

Variable year 05–06 has a positive effect on iron intake for non-participating men and women non-participants, with those sampled between years 2005 and 2006 having higher iron intakes than those sampled during 2003–04.

Good health has a positive effect on iron intake while poor health has a negative effect on intake, with men in good health having 25.53% higher intake and men in poor health having 27.25% lower intake than men in fair health, conditional on non-participation. Health has similar effects on women: 10.42% for women in good health and 11.02% lower for women in poor health, conditional on non-participation. Self-assessed health condition is special in this paper because it evaluates people's psychological momentum, through which one individual's nutrient intake can be affected. For instance, the positive effect on nutrient intakes of good health may be due to the fact that those who consider themselves in good health might pay more attention to nutrition, in selecting and preparing food, resulting in higher nutrient intakes.

Home ownership plays a role in iron intake. Participating men who rent have 17.34% higher intake, where non-participating men who rent have 5.45% lower intake than men who own a home. The effects of home ownership are similar for women (5.54% conditional on participation and –2.90% conditional on non-participation). Age has notable effects on iron intake. Compared to their elderly counterparts, men and women age 20–50 (two categories) have higher iron intake conditional on participation and lower intake conditional on non-participation.

Men with high blood pressure have 85.06% lower iron intake conditional on participation and 33.88% lower intake conditional on non-participation. The effects on women are similar (–29.35% conditional on participation and –12.90% conditional on non-participation). Finally, physical activity plays a role in iron intake, with physically active men having 22.24% high intake than their physically inactive counterparts. Physical activity has positive effects for women as well, with physically active women having 51.30% higher intake conditional on participation and 47.04% higher intake conditional on non-participation, compared to women who are physically inactive. The concept that weight-bearing physical activity or mechanical loading determines the strength, shape, and mass of bone is generally accepted (Frost 1987).

Chapter 5

Concluding Remarks and Discussion

SNAP is an important food and nutrition assistance program administered by the USDA to improve the nutritional well-being of low-income individuals, and there is continued interest in investigating the roles of this program in achieving its goals. Previous studies show that although SNAP increases participants' food expenditures, it does not necessarily improve their nutrient intakes, because the link between food expenditures and nutrient intakes is not a direct one (Butler, Ohls, and Posner 1985).

This study focuses on nutrient intakes among individuals who are eligible to participate in SNAP, by investigating the determining factors of participation in SNAP, and the effects of SNAP participation on nutrient intakes. This is accomplished by developing and estimating switching regression system (SRS), a multi-equation extension of the conventional switching regression model (with a single outcome variable) which, to our knowledge, has not been attempted in empirical analysis. Since participation in the program 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. On statistical grounds, joint estimation of the system also improves statistical efficiency of parameter estimates and endogenization of SNAP participation also avoids simultaneous-equation and sample selection biases in the parameter estimates caused by non-random selection of SNAP eligibles into the participating and non-participating states.

The SRS allows estimation of various treatment effects of SNAP participation and the marginal effects of socio-demographic variables on nutrient intakes, separately for SNAP participants and non-participants. Results suggest the effects of socio-demographic variables are very different, in signs and magnitudes, between the participants and non-participants. These differentiated effects of socio-demographic variables are likely to be masked by the use of a more conventional model (such as the single or multiple equation treatment effect models) and highlight the importance of using the SRS.

Unlike many previous studies which investigate nutrient intakes either in absolute forms or as percentages of the older recommended daily allowances (RDAs), this paper focuses on (the effects of SNAP participation on) the levels of nutrient intakes expressed as a percentage of the more recent Dietary Reference Intakes (DRIs). Such intake measures are believed to be better indicators of nutritional statuses of the individuals. Further, unlike many previous studies which are based on very old data in which case empirical relevance is compromised, we use the more recent NHANES 2003–06, which are more suitable for a timely policy analysis.

The empirical findings are summarized as follows. First, sample regime switching is found to be endogenous, and the SRS is found to perform better than the treatment effect system and several other forms of restricted models. Second, socio-demographic variables play important roles in SNAP participation. Third, socio-demographic variables also play important roles in nutrient intakes and these effects differ between participants and non-participants. Last but not least, SNAP participation is found to increase the intakes of protein, vitamin A, iron, and calcium, but decrease the intake of vitamin C.

The current results differ from findings in many previous studies. These differences may be caused by the age of the data used and the different methodology. SNAP has improved significantly during recent decades, and yet, data used in many previous studies went as far back as the 1980s or earlier. During that time, instead of EBT card, program benefits were distributed in paper forms. There was no guarantee that participants would use food stamps to buy food. In fact, some of the recipients reportedly would sell their food stamps for cash. Black market for food stamps was a well-known fact (Ohls and Beebout 1993). The Personal Responsibility and Work Opportunity Act of 1996 mandated that all states must convert from paper coupon systems to an electronic benefit transfer (EBT) system before October 1, 2002. After that, participants were less likely to sell their program benefits. It is believed that recipients tend to buy food for their own households after this significant change in benefit methods. Therefore, SNAP has since had a more direct influence on program recipients.

Another example of SNAP improvement is nutrition education. Nutrition education is a relatively recent, but fast increasing project which is an emphasis in SNAP. As stated in the USDA's Food and Nutrition Service (FNS) strategic plan for 2000–05, there is a "growing awareness that making sure people have enough food is not enough; people must have the knowledge and motivation to make food choices that promote health and prevent disease" (USDA 2000).

One important goal of SNAP Nutrition Education (SNAP-Ed) is to improve the likelihood that SNAP participants will make healthy choices within a limited budget and choose active lifestyles consistent with the current Dietary Guidelines for Americans and the Food Guide Pyramid (USDA 2009c). Nutrition education programs have helped individuals improve food buying, meal planning and preparation, and food safety practices as demonstrated by several studies with Expanded Food and Nutrition Education Program participants (Cason et. al. 2002).

Besides the aforementioned improvements, results from this paper have shown that income has no significant effect on program participants' nutrient intakes. It supports the view that SNAP has successfully removed income from the contributing factors of recipients' nutrient intakes.

Nutritional well-being among adults participating in SNAP has improved substantially over the years. Overall, it is fair to state that SNAP has improved the diet and nutrition intake among the low-income individuals over these years.

This paper offers four recommendations. First recommendation is toward an effective SNAP-Ed. Based on treatment effect results from this paper, SNAP does not improve recipient's vitamin C intake. Almost 90% vitamin C comes from fruits and vegetables (IOM 2000). Therefore, consumption of fresh fruits and vegetables, especially those rich in vitamin C (e.g. citrus, tomatoes, and tomato juice), should be emphasized in nutrient education. Besides, in current nutrition education, only 50% of the targeted groups are adults. A larger percentage of adult participants in the education program is recommended because adults play major roles in food preparation for the households and therefore have a more direct influence on nutrient intakes than children and elderly do.

Other than emphasis on vitamin C and adult recipients in nutrition education, specific groups of individuals can be targeted for nutrition education. This study finds that individuals with good self-assessed health have higher nutrient intakes. Male non-participants who think themselves in good health condition, for instance, have higher levels of vitamin C intakes than other males. In contrast, individuals who consider themselves in poor health have lower nutrient intakes. These groups can be targeted for nutrition education.

Second, it is recommended that recipients be allowed to purchase dietary supplements with SNAP benefits. The marginal effect results suggest that dietary supplements have a positive effect on female participants' vitamin C intake, whereas SNAP has a negative effect on vitamin

C overall. The reason that dietary supplements increases nutrient intake is obvious and has been discussed in the previous chapter. However, current SNAP policy does not allow recipients to purchase dietary supplements with food stamp benefits. A lift of this restriction can have direct and notable effects on participants' nutrient intakes.

Thirdly, promoting SNAP participation among targeted racial groups is important. Individuals of other races (besides White, African-American, and Hispanics) are found to be less likely to participate in SNAP. The marginal effect results suggest that non-participants in this group have lower calcium intake, and participants in the same group have higher iron intake. Participation in SNAP can improve nutrient intake by this racial group, but these people have a lower tendency to participate. Thus, an effort to promote SNAP participation can improve nutrition intakes greatly among this racial group.

Finally, quality data are of utmost importance in a credible analysis and it is important to carry out detailed and consistent survey focusing on SNAP. One limitation in this study is the relatively small sample size due to the large number of observations with missing values in important (outcome and explanatory) variables. Further, as in other simultaneous equations, treatment effects, and sample selection models, identification of model parameters relies crucially on good exclusion restrictions. The survey might be carried out with this data need in mind. For example, one important barrier to SNAP participation might be the stigma factors (Moffitt 1983) during food purchases with the EBT cards. These stigma factors can offer good exclusion restriction in estimating the equation system. Collection of data on these stigma variables can prove to be very useful.

A few caveats pertain. The nutrient intake data came from individual records taken in one day, and these snapshots are not strong indicators of individuals' everyday diets. NHANES did provide second-day data, but due the telephone recall method in data collection, many missing values occurred. Further, because interviews are not conducted in MECs with professional interviewers, measurements are subject to errors.

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Appendices

Appendix A

Table 1. Variable Definitions and Sample Statistics

Variable	Definition	Mean	SD
Endogenous binary variable (yes = 1, no = 0)			
SNAP	Individual currently receiving SNAP benefits	0.17	
Nutrient intakes (expressed as % of dietary reference intakes, DRIs)			
Protein		152.91	84.52
Vitamin C		109.87	143.80
Vitamin A		67.67	57.83
Calcium		76.91	57.83
Iron		161.52	119.02
Continuous explanatory variables			
Income	Household income as a % of Federal poverty level	0.83	0.34
BMI	Body mass index: (weight in kg) / (height in *m*)^2	2.87	0.72
Household size	Number of members in household	3.23	1.89
Age	Age in years	5.02	1.97
Binary explanatory 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	
U.S. born	Reference person born in the U.S. (reference)	0.72	
Mexico born	Reference person born in Mexico	0.20	
Other country	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	
Child(ren)	Presence of child(ren) (under 17 years of age)	0.46	
Year 05–06	Year 2005–2006	0.48	
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
Renter	Current residence is rented	0.54
Diet. supp.	Taking dietary supplement(s)	0.39
High BP	Has been diagnosed with high blood pressure	0.37
Active	Has physical activity in the past 30 days	0.29

Table 2. LR Tests for Nested Specifications

		LR Statistics: Nested Models Tested Against					
Model	Log likelihood	TES	Exog. Switching SUR	Exog. Switching OLS	Exog. Treatment SUR	Exog. Treatment OLS	SRS with no gender difference
SRS	–50503.565	301.248	14.584	3769.056	337.734	4237.65	112.182
	[310]	(155)	(10)	(30)	(150)	(140)	(40)
Exog. switching SUR[a]	–50510.857			3754.472	323.15	4223.066	
	[300]			(20)	(140)	(130)	
Exog. switching OLS[b]	–52388.093					468.594	
	[280]					(130)	
TES	–50654.189				36.486	3936.402	
	[165]				(5)	(15)	
Exog. treatment SUR[c]	–50672.432					3899.916	
	[160]					(10)	
Exog. treatment OLS[d]	–52622.390						
	[150]						
SRS with no gender difference	–50559.656						
	[270]						

Note: Number of parameters in brackets, and degrees of freedom (number of restrictions) in parentheses. All tests are significant with a p-value < 0.001.

a. Exogenous switching SUR refers to SUR system of equations with exogenous switching.

b. Exogenous switching OLS refers to single equations with exogenous switching.

c. Exogenous treatment SUR refers to SUR system of equations with an exogenous program variable.

d. Exogenous treatment OLS refers to single equations with an exogenous program variable.

Table 3. Maximum-Likelihood Estimation of Switching Regression System for Nutrition Intakes (%DRIs)

	SNAP	Protein		Vitamin C		Vitamin A	
Variable	Participation	Participants	Non-participants	Participants	Non-participants	Participants	Non-participants
Constant	–0.691***	6.371***	5.188***	4.148***	4.428***	5.125***	3.922***
	(0.217)	(0.479)	(0.141)	(0.954)	(0.333)	(0.813)	(0.235)
Income	–0.583***	0.370***	0.028	–0.188	0.127	0.511***	0.219***
	(0.105)	(0.127)	(0.046)	(0.265)	(0.099)	(0.190)	(0.072)
Mexican born	–0.853***	0.523**	0.041	0.304	0.355**	1.053***	–0.070
	(0.181)	(0.222)	(0.069)	(0.475)	(0.156)	(0.337)	(0.111)
Other-country born	–0.391***	0.227	–0.135***	0.140	0.324***	0.135	0.005
	(0.139)	(0.155)	(0.051)	(0.333)	(0.121)	(0.235)	(0.087)
Married	–0.449	0.250**	0.029	–0.420*	0.061	0.285	0.035
	(0.100)	(0.117)	(0.046)	(0.228)	(0.106)	(0.179)	(0.078)
Divorced	0.033	–0.136	0.084*	–0.092	–0.177	–0.191	0.052
	(0.125)	(0.138)	(0.050)	(0.219)	(0.118)	(0.202)	(0.084)
Education	–0.107	0.123	0.017	0.987***	0.149	0.262	0.233***
	(0.082)	(0.144)	(0.043)	(0.315)	(0.104)	(0.203)	(0.074)
Hispanic	0.272**	–0.137	–0.022	–0.150	0.144	–0.450**	–0.119
	(0.129)	(0.138)	(0.054)	(0.278)	(0.129)	(0.206)	(0.091)
Black	0.225***	–0.001	–0.006	–0.097	0.215**	–0.285**	–0.242***
	(0.092)	(0.090)	(0.043)	(0.184)	(0.100)	(0.136)	(0.071)
Other race	–0.362*	0.520**	0.022	–0.345	–0.048	0.283	–0.061

	(0.196)	(0.231)	(0.067)	(0.459)	(0.160)	(0.352)	(0.113)
Year 05–06	–0.263***	0.086	0.005	–0.286*	0.153**	0.216*	0.107**
	(0.070)	(0.077)	(0.029)	(0.153)	(0.067)	(0.117)	(0.048)
Child	0.422***	–0.115	0.013	0.650***	–0.178**	–0.217	–0.156***
	(0.090)	(0.107)	(0.036)	(0.211)	(0.082)	(0.165)	(0.059)
Good health	–0.117	0.017	0.010	–0.045	0.131*	0.176	0.087
	(0.082)	(0.092)	(0.033)	(0.200)	(0.076)	(0.140)	(0.054)
Poor health	0.142	–0.413***	–0.232***	–0.061	–0.249*	–0.418**	–0.294***
	(0.134)	(0.141)	(0.060)	(0.283)	(0.143)	(0.211)	(0.101)
Female	0.324***	–1.232***	–0.216*	–1.622**	–0.309	–1.686***	–0.097
	(0.077)	(0.320)	(0.122)	(0.756)	(0.300)	(0.482)	(0.207)
Renter	0.147***						
	(0.055)						
Age 20–30	0.432***						
	(0.177)						
Age 31–50	0.577***						
	(0.187)						
Age 51–70	0.191						
	(0.147)						
Household size	–0.078***						
	(0.019)						
Diet. supp.		–0.106	0.002	0.355*	0.032	–0.008	0.012
		(0.099)	(0.029)	(0.197)	(0.071)	(0.193)	(0.051)

High BP	–0.322***	–0.046	–0.484*	–0.069	–0.058	–0.031
	(0.115)	(0.047)	(0.290)	(0.114)	(0.178)	(0.079)
Active	0.092	0.089***	–0.201	0.125*	0.172	0.116
	(0.097)	(0.031)	(0.177)	(0.076)	(0.142)	(0.054)
BMI	–0.057	0.038	–0.493**	–0.086	–0.257*	–0.027
	(0.094)	(0.034)	(0.230)	(0.084)	(0.140)	(0.059)
Age	–0.123	–0.057	0.115	–0.253**	0.178	–0.123
	(0.160)	(0.048)	(0.281)	(0.111)	(0.285)	(0.079)
Age^2	0.182	–0.010	–0.086	0.263***	0.024	0.132*
	(0.179)	(0.046)	(0.289)	(0.107)	(0.324)	(0.076)
Female × college	–0.086	–0.045	–0.765**	0.081	0.031	–0.097
	(0.147)	(0.057)	(0.356)	(0.139)	(0.217)	(0.098)
Female × active	0.216	0.140**	0.836***	0.288**	–0.008	0.187*
	(0.141)	(0.061)	(0.343)	(0.148)	(0.233)	(0.103)
Female × BMI	0.191*	0.000	0.618**	0.079	0.400***	0.050
	(0.109)	(0.043)	(0.254)	(0.105)	(0.163)	(0.072)
σ, ω	0.537***	0.871***	1.268***	1.367***	0.896***	1.308***
	(0.015)	(0.062)	(0.023)	(0.066)	(0.016)	(0.087)

Table 3 continued

	Calcium		Iron	
Variable	Participants	Non-participants	Participants	Non-participants
Constant	5.990***	4.759***	6.355***	5.323***
	(0.591)	(0.172)	(0.567)	(0.156)
Income	0.234*	0.137***	0.404***	0.006
	(0.141)	(0.054)	(0.139)	(0.047)
Mexican born	0.496**	0.096	0.472**	–0.079
	(0.254)	(0.082)	(0.245)	(0.076)
Other-country	0.013	–0.270***	0.296*	–0.121**
born	(0.166)	(0.062)	(0.167)	(0.059)
Married	0.168	0.044	0.199	–0.028
	(0.135)	(0.056)	(0.127)	(0.051)
Divorced	–0.013	0.079	–0.111	0.182***
	(0.160)	(0.061)	(0.138)	(0.058)
Education	0.286*	0.141***	0.221	0.144***
	(0.170)	(0.053)	(0.161)	(0.049)
Hispanic	–0.337**	–0.135**	–0.196	0.031
	(0.148)	(0.066)	(0.143)	(0.062)
Black	–0.347***	–0.275***	–0.044	–0.019
	(0.096)	(0.052)	(0.092)	(0.048)
Other race	0.492*	–0.271***	0.605***	–0.028
	(0.259)	(0.081)	(0.244)	(0.078)
Year 05–06	0.180**	0.114***	0.059	0.022

	(0.085)	(0.035)	(0.082)	(0.033)
Child	0.002	–0.020	–0.271**	0.038
	(0.124)	(0.043)	(0.118)	(0.040)
Good health	0.078	0.086**	0.063	0.088**
	(0.102)	(0.040)	(0.097)	(0.037)
Poor health	–0.289*	–0.053	–0.291**	–0.103
	(0.154)	(0.074)	(0.150)	(0.068)
Female	–1.805***	–0.315**	–2.202***	–0.961***
	(0.402)	(0.151)	(0.384)	(0.133)
Renter				
Age 20–30				
Age 31–50				
Age 51–70				
Household size				
Diet. supp.	–0.022	0.053	–0.093	0.050
	(0.146)	(0.036)	(0.127)	(0.032)
High BP	–0.380***	–0.048	–0.379***	–0.150***
	(0.145)	(0.057)	(0.138)	(0.052)
Active	0.116	0.109***	0.000	0.083**
	(0.119)	(0.039)	(0.135)	(0.034)

BMI	–0.249**	0.002	–0.146	–0.002
	(0.120)	(0.043)	(0.113)	(0.037)
Age	–0.101	–0.185***	–0.113	–0.049
	(0.186)	(0.057)	(0.184)	(0.053)
Age^2	0.088	0.082	0.267	0.091*
	(0.213)	(0.055)	(0.206)	(0.051)
Female × college	–0.209	–0.098	–0.079	–0.228***
	(0.181)	(0.071)	(0.172)	(0.063)
Female × active	0.342**	0.207***	0.546***	0.392***
	(0.177)	(0.074)	(0.168)	(0.067)
Female × BMI	0.386***	–0.006	0.294**	–0.002
	(0.138)	(0.052)	(0.132)	(0.046)
σ, ω	0.647***	0.821***	0.635***	0.818***
	(0.012)	(0.055)	(0.016)	(0.065)
Log likelihood	–50503.565			

Note: Asymptotic standard errors in parentheses. Asterisks indicate levels of significance: *** = 1%, ** = 5%, * = 10%.

Table 4. Maximum-Likelihood Estimates of Error Correlations (Switching Regression System for Nutrient Intakes (% DRIs))

	SNAP Participation	Protein	Vitamin C	Vitamin A	Calcium
			SNAP Non-participants		
Protein	0.415***				
	(0.151)				
Vitamin C	0.002	0.313***			
	(0.082)	(0.026)			
Vitamin A	0.083	0.474***	0.431***		
	(0.104)	(0.022)	(0.021)		
Calcium	0.049	0.634***	0.397***	0.630***	
	(0.136)	(0.018)	(0.022)	(0.016)	
Iron	0.724***	0.680***	0.334***	0.458***	0.528***
	(0.057)	(0.026)	(0.030)	(0.029)	(0.032)
			SNAP Participants		
Protein	–0.860***				
	(0.037)				
Vitamin C	0.295**	–0.025			
	(0.122)	(0.099)			
Vitamin A	–0.865***	0.773***	0.023		
	(0.033)	(0.030)	(0.097)		
Calcium	–0.640***	0.783***	0.117	0.759***	
	(0.077)	(0.037)	(0.083)	(0.040)	
Iron	–0.698***	0.842***	0.072	0.750***	0.768***
	(0.084)	(0.030)	(0.091)	(0.043)	(0.034)

Note: Asymptotic standard errors in parentheses. Asterisks indicate level of significance: *** = 1%, * = 10%

Table 5. Treatment Effects of SNAP Participation on Nutrient Intakes

Nutrient	Male	Female	Pooled
		ATT	
Protein	–66.306	–73.156**	–70.064*
	(48.406)	(31.510)	(38.546)
Vitamin C	3.449	0.729	1.957
	(40.272)	(30.253)	(32.183)
Vitamin A	–6.924	–21.973	–15.180
	(17.164)	(15.276)	(15.552)
Calcium	15.059	–6.955	2.983
	(21.526)	(12.240)	(15.832)
Iron	–306.322***	–113.866***	–200.747***
	(56.130)	(17.794)	(33.959)
		ATE	
Protein	859.376***	332.802***	570.514***
	(226.920)	(87.704)	(147.516)
Vitamin C	–60.217***	–47.189***	–53.070***
	(23.870)	(18.525)	(19.241)
Vitamin A	1012.477***	508.855***	736.206***
	(380.237)	(175.951)	(263.170)
Calcium	251.751***	86.260***	160.968***
	(81.897)	(29.592)	(51.999)
Iron	645.215***	139.909**	368.020***
	(252.769)	(58.501)	(144.451)
		Treatment Effects (at Sample Means of Variables)	
Protein	15.789	–5.749	–10.772
	(13.963)	(8.436)	(8.836)
Vitamin C	–36.835**	11.208	–6.931
	(15.153)	(17.361)	(14.462)
Vitamin A	9.195	–8.779	–4.205
	(8.434)	(6.582)	(6.381)
Calcium	7.475	0.257	–5.376
	(8.879)	(4.926)	(5.232)
Iron	–0.707	–11.193*	–39.012***
	(19.900)	(6.045)	(7.992)

	Treatment Effects (Individuals)		
Protein	29.066**	3.944	1.948
	(12.245)	(6.261)	(5.992)
Vitamin C	–29.364	10.419	–1.425
	(19.993)	(20.487)	(17.227)
Vitamin A	8.873	–13.002***	–5.774
	(7.327)	(4.653)	(4.082)
Calcium	10.786	0.684	–3.224
	(8.537)	(4.024)	(4.077)
Iron	16.743	–6.454	–31.461***
	(18.262)	(4.765)	(6.752)

Note: Asymptotic standard errors in parentheses. Asterisks indicate level of significance: ***=1%, **=5%, *=10%.

Table 6. Marginal Effects of Explanatory Variables on the Probability of SNAP Participation (Both Genders)

Variable	Prob. of SNAP Participation
Continuous explanatory variables	
Income	–0.136***
	(0.024)
Household size	–0.018***
	(0.005)
Binary explanatory variables	
Mexico born	–0.145***
	(0.020)
Other-country born	–0.086***
	(0.026)
Married	–0.103***
	(0.026)
Divorced	0.009
	(0.036)
College	–0.025
	(0.018)
Hispanic	0.067**
	(0.034)
Black	0.055**
	(0.024)
Other	–0.063**
	(0.028)
Year 05–06	–0.061***
	(0.016)
Child	0.099***
	(0.021)
Good health	–0.026
	(0.018)
Poor health	0.036
	(0.036)
Female	0.075***
	(0.017)

Renter	0.034***
	(0.013)
Age 20–30	0.084***
	(0.030)
Age 31–50	0.123***
	(0.034)
Age 51–70	0.032
	(0.022)

Note: Asymptotic standard errors in parentheses.
Asterisks indicate level of significance: ***=1%, **=5%, *=10%.

Table 7. Marginal Effects of Explanatory Variables on Nutrient Intakes (Males)

Variable	Protein		Vitamin C		Vitamin A	
	Participants	Non-participants	Participants	Non-participants	Participants	Non-participants
Continuous explanatory variables						
Income	–1.482	12.385*	0.295	14.817	–4.732	15.231***
	(20.689)	(6.856)	(27.421)	(11.242)	(11.080)	(4.477)
Household size	–9.885***	0.982**	2.763*	0.005	–5.545***	0.112
	(3.443)	(0.462)	(1.505)	(0.181)	(1.475)	(0.161)
BMI	–11.123	6.867	–53.274*	–9.973	–18.404*	–1.743
	(18.496)	(6.108)	(27.759)	(9.839)	(10.321)	(3.796)
Age	6.165	–11.821***	4.520	–3.481	14.194***	–0.718
	(7.067)	(2.132)	(8.677)	(3.415)	(4.490)	(1.422)
Binary explanatory variables						
Mexico born	–7.586	16.261	77.682	45.676**	15.303	–3.562
	(34.984)	(12.108)	(78.416)	(22.365)	(23.976)	(6.847)
Other-country born	–5.089	–18.219**	29.609	40.879**	–15.921	0.877
	(24.770)	(8.081)	(39.802)	(16.995)	(11.024)	(5.723)
Married	–7.784	10.872	–31.123	7.281	–11.767	2.941
	(17.821)	(7.392)	(26.208)	(12.226)	(10.139)	(4.842)
Divorced	–22.268	14.364*	–12.560	–18.762	–11.864	3.325
	(18.952)	(8.505)	(27.652)	(12.870)	(10.660)	(5.448)
College	10.652	4.362	136.244**	17.775	11.468	16.057***
	(25.758)	(7.693)	(60.660)	(12.772)	(14.232)	(5.246)
Hispanic	7.314	–7.363	–25.176	16.960	–12.576	–8.291

	(22.351)	(9.166)	(28.186)	(15.641)	(11.676)	(5.844)
Black	28.921*	–3.963	–18.603	26.176**	–4.615	–15.406***
	(15.712)	(7.272)	(19.352)	(13.026)	(8.452)	(4.172)
Other race	60.650	7.662	–23.729	–5.096	–5.977	–3.763
	(43.616)	(12.528)	(44.218)	(16.727)	(19.899)	(7.560)
Year 05–06	–16.409	4.256	–21.642	17.942**	–3.182	7.420**
	(12.383)	(4.893)	(16.554)	(7.799)	(6.609)	(3.081)
Child	30.919*	–2.993	56.712**	–20.671**	14.395	–10.830***
	(18.542)	(5.907)	(25.134)	(9.656)	(10.244)	(3.817)
Good health	–11.700	3.199	–0.701	15.925*	4.396	6.044
	(14.890)	(5.844)	(21.243)	(9.572)	(9.001)	(3.748)
Poor health	–55.807***	–38.962***	–10.989	–24.957*	–17.326*	–16.675***
	(17.751)	(8.493)	(27.603)	(13.007)	(9.576)	(5.046)
Renter	18.405***	–1.822**	–5.206*	–0.009	10.287***	–0.208
	(6.507)	(0.919)	(3.047)	(0.498)	(4.156)	(0.271)
Age 20–30	49.092***	–4.561**	–16.604	–0.022	25.884***	–0.512
	(18.275)	(2.298)	(10.389)	(1.216)	(8.833)	(0.671)
Age 31–50	68.506***	–6.541**	–21.494*	–0.032	37.179***	–0.741
	(19.074)	(2.834)	(12.208)	(1.767)	(9.406)	(0.936)
Age 51–70	20.185	–1.773	–7.737	–0.008	10.162	–0.197
	(14.581)	(1.545)	(7.095)	(0.464)	(6.789)	(0.306)
Diet. supp.	–20.273	0.405	40.997	3.747	–0.534	0.794
	(18.252)	(5.180)	(25.308)	(8.382)	(13.730)	(3.339)
High BP	–58.733***	–8.079	–47.336	–7.964	–4.115	–2.001
	(21.403)	(8.186)	(29.225)	(12.927)	(12.592)	(5.108)

Active	18.213	16.193***	–20.959	14.892	12.714	7.821**
	(19.095)	(5.780)	(18.428)	(9.338)	(10.234)	(3.698)

Table 7 continued

Variable	Calcium		Iron	
	Participants	Non-participants	Participants	Non-participants
Continuous explanatory variables				
Income	–3.122	13.378***	28.955	23.372***
	(14.408)	(4.609)	(30.229)	(9.421)
Household size	–3.877***	0.067	–9.299	2.935***
	(1.477)	(0.192)	(6.902)	(0.777)
BMI	–27.405**	0.216	–35.500	–0.557
	(13.218)	(4.026)	(27.505)	(9.057)
Age	–2.890	–10.791***	27.513***	6.648*
	(4.819)	(1.385)	(9.933)	(3.548)
Binary explanatory variables				
Mexico born	12.133	10.229	11.333	7.005
	(28.371)	(8.116)	(54.779)	(16.764)
Other-country born	–16.631	–22.232***	26.137	–13.500
	(14.732)	(4.779)	(39.507)	(12.102)
Married	–3.654	4.407	–4.691	10.519
	(12.799)	(4.863)	(25.569)	(10.197)
Divorced	0.156	7.332	–22.753	42.191***
	(15.103)	(5.623)	(26.732)	(12.347)
College	27.342	13.628***	42.091	38.553***
	(19.732)	(5.233)	(39.576)	(11.778)
Hispanic	–22.991	–13.143**	–14.714	–3.497
	(14.436)	(6.079)	(30.803)	(13.231)
Black	–25.898***	–24.732***	16.307	–12.848

	(9.494)	(4.311)	(21.997)	(9.930)
Other	45.706	–24.091***	126.365*	4.203
	(37.945)	(6.624)	(77.308)	(17.811)
Year 05–06	6.806	10.877***	–16.828	14.933**
	(8.742)	(3.193)	(17.994)	(6.969)
Child	21.161*	–2.199	–15.838	–7.027
	(12.638)	(3.860)	(26.162)	(8.518)
Good health	2.837	8.309**	1.384	25.533***
	(10.762)	(3.839)	(21.833)	(8.606)
Poor health	–22.408*	–4.842	–48.973*	–27.249**
	(12.985)	(6.361)	(27.631)	(12.620)
Renter	7.235***	–0.123	17.343***	–5.454***
	(2.920)	(0.345)	(6.554)	(2.043)
Age 20–30	19.976***	–0.302	47.552***	–14.047***
	(8.009)	(0.847)	(18.741)	(5.124)
Age 31–50	27.432***	–0.439	65.509***	–19.858***
	(8.784)	(1.216)	(19.656)	(5.624)
Age 51–70	8.430	–0.116	19.963	–5.588
	(6.245)	(0.349)	(14.963)	(4.049)
Diet. supp.	–2.430	4.963	–22.218	11.760
	(15.849)	(3.445)	(29.371)	(7.540)
High BP	–38.734***	–4.465	–85.056***	–33.875***
	(15.047)	(5.217)	(31.620)	(11.438)
Active	13.106	10.441***	0.100	19.567**
	(13.343)	(3.805)	(32.697)	(8.218)

Note: Asymptotic standard errors in parentheses. Asterisks indicate levels of significance: *** = 1%, ** = 5%, * = 10%.

Table 8. Marginal Effects of Explanatory Variables on Nutrient Intakes (Females)

	Protein		Vitamin C		Vitamin A	
Variable	Participants	Non-participants	Participants	Non-participants	Participants	Non-participants
Continuous explanatory variables						
Income	1.349	12.114**	–1.336	13.461	–2.466	16.201***
	(12.744)	(5.380)	(27.945)	(10.109)	(9.738)	(4.614)
Household size	–5.792***	1.101*	2.613*	0.007	–4.474***	0.173
	(1.532)	(0.605)	(1.396)	(0.517)	(1.471)	(0.240)
BMI	16.185***	5.251	13.841	–0.705	8.646*	1.560
	(5.269)	(3.738)	(11.473)	(6.918)	(4.595)	(3.082)
Age	5.999	–9.267***	3.683	–0.375	12.119***	0.154
	(4.458)	(1.428)	(8.263)	(2.651)	(3.381)	(1.282)
Binary explanatory variables						
Mexico born	–2.298	16.040*	80.194	42.567**	15.024	–3.192
	(21.820)	(9.601)	(83.868)	(21.270)	(21.074)	(7.064)
Other-country born	–1.862	–12.752**	30.554	38.085**	–12.851	1.155
	(15.308)	(6.342)	(42.324)	(16.020)	(9.357)	(5.933)
Married	–3.466	9.864*	–31.865	6.987	–9.016	3.292
	(11.184)	(5.683)	(25.249)	(11.688)	(8.468)	(4.992)
Divorced	–14.044	10.862*	–12.416	–17.976	–10.071	3.413
	(12.059)	(6.434)	(27.801)	(12.582)	(9.167)	(5.587)
College	–3.428	–2.378	29.446	25.192**	11.966	9.687**
	(9.722)	(5.622)	(23.870)	(11.479)	(8.158)	(5.027)

Hispanic	3.405	–6.850	–24.827	15.372	–11.196	–8.811
	(13.680)	(7.038)	(28.261)	(14.310)	(9.572)	(6.033)
Black	16.827*	–4.043	–18.254	23.731**	–4.469	–16.161***
	(9.541)	(5.539)	(19.560)	(11.766)	(6.987)	(4.343)
Other	38.901	7.586	–24.804	–4.612	–4.222	–3.653
	(27.303)	(9.950)	(44.143)	(15.189)	(16.859)	(7.918)
Year 05–06	–9.095	4.420	–22.758	16.372**	–2.008	7.905***
	(7.554)	(3.786)	(16.437)	(7.146)	(5.558)	(3.214)
Child	17.382	–4.128	59.085***	–18.804**	11.001	–11.541***
	(11.038)	(4.669)	(22.929)	(8.785)	(8.320)	(3.981)
Good health	–6.803	3.002	–1.037	14.615*	4.051	6.414*
	(9.208)	(4.557)	(21.787)	(8.869)	(7.678)	(3.950)
Poor health	–34.926***	–30.701***	–10.910	–22.903*	–15.019*	–17.518***
	(11.108)	(6.561)	(28.629)	(11.955)	(8.226)	(5.284)
Renter	10.802***	–2.051**	–4.920*	–0.012	8.319***	–0.322
	(3.797)	(1.015)	(2.885)	(0.682)	(3.310)	(0.416)
Age 20–30	29.734***	–5.580**	–15.493*	–0.033	21.915***	–0.864
	(11.294)	(2.860)	(9.473)	(1.818)	(7.707)	(1.124)
Age 31–50	41.242***	–7.769**	–19.998*	–0.047	31.264***	–1.213
	(11.622)	(3.402)	(11.102)	(2.564)	(7.961)	(1.522)
Age 51–70	12.333	–2.284	–7.251	–0.013	8.689	–0.349
	(8.928)	(2.020)	(6.548)	(0.729)	(5.823)	(0.542)
Diet. supp.	–12.666	0.312	40.225*	3.387	–0.451	0.822
	(11.493)	(3.997)	(23.969)	(7.547)	(11.605)	(3.449)
High BP	–36.939***	–6.255	–49.982*	–7.257	–3.485	–2.077

	(12.957)	(6.344)	(28.968)	(11.794)	(10.600)	(5.305)
Active	39.856*	33.438***	82.649	48.238**	10.291	22.238***
	(21.075)	(10.402)	(56.785)	(21.442)	(14.766)	(9.069)

Table 8 continued

Variable	Calcium		Iron	
	Participants	Non-participants	Participants	Non-participants
Continuous explanatory variables				
Income	–0.854	9.370***	11.001	12.133***
	(7.728)	(3.120)	(10.209)	(3.553)
Household size	–2.004***	0.069	–2.968***	1.552***
	(0.580)	(0.231)	(0.892)	(0.402)
BMI	8.261***	–0.215	12.100***	–0.349
	(3.250)	(2.044)	(3.989)	(2.590)
Age	–1.048	–6.891***	11.465***	3.310***
	(2.704)	(0.845)	(3.143)	(1.117)
Binary explanatory variables				
Mexico born	7.675	7.292	5.205	7.010
	(15.860)	(5.632)	(18.816)	(6.535)
Other-country born	–8.705	–15.274***	9.599	–3.232
	(8.078)	(3.270)	(13.477)	(4.675)
Married	–1.469	3.106	–0.832	5.744
	(6.943)	(3.308)	(8.787)	(3.732)
Divorced	0.040	4.989	–7.846	15.148***
	(8.214)	(3.794)	(9.271)	(4.390)
College	1.937	2.907	7.628	–5.276
	(6.244)	(3.342)	(7.976)	(3.838)
Hispanic	–12.927*	–9.143**	–5.502	–2.869
	(7.743)	(4.169)	(10.226)	(4.974)
Black	–14.440***	–17.116***	4.957	–6.111*
	(5.099)	(2.977)	(7.318)	(3.719)
Other	25.652	–16.534***	43.425*	3.780
	(20.953)	(4.588)	(26.314)	(7.015)
Year 05–06	4.105	7.586***	–5.114	7.123***
	(4.824)	(2.209)	(5.998)	(2.666)
Child	10.914*	–1.633	–6.236	–5.006
	(6.616)	(2.675)	(8.936)	(3.282)
Good health	1.728	5.780**	0.713	10.416***
	(5.931)	(2.673)	(7.405)	(3.340)
Poor health	–12.478*	–3.385	–16.829*	–11.020**
	(7.240)	(4.388)	(9.482)	(4.761)
Renter	3.744***	–0.128	5.544***	–2.897***

	(1.508)	(0.355)	(2.091)	(1.080)
Age 20–30	10.578***	–0.341	15.579***	–8.066***
	(4.251)	(0.953)	(6.190)	(3.170)
Age 31–50	14.447***	–0.480	21.342***	–11.071***
	(4.595)	(1.328)	(6.405)	(3.407)
Age 51–70	4.500	–0.137	6.594	–3.378
	(3.317)	(0.412)	(4.932)	(2.558)
Diet. supp.	–1.331	3.391	–7.576	4.412
	(8.693)	(2.339)	(10.064)	(2.813)
High BP	–21.661***	–3.080	–29.345***	–12.904***
	(8.078)	(3.601)	(10.485)	(4.370)
Active	30.935**	21.952***	51.298***	47.038***
	(14.122)	(6.234)	(19.514)	(8.320)

Note: Asymptotic standard errors in parentheses. Asterisks indicate levels of significance: *** = 1%, ** = 5%, * = 10%

Appendix B

Table A1. Maximum-Likelihood Estimation of Nutrient Equation System with an Endogenous Treatment (SNAP)

Variable	SNAP	Protein	Vitamin A	Vitamin C	Calcium	Iron
Constant	–0.865***	5.178***	4.516***	3.881***	4.809***	5.364***
	(0.210)	(0.141)	(0.338)	(0.233)	(0.171)	(0.157)
Income	–0.536***	0.086**	0.103	0.249***	0.158***	0.060
	(0.105)	(0.041)	(0.096)	(0.067)	(0.050)	(0.046)
Mexican born	–0.732***	0.098	0.458***	0.037	0.135*	–0.017
	(0.182)	(0.061)	(0.148)	(0.103)	(0.076)	(0.070)
Other-country	–0.383***	–0.109**	0.367***	–0.002	–0.259***	–0.083
born	(0.142)	(0.047)	(0.113)	(0.084)	(0.059)	(0.054)
Married	–0.383***	0.030	0.049	0.002	0.044	–0.038
	(0.106)	(0.050)	(0.123)	(0.131)	(0.071)	(0.056)
Divorced	0.094	0.025	–0.138	–0.011	0.057	0.118**
	(0.113)	(0.055)	(0.137)	(0.144)	(0.077)	(0.061)
Education	–0.117	0.035	0.232	0.246***	0.151***	0.152***
	(0.078)	(0.044)	(0.195)	(0.081)	(0.057)	(0.051)
Hispanic	0.182	–0.034	0.041	–0.178**	–0.160***	0.003
	(0.130)	(0.049)	(0.117)	(0.081)	(0.060)	(0.056)
Black	0.229***	0.005	0.137	–0.228***	–0.279***	–0.008
	(0.094)	(0.040)	(0.094)	(0.067)	(0.048)	(0.046)
Other race	–0.270	0.069	–0.101	–0.035	–0.186**	0.018
	(0.198)	(0.064)	(0.152)	(0.109)	(0.079)	(0.074)
Year 05–06	–0.214***	0.021	0.108*	0.120***	0.124***	0.022
	(0.071)	(0.026)	(0.062)	(0.043)	(0.032)	(0.030)
Child	0.542***	0.002	–0.079	–0.130**	–0.006	0.007
	(0.108)	(0.039)	(0.080)	(0.066)	(0.048)	(0.042)
Good health	–0.126	0.002	0.113	0.078	0.074**	0.075**
	(0.083)	(0.029)	(0.071)	(0.049)	(0.036)	(0.034)
Poor health	0.146	–0.311***	–0.165	–0.341***	–0.128**	–0.172***
	(0.141)	(0.053)	(0.127)	(0.089)	(0.065)	(0.061)
Female	0.349***	–0.410***	–0.670**	–0.395*	–0.582***	–1.256***
	(0.078)	(0.126)	(0.319)	(0.211)	(0.154)	(0.140)
Renter	0.271***					
	(0.074)					

Age 20–30	0.462***					
	(0.160)					
Age 31–50	0.745***					
	(0.149)					
Age 51–70	0.131					
	(0.138)					
Household size	–0.123***					
	(0.028)					
Diet. supp.		–0.004	0.104	0.030	0.059*	0.036
		(0.030)	(0.067)	(0.046)	(0.035)	(0.032)
High BP		–0.061	–0.131	0.006	–0.072	–0.175***
		(0.051)	(0.112)	(0.105)	(0.064)	(0.056)
Active		0.086***	0.088	0.134***	0.113***	0.059*
		(0.029)	(0.070)	(0.049)	(0.036)	(0.032)
BMI		0.008	–0.156*	–0.092	–0.042	–0.038
		(0.036)	(0.082)	(0.060)	(0.043)	(0.039)
Age		–0.065	–0.237**	–0.068	–0.177***	–0.045
		(0.042)	(0.100)	(0.071)	(0.051)	(0.048)
Age^2		0.011	0.254***	0.098	0.085*	0.095**
		(0.044)	(0.099)	(0.068)	(0.052)	(0.048)
Female × college		–0.036	0.001	–0.069	–0.093	–0.177**
		(0.063)	(0.332)	(0.119)	(0.084)	(0.073)
Female × active		0.137**	0.340***	0.134	0.201***	0.424***
		(0.061)	(0.138)	(0.116)	(0.076)	(0.067)
Female × BMI		0.051	0.217**	0.139*	0.077	0.088*
		(0.044)	(0.099)	(0.073)	(0.053)	(0.048)
SNAP		0.000	0.062	0.197	0.146	–0.510***
		(0.071)	(0.193)	(0.121)	(0.097)	(0.078)
σ		0.543***	1.297***	0.906***	0.665***	0.627***
		(0.009)	(0.021)	(0.015)	(0.011)	(0.013)
Log likelihood	–50654.189					

Note: Asymptotic standard errors in parentheses. Asterisks indicate levels of significance: *** = 1%, ** = 5%, * = 10%

Table A2. Maximum-Likelihood Estimates of Error Correlations (Treatment Effect System for Nutrient Intakes (% DRIs))

	SNAP Participation	Protein	Vitamin C	Vitamin A	Calcium
			SNAP Non-participants		
Protein	–0.001				
	(0.075)				
Vitamin C	–0.075	0.296***			
	(0.080)	(0.021)			
Vitamin A	–0.106	0.488***	0.406***		
	(0.071)	(0.018)	(0.020)		
Calcium	–0.125	0.655***	0.380***	0.633***	
	(0.079)	(0.014)	(0.020)	(0.014)	
Iron	0.455***	0.654***	0.313***	0.462***	0.543***
	(0.062)	(0.017)	(0.025)	(0.023)	(0.022)

Note: Asymptotic standard errors in parentheses. Asterisks indicate level of significance: *** = 1%, * = 10%

Table A3. Treatment Effects of SNAP Participation on Nutrient Intakes (TES)

Nutrient	Male	Female	Pooled
		Treatment Effects (Individuals)	
Protein	–5.223	4.063	–8.232*
	(6.401)	(4.676)	(4.989)
Vitamin C	–34.645***	–22.946***	–26.119***
	(9.099)	(9.344)	(8.864)
Vitamin A	–2.315	–6.762*	–4.775
	(4.171)	(3.975)	(3.832)
Calcium	–8.237**	0.801	–8.871***
	(4.129)	(2.819)	(3.109)
Iron	–13.536	–11.626***	–44.281***
	(8.778)	(3.176)	(4.747)
		Treatment Effects (at Sample Means of Variables)	
Protein	–4.750	4.166	–7.246
	(6.160)	(4.630)	(4.861)
Vitamin C	–28.172***	–14.964*	–19.355***
	(8.066)	(8.475)	(7.922)
Vitamin A	–0.737	–4.891	–3.033
	(3.898)	(3.772)	(3.600)
Calcium	–5.887	2.079	–5.918**
	(3.864)	(2.684)	(2.905)
Iron	–15.410*	–12.381***	–41.281***
	(8.353)	(3.088)	(4.199)

Note: Asymptotic standard errors in parentheses. Asterisks indicate level of significance: ***=1%, **=5%, *=10%.

Vita

Xiaowen Liu was born in Zhengzhou, China. Her parents are Shiying Li and Wenhua Liu. She came to the University of Tennessee, Knoxville in 2007, studying in Agricultural Economics. Her major professor is Sr. Steven Yen. After getting master degree in Agricultural Economics, she will start PhD study in Economics, general.