Causal Effects of Multiple Food Assistance Program Participation on Child Food Insecurity

Helen H. Jensen, *Iowa State University*
Brent Kreider, *Iowa State University*
Oleksandr Zhylyevskyy, *Iowa State University*

MEA Annual Meeting

Cincinnati, OH
April 1, 2017

Motivation

Food insecurity harms child's physical, intellectual, social development and health (Gundersen et al., 2011)

Prevalence of food insecurity in low-income population is high. Among households with children and income below 130% poverty (Coleman-Jensen et al., 2016):

- **29%** had low food security
- **12%** had very low food security

} **3.2M** food-insecure households

- Also, **20%** (**1.5M** households) had food-insecure children

Food programs—e.g., SNAP, NSLP, WIC—aim at reducing food insecurity. Most papers focus on one program. Few study **multiple** programs (e.g., Keane & Moffitt, 1998)

Many assistance recipients participate in multiple programs. How do various programs interact in creating a **food safety net**?

Methodological Challenge

Identifying **causal** effect is difficult even for a single program:

- **Nonrandom selection**: unobservables simultaneously affect food security and program participation
  - Simple regression methods produce **inconsistent** estimates of causal effects
- **Nonclassical measurement error**: households systematically underreport benefits, misreporting varies across households with different attributes
  - Standard IV methods produce **inconsistent** estimates

Allowing for **multiple** programs adds another layer of complexity:

- Participation can no longer be modeled using a binary variable
- Dimensionality of measurement error problem increases

Our approach and methodological contribution:

- Introduce a multinomial, **partially-ordered** treatment variable to model participation
- Extend partial identification methods of Kreider & Hill (2009), Kreider et al. (2012), which account for selection and measurement error in a single framework

Research Focus and Relevance

We develop methodology to study **two** programs **jointly**

In application, we focus on:

- **SNAP**: Supplemental Nutrition Assistance Program (food stamps)
- **NSLP**: National School Lunch Program (school lunches)

Both are large programs. In 2015 (Oliveira, 2016):

- 46M people participated in SNAP on average per month
- 22M children received free/reduced-price school lunches on average per day
- Annual federal expenditures on SNAP: $74B, NSLP: $13B

Receipt of benefits is underreported in surveys (Meyer et al., 2015):

- 40% of SNAP benefits are not reported in CPS; 45% underreporting for NSLP

Our goal is to account for selection and misreporting and quantify:

- To what extent participation in SNAP+NSLP improves food security compared to no participation
- To what extent participation in both programs augments effect of either one alone

Data Sources

Main source: **Food Security Supplement** of **CPS**

FSS is administered in December; we pool years 2002–2010

FSS/CPS provides info on food security, food program participation, food expenditures, socioeconomic characteristics

Analytical sample: households with **school-age** children and income below **130%** of poverty line, ***N* = 10,390**

Additional sources (data on IVs and MIVs):

- Quarterly Food-at-Home Price Database (**QFAHPD**) provides **prices** for 50+ food groups across 35 geographic areas
- **SNAP Policy Database** provides state-level info on **policies** regarding eligibility, reporting requirements, use of biometrics

Child Food Security Measure

FSS has 18-item **Household Food Security Survey Module**

8 items are child specific (answered by adult proxy)

Examples of questions (referenced to past month):

- *Did any of the children ever skip a meal because there wasn't enough money for food?* Yes/No
- *Did any of the children ever not eat for a whole day because there wasn't enough money for food?* Yes/No

Responses are scored (0-1) and summed. Summary score is used to construct categories of child food security:

food secure (**88.3%**)
- (1) high: score = 0 (79.5%)
- (2) marginal: score = 1 (8.8%)

food insecure (**11.7%**)
- (3) low: 2 ≤ score ≤ 4 (10.2%)
- (4) very low: score ≥ 5 (1.5%)

Reported Program Participation

Weighted sample distribution by program participation, N = 10,390:

		SNAP	
		yes	*no*
NSLP	*yes*	34.9%	35.6%
	no	5.0%	24.6%

- Reference period for food assistance program participation: **past month**
- Sample: households with 1+ school-age child, income below 130% poverty

Motivation for Our Methodology

Simple parametric approach:

$$Y_i = \gamma \cdot S_i + x_i \cdot \beta + \varepsilon_i$$

Outcome | Treatment | Covariates | Error term

Treatment S_i is **binary**. E.g., $S_i = 1$ if i is on SNAP, 0 if not

If same unobservables affect S_i and Y_i, then $cov(S_i, \varepsilon_i) \neq 0$ and OLS is inconsistent due to **endogeneity**

Measurement error in S_i is **nonclassical** → standard IV estimation is inconsistent too

Our **nonparametric bounding** methodology handles endogeneity, misreporting, and multiple treatments (not just *binary* S_i). Also, it allows for heterogeneous response to treatment across i

Our Approach: Basics

$\boldsymbol{S^*}$: **true** program participation; $S^* = 0$: none, $S^* = 1$: SNAP only, $S^* = 2$: NSLP only, $S^* = 3$: SNAP+NSLP; S^* is *partially ordered*

$\boldsymbol{S}$: **reported** participation; S need not equal S^*

Potential outcomes framework:

$\boldsymbol{Y(S^*)}$: potential outcome under treatment S^*; $Y = 1$ if FS, 0 otherwise

$\boldsymbol{X}$: covariates (some used as instruments)

We focus on **average treatment effects** (**ATEs**):

$$ATE_{jk} = P[Y(S^* = j) = 1 \mid X] - P[Y(S^* = k) = 1 \mid X] \text{ for } j \neq k$$

E.g., ATE_{31} measures how likelihood of FS would change if household were to participate in SNAP+NSLP vs. in SNAP only

There are no regression orthogonality conditions to satisfy

Covariates are only used to specify subpopulations

Decomposition Strategy

ATE cannot be point-identified without assumptions even if $S = S^*$

We decompose every formula into what is identified and what isn't

Let's simplify notation: $ATE_{31} = P[Y(3)=1] - P[Y(1)=1]$

Consider decomposition:

$$P[Y(3)=1] = \underbrace{P[Y(3)=1 \mid S^* = 3]}_{\text{identified}} \underbrace{P(S^* = 3)}_{\text{identified}} + \underbrace{P[Y(3)=1 \mid S^* \neq 3]}_{\text{not identified}} \underbrace{P(S^* \neq 3)}_{\text{identified}}$$

Data cannot identify $P[Y(3)=1 \mid S^* \neq 3]$ because it refers to unobserved **counterfactual**. We only know $P[Y(3)=1 \mid S^* \neq 3] \in [0,1]$

However, using methods of Manski (1995), we can still find worst-case bounds for $P[Y(3)=1]$, $P[Y(1)=1]$, and ATE_{31}

Addressing Misreporting

When S may deviate from S^*, define: $\theta_i^{j,k} \equiv P(Y = i, S = j, S^* = k)$

$P[Y(3) = 1]$ becomes:

$$P[Y(3)=1] = P(Y=1, S=3) + \theta_1^{-3,3} - \theta_1^{3,-3}$$
$$+P[Y(3)=1 \mid S^* \neq 3]\left\{P(S \neq 3) + \sum_{j \neq 3}(\theta_1^{-j,j} + \theta_0^{-j,j} - \theta_1^{j,-j} - \theta_0^{j,-j})\right\}$$

ATE_{31} is "bounded" as:

$$-P(Y=0, S \neq 1) - P(Y=1, S \neq 3) + \Theta_{3,1}^{LB}$$
$$\leq ATE_{3,1} \leq$$
$$P(Y=0, S \neq 3) + P(Y=1, S \neq 1) + \Theta_{3,1}^{UB}$$

unobserved

$$\Theta_{3,1}^{LB} \equiv \theta_1^{-3,3} - \theta_1^{3,-3} + \theta_0^{-1,1} - \theta_0^{1,-1}, \quad \Theta_{3,1}^{UB} \equiv -\theta_0^{-3,3} + \theta_0^{3,-3} - \theta_1^{-1,1} + \theta_1^{1,-1}$$

Tightening Bounds

Without assumptions, ATE bounds are **wide** and **contain zero**

To **tighten** them, we can:

- Use logical constraints on probabilities and auxiliary data to restrict θ's. Say:

$$\theta_1^{-1,1} \leq \min\{P(Y=1, S \neq 1), P(S^*=1)\}$$

- Restrict prevalence of misreporting. Say, constrain value of $\Delta_j \equiv P_j^* - P_j$
- Restrict pattern of misreporting. Say, impose "**no-stigma verification**" assumption: Household with $S \neq 0$ is presumed to provide accurate participation response for both SNAP and NSLP. This assumption zeroes out several θ's
- Restrict selection process by imposing **exogenous selection**, monotone treatment selection (**MTS**), monotone treatment response (**MTR**), monotone instrumental variables (**MIVs**), instrumental variables (**IVs**)

By layering progressively stronger assumptions we demonstrate how they shape inference

Example of Analytical Results

Proposition 2(ii)(B):

Under "no-stigma verification" with endogenous selection, bounds on $ATE_{3,1}$ are as follows:

- **Lower bound**:

$$ATE_{3,1}^{LB} = -P(Y=1, S \neq 3) - P(Y=0, S \neq 1) + \max\{0, \Delta_3 - P_{000}\} + \max\{0, \Delta_1 - P_{100}\}$$

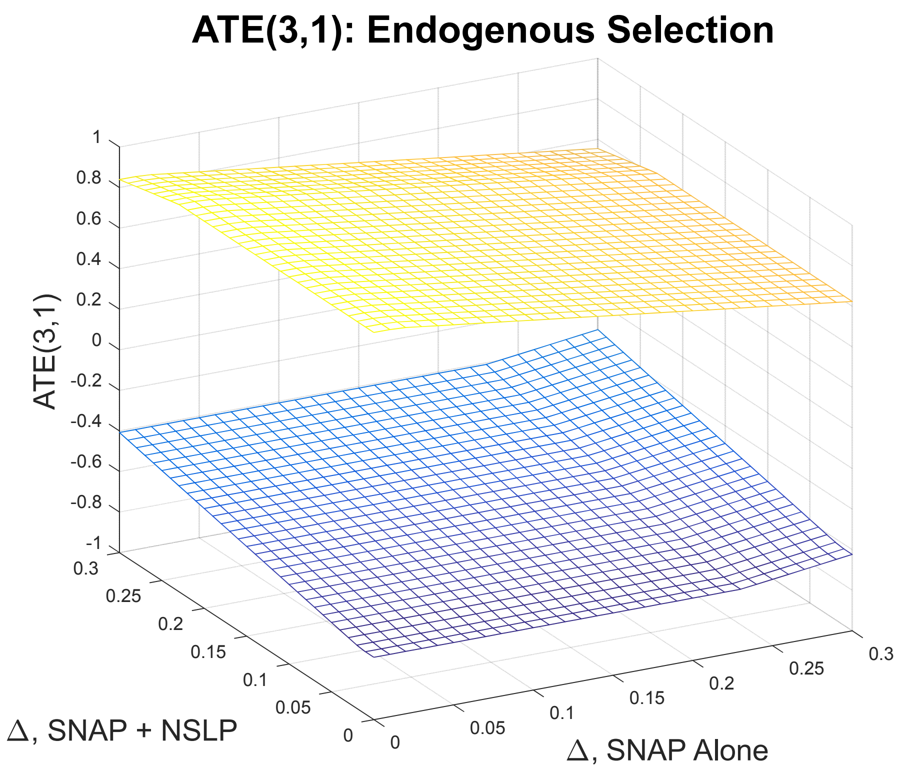
- **Upper bound**:

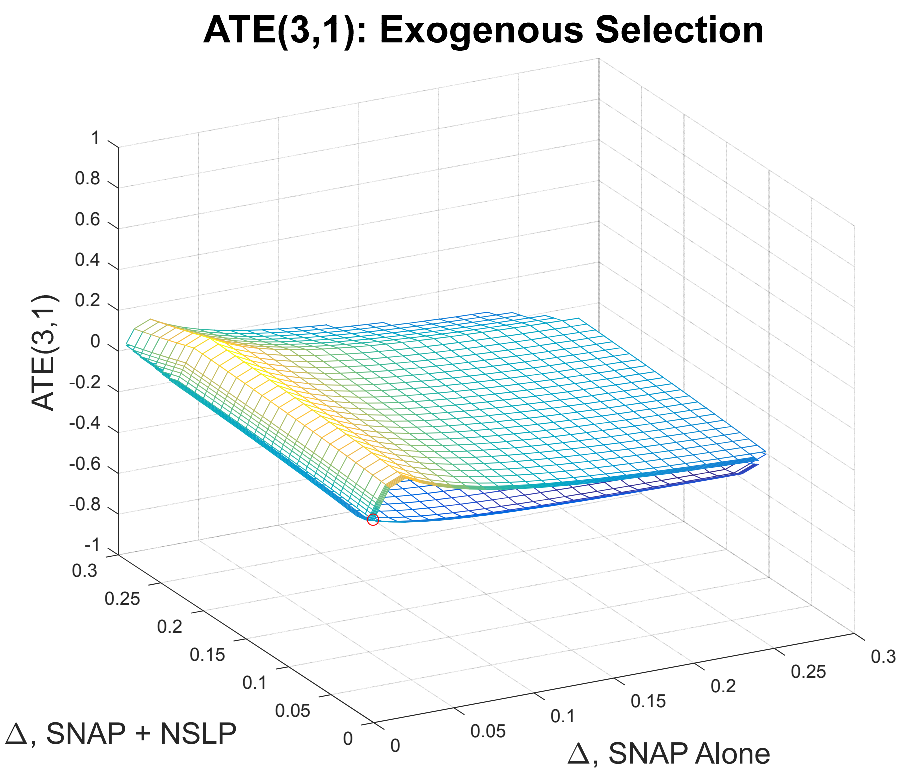
$$ATE_{3,1}^{UB} = P(Y=0, S \neq 3) + P(Y=1, S \neq 1) - \max\{0, \Delta_3 - P_{100}\} - \max\{0, \Delta_1 - P_{000}\}$$

$\Delta_1 \equiv P_1^* - P_1$, $\Delta_3 \equiv P_3^* - P_3$, $P_{000} \equiv P(Y=0, S=0, V=0)$,
$P_{100} \equiv P(Y=1, S=0, V=0)$

Results: Endog. vs. Exog. Selection

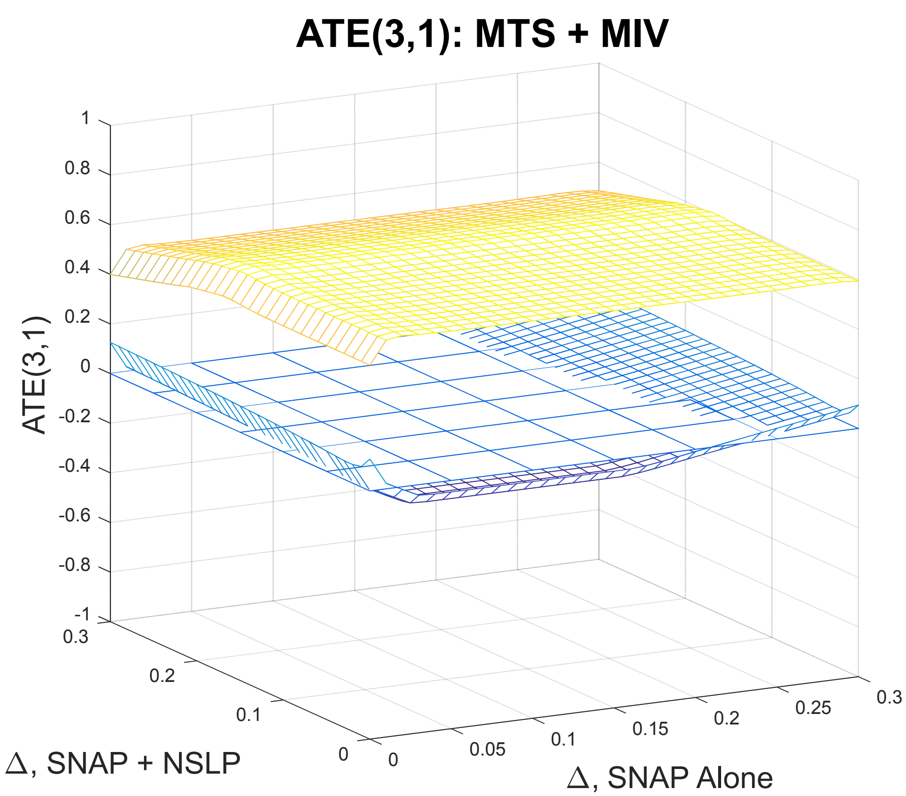
Bounds on ATE of participating in SNAP+NLSP vs. in SNAP only:

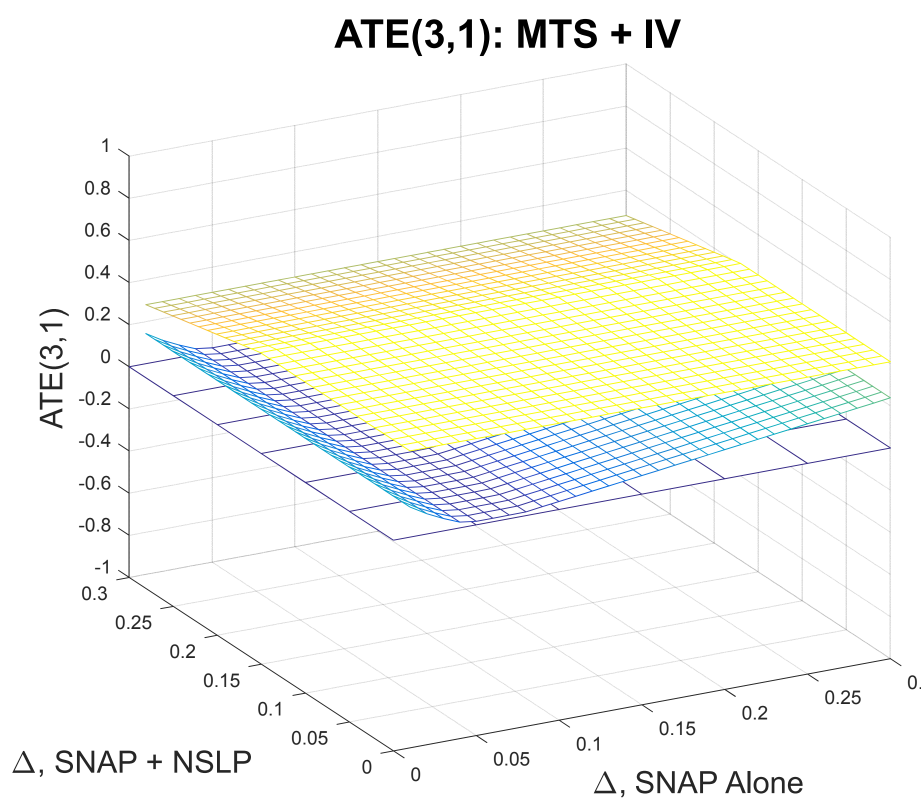




Results: MTS + MIV and MTS + IV

Bounds on ATE of participating in SNAP+NLSP vs. in SNAP only:





Summary

Motivating question: How do food programs interact in creating a food safety net?

Research goal: Quantify by how much SNAP+NSLP improves child food security relative to SNAP or NSLP only and relative to nonparticipation

Data: Large national sample drawn from FSS/CPS

Methodology: Nonparametric bounding approach handles endogeneity, misreporting, multiple treatments

Selected result: Bounding under MTS and IV indicates SNAP+NSLP improves child food security beyond effect of SNAP only $(ATE_{3,1} > 0)$

Thank you!

Appendix

More on Food Security

Conceptually, food security means access to enough food for active, healthy life. It implies:

- Ready availability of nutritionally adequate and safe foods, and
- Assured ability to acquire such foods in socially acceptable ways

In practice, food security status is assigned based on a survey module with questions on food-related behaviors under lack of resources:

- Example: "*Did you ever cut the size of your meals or skip meals because there wasn't enough money for food?" (Yes/No)*
- FSS/CPS uses 18 questions, other surveys may use ≤ 10 questions
- Questions can focus on household, adults, or children

Answers are converted into # of food-insecure conditions. A threshold separates food secure from food insecure

Prevalence of Child Food Security

Unweighted prevalence by food program participation:

NSLP \ SNAP	yes	no
yes	0.8634	0.8777
no	0.8691	0.9374

Weighted prevalence by food program participation:

NSLP \ SNAP	yes	no
yes	0.8626	0.8661
no	0.8700	0.9386

- Reference period: **past month**. All variables are as reported
- Each cell shows fraction of households with given condition in subsample

Prevalence of No Very Low Child FS

Unweighted prevalence by food program participation:

NSLP \ SNAP	yes	no
yes	0.9783	0.9881
no	0.9863	0.9919

Weighted prevalence by food program participation:

NSLP \ SNAP	yes	no
yes	0.9782	0.9877
no	0.9870	0.9921

- Reference period: **past month**. All variables are as reported
- Each cell shows fraction of households with given condition in subsample

Reported Program Participation (II)

Unweighted sample distribution by program participation, *N* = 10,390:

		SNAP	
		yes	*no*
NSLP	*yes*	34.5%	35.5%
	no	4.9%	25.0%

- Reference period for food assistance program participation: **past month**
- Sample: households with 1+ school-age child, income below 130% poverty line

QFAHPD, SNAP Policy Database: Details

QFAHPD is based on Nielsen Homescan: food purchase transactions by a large panel of households. ERS aggregated data within/across households by food group, area, time period

- Time coverage: every quarter between 1999 and 2010
- 54 food groups: e.g., fresh orange vegetables, low fat cheese
- 35 areas partitioning U.S. = 26 metro areas + 9 non-metro areas
- Food prices are expressed in $ per 100 grams as purchased

SNAP Policy Database is compiled by ERS to provide state-level information on policies regarding program eligibility, reporting requirements, use of biometric technology, etc.

- Coverage: every state and DC, every month between 1996 and 2014
- Allows us to construct nearly all IVs used in previous literature:
  - Continuous: e.g., per capita SNAP outreach spending
  - Binary: e.g., fingerprinting, noncitizen eligibility

Restricting Selection Process

Exogenous selection: expected potential outcomes do not depend on realized treatment:

$$P[Y(j)=1]=P[Y(j)=1 \mid S^{*}=k] \quad \forall j,k$$

Monotone instrumental variable (**MIV**):

$$u_1 \le u \le u_2 \Rightarrow P[Y(j)=1 \mid v=u_1] \le P[Y(j)=1 \mid v=u] \le P[Y(j)=1 \mid v=u_2]$$

Monotone treatment selection (**MTS**) is a special case of MIV: decision to participate is monotonically related to food insecurity:

$$P[Y(j)=1 \mid S^{*}=3] \le P[Y(j)=1 \mid S^{*}=k] \le P[Y(j)=1 \mid S^{*}=0] \quad \forall\, j;\, k=1,2$$

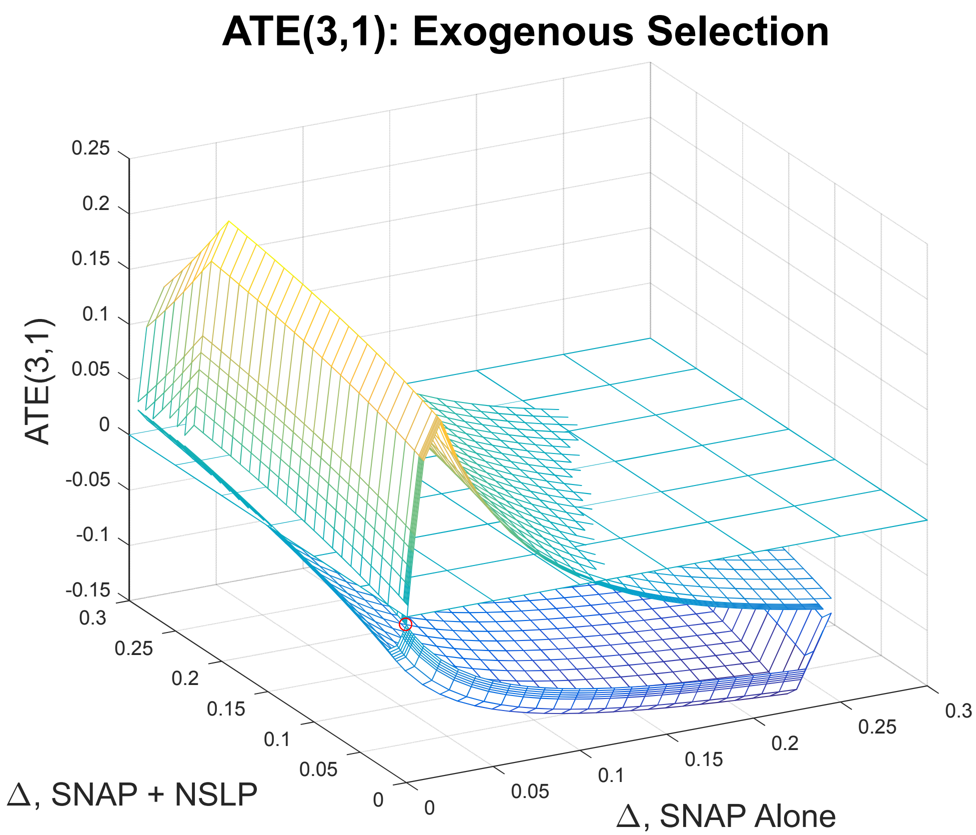
Monotone treatment response (**MTR**): potential participation in food programs would not harm food security:

$$P[Y(3)=1 \mid S^{*}] \ge P[Y(1)=1 \mid S^{*}] \ge P[Y(0)=1 \mid S^{*}]$$

$$P[Y(3)=1 \mid S^{*}] \ge P[Y(2)=1 \mid S^{*}] \ge P[Y(0)=1 \mid S^{*}]$$

Exogenous Selection: Closer View

Bounds on ATE of participating in SNAP+NSLP vs. in SNAP only:



Exog. Selection: Identification Decay

Bounds on ATE of participating in SNAP+NSLP vs. in SNAP only:

		$\Delta_1 = 0$			$\Delta_1 = 0.01$			$\Delta_1 = 0.10$		
		LB	UB	width	LB	UB	width	LB	UB	width
$\Delta_3 = 0$	p.e.	[-0.007,	-0.007]	0.000	[-0.029,	0.14]	0.167	[-0.094,	0.007]	0.101
	CI	[-0.040,	0.026]		[-0.051,	0.16]		[-0.106,	0.022]	
$\Delta_3 = 0.01$	p.e.	[-0.031,	-0.004]	0.028	[-0.053,	0.14]	0.195	[-0.118,	0.010]	0.129
	CI	[-0.057,	0.022]		[-0.075,	0.17]		[-0.130,	0.025]	
$\Delta_3 = 0.10$	p.e.	[-0.010,	0.023]	0.034	[-0.032,	0.17]	0.201	[-0.097,	0.037]	0.134
	CI	[-0.036,	0.049]		[-0.054,	0.19]		[-0.108,	0.051]	

Identification deteriorates with extent of underreporting of SNAP

MTS: Definition

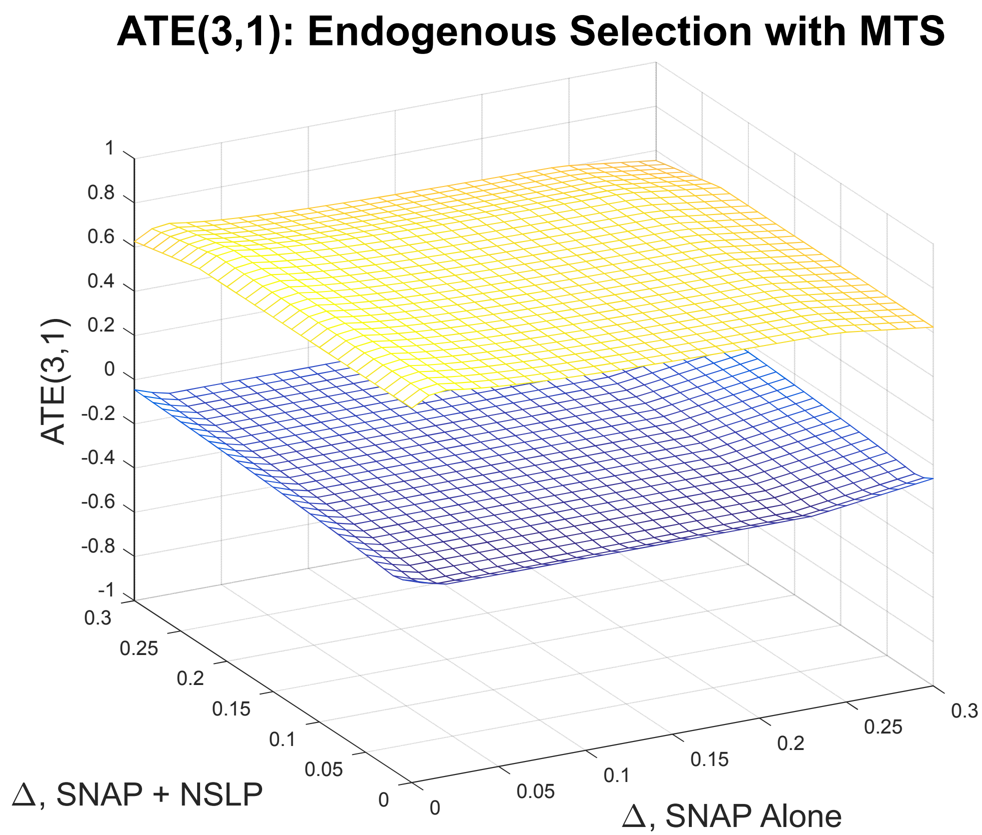
Monotone treatment selection (**MTS**):

$$P[Y(j)=1 \mid S^* = 3] \le P[Y(j)=1 \mid S^* = k] \le P[Y(j)=1 \mid S^* = 0] \quad \forall\, j;\, k = 1,2$$

Under MTS assumption, decision to participate is monotonically related to food insecurity: households choose to participate in more programs in anticipation of worse food security situation

Endogenous Selection with MTS

Bounds on ATE of participating in SNAP+NSLP vs. in SNAP only:



MTR: Definition

Monotone treatment response (**MTR**):

$$P[Y(3) = 1 \mid S^*] \geq P[Y(1) = 1 \mid S^*] \geq P[Y(0) = 1 \mid S^*]$$

$$P[Y(3) = 1 \mid S^*] \geq P[Y(2) = 1 \mid S^*] \geq P[Y(0) = 1 \mid S^*]$$

Under MTR assumption, potential participation in (more) food programs would not harm food security on average

MIV: Definition

Monotone instrumental variable (**MIV**):

$$u_1 \leq u \leq u_2 \Rightarrow$$

$$P[Y(j)=1 \mid v=u_1]$$

$$\leq P[Y(j)=1 \mid v=u] \leq$$

$$P[Y(j)=1 \mid v=u_2]$$

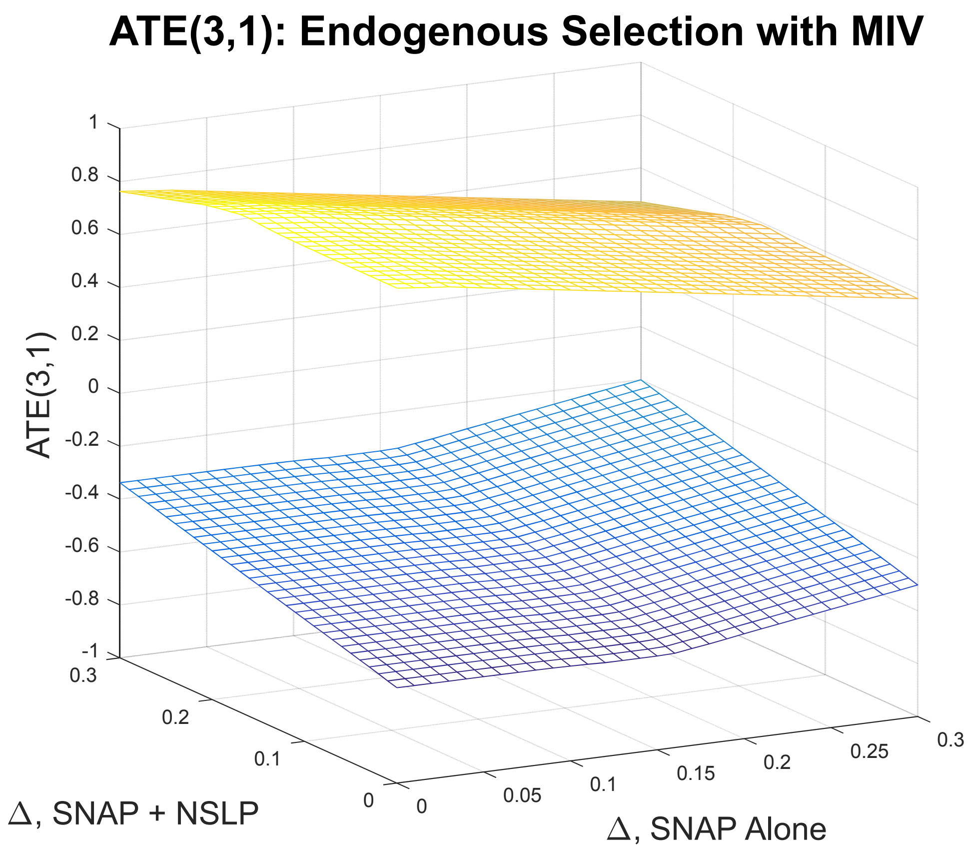
We construct and use:

$$v = \frac{\text{Usual household food expenditures}}{\text{TFP-based minimum expenditures}}$$

Assumption: higher v would not harm food security on average

Bounds under MIV

Bounds on ATE of participating in SNAP+NSLP vs. in SNAP only:



IV: Definition

Instrumental variable (**IV**):

$$\forall u_1, u_2 :$$
$$P[Y(j)=1 \mid v=u_1] = P[Y(j)=1 \mid v=u_2]$$

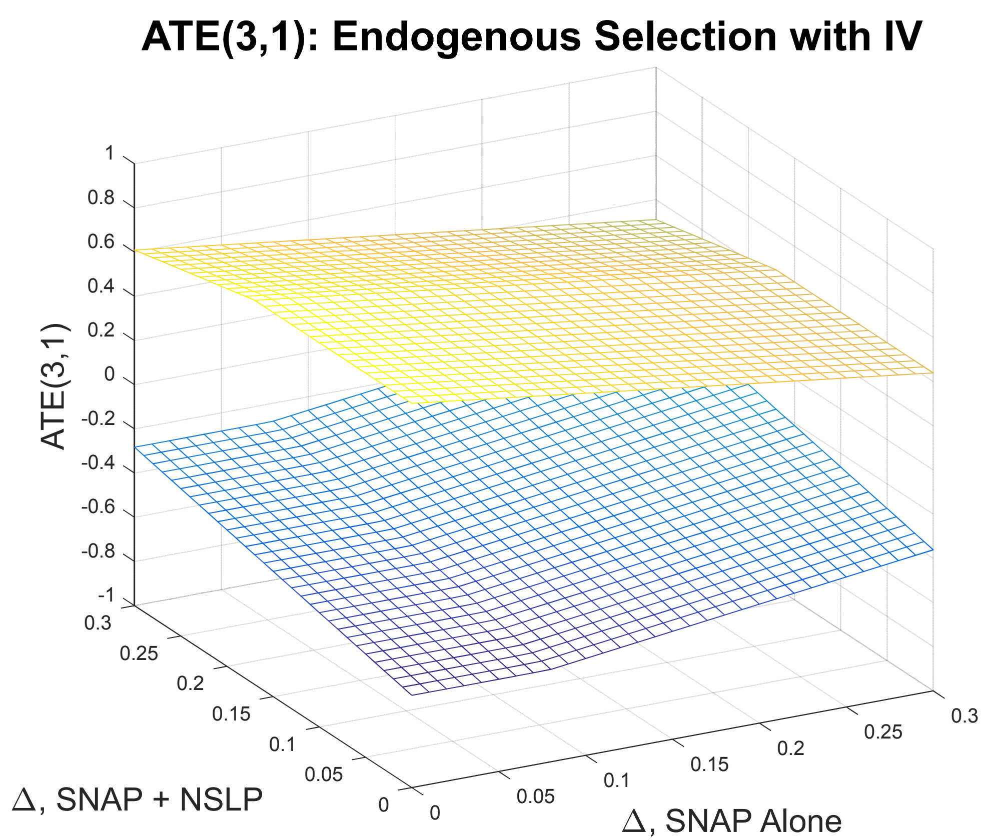
IV is a special case of MIV

We employ **SNAP Policy Database** to construct conventional IVs used in previous literature to instrument for SNAP participation. Many such IVs are binary

We create a multinomial scalar IV by combining seven conventional IVs

Bounds under IV

Bounds on ATE of participating in SNAP+NSLP vs. in SNAP only:



Combining Assumptions

We can combine monotonicity assumptions to **further tighten bounds**

In many cases, $ATE_{3,1}$ can be identified as **strictly positive** even in the presence of substantial classification error

Abbreviations

ATE: average treatment effect

CPS: Current Population Survey

ERS: Economic Research Service of USDA

FSM: food security module

FSS: Food Security Supplement of CPS

MIV: monotone instrumental variable

MTR: monotone treatment response

MTS: monotone treatment selection

NSLP: National School Lunch Program

QFAHPD: Quarterly Food-at-Home Price Database

SNAP: Supplemental Nutrition Assistance Program

TFP: Thrifty Food Plan