Effects of Family, Friends, and Relative Prices on Fruit and Vegetable Consumption by African American Youths

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Research Goals

Focus:

- fruit and vegetable (**FV**) intake by **African American** youths

Primary goal:

- assess effects of FV intake by parent and best friend on FV intake by youth and vice versa

Secondary goal:

- evaluate effects of relative FV prices on FV consumption

Relevance:

- dietary habits persist from adolescence into adulthood
- African Americans have the **lowest** FV intake among all ethnic groups in the U.S.
- inadequate nutrition contributes to **obesity epidemic**

Motivation

Scientific literature indicates that diets rich in FV:

- protect against cancer, other illnesses (e.g., CVD, diabetes)
- reduce the likelihood of gaining excess weight

Adolescents consume **less** FV than recommended by DG 2010

Recent NPD Group study shows that FV intake by 13-17 y.o.'s is on a **downward trajectory**:

- F $\downarrow 2\%$: from 250 annual servings in 2004 to 245 in 2009
- V $\downarrow 6\%$: from 422 annual servings in 2004 to 397 in 2009

Growing public interest in policy interventions to:

- shift diets toward *energy light* and *nutrient rich* foods
- exploit **social network effects** to amplify policy effectiveness

Related Literature

Large literature on peer effects in youths' substance use:

- Gaviria & Raphael (2001), Powell et al. (2005), Krauth (2006), Lundborg (2006), Clark & Lohéac (2007), Fletcher (2010)

Fledgling literature on social networks and spread of obesity:

- Christakis & Fowler (2007), Renna et al. (2008), Trogdon et al. (2008)

Focus group and experimental studies in nutrition literature:

- de Castro & Brewer (1991), Neumark-Sztainer et al. (1999), Epstein et al. (2001), Salvy et al. (2011)

Growing literature on impact of food prices on BMI:

- Chou et al. (2004), Auld & Powell (2009), Powell (2009), Beydoun et al. (2011)

Novelty and Contribution

We use rich behavioral data from the Family and Community Health Study (**FACHS**) to:

- investigate the role of social interactions in FV intake
- separate out parent's impact on youth from friend's impact

We use comprehensive food price data from the ERS's Quarterly Food-at-Home Price Database (**QFAHPD**) to:

- construct relative FV prices specific to **location** and **time**

Methodological novelty:

- we propose and estimate a **simultaneous equation ordered probit model** with social interactions

Family and Community Health Study (FACHS)

Key features of **FACHS**:

- ongoing panel survey of African American youths & families
- originated in 1997 as a study of 10-12 y.o.'s in GA and IA
- Wave 4 (May 2005 to June 2007) added best same-sex friend
- contains demographic and behavioral data, including FV intake
- not designed to be nationally representative, but resembles corresponding NHANES and CPS samples

We use **Wave 4** to link together a youth, his/her primary caregiver ("parent") and friend

Sample: **502** youth-parent-friend **triplets**

▸ demographics

FACHS: Fruit Consumption

During the past seven days, how many times did you eat a whole piece of fruit (for example, an apple, orange or banana) or drink a glass of 100% fruit juice (do not count punch, Kool-Aid, or sports drinks)?

Answer	Youth, %	Friend, %	Parent,%
(1) none	12.75	14.94	10.96
(2) less than once a day (1-6 times)	26.49	24.70	23.71
(3) once a day	30.48	30.88	40.24
(4) 8-12 times	11.55	8.37	6.77
(5) twice a day (or more)	18.73	21.12	18.33
Total	100.00	100.00	100.00

FACHS: Vegetable Consumption

During the past seven days, how many times did you eat vegetables like green salad, carrots or potatoes (do not count French fries, fried potatoes, or potato chips)?

Answer	Youth, %	Friend, %	Parent,%
(1) none	13.75	14.94	3.19
(2) less than once a day (1-6 times)	26.10	26.29	20.52
(3) once a day	37.85	35.86	43.82
(4) 8-12 times	8.17	7.77	8.96
(5) twice a day (or more)	14.14	15.14	23.51
Total	100.00	100.00	100.00

Quarterly Food-at-Home Price Database (QFAHPD)

Key features of **QFAHPD**:

- compiled by ERS, based on Nielsen Homescan survey
- contains quarterly prices in $ per 100 grams of food as purchased
- includes 52 separate food groups
- covers 35 market areas (contiguous U.S.) from 1999 to 2006
- more comprehensive than ACCRA database

We construct price measures for F and V:

- obtain F price index by averaging prices of 3 fruit/juice groups
- obtain V price index by averaging prices of 12 vegetable groups
- compute relative F and V price indices
- link price variables to FACHS respondents' records

▸ relative prices ▸ food groups

Theoretical Framework

Standard utility maximization setting (Cawley, 2004):

- individual makes choices about work/leisure, home production, production of health, consumption of foods/other goods
- choices are constrained by budget, time, biology
- food intake affects utility directly, and indirectly via health outcome

We augment this framework by incorporating **social interactions**

Brock & Durlauf (2001):

utility may directly depend on choices and characteristics of reference group members, as opposed to dependence arising through intermediation of markets

▸ social network effects

Econometric Model: Notation

Youth: Y, friend: F, parent: P, triplet: t

Unobservable food intake **levels**: $w^*_{Y,t}$, $w^*_{F,t}$, $w^*_{P,t}$

Observable food intake **frequencies**: $w_{Y,t}$, $w_{F,t}$, $w_{P,t}$

Observable individual characteristics: $\mathbf{x}_{Y,t}$, $\mathbf{x}_{F,t}$, $\mathbf{x}_{P,t}$

Unobservable errors: $\epsilon_{Y,t}$, $\epsilon_{F,t}$, $\epsilon_{P,t}$:

$$\left(\epsilon_{Y,t}, \epsilon_{F,t}, \epsilon_{P,t}\right)' | \mathbf{x}_t \sim i.i.d.\ N\left(\mathbf{0}, \mathbf{\Sigma}\right)$$

$\mathbf{x}_t = \mathbf{x}_{Y,t} \cup \mathbf{x}_{F,t} \cup \mathbf{x}_{P,t}$; $\mathbf{\Sigma} \neq \mathbf{I}_3$, in general

▸ explanatory variables

Econometric Model: Equation System

Simultaneous equation model:

$$\begin{cases} w^*_{Y,t} = w^*_{F,t} \cdot \gamma_{FY} + w^*_{P,t} \cdot \gamma_{PY} + \mathbf{x}'_{Y,t} \cdot \boldsymbol{\beta}_Y + \epsilon_{Y,t} \\ w^*_{F,t} = w^*_{Y,t} \cdot \gamma_{YF} + \mathbf{x}'_{F,t} \cdot \boldsymbol{\beta}_F + \epsilon_{F,t} \\ w^*_{P,t} = w^*_{Y,t} \cdot \gamma_{YP} + \mathbf{x}'_{P,t} \cdot \boldsymbol{\beta}_P + \epsilon_{P,t} \end{cases}$$

In matrix form: $\left(w^*_{Y,t}, w^*_{F,t}, w^*_{P,t}\right) \cdot \mathbf{\Gamma} + \mathbf{x}'_t \cdot \mathbf{B} = (\epsilon_{Y,t}, \epsilon_{F,t}, \epsilon_{P,t})$

We extend Maddala & Lee (1976) to **ordered response** setting:

$$w_{Y,t} = j \;\Leftrightarrow\; \alpha_Y(j) < w^*_{Y,t} \leq \alpha_Y(j+1) \text{ for } j = 1, ..., 5$$

thresholds $\alpha_Y(1) \leq ... \leq \alpha_Y(6)$; treat $w_{F,t}, w_{P,t}$ analogously

Identification and Estimation

Identification is similar to Maddala & Lee (1976), involves normalization and exclusion restrictions

▸ normalization

Solve for **reduced form**:

$$\left(w^*_{Y,t}, w^*_{F,t}, w^*_{P,t}\right) = \mathbf{x}'_t \cdot \mathbf{\Pi} + \left(v_{Y,t}, v_{F,t}, v_{P,t}\right)$$

$$\mathbf{\Pi} = -\mathbf{B}\mathbf{\Gamma}^{-1}, \left(v_{Y,t}, v_{F,t}, v_{P,t}\right)' | \mathbf{x}_t \sim i.i.d.N\left(\mathbf{0}, \mathbf{\Omega}\right), \mathbf{\Omega} = \left(\mathbf{\Gamma}^{-1}\right)' \mathbf{\Sigma}\mathbf{\Gamma}^{-1}$$

Solve for **likelihood contribution** of triplet t:

$$L_t\left(\boldsymbol{\theta}\right) \equiv L\left(w_{Y,t}, w_{F,t}, w_{P,t} | \mathbf{x}_t; \boldsymbol{\theta}\right)$$

▸ likelihood contribution

Estimate parameters by ML: $\widehat{\boldsymbol{\theta}}_{MLE} = \arg\max_{\boldsymbol{\theta}} \sum_{t=1}^{T} \ln L_t\left(\boldsymbol{\theta}\right)$

Results: Fruit Consumption

	Youth: $w^*_{Y,t}$			Friend: $w^*_{F,t}$			Parent: $w^*_{P,t}$	
	Coeff.	Std.Err.		Coeff.	Std.Err.		Coeff.	Std.Err.
Endogenous Effects								
$\widehat{\gamma}_{FY}$	0.285	(0.182)	$\widehat{\gamma}_{YF}$	−0.251	(0.243)	$\widehat{\gamma}_{YP}$	0.382**	(0.192)
$\widehat{\gamma}_{PY}$	0.620**	(0.142)						
Effects of Explanatory Variables								
constant	1.658**	(0.592)		1.584**	(0.442)		0.495	(0.345)
Y_age $\times 10^{-1}$	−0.400	(0.358)						
Y_age2 $\times 10^{-2}$	−0.184**	(0.051)						
Y_male	0.038	(0.071)		0.084	(0.100)			
F_age $\times 10^{-1}$				−0.028	(0.190)			
F_age2 $\times 10^{-2}$				−0.029	(0.027)			
F_black				0.186	(0.135)			
P_age $\times 10^{-1}$							0.229**	(0.049)
P_age2 $\times 10^{-2}$							−0.015**	(0.001)
P_higher_educ	0.134	(0.107)					0.026	(0.103)
P_married	−0.195*	(0.105)					0.216*	(0.107)
P_poverty	−0.050	(0.114)					0.152	(0.112)
Y_rel_price	−0.594	(0.486)						
F_rel_price				−0.717*	(0.416)			
P_rel_price							−1.012*	(0.548)

* and ** denote significance at 10% and 5%, respectively

Results: Vegetable Consumption

	Youth: $w^*_{Y,t}$			Friend: $w^*_{F,t}$			Parent: $w^*_{P,t}$	
	Coeff.	Std.Err.		Coeff.	Std.Err.		Coeff.	Std.Err.
Endogenous Effects								
$\widehat{\gamma}_{FY}$	-0.351	(0.273)	$\widehat{\gamma}_{YF}$	-0.168	(0.384)	$\widehat{\gamma}_{YP}$	-0.234	(0.386)
$\widehat{\gamma}_{PY}$	0.586^{**}	(0.250)						
Effects of Explanatory Variables								
constant	2.147^{**}	(1.090)		1.204^{**}	(0.562)		0.271	(0.413)
Y_age $\times 10^{-1}$	-1.256^{**}	(0.057)						
Y_age2 $\times 10^{-2}$	0.319^{**}	(0.075)						
Y_male	-0.006	(0.099)		0.071	(0.095)			
F_age $\times 10^{-1}$				0.328^{*}	(0.177)			
F_age2 $\times 10^{-2}$				-0.037^{**}	(0.018)			
F_black				0.123	(0.119)			
P_age $\times 10^{-1}$							0.524^{**}	(0.059)
P_age2 $\times 10^{-2}$							-0.045^{**}	(0.002)
P_higher_educ	0.052	(0.093)					0.012	(0.105)
P_married	-0.039	(0.128)					0.320^{**}	(0.110)
P_poverty	0.006	(0.094)					-0.010	(0.122)
Y_rel_price	-1.559^{*}	(0.902)						
F_rel_price				$-1.352^{\dagger}$	(0.839)			
P_rel_price							0.485	(0.672)

* and ** denote significance at 10% and 5%, respectively; † denotes significance at 11%

Implications for Public Policy

FACHS sample is comparable to NHANES and CPS samples
$\Rightarrow$ results may apply to broader population of African American youths

Estimates indicate existence of **social multipliers** in FV intake within families
$\Rightarrow$ policy interventions can exploit social network effects

No evidence for endogenous effects between youths and friends
$\Rightarrow$ peer-group interventions may be less effective than family-based ones

Reducing relative FV prices via subsidies/taxes may increase FV consumption, but effects are statistically weak

Thank you!

Questions?

Characteristics of Youths and Friends in FACHS

Characteristic	Mean	Std.Dev.	Min	Max
Youth				
Age in years	19.28	0.83	16.85	21.89
Indicator of male sex	0.42	0.49	0	1
Indicator of African American race	0.96	0.20	0	1
Friend				
Age in years	19.87	3.34	13.54	51.59
Indicator of male sex	0.42	0.49	0	1
Indicator of African American race	0.84	0.36	0	1

▸ continue

◂ back to FACHS

Characteristics of Parents in FACHS

Characteristic	Mean	Std.Dev.	Min	Max
Age in years	45.06	7.68	32.56	88.87
Indicator of male sex	0.05	0.22	0	1
Indicator of African American race	0.92	0.27	0	1
Indicator of no high school degree	0.18	0.38	0	1
Indicator of high school degree	0.34	0.47	0	1
Indicator of some college education	0.35	0.48	0	1
Indicator of BA or higher degree	0.14	0.35	0	1
Indicator of married parent	0.36	0.48	0	1
Indicator of poverty	0.28	0.45	0	1

back to FACHS

Relative Prices

	Mean	Std.Dev.	Min	Max
Relative fruit prices				
Relative price faced by youth	0.466	0.033	0.379	0.527
Relative price faced by friend	0.468	0.033	0.393	0.527
Relative price faced by parent	0.454	0.023	0.407	0.527
Relative vegetable prices				
Relative price faced by youth	0.488	0.025	0.429	0.566
Relative price faced by friend	0.490	0.025	0.424	0.566
Relative price faced by parent	0.476	0.030	0.429	0.566

Remark:

price variables are specific to place of residence and interview date

◂ back to QFAHPD

Food Groups in QFAHPD

Fruit groups	Vegetable groups
fresh/frozen whole fruit	fresh/frozen dark green vegetables
canned whole fruit	canned dark green vegetables
fruit juice	fresh/frozen orange vegetables
	canned orange vegetables
	fresh/frozen starchy vegetables
	canned starchy vegetables
	fresh/frozen other-nutrient dense vegetables
	canned other-nutrient dense vegetables
	fresh/frozen other-mostly water vegetables
	canned other-mostly water vegetables
	fresh/frozen/dried legumes
	canned/processed legumes

◂ back to QFAHPD

Social Network Effects

Classification is due to Manski (1993)

Endogenous effect: impact of **behavior** of reference group members on individual's own behavior

Endogenous effect is associated with **social multiplier**

Contextual effect: impact of **characteristics** of reference group members on individual's behavior

Correlated effect: similarity of behaviors within reference group may result from:

- sorting according to unobservable preferences
- common unobservable environmental factors

◂ back to theoretical framework

Explanatory Variables

Variable in $\mathbf{x}_t$	$\mathbf{x}_{Y,t}$	$\mathbf{x}_{F,t}$	$\mathbf{x}_{P,t}$	Description
constant	$\surd$	$\surd$	$\surd$	Constant term
Y_age	$\surd$			Age of Y
Y_age2	$\surd$			Age squared of Y
Y_male	$\surd$	$\surd$		Indicator of male sex of Y and F
F_age		$\surd$		Age of F
F_age2		$\surd$		Age squared of F
F_black		$\surd$		Indicator of African American race of F
P_age			$\surd$	Age of P
P_age2			$\surd$	Age squared of P
P_higher_educ	$\surd$		$\surd$	Indicator of college education of P
P_married	$\surd$		$\surd$	Indicator of married P
P_poverty	$\surd$		$\surd$	Indicator of P in poverty
Y_rel_price	$\surd$			Relative price faced by Y
F_rel_price		$\surd$		Relative price faced by F
P_rel_price			$\surd$	Relative price faced by P

back to notation

Normalization

Variances of $\epsilon_{Y,t}, \epsilon_{F,t}, \epsilon_{P,t}$ are unidentifiable $\Rightarrow$ normalize $\mathbf{\Sigma}$:

$$\mathbf{\Sigma} = \begin{pmatrix} 1 & \rho_{YF} & \rho_{YP} \\ \rho_{YF} & 1 & \rho_{FP} \\ \rho_{YP} & \rho_{FP} & 1 \end{pmatrix}$$

One unknown threshold per triplet member is unidentifiable $\Rightarrow$ fix the following thresholds:

$$\alpha_Y(2) = \alpha_F(2) = \alpha_P(2) = 0$$

Remark:

9 thresholds are estimated:

$$\{\alpha_Y(j), \alpha_F(j), \alpha_P(j)\}_{j=3}^{5}$$

◂ back to identification/estimation

Likelihood Contribution

Parameters $\boldsymbol{\theta} = \left(\left\{ \alpha_Y(j), \alpha_F(j), \alpha_P(j) \right\}_{j=3}^{5}, \rho_{YF}, \rho_{YP}, \rho_{FP}, \gamma_{FY}, \gamma_{PY}, \gamma_{YF}, \gamma_{YP}, \boldsymbol{\beta}_Y', \boldsymbol{\beta}_F', \boldsymbol{\beta}_P' \right)'$

Partition $\boldsymbol{\Pi}$ as $\boldsymbol{\Pi} = [\boldsymbol{\pi}_Y, \boldsymbol{\pi}_F, \boldsymbol{\pi}_P]$; $\boldsymbol{\pi}_Y, \boldsymbol{\pi}_F, \boldsymbol{\pi}_P$ are known functions of $\boldsymbol{\theta}$

Likelihood contribution of triplet t:

$$
\begin{aligned}
L_t(\boldsymbol{\theta}) \equiv L(w_{Y,t}, w_{F,t}, w_{P,t} | \mathbf{x}_t; \boldsymbol{\theta}) = \Pr\big[& \alpha_Y(w_{Y,t}) < w_{Y,t}^* \leq \alpha_Y(w_{Y,t}+1), \\
& \alpha_F(w_{F,t}) < w_{F,t}^* \leq \alpha_F(w_{F,t}+1), \alpha_P(w_{P,t}) < w_{P,t}^* \leq \alpha_P(w_{P,t}+1) \,|\mathbf{x}_t; \boldsymbol{\theta}\big] = \\
= \Pr\big[& \alpha_Y(w_{Y,t}) - \mathbf{x}_t' \cdot \boldsymbol{\pi}_Y < v_{Y,t} \leq \alpha_Y(w_{Y,t}+1) - \mathbf{x}_t' \cdot \boldsymbol{\pi}_Y, \\
& \alpha_F(w_{F,t}) - \mathbf{x}_t' \cdot \boldsymbol{\pi}_F < v_{F,t} \leq \alpha_F(w_{F,t}+1) - \mathbf{x}_t' \cdot \boldsymbol{\pi}_F, \\
& \alpha_P(w_{P,t}) - \mathbf{x}_t' \cdot \boldsymbol{\pi}_P < v_{P,t} \leq \alpha_P(w_{P,t}+1) - \mathbf{x}_t' \cdot \boldsymbol{\pi}_P | \mathbf{x}_t; \boldsymbol{\theta}\big] = \\
= \int_{\alpha_Y(w_{Y,t}) - \mathbf{x}_t'\boldsymbol{\pi}_Y}^{\alpha_Y(w_{Y,t}+1) - \mathbf{x}_t'\boldsymbol{\pi}_Y} & \int_{\alpha_F(w_{F,t}) - \mathbf{x}_t'\boldsymbol{\pi}_F}^{\alpha_F(w_{F,t}+1) - \mathbf{x}_t'\boldsymbol{\pi}_F} \int_{\alpha_P(w_{P,t}) - \mathbf{x}_t'\boldsymbol{\pi}_P}^{\alpha_P(w_{P,t}+1) - \mathbf{x}_t'\boldsymbol{\pi}_P} f(v_{Y,t}, v_{F,t}, v_{P,t} | \mathbf{x}_t; \boldsymbol{\theta}) \, dv_{P,t} dv_{F,t} dv_{Y,t}
\end{aligned}
$$

$f(v_{Y,t}, v_{F,t}, v_{P,t} | \mathbf{x}_t; \boldsymbol{\theta})$ is **trivariate normal density**

◂ back to identification/estimation

Selected References

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