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Supermarket Proximity and Price: Food Insecurity and Obesity in the United States

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Introduction

Where we live matters for our health. The social, economic, and physical features of neighborhoods can play a powerful role in health and longevity. Neighborhood concentration of poverty and poor health have been shown to be linked (1). Residing in low-income neighborhoods has been associated with diet related chronic diseases such as obesity and diabetes (2).

One in seven American households, mostly those living at or below the poverty line, were considered food insecure in 2014, which means they were without access to enough food to lead a healthy life (3). Those who report being food insecure are at greater risk for poor mental health, obesity, and chronic disease (4). Food insecure households face several barriers to accessing food including: 1) living geographically too far from supermarkets or other venues selling healthy foods, and, 2) the cost of purchasing healthy foods is higher than households can afford. We refer to these barriers as the "distance problem" and the "food price problem" respectively.

Policy interventions, such as the Health Food Financing Initiative, were designed to target the first barrier of reducing food deserts through incentivizing healthy food retailers to open in low-income neighborhoods. Despite the intent of these initiatives, there has been little evidence to show that reducing the "distance problem" through building supermarkets in low-income communities has pushed the needle on changing health outcomes (5-7) or food consumption behavior (8, 9).

The second barrier, the "food price problem," may exacerbate the lived experience of household food insecurity if food prices (and cost of living) are high and wages are low. The Supplemental Nutrition Assistance Program (SNAP), formerly known as the Food Stamp Program since the 1960s, is an in-kind transfer program to help families improve their ability to purchase foods through normal channels of commerce and provided food-purchasing assistance for some 46.5 million low-income U.S. households in 2014. The amount of the assistance is a function of household net income, deductions, the Thrifty Food Plan (TFP), and the maximum benefit for each household size. The TFP represents the price of a nutritionally adequate monthly basket of food based on family composition, and is calculated based on national food prices. However, supermarket prices vary between market areas. This means that if food costs are too high within a given food shopping area, even participation in SNAP may not be enough to alleviate household food insecurity.

Despite the efforts to understand how the distance and food price problems have led to food insecurity and poor health, inconsistency of findings among these relationships remain in part because we knew very little about how household preferences played a role in the food purchasing decisions of households. Households might select to shop at a supermarket based on perception of food prices, proximity to the home, or some combination of these factors. Little is known about how perception of these factors maps with objective measures of food prices and distance.

Two cross-sectional studies found that participants were more likely to be obese who shopped at stores where (actual) prices were lower (10, 11). This is likely because obese participants were also likely to be lower socioeconomic status, and thus sought lower priced stores. If food insecurity is associated with obesity among U.S. adults, as one study showed (12), we anticipate that there will be an association between households preferences to shop at stores with low prices and food insecurity.

Our research aims to address understand how both the subjective experience and objective measures of the "distance problem" and "food price problem" are associated with household food insecurity and obesity. First, we estimate the association of perceived distance and low prices with food insecurity and obesity. Next, we estimate how objectively measured access to supermarkets – based on presence of supermarkets and prices – relate to food insecurity and obesity. Specifically, our research questions are as follows:

1. Are individuals who select their primary supermarket based on perceived price or proximity more likely to live in a food insecure household and be obese, compared to those who select their primary supermarket based on <u>both</u> low prices and perceived proximity?
2. Are individuals who reside in a food desert more likely to be a part of a food insecure household and be obese, compared to those who do not live in a food desert?
3. Are individuals who reside in a high poverty area with higher than average supermarket prices are more likely to be a part of a food insecure household and be obese, compared to those who live in areas with low or average supermarket prices?

Conceptual Model of Food Insecurity

Drawing from Barrett (2002), the lack of access to goods market can be viewed as one of several structural

characteristics of households that increases risk of food insecurity (13). Residing at a great distance from a food retailer is expected to increase food insecurity by a lower access to the goods market by way of increasing travel costs (13, 14). Also, the combination of living in a high poverty neighborhood located at a great distance from food retailers (e.g., food desert) is expected to increase food insecurity by limiting access to the labor market (15). Finally, those with very low-incomes who live far from stores with affordably priced foods might experience a greater risk of food insecurity if they have low purchase power in their local market. Becker's human capital theory (1975) and theory for demand for children (1991) suggest that food insecurity is directly related to household composition, income, and transfers. We expect that additional children in the household will increase food insecurity and additional adults will decrease food insecurity through household labor supply. Age, race, and sex are expected to impact household food insecurity through wage rate.

Methods

Study Design and Subjects

This study uses data collected by the Economic Research Service of the United States Department of Agriculture, the National Household Food Acquisition and Purchase Survey (FoodAPS), from April 2012 to January 2013. This includes nationally representative data from 4,826 households on household food shopping and purchasing behaviors. There were 2,015 households (SNAP participants and non-participants) with household income below the federal poverty threshold. For this analysis, we included the full sample, not restricted to SNAP participants or low-income households.

We also used data from the 2010 U.S. Census, which provides detailed counts and characteristics of the US population, and the American Community Survey, which includes demographic, housing, social, and economic information from the 5-year average data from 2008 to 2012. In addition, we used data from Nielsen TDLinx, FNS Store Tracking and Redemption System (STARS) sources, and Information Resources, Inc (IRI) which includes information on the location and type of food retailers in 2012.

Outcomes

The primary outcome of interest, food security, is measured at the household level and takes into account whether households have enough food to eat and are able to afford balanced meals in the last month. This was assessed using the 10-item U.S. Adult Food Security Survey Module with a reference to the prior month (16). We created a binary variable of food secure (1/0) that was turned on if a household gave 2 or fewer responses in the affirmative. As a sensitivity analysis we also created an ordered outcome: *very low* (6-10), *low* (3-5)*, marginal* (1-2)*,* and *high* (0) answers in the affirmative.

The secondary outcome of interest, obesity, is based on a self reported measure for each primary respondent adult, and is a binary indicator that is turned on if the individual has a body mass index (BMI) of 30 kg/m^2 or greater. As a sensitivity analysis, we also used the natural log of BMI as a continuous measure.

Exposures

Subjective Measure of Food Access: Determinants of Store Choice

Primary respondents were asked to indicate all of the main reasons for shopping at the store where most of the household shopping was done including options such as low prices, produce selection, meat department, variety of foods, variety of special foods, close to home, and loyalty/frequent shopper program. We created a variable that was coded 1 if the primary respondent selected "low prices", 2 for "close to home" or both "low price" and "close to home" (0). Respondents who did not select any of these items were set as missing for purposes of this analysis.

Objective Measure of Food Access

Two approaches were used to measure food access within the household's "neighborhood." First, we created a measure of a *food desert* which was defined as having a poverty rate of 20 percent or greater (or the BG median income is less than or equal to 80 percent of the Metropolitan area median family income) and the closest supermarket is more than one mile away from the census block centroid (10 miles, for non-metropolitan block groups). 90% of all census block groups in 2010 had less than 2 square miles of land area, and the median block group was 0.2 square miles.

Next, we create a similar measure at the census tract level for purposes of comparability with other studies.

Also the census tract is the geographical unit that best represents the average size of a shopping area; nationwide the mean area of a census tract is 13.7 square miles and three-quarters of all census tracts located within metropolitan statistical areas (MSAs) are less than 4.5 square miles (17). The indicator is turned on when a participant lives in a low income census tract (defined by Department of Treasury's New Markets Tax Credit program where the tract has a poverty rate 20 percent or greater or the tract's median income is less than or equal to 80 percent of the Metropolitan area median family income) and at least 500 persons or at least 33% of the census tract's population live more than one mile from a supermarket or large grocery store (10 miles, for non-metropolitan census tracts).

The second measure, *food tundra*[1], builds upon the food desert measure and reflects that proximity to supermarket is only a relevant criterion to characterize food access if store prices are not too high. First, we create two measures for each block group that reflect the weekly median and low cost of the Thrifty Food Plan (TFP) for a family of 4 of all store chains within three buffers (3, 5, 10 miles) of the block group centroid during the study period. These distances were selected based on our descriptive estimates from Table 3. The average distance traveled to closest supermarket (3 miles) and primary supermarket (5 miles). Less than 1 percent of all block groups did not have a supermarket within 10 miles from its centroid.

The TFP was created by the USDA's Center for Nutrition Policy and Promotion and includes quantities of 29 categories of food types based on age and sex (18). The median cost measure was derived using the median costs per pound (after removing outliers) and the low cost measure uses the per pound price at the 10^{th} percentile. The data was obtained from the Information Resources, Inc (IRI), a private company that provides retail store scanner data. Some store chains such as Target, Safeway, and Kroger do not report item-level prices for private label items, and are thus not included. More information on the specifics of the construction of this measure and its limitations have been published elsewhere (19). We use the median costs of only stores with all TFP categories. To account for missingness of categories that preclude a store's inclusion in the analysis, as a sensitivity analysis we construct an alternate measure which uses the median cost of each category in each block group and multiplies that by the number of pounds to get a price measure.

[1] A tundra is a frozen, treeless plain that makes it difficult for plants and animals to survive.

To create the measure of *food tundra*, which is defined having poverty rate of 20 percent or greater (or the BG median income is less than or equal to 80 percent of the Metropolitan area median family income), and having a median weekly TFP cost that is in the top quintile of all block groups. As an alternate measure, we substitute low cost for median cost.

Covariates

Several variables were constructed that were hypothesized to influence both household food security and food access. This includes primary respondent characteristics such as sex (female =1, male =0), age at time of survey, marital status (currently married = 1, prior/never married = 0), race/ethnicity (0 = non-Hispanic White, 1 = Black, 2 = Hispanic, 3 = Asian), citizenship status (1=U.S. citizen, 0 = not U.S. Citizen), highest educational attainment (0 = bachelors degree+, 1= some college, 2 = high school degree, 3 = some high school), and employment status (1= employed in the prior month, 0= not employed), as well as household-characteristics such as monthly income (in $US), home ownership (1= owns home, 2= renter or other), number of children, number of disabled members, and number of adults.

Statistical Methods

The relationship between store determinant choice or food access and food insecurity or obesity is specified with the general form of the model as follows:

$$Y_{ij} = \beta_{oj} + \beta_1 A_{ij} + \beta_2 X_{ij} + \beta_3 W_{ij} + \varepsilon_{ij}$$

where Y_{ij} is a measure of food insecurity or obesity in household *i* in census block *j*; β_{oj} is the census block-specific intercept; A_{ij} is a measure of store determinant choice or food access of household *i* in in census tract; X_{ij} is a vector of primary-respondent characteristics of household *i* in census tract *j*; W_{ij} is a vector of household-characteristics of household *i* in census tract *j*; and ε_{ij} is the error term.

A_j = selection of primary supermarket based on perceived price (1), distance (2), or both price & distance (0) or residence in a food desert (1/0) or residence in a food tundra (1/0)

X_{ij} = *female, age, race/ethnicity, US citizen, marital status, education, employment status*

W_{ij} = *log of income, home ownership, car ownership, number of children, number of adults, number of disabled*

We fit a series of logit and multinomial logit models to estimate the log odds of household food insecurity or adult obesity as a function of the above variables.

Sensitivity Analyses

We measured food security as both as a binary and ordinal outcome. Additionally, we measured obesity as a binary outcome and used log of BMI as an alternate measure. For comparability to prior research, we also estimated the effect of residing in a food desert at the census tract level in addition to the census block level. Next, as we were concerned with the robustness of the supermarket price variable, we created an alternate measure of low cost TFP in addition to the median cost TFP we used in our main model. In addition, as we were concerned with potential bias introduced by missing stores, we created another alternate measure of the median cost TFP by taking the median cost of each of the 29 categories of the TFP. Finally, our measure of food tundra was assessed at 3 distances from the block group centroid (3, 5, and 10 miles).

Table 1: Primary respondent and household characteristics

	All	Food Insecure	Poor (<=FPL)
Female	67.4%	69.2%	71.1%
Age			
18 to 24	5.1%	8.1%	8.8%
25 to 34	16.9%	20.3%	15.3%
35 to 44	16.7%	20.6%	15.7%
45 to 54	19.8%	22.4%	20.1%
55 to 65	21.1%	16.6%	20.9%
65+	20.2%	12.0%	19.0%
Marital Status			
Currently Married	44.1%	28.1%	25.8%
Previously Married	33.5%	41.7%	41.8%
Never Married	22.3%	30.2%	32.4%
Race			
Black	13.3%	23.2%	23.1%
White	80.1%	68.5%	67.9%
U.S. Citizen	57.8%	47.6%	52.1%
Educational Attainment			
Some High School	9.9%	23.6%	24.2%
High School Diploma	25.6%	32.1%	27.1%
Some College	33.1%	32.3%	27.8%
Bachelor's Degree +	31.4%	11.9%	19.7%
Worked in Prior Week	55.6%	43.2%	30.3%
Obesity (BMI>30)	32.0%	40.8%	34.0%
Poor Health	17.8%	36.2%	27.9%
SNAP Participation	13.6%	37.7%	39.5%
Mean Monthly Household Income	$5,074.63	$2,344.12	$646.76
Owns/Leases Car	89.5%	64.3%	69.0%
Homeowner	61.6%	30.2%	42.6%
Moved in Past Year	10.9%	18.5%	15.2%
Household Size			
1	33.9%	37.4%	45.8%
2	27.4%	19.0%	15.9%
3	16.5%	15.0%	12.0%
4	13.5%	14.9%	13.7%
5 +	8.6%	13.7%	12.6%

Note: Survey weights applied

Table 2. Block Group Supermarket Price Environment (n = 748 block groups)

	Distance from Block Group Centroid		
	3 miles	**5 miles**	**10 miles**
Number of Block Groups without any Stores	146	86	30
Number of Block Groups with Median Price	416	462	511
Mean (Standard Deviation) of Basket Cost - Median	360.97 (59.09)	367.02 (62.39)	362.65 (57.54)
Mean (Standard Deviation) of Basket Cost - Low	157.24 (23.41)	158.89 (24.62)	158.11 (21.26)

Table 3: Food Environment Household Characteristics, by Food Security and Obesity

	All	Food Insecure	Food Secure	Obese	Non-Obese
Household characteristics					
Miles to closest supermarket	3.08 (0.36)	2.49 (0.35)	3.18 (0.36)	3.42 (0.43)	2.93 (0.35)
Driving distance (miles) to primary supermarket	5.11 (0.62)	3.82 (0.38)	5.36 (0.67)	5.59 (0.59)	4.89 (0.67
# supermarkets within 1 mile of BG centroid	1.34 (0.17)	1.73 (0.24)	1.27 (0.16)	1.21 (0.14)	1.39 (0.19)
Residence in Block Group Food Desert (%)	4.30 (1.11)	6.56 (1.92)	3.87 (1.02)	5.62 (1.72)	3.70 (1.02)
Residence in Census Tract Food Desert (%)	13.82 (2.05)	18.81 (2.61)	12.87 (2.09)	17.16 (2.09)	12.19 (2.33)
Residence in Food Tundra[a] (%)	6.29 (1.83)	12.95 (4.93)	4.93 (1.51)	6.49 (1.93)	6.16 (2.04)
Residence in top fifth most expensive environment [a] (%)	21.16 (4.62)	25.02 (5.09)	20.37 (4.76)	17.69 (4.17)	22.93 (5.09)
Median cost of TFP ($)	363.28 (6.07)	368.10 (6.65)	362.30 (6.30)	359.04 (5.61)	365.44 (6.76)
Low cost of TFP ($)	158.18 (2.44)	157.36 (3.07)	158.34 (2.46)	155.92 (2.49)	159.37 (2.57)
Determinants of Primary Store Choice (%)					
Low Prices	30.1 (1.8)	40.0 (3.0)	28.2 (1.8)	32.9 (2.3)	28.5 (1.9)
Close	30.3 (1.3)	26.6 (2.1)	31.0 (1.3)	30.0 (2.3)	30.3 (1.6)
Both Low Prices and Close	22.7 (1.9)	18.9 (2.2)	23.4 (2.0)	21.7 (2.5)	23.5 (2.1)
Note: Standard errors are in parentheses					

(a) Estimates from 3 miles from Block Group Centroid. N= 3,484; excludes those with no stores or missing store price data. For 5 and 10 miles, estimates are similar.

Table 4: Marginal Effects of Food Environment on Food Security

	M1, Predictor: Tundra		M2, Predictor: Desert		M3, Predictor: Both	
	dy/dx	**SE**	**dy/dx**	**SE**	**dy/dx**	**SE**
Tundra (3mi)	0.070***	0.027			0.069***	0.028
Food Desert			0.013	0.023	0.007	0.023
Female	0.012	0.014	0.012	0.015	0.012	0.014
Age	-0.001	0.001	0.001	0.001	-0.001	0.001
White	ref		ref		ref	
Black	-0.023	0.019	-0.021	0.019	-0.023	0.019
Hispanic	0.029	0.025	0.035	0.025	0.030	0.025
Other	0.039*	0.02	0.039	0.020	0.040	0.020
US Citizen	0.009	0.029	0.011	0.029	0.009	0.029
Married	-0.063***	0.013	-0.063***	0.013	-0.063***	0.013
< HS	ref		ref		ref	
High School	-0.081***	0.017	-0.081***	0.0169	0.081***	0.017
Some College	-0.099***	0.018	-0.099***	0.0176	-0.100***	0.017
Bachelors +	-0.238***	0.022	-0.238***	0.022	-0.237***	0.022
Owns Car	-0.036**	0.017	-0.041**	0.017	-0.036**	0.018
Renter	0.137***	0.015	0.139***	0.015	0.137***	0.0159
Unemployed	0.059***	0.019	0.061***	0.019	0.0591***	0.019
Income (log)	-0.017***	0.003	-0.017***	0.002	-0.017***	0.003
# Adults	0.027***	0.006	0.028***	0.006	0.027***	0.006
# Children	0.012***	0.006	0.012**	0.006	0.012**	0.006
# Disabled	0.159***	0.013	0.159***	0.014	0.159***	0.014

Note: *p<0.1, **p<0.05, ***p<0.01. All models included robust standard errors clustered at the Census Block Group. Models fit with logit produced similar results to probit estimates. Number of Households is 4,826. Missing-Indicator approach was used. Results were nearly identical with complete case analysis, including sampling weights, and adjusting for region.

Figure 1: Proportion of Block Groups in each Geographic Region, by Food Price Environment

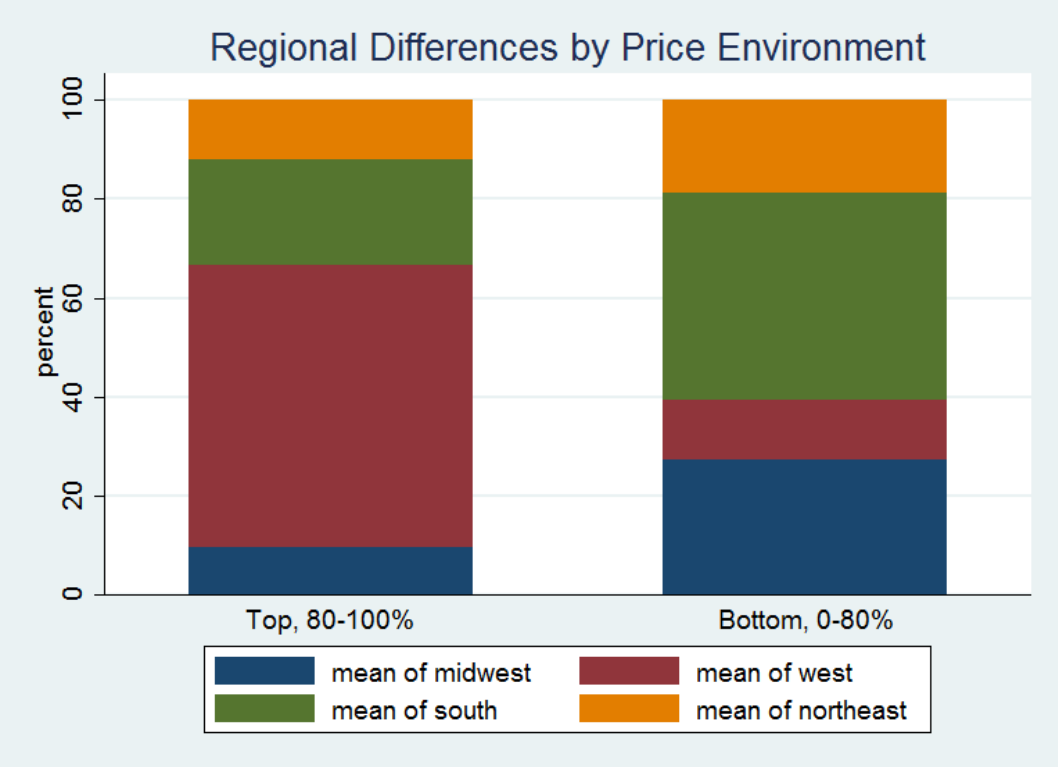


Figure 2: Proportion of Rural and Urban Block Groups in High (Top 5th) Food Price Environment

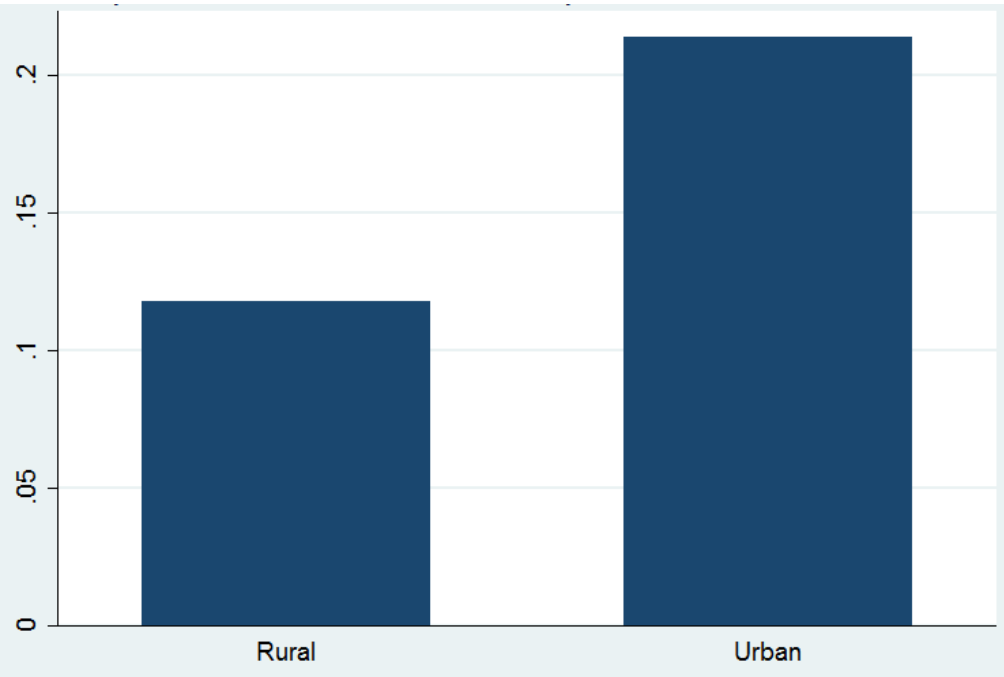


Figure 3: Proportion of Income on Housing, by Price Environment

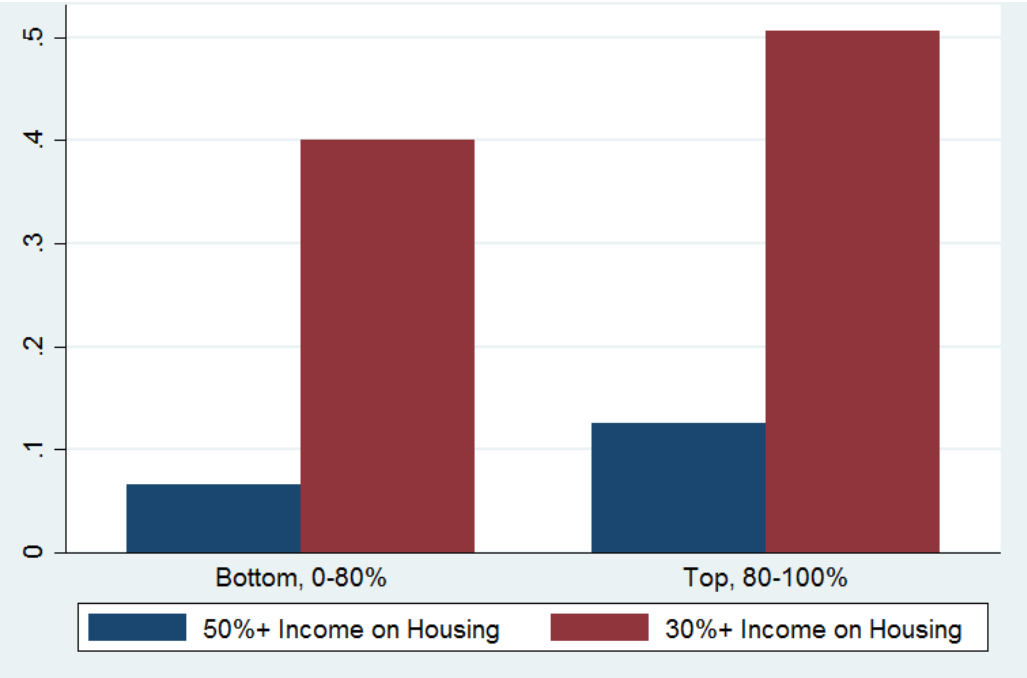


Figure 4: Household Reasons for Selecting Primary Supermarket, by Food Security and Obesity

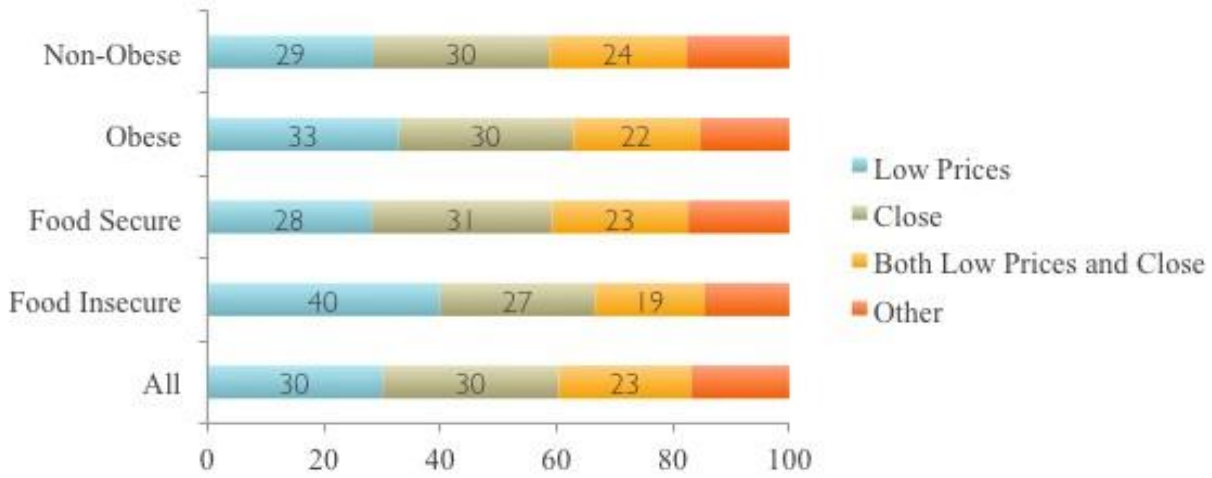
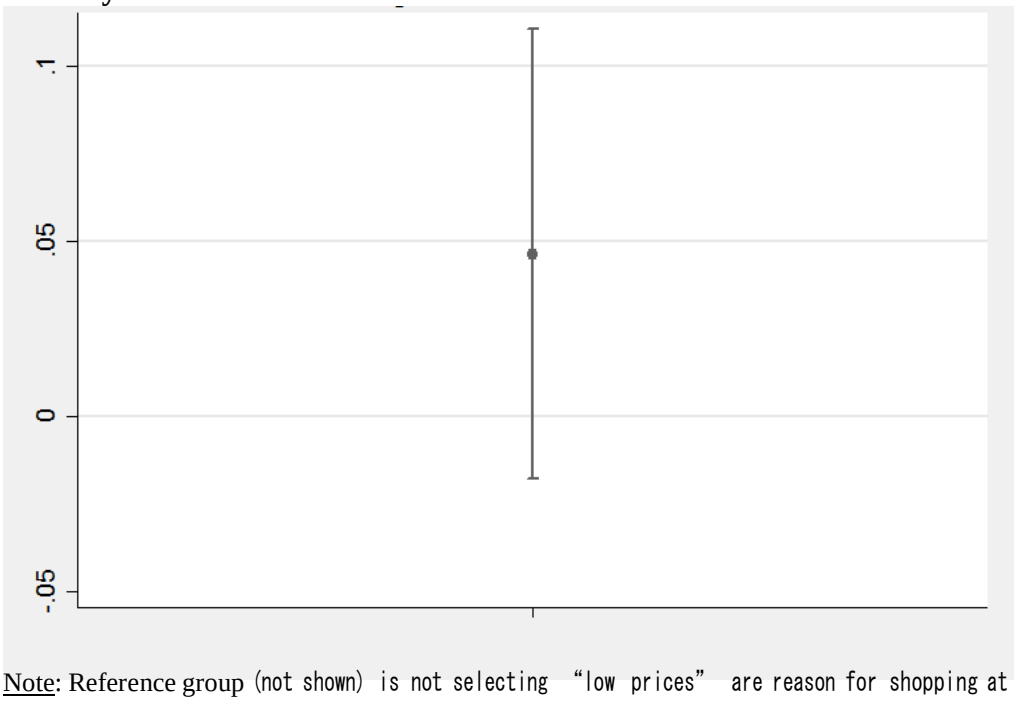


Figure 5: Predictive Margins of Food Insecurity (Binary) with 95% CI, by Reasons for Shopping at Primary Store

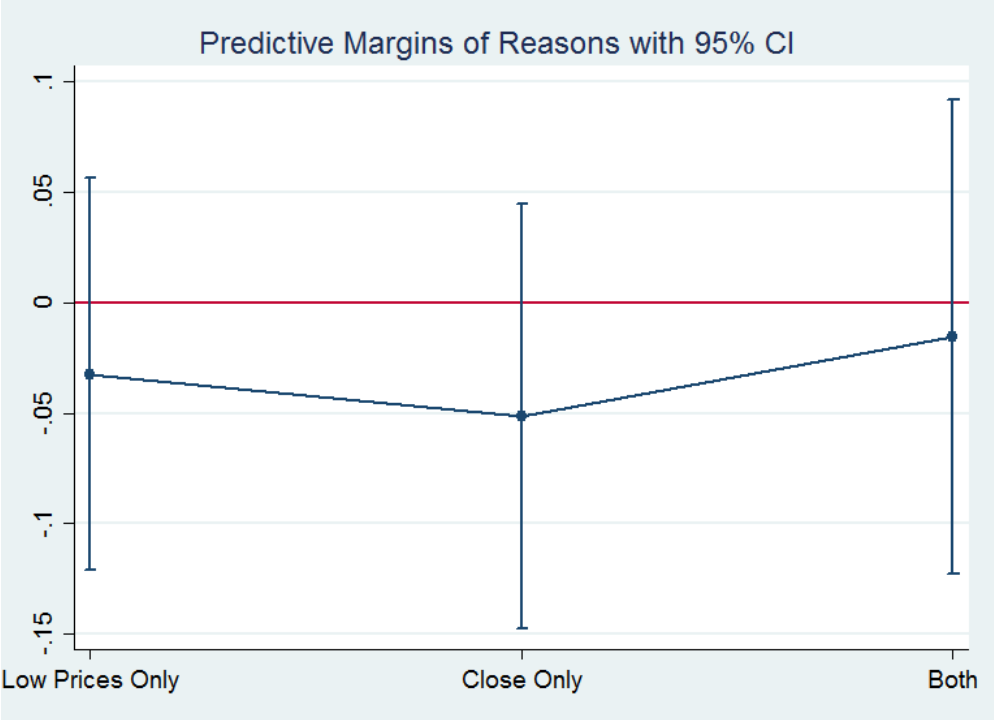
Note: Reference group (not shown) is "other" reasons for selecting primary store. Graph shows the marginal effects
after a logit model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

Figure 6: Predictive Margins of Food Insecurity (Binary) with 95% CI, by Shopping at Primary Store for Low Prices



Note: Reference group (not shown) is not selecting "low prices" are reason for shopping at primary store. Graph shows the marginal effects after a logit model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

Figure 7: Predictive Margins of Obesity (Binary) with 95% CI, by Reasons for Shopping at Primary Store

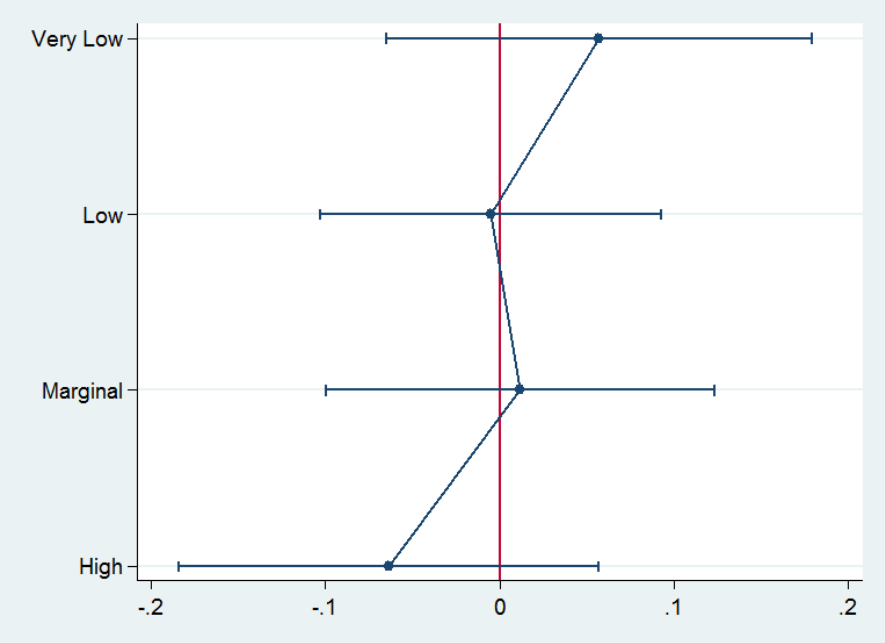


Note: Reference group (not shown) is "other" reasons for selecting primary store. Graph shows the marginal effects
after a logit model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

Figure 8: Predictive Margins of Obesity (Binary) with 95% CI, by Shopping at Primary Store for Low Prices

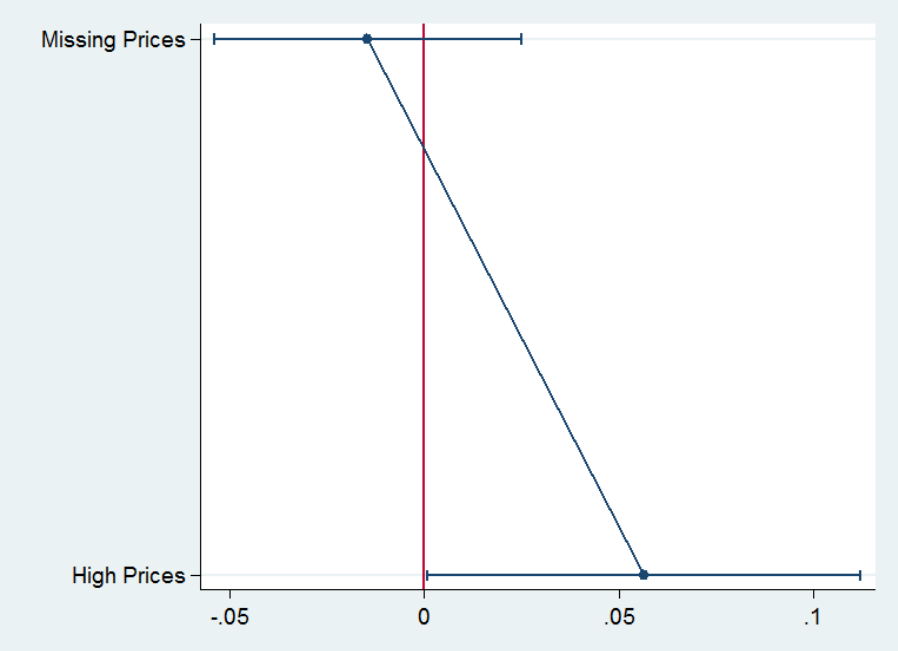
Note: Reference group (not shown) is not selecting "low prices" are reason for shopping at primary store. Graph shows the marginal effects after a logit model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

Figure 9: Predictive Margins of Food Security (Ordinal) with 95% CI, by Food Desert (Block Group)



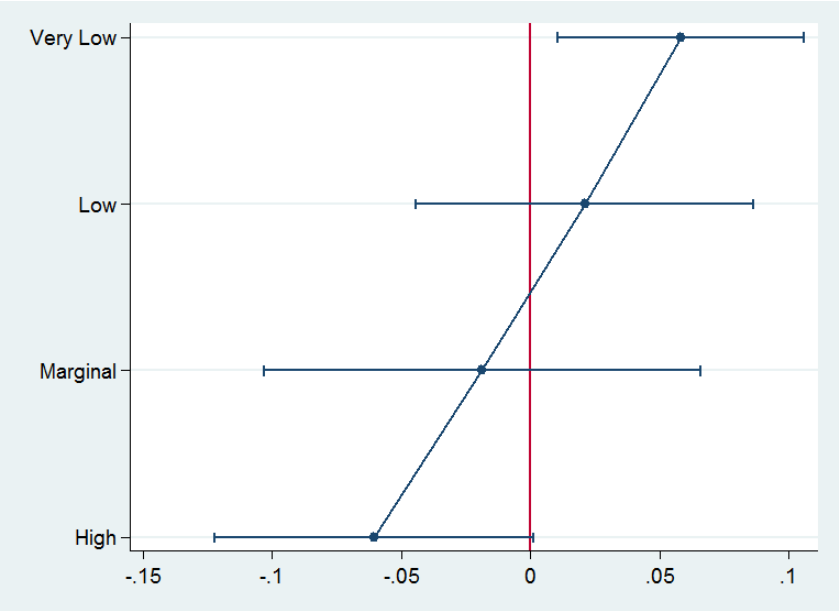
Note: Graph shows the marginal effects of living in a food desert on high, marginal, low, and very low food security after a multinomial logit model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

Figure 10: Predictive Margins of Food Insecurity (Binary) in Poor Block Groups with 95% CI, by Food Tundra (3mi)



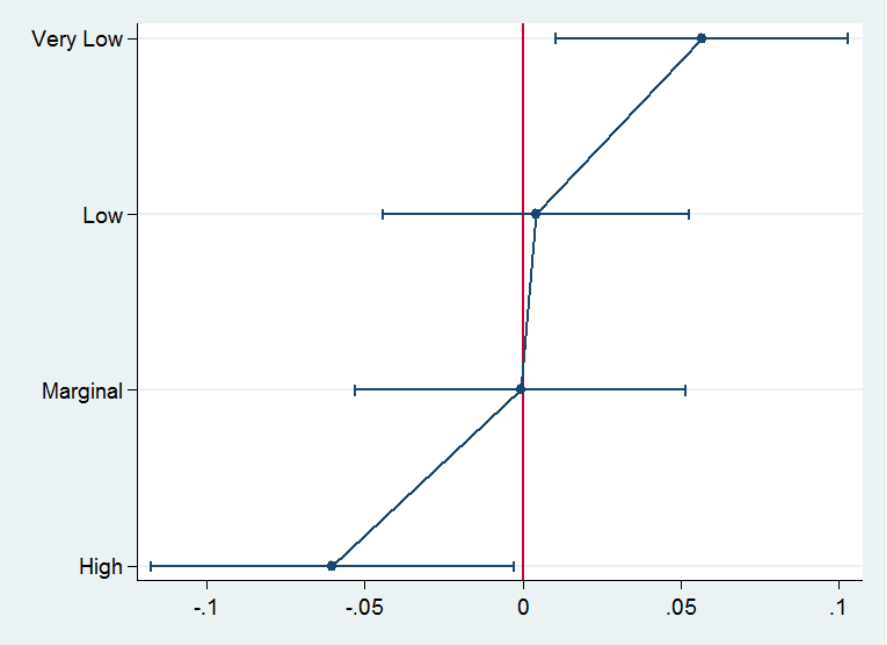
Note: Reference group (not shown) is not residing in a block group with food prices in top 5th. Graph shows the marginal effects of food insecurity after a logit model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

Figure 11: Predictive Margins of Food Security (Ordinal) with 95% CI, by Food Tundra (3mi)



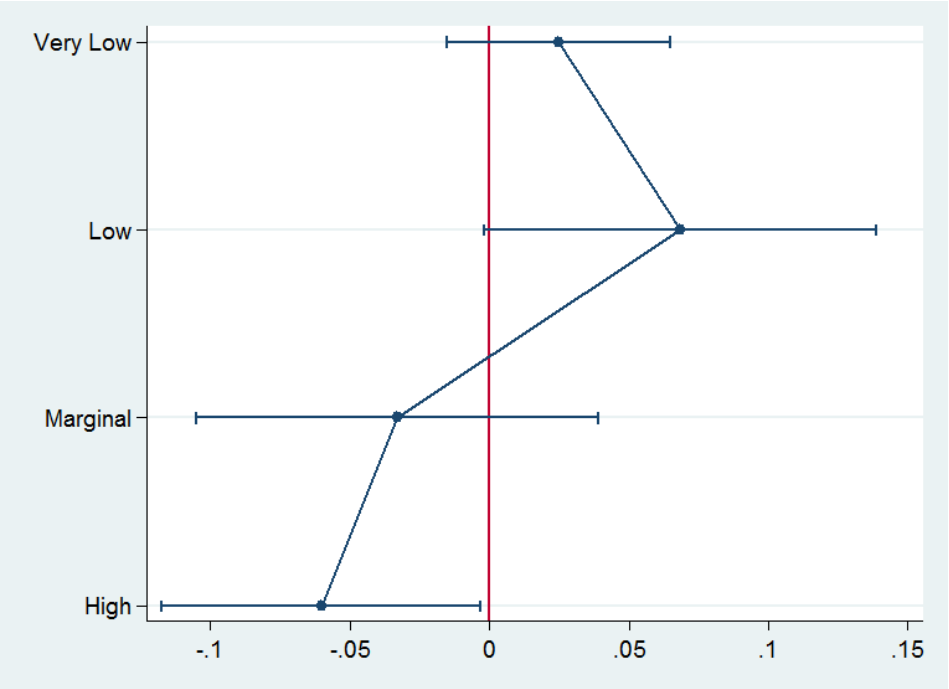
Note: Graph shows the marginal effects of residing in a food tundra (3mi) on high, marginal, low, and very low food security after a multinomial logit model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

Figure 12: Predictive Margins of Food Security (Ordinal) in Poor Block Groups with 95% CI, by Food Tundra (3mi)



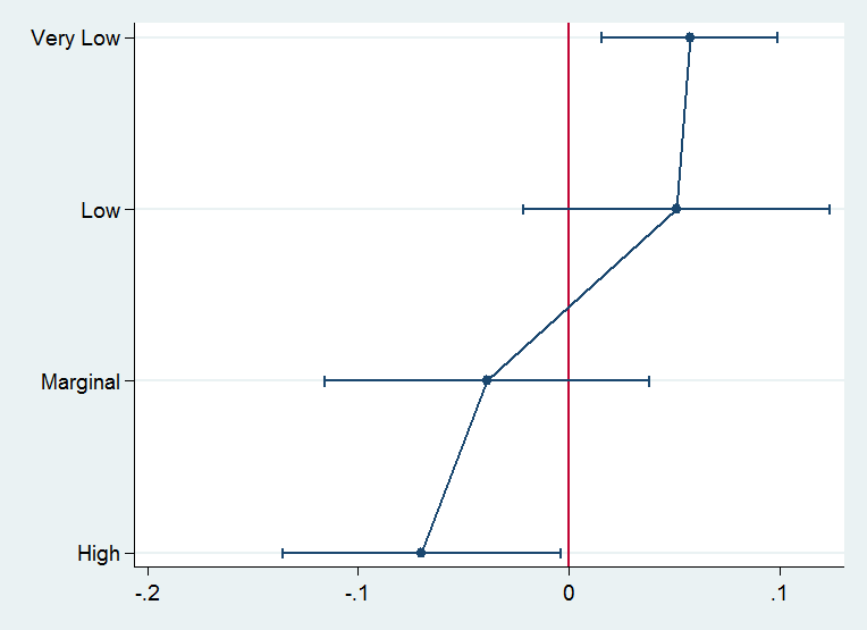
Note: Graph shows the marginal effects of residing in a food tundra on high, marginal, low, and very low food security among residents of poor block groups after a multinomial logit model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

Figure 13: Predictive Margins of Food Security (Ordinal) with 95% CI, by Food Tundra (5mi)



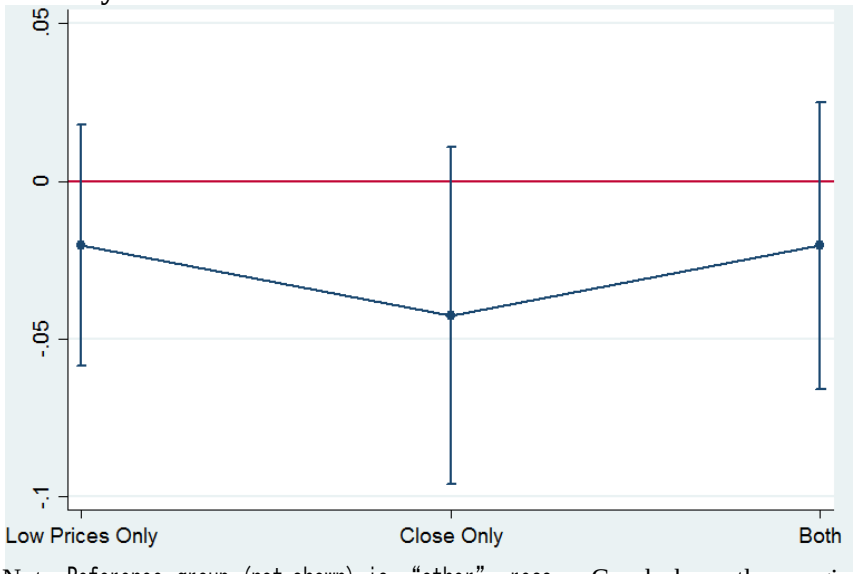
Note: Graph shows the marginal effects of residing in a food tundra (5mi) on high, marginal, low, and very low food security after a multinomial logit model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

Figure 14: Predictive Margins of Food Security (Ordinal) with 95% CI, by Food Tundra (10mi)



Note: Graph shows the marginal effects of residing in a food tundra (10mi) on high, marginal, low, and very low food security after a multinomial logit model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

Figure 15: Predictive Margins of BMI (log) with 95% CI, by Reasons for Shopping at Primary Store



Note: Reference group (not shown) is "other" reason. Graph shows the marginal effects of shopping at a primary store on the log of BMI after a linear model adjusted for full set of covariates, with robust standard errors clustered at the block group. 95% confidence intervals that cross zero are not statistically significant.

References

1. Walker RE, Keane CR, Burke JG: Disparities and access to healthy food in the United States: a review of food deserts literature. *Health & place* 2010, 16(5):876-884.

2. Sanbonmatsu L, Ludwig J, Katz LF, Gennetian LA, Duncan GJ, Kessler RC, Adam E, McDade TW, Lindau ST: Moving to Opportunity for Fair Housing Demonstration Program--Final Impacts Evaluation. 2011.

3. Ludwig J, Sanbonmatsu L, Gennetian L, Adam E, Duncan GJ, Katz LF, Kessler RC, Kling JR, Lindau ST, Whitaker RC: Neighborhoods, obesity, and diabetes−a randomized social experiment. *New England Journal of Medicine* 2011, 365(16):1509-1519.

4. Coleman-Jensen A, Rabbitt MP, Gregory C, Singh A: Statistical Supplement to Household Food Security in the United States in 2014. In.: AP-069, USDA, Economic Research Service. http://www/ers.usda.gov/publications/ap-administrative-publication/ap069.aspx; 2015.

5. Seligman HK, Laraia BA, Kushel MB: Food insecurity is associated with chronic disease among low-income NHANES participants. *The Journal of nutrition* 2010, 140(2):304-310.

6. Sturm R, Datar A: Body mass index in elementary school children, metropolitan area food prices and food outlet density. *Public health* 2005, 119(12):1059-1068.

7. Bell JF, Wilson JS, Liu GC: Neighborhood greenness and 2-year changes in body mass index of children and youth. *American journal of preventive medicine* 2008, 35(6):547-553.

8. Ewing R, Brownson RC, Berrigan D: Relationship between urban sprawl and weight of United States youth. *American journal of preventive medicine* 2006, 31(6):464-474.

9. Dubowitz T, Ncube C, Leuschner K, Tharp-Gilliam S: A Natural Experiment Opportunity in Two Low-Income Urban Food Desert Communities Research Design, Community Engagement Methods, and Baseline Results. *Health Education & Behavior* 2015, 42(1 suppl):87S-96S.

10. Ghosh-Dastidar B, Cohen D, Hunter G, Zenk SN, Huang C, Beckman R, Dubowitz T: Distance to store, food prices, and obesity in urban food deserts. *American journal of preventive medicine* 2014, 47(5):587-595.

11. Drewnowski A, Aggarwal A, Hurvitz PM, Monsivais P, Moudon AV: Obesity and supermarket access: proximity or price? *American Journal of Public Health* 2012, 102(8):e74-e80.

12. Pan L, Sherry B, Njai R, Blanck HM: Food insecurity is associated with obesity among US adults in 12 states. *Journal of the Academy of Nutrition and Dietetics* 2012, 112(9):1403-1409.

13. Barrett CB: Food security and food assistance programs. *Handbook of agricultural economics* 2002, 2:2103-2190.

14. Gundersen C, Kreider B, Pepper J: The economics of food insecurity in the United States. *Applied Economic Perspectives and Policy* 2011:ppr022.

15. Bertrand M, Mullainathan S: **A**re Emily and Greg more employable than Lakisha and Jamal? A field experiment on labor market discrimination. In.: National Bureau of Economic Research; 2003.

16. Nord M, Andrews M: Household food security in the United States, 2003. *USDA-ERS Food Assistance and Nutrition Research Report* 2004(42).

17. Burton LM, Kemp SP, Leung M, Matthews SA, Takeuchi DT: Communities, neighborhoods, and health: expanding the boundaries of place, vol. 1: Springer Science & Business Media; 2011.

18. Carlson A, Lino M, Juan W, Hanson K, Basiotis PP: Thrifty food plan, 2006. In.: United States Department of Agriculture, Center for Nutrition Policy and Promotion; 2007.

19. Gundersen C: Construction of Weekly Store-Level Food Basket Costs. In: *Food Acquisition and Purchase Survey Geography Component (FoodAPS-GC).* 2016.

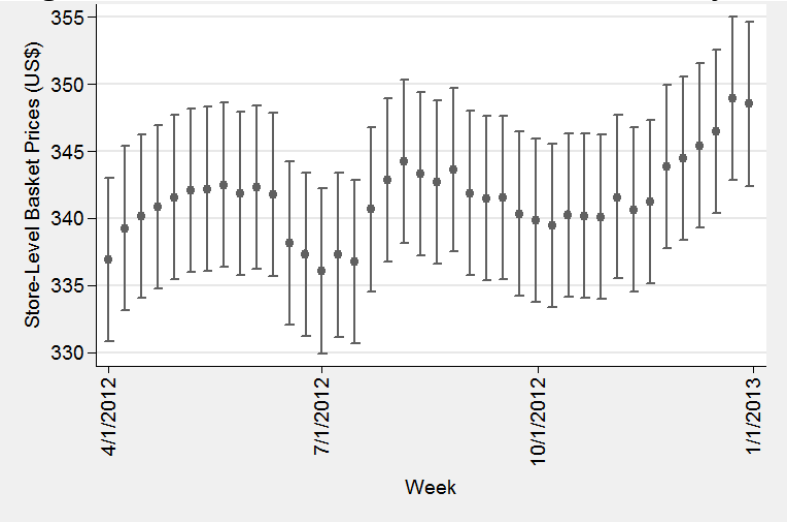
20. Coleman-Jensen A, Gregory C: **I**nflation and Higher Food Prices Kept Food Insecurity Rates Relatively High After the 2007-09 Recession. *Amber Waves* 2014:1A.

21. Zhang Q, Jones S, Ruhm CJ, Andrews M: Higher food prices may threaten food security status among American low-income households with children. *The Journal of nutrition* 2013, 143(10):1659-1665.

22. Mhurchu CN, Blakely T, Jiang Y, Eyles HC, Rodgers A: Effects of price discounts and tailored nutrition education on supermarket purchases: a randomized controlled trial. *The American journal of clinical nutrition* 2010, 91(3):736-747.

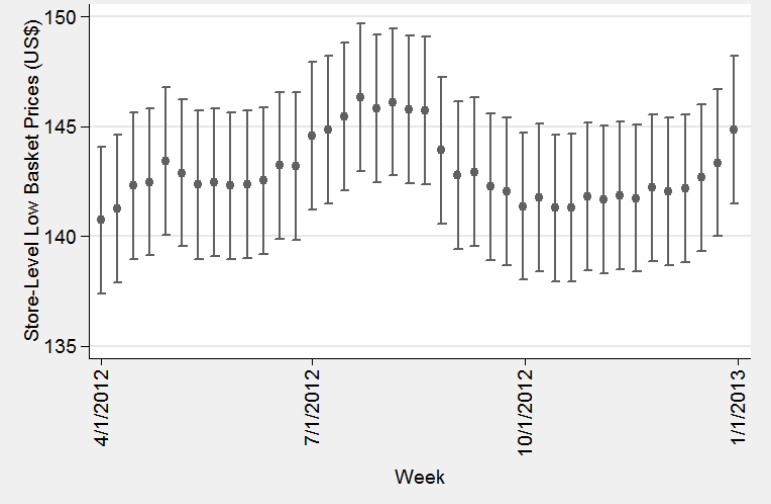
Appendix

Figure A1: Mean and Standard Deviation of County Weekly Store-Level Basket Prices



Note: The weekly Thrifty Food Plan (TFP) store-level basket prices were created from IRI store sales data using both the Universal Product Code (UPC) and random-weight purchases. For stores that do not report store-level sales, data from aggregate sales at a Regional Market Area (RMA) level was used. The median price was weighted by the TFP category weights for a family of four (male 19 to 50, female 19 to 50, child age 6 to 8, child age 9 to 11) for
each TFP category.

Figure A2: Mean and Standard Deviation of County Weekly Low Store-Level Basket Prices



Note: The weekly Thrifty Food Plan (TFP) store-level basket prices were created from IRI store sales data using both the Universal Product Code (UPC) and random-weight purchases. For stores that do not report store-level sales, data from aggregate sales at a Regional Market Area (RMA) level was used. To create the "low-cost food basket"
measure, the 10th percentile of price for each category was adjusted by the TFP category weights for a family of four (male 19 to 50, female 19 to 50, child age 6 to 8, child age 9 to 11)