Food Access, Food Deserts, and the Women, Infants, and Children Program

Qi Wu
Graduate Student
University of California, Davis
qiiwu@ucdavis.edu

Tina L. Saitone
Cooperative Extension Specialist
University of California, Davis
saitone@primal.ucdavis.edu

Richard J. Sexton
Professor and Chair
University of California, Davis
rich@primal.ucdavis.edu

Selected Paper prepared for presentation at the 2016 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, Boston, Massachusetts, July 31 – Aug 2

Food Access, Food Deserts, and the Women, Infants, and Children Program

Abstract: This paper examines the effects of food deserts in the Greater Los Angeles area on the Women, Infants and Children (WIC) Program participants' shopping behavior. Research on WIC program cost containment shows that costs are significantly higher at small, convenience-type vendors compared to supermarkets. However, to address the concern that stopping authorizing these small vendors or restricting their pricing practices could limit food access for participants living in food deserts, we use various approaches to study the WIC purchasing behavior of participants located in food deserts relative to a control group of participants located in non food-desert areas. Our results indicate that food-desert status has a positive effect on participants' travel distance to shop. Food-desert participants were slightly more likely to visit multiple vendors than non-food-desert counterparts. Food-desert participants were also slightly more likely to visit a large vendor than non-food-desert counterparts. On balance we conclude that food-desert participants are not more reliant on small vendors to make WIC purchases than participants in the control group. This result suggests policies to restrict behavior high-cost small vendors can be implemented by WIC agencies without causing much impact on participant access.

Keywords: food desert, WIC program, travel distance

1. Introduction

The Women, Infants and Children (WIC) Program provides food access, health care, and nutritional education to low-income pregnant and postpartum women, infants, and children up to five years of age. It is the third largest food assistance program in the United States, with FY 2015 spending totaling nearly $6.7 billion. Cost containment is a fundamental problem for the WIC Program. Participants receive the foods offered under the Program at no charge, and, thus, they lack incentive to be price conscious in their purchase decisions and, accordingly, vendors have incentives to set high margins for WIC-eligible foods. Research on WIC program cost containment (e.g., Saitone, Sexton, and Volpe 2015) shows that program costs are significantly higher at small, convenience-type vendors compared to supermarkets. Thus, cost containment can be enhanced markedly by directing participants away from such vendors by either disqualifying them from the Program (which is allowed under WIC regulations), or imposing stringent price caps to severely restrain the prices charged by such vendors. Such price caps are the primary means of cost containment used by state agencies that implement the program, but if set too stringently can drive small vendors from the program.

WIC participants have low incomes based on eligibility standards and often live within areas designated officially as food deserts. The stark problem confronted by cost-containment strategies is that, by eliminating or discouraging small retailers from participating in WIC, Program administrators may well impede participant access to Program benefits.

This paper address food-access issues for WIC Program participants using detailed administrative data for the California WIC Program, the Nation's largest. We focus on the five-county area that comprises Greater Los Angeles (GLA) and is home to nearly half of the State's WIC participants. We seek to determine the extent to which WIC participants located in food-desert regions in GLA face Program access issues compared to a control group of participants located in non-food-desert areas. Specifically, we seek to determine the extent to which food-desert participants (i) travel further to shop, (ii) switch less frequently among Program vendors (indicating a lack of shopping options), and (iii) shop more often at high-cost convenience-type vendors than control participants located in GLA in non-food-desert areas. Answers to these questions address directly the important question of the degree to which food-desert participants are constrained in their ability to shop relative to peers situated outside of food deserts, and, thus, the degree to which limiting participation by high-cost small vendors will impede participants' access to program benefits. This information is essential to Program administrators' and policy makers' decisions regarding the cost-containment vs. participant-access tradeoff.

Section two of this paper provides background on WIC program program cost-containment. Section three defines and discusses food deserts and reviews the previous research related to food deserts and consumer shopping behavior. Section four introduces the methodologies employed in the paper and describes the datasets used in the thesis. Section five provides basic results, including summary statistics for participant's redemption patterns and average travel distance. Then section six presents econometric evidence. The OLS, fixed effects and multinomial logit model is adopted to analyze participants' travel distance and vendor choices. Section seven concludes and discusses the policy implications of the thesis.

2. WIC Program and Cost Containment

California WIC Program participants are able to acquire nutritious food at no direct cost. Upwards of 239 active food instruments (FIs) and cash value vouchers (CVV) for the purchase of fruits and vegetables are available to meet diverse participant needs in California. The FIs consist of food products targeted either to infants or to small children and pregnant or post-partum women. The most frequently redeemed infant FI contains formula, and the most frequently redeemed FI for women and children contain a combination of two to four foods such as whole or low-fat milk, cheese, eggs, dried beans, peas, and lentils or peanut butter, whole grains, breakfast cereal, and fruit juice.

Because program participants receive the food products contained in the FI issued to them at no direct cost, they lack incentive to be cost conscious in shopping. Participants' lack of attention to price gives food retailers the incentive to attach additional markups their WIC-eligible food products.

Sexton and Saitone (2012) and Saitone, Sexton, and Volpe (2015) analyzed cost-containment issues for the California WIC Program. Based on the analysis of FI redemptions and in-store pricing for Program vendors, they found great pricing disparities as a function of vendor scale (measured by number of registers operated). Compared to large vendors, small vendors charged substantially higher prices on average. Furthermore, dispersion of prices and FI redemption values was much greater among small stores. Four-, five-, and six-register vendors usually charged much less than their counterparts with three registers, who in turn charged much less than 1-2 register vendors. Two-register vendors had slightly lower in-store prices than one-register vendors. There was much less dispersion of redemption rates in the peer groups containing larger vendors, such as five- and six-register vendors.

Stores with at least six registers were found to achieve nearly all of the savings in redemption values associated with vendor size achieve. Hence, Saitone and Sexton (2012) and Saitone, Sexton, and Volpe (2015) concluded that an excellent opportunity to contain Program costs was to restrain the prices of smaller authorized vendors, specifically those in the 1-4 register groups. Curtailing the number of small vendors in the program thus presents itself as an obvious cost-containment strategy, except for access issues for participants, especially those who live in food deserts. Such participants may rely heavily on the small vendors due to lack of access to larger food retailers.

3. Food Deserts

A food desert is a low-income census tract where a substantial share of residents has low access to a supermarket or large grocery store. There are two crucial parts of the food desert definition: low-income and low access. In a food desert at least 33 percent of the tract's population or a minimum of 500 people in the tract must have low access to a supermarket or large grocery store. Low access to a healthy food retail outlet is defined as more than one mile from a supermarket or large grocery store in urban areas and as more than 10 miles from a supermarket or large grocery store in the countryside.

There are 6,529 food-desert census tracts in the continental U.S. Approximately, 75 percent of these food-desert tracts are urban, while the remaining 25 percent are rural. An estimated 13.6 million people live in these census tracts.

We seek to understand the dependency of WIC participants in food deserts on small vendors, given the possible cost containment policy of removing such vendors from the program or restricting their participation. Participant access to WIC Program benefits is a key concern. If cost-saving policies were implemented in the form of vendor removal, instead, access problems could be created for some participants, particularly for low-income households. Thus we seek to better understand the shopping behavior of WIC

Program participants located in food desert areas and compare that behavior to participants in nearby regions not designated as food deserts.

4. Methodology

Our methodology begins by sorting food-desert and non food-desert participants into treatment and control groups. The descriptive summaries of data provide direct within-group comparison of travel distance and vendor patronage patterns between the two groups. We then undertake econometric analysis to study the difference in travel distance to redeem WIC vouchers and vendor choice between the two groups.

4.1 Description of the Datasets

The analysis relies on an unbalanced panel of purchasing records of WIC participants for a 24-month period, spanning January 2010 through December 2011. A short time series is needed because the same participant need not remain in the program for a long period. Each transaction or Food Instrument (FI) redeemed is associated with a unique participant ID, clinic ID, and vendor ID. Each record also contains the specific FI redeemed and the price charged (or redemption requested) by the vendor.

The vendor ID indicates the program vendor that sold the FI. From WIC Agency records we can know the exact geographic location of the vendor and its status in terms of number of registers operated and whether it is an "above 50" (A50) vendor that obtains at least half of its food product sales through the WIC Program.[1] The clinic ID indicates the WIC clinic assigned to the participant, where she goes to obtain her allocation of FI each month and receive other Program services.

By tracking participants by ID number across time we know the vendor and its exact geographic location for each WIC transaction made by the participant during the study period. A key limitation in the data is that we lack any information on participants beyond identification number and their WIC shopping behavior. We do not know a participant's home location or any demographic information. The alternative used is to rely on the location of the participant's clinic as a proxy for her location. The California WIC Agency operates approximately 611 WIC clinics. Because participants are assigned a clinic in close proximity to their residence and must visit the clinic monthly to receive WIC vouchers, the clinic location should proxy closely to the location for participants assigned to that clinic, especially in highly urbanized areas such as Greater Los Angeles.

Also lacking information on participant demographics, we instead relied on demographic data retrieved through California Census Tract Demographic Characteristics based on the 2009 American Community Survey to capture demographic information for the Census Tract where each treatment and control clinic is located. Census tracts are defined by the Census Bureau and organized as sub-county building blocks. This set of data is jointed with the Program redemption data based on the sub-county code. Important variables from the two datasets and their abbreviations are provided in Table 1. There are five participant Program statuses: breastfeeding mom, B, child 13 months to 5

[1]Cost containment is not an issue for A50 vendors because they are constrained by federal regulation to charge no more than the statewide average cost to redeem food instruments.

years of age, C, infant (birth to 12 months),I, postpartum mom, N, and pregnant woman, P.

Table 1. Variable Description

Variables	Variable Description
FD	Food-desert dummy
CVV	Voucher for vegetables and fruits
CatI	Infant (birth to 12 months)
CatB	Breastfeeding mom
CatP	Pregnant woman
CatN	Post-partum woman (non-breastfeeding mom)
CatC	Child (13 months to 5 years of age)
IFD	Infant*food-desert interaction
BFD	Breastfeeding mom*food-desert interaction
PFD	Pregnant*food-desert interaction
NFD	Post-partum*food-desert interaction
y2011	Year dummy 2011
winter	Season dummy
spring	Season dummy
summer	Season dummy
under5	Population under age 5 as percent of total population
pop517	School age population, ages 5-17, as percent of total population
Asian	Asian population (of one race) as percent of total population
Hispanic	Hispanic population (all races) as percent of total population
African American	African American population (of one race) as percent of total population
MHI	Median household income
Poverty	Percent all population in poverty (with income in past 12 months below poverty level)
Redeemed	The amount redeemed of each transaction in dollar value

Summary statistics for the demographic variables are contained in Table 2. In our sample, about 10% of the population in the census tracts is African American. Another 10% is Asian. More than half of the population is Hispanic. The median household income is about $46,000.

Table 2. Demographic Variables: Summary Data

Variable	Observations	Mean	Std. Dev.	Min	Max
under5 %	6,964,929	9.30	2.32	0.53	12.11
pop517 %	6,964,929	18.94	5.03	8.30	31.59
Asian %	6,964,929	10.32	8.93	0.52	27.83
Hispanic %	6,964,929	57.49	20.54	22.36	95.95
Black %	6,964,929	10.11	16.70	0.09	53.19
MHI ($000)	6,964,929	46.23	15.75	10.64	75.00
Poverty %	6,964,929	19.14	14.86	1.80	76.60
Redeemed $	6,964,929	18.27	21.72	0.01	459.02

4.2 Constructing Treatment and Control Groups

We define a participant as a food-desert participant if she is assigned to a clinic located in a food desert and as a non-food-desert participant if her assigned clinic is located outside of a food-desert region. The former comprise the "treatment group," while the latter represent the control group. We assign a dummy variable, FD, to each participant, which equals one if she is in the treatment group and equals zero otherwise.

We rely on Arc Map (Arc GIS) to create this dummy variable. The map allows us to locate (1) the polygons of food deserts defined by USDA (2013),[2] and (2) the geographic coordinates of clinics in the Los Angeles Metropolitan Statistical Area. Note that our definition of FD is different from the one used by USDA. As WIC participants' access to Program foods is not restricted by their income levels, we only take the

[2] The food-desert data is acquired from USDA ERS Food Access Research Atlas, based on 2010 census tract polygons, updated on May 08, 2013. This Atlas presents a spatial overview of food access indicators for low-income and other census tracts using different measures of supermarket accessibility and provides food access data for populations within census tracts.

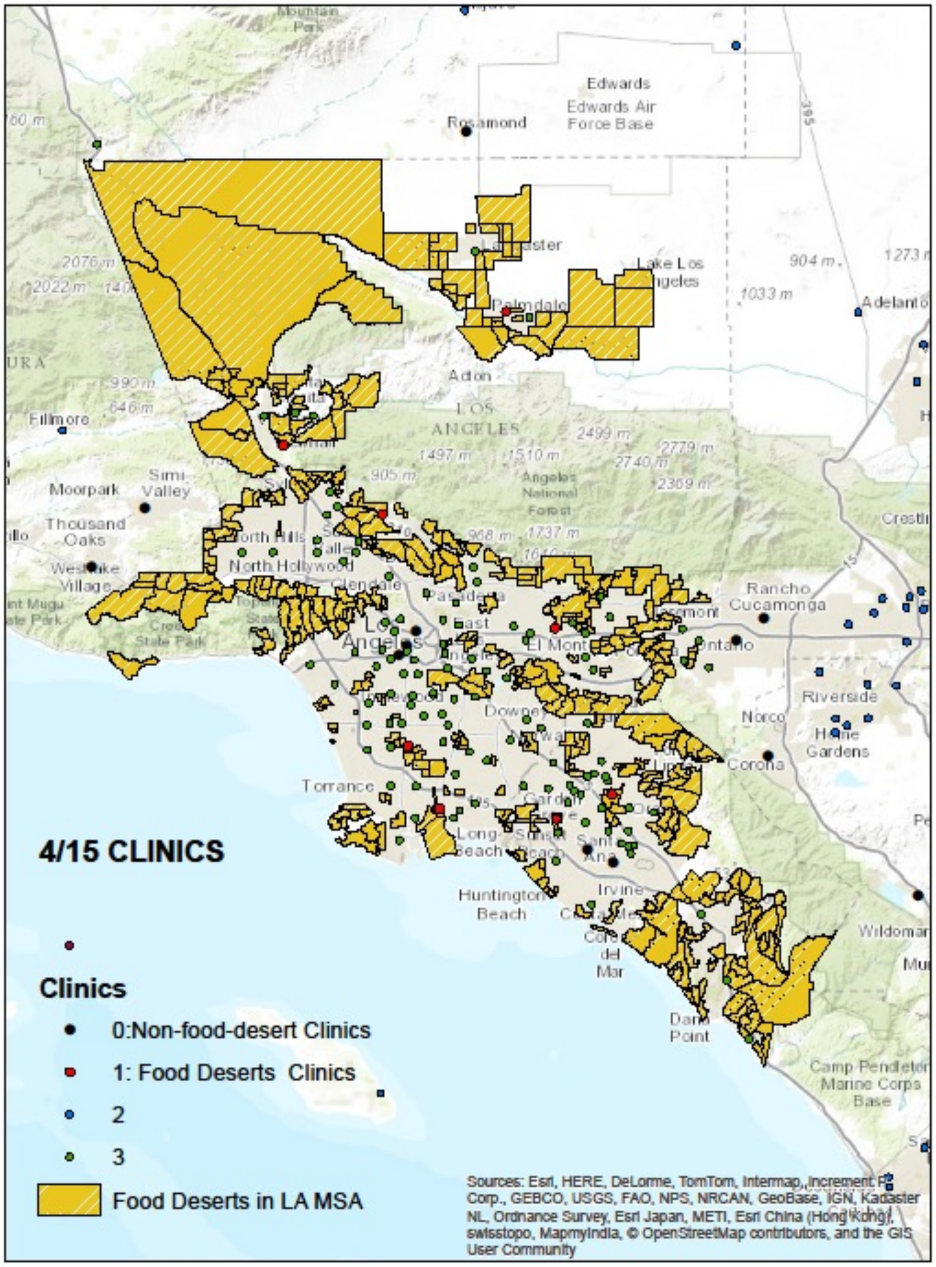
indicator of low access, not low income, to define the food deserts. If the geographic coordinate of a clinic falls within a food-desert polygon, the clinic belongs to the treatment group. We identified eight treatment clinics in total by this method. Any participant assigned to a treatment clinic is a treatment participant.

The next step was to define a control group of clinics. In principle, any WIC clinic located outside the boundaries of a food desert could be considered part of the control group. However, this could be misleading because the location of clinics is only a proxy for the unavailable home addresses of participants. For example, a WIC participant who lives within a food desert may be assigned a clinic that is located outside but close to the boundary of the food desert. It would be a mistake to assign such a person to the control group.

Thus, we avoid clinics that are located very close to food deserts to limit the risk of making the wrong categorization. On the other hand, to ensure that control participants are comparable to treatment participants apart from food-desert status, we also do not want to include clinics that are too far away from the treatment clinics. If we enlarge the comparison scope too much, we increase the tendency to introduce unobservable factors that we may not be able to control in the econometric analysis. Thus, we used a range of four miles to fifteen miles to select control clinics, to exclude the too-close and too-far clinics.

Using the range of four to fifteen miles, we show treatment and control clinics in Figure 1. The yellow striped polygons represent food desert areas based on the Atlas data (USDA ERS 2013) using only low access as the indicator. Red dots represent the locations of treatment clinics located inside of food deserts. Black dots represent the locations of control clinics within a band of four to fifteen miles from a food desert. Green dots are clinics located within four miles from food-desert areas. Blue dots are clinics that are at least fifteen miles away from food-desert areas. We exclude green and blue dots from the control group. Eight red dots (treatment clinics) and eleven black dots (control clinics) were selected initially. One control clinic and two treatment clinics had no demographic data associated with its census tract, and each was omitted. Another clinic was also dropped from treatment group due to the insufficient amount of FI redeemed. This clinic apparently began operating in late 2011 so that it had no FI record in 2010 and only 15 FIs in 2011.

Figure 1. Map of Food Deserts and WIC Clinics in Los Angeles



4.3 Control and Treatment Group Features

Table 3 contains a summary of the number of Food Instrument (FI) redeemed by year and category for control and treatment clinics. The treatment and control clinics are quite comparable on average in terms of numbers of FI redeemed annually by participants assigned to the clinics.

Table 3. Number of FIs Redeemed by Year and Group

Control			Treatment		
Number of FIs Redeemed by Year					
Clinic ID	2010	2011	Clinic ID	2010	2011
311002	220,017	208,228	308001	105,481	105,420
314016	262,741	261,424	311038	221,058	207,038
314046	222,033	203,925	313005	461,027	435,624
314077	257,965	245,895	323001	322,276	263,588
314104	383,976	375,925	325003	301,261	292,006
315039	229,854	227,342			
315093	319,635	315,614			
317005	421,159	385,431			
321003	59,124	57,992			
321006	85,476	81,539			
min	59,124.0	57,992.0	min	105,481.0	105,420.0
max	421,159.0	385,431.0	max	461,027.0	435,624.0
average	234,994.5	225,594.9	average	282,220.6	260,735.2
std. dev	114,704.5	109,128.6	std. dev	131,259.7	121,014.8

The treatment group consisted of 77,913 WIC participants who visited one of five clinics located within a food desert area of GLA. The "control" group consisted of the over 131,371 WIC participants who visited one of ten clinics in GLA located within a band of 4 to 15 miles from a food desert. Nearly seven million total WIC transactions were included in the study across the treatment and control groups for the two-year study period.

Tables 4 and 5 show the number of food instruments redeemed by year and participant categories for control and treatment groups, respectively, including the share redeemed in each category. The participant status of child, C, has the highest share of FI redeemed across all the clinics, followed by infant, I, and pregnant woman, P. Participant status C's FI amount takes account of about 60% of the share among the five categories over all clinics, followed by I and P. Category of post-partum woman, N, has the lowest proportion of the FI's redeemed. This breakdown is consistent between the treatment and control groups.

Table 4. Control Group by Participant Category

Clinic ID	Total FIs Redeemed	Category	2010	2011	Two-year Sum	Share
311002	428,245	B	16,931	16,129	33,060	7.72%
		C	141,588	136,168	277,756	64.86%
		I	29,440	25,967	55,407	12.94%
		N	9,880	9,505	19,385	4.53%
		P	22,178	20,459	42,637	9.96%
314016	524,163	B	22,058	23,047	45,105	8.61%
		C	164,779	167,270	332,049	63.35%
		I	30,470	27,772	58,242	11.11%
		N	10,921	10,830	21,751	4.15%
		P	34,513	32,503	67,016	12.79%
314046	425,958	B	17,884	15,214	33,098	7.77%
		C	145,019	139,809	284,828	66.87%
		I	28,212	21,615	49,827	11.70%
		N	7,550	6,975	14,525	3.41%
		P	23,368	20,312	43,680	10.25%
314077	503,860	B	20,969	20,423	41,392	8.21%
		C	166,861	162,108	328,969	65.29%
		I	32,761	27,718	60,479	12.00%
		N	9,657	9,443	19,100	3.79%
		P	27,717	26,203	53,920	10.70%

(continued Table 4)

314104	759,897	B	30,932	31,801	62,733	8.26%
		C	249,047	251,210	500,257	65.83%
		I	50,529	42,500	93,029	12.24%
		N	13,898	11,684	25,582	3.37%
		P	39,566	38,730	78,296	10.30%
315039	457,196	B	30,427	30,022	60,449	13.22%
		C	135,577	140,657	276,234	60.42%
		I	34,014	29,225	63,239	13.83%
		N	7,679	6,467	14,146	3.09%
		P	22,157	20,971	43,128	9.43%
315093	635,249	B	28,953	30,345	59,298	9.33%
		C	195,398	197,946	393,344	61.92%
		I	48,391	42,540	90,931	14.31%
		N	15,687	14,971	30,658	4.83%
		P	31,206	29,812	61,018	9.61%
317005	806,590	B	21,483	22,088	43,571	5.40%
		C	255,978	241,036	497,014	61.62%
		I	75,216	61,826	137,042	16.99%
		N	28,138	24,259	52,397	6.50%
		P	40,344	36,222	76,566	9.49%
321003	117,116	B	5,464	5,881	11,345	9.69%
		C	35,433	35,042	70,475	60.18%
		I	9,400	9,026	18,426	15.73%
		N	3,037	2,948	5,985	5.11%
		P	5,790	5,095	10,885	9.29%
321006	167,015	B	8,549	8,465	17,014	10.19%
		C	47,853	47,750	95,603	57.24%
		I	16,036	14,091	30,127	18.04%
		N	4,632	4,122	8,754	5.24%
		P	8,406	7,111	15,517	9.29%

Table 5. Treatment Clinics by Participant Category

Clinic_id	Total FIs Redeemed	Category	2010	2011	Two-year Sum	Share
308001	210,901	B	5,865	6,473	12,338	5.85%
		C	67,171	68,914	136,085	64.53%
		I	15,282	13,807	29,089	13.79%
		N	5,784	5,298	11,082	5.25%
		P	11,379	10,928	22,307	10.58%

(continued Table 5)

311038	428,096	B	17,761	16,827	34,588	8.08%
		C	139,759	137,135	276,894	64.68%
		I	33,399	25,940	59,339	13.86%
		N	10,515	8,904	19,419	4.54%
		P	19,624	18,232	37,856	8.84%
313005	896,651	B	24,535	22,134	46,669	5.20%
		C	303,649	293,769	597,418	66.63%
		I	61,507	53,459	114,966	12.82%
		N	25,007	23,443	48,450	5.40%
		P	46,329	42,819	89,148	9.94%
323001	585,864	B	20,302	17,740	38,042	6.49%
		C	204,018	170,122	374,140	63.86%
		I	53,762	37,389	91,151	15.56%
		N	16,756	13,819	30,575	5.22%
		P	27,438	24,518	51,956	8.87%
325003	593,267	B	18,100	16,847	34,947	5.89%
		C	191,621	194,511	386,132	65.09%
		I	49,174	40,122	89,296	15.05%
		N	15,237	13,611	28,848	4.86%
		P	27,129	26,915	54,044	9.11%

5. Evidence from Descriptive Statistics

We identify the location and type of vendor visited by the treatment and control participant for each FI redemption and calculate the number of vendors visited over the first six months of 2010. Focus on a short time interval such as six months limits distortions to the results from participants joining and exiting the program. We also calculate each participant' shopping distance per trip.

5.1 Redemption Patterns by Peer Group

Table 6 demonstrates the relationship between the number of FIs redeemed and redemption locations. For control group participants, we focus on the following three scenarios: (1) a participant redeems the FI at a vendor within the same non food-desert area as the clinic she is assigned to, (2) a participant redeems the FI at a vendor in a food-desert area, (3) a participant redeems the FI at a vendor in a non-food-desert area outside the area where her assigned clinic is located. As shown in the fifth column of table 6, about 25% of the FIs are redeemed by control participants within their clinic area. Another 75% of the FIs are redeemed in non food-desert regions outside the clinic area, i.e., more than three-quarters of the control participants travel to shop out of their clinic Census Tract. Only 0.3% of the FI are redeemed in a food-desert area. Over half of treatment participants' FIs were redeemed at large vendors with 6+ registers.

For the treatment group, we also identify are three redemption scenarios: (1) a food-desert participant travels to a non-food-desert area to redeem the FI, (2) a food-desert participant shops at a vendor located in the same (food-desert) area as her assigned clinic, (3) a food-desert participant travels to another food-desert area to redeem her FI. Not surprisingly, about 88% of FIs are redeemed outside of the food desert, which indicates that treatment participants with low food access are willing and able to travel to shop for WIC benefits. The majority of FI are redeemed at A50 vendors and large vendors with 6+ registers. Only 3.3% of FIs are redeemed in the same food-desert area as the clinic where the FIs are issued. This small portion of FIs is redeemed at small vendors with one or two registers or at A50 vendors. Interestingly, 8.8% of the treatment participants redeem their FI in a different food-desert census tract than where their clinic is located.

Table 6. FI Redemption Patterns by Vendor Types and Locations

Control	Same as Clinic/not FD			Different/FD			Different/not FD			Total	
Register	Number of FI	Column Percent	Row Percent	Number of FI	Column Percent	Row Percent	Number of FI	Column Percent	Row Percent	Number of FI	Column Percent
A50	929,894	83.0	46.6	872	6.3	0.0	1,065,561	30.9	53.4	1,996,327	43.6
1-2	11,037	1.0	8.1	226	1.6	0.2	124,540	3.6	91.7	135,803	3.0
3-4	17,401	1.6	12.3	208	1.5	0.1	124,263	3.6	87.6	141,872	3.1
5-6	5,342	0.5	1.7	30	0.2	0.0	307,721	8.9	98.3	313,093	6.8
7-9	75,811	6.8	13.0	3,629	26.1	0.6	505,566	14.7	86.4	585,006	12.8
10+	81,066	7.2	5.8	8,954	64.3	0.6	1,318,460	38.3	93.6	1,408,480	30.7
Total FI/Column/Row	1,120,551	100.0	**24.5**	13,919	100.0	**0.3**	3,446,111	100.0	**75.2**	4,580,581	100.0

Treatment	NOT FD			FD/inside Clinic area			FD/outside Clinic area			Total	
Register	Number of FI	Column Percent	Row Percent	Number of FI	Column Percent	Row Percent	Number of FI	Column Percent	Row Percent	Number of FI	Column Percent
A50	896,977	42.8	88.1	69,227	88.4	6.8	51,977	24.7	5.1	1,018,181	42.7
1-2	116,582	5.6	86.5	9,128	11.6	6.8	9,010	4.3	6.7	134,720	5.7
3-4	48,266	2.3	84.8	0	0.0	0.0	8,681	4.1	15.2	56,947	2.4
5-6	116,418	5.6	100.0	0	0.0	0.0	0	0.0	0.0	116,418	4.9
7-9	244,409	11.7	82.2	0	0.0	0.0	52,920	25.1	17.8	297,329	12.5
10+	672,858	32.1	88.4	0	0.0	0.0	87,895	41.8	11.6	760,753	31.9
Total FI/Column/Row	2,095,510	100.0	**87.9**	78,355	100.0	**3.3**	210,483	100.0	**8.8**	2,384,348	100.0

5.2 Average Travel Distance

The shopping distance of a participant is defined as the straight-line distance between th where is assigned to the vendor where she shops. We geocode the addresses of each cli vendor into sets of longitude and latitude, and then calculate the straight-line distance b the two points. In Table 7 we compare the difference in travel distance between fooc participants and non-food-desert participants.[3]

Table 7. Travel Distance Summary by FI

Number of **Treatment** Participants:			83,100		Number of **Control** Participants:			144,110
Less than1 mile	6588	7.93%				34827	24.17%	
1 mile or more	76512	92.07%				109283	75.83%	
Observations	Mean	Std. Dev.	Min	Max	Observations	Mean	Std. Dev.	Min
81,212	**4.20**	3.73	0.0004	24.98	140,488	**3.42**	4.00	0.007

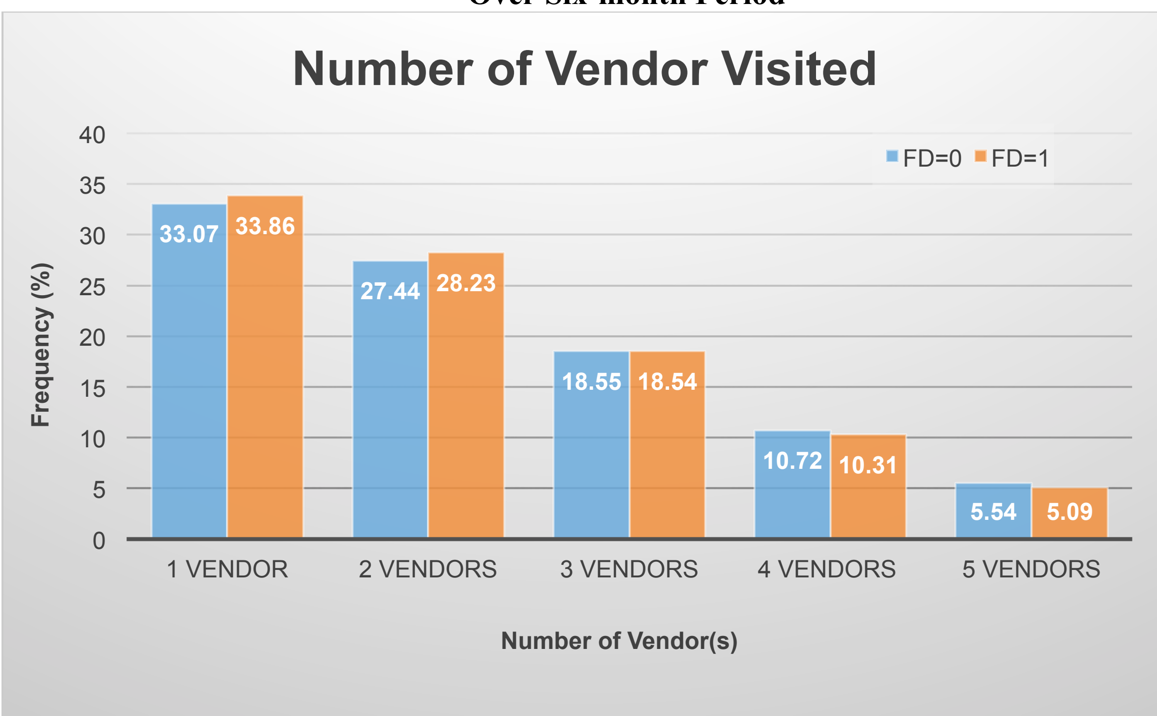
Food-desert or treatment participants travel on average of 4.2 miles to shop fc products. Over 92% of the FIs are redeemed more than one mile from the clinic loca comparison, control participants travel 3.42 miles on average, and about 76% of then more than one mile. A reasonable walking distance in the range of 0.31 miles (Wrigley, and Margetts, 2003) to 1 mile (Ver Ploeg et al., 2009) is used as the estimated bre between high and low access in urban areas. In general then, a participant's access to foo limited by walking distance in GLA.

[3] A handful of redemptions were associated with very long travel distances. For example, a participant coul FI while on vacation. We removed any observation that involved a travel distance in excess of 25 miles.

5.3 Venders Visited

Food-desert participants were slightly more likely to visit multiple vendors than those in the control group during a six-month period, from January 2010 to June 2010. The modal number of vendors visited by each group was two, followed by three and then one. About 25% (23%) of food-desert participants visited two (three) vendors. Nearly 80% of participants in both groups redeemed benefits at multiple vendors, indicating the presence of vendor choices for the vast majority. Thus, there is little difference between the treatment and control groups for this measure of participant access.

Figure 2. Number of Vendors Visited by Control and Treatment Participants Over Six-month Period



6. Econometric Analysis

One facet of the econometric analysis was to seek to explain participants' travel distance in miles, M, to redeem FIs to determine if there is a significant difference in travel distance for food-desert participants. As noted, summary statistics suggest that treatment participants traveled on average about 0.8 miles further than control participants. We start with a simple OLS model and then add in more controls. A fixed effects model is also constructed to check the robustness of the OLS.

6.1 OLS Model

We seek to test whether food-desert participants travel farther on average to shop compared to control participants as a measure of comparative measure of food access. Use of clinic locations as the proxy of participants' residence locations introduces error into the analysis, but there is no reason to expect that the error or bias is greater or less for the treatment vs. control participants.

(1) $$M_{1i}=\beta_0+\beta_1\cdot FD_{1i} + \mu_{1i},$$

where FD is the food desert dummy variable. Standard errors are clustered by participant.

Results show that there is a positive relationship associated with the food desert dummy variable:

$$\widehat{M_1}= -0.108+0.856\ FD_1$$

Compared to control participants, food-desert participants travel 0.856 miles further to shop for WIC benefits, an estimate comparable to the simple mean difference. The standard error of the FD coefficient is 0.007, meaning the result is highly statistically significant. However, about 95% of the variation in travel distance is not explained by the FD variable.

Model (1) omits many factors that may affect travel distances. Other variables available in the data are a participant's program status: pregnant woman, post-partum mother, breastfeeding mother, or woman with an infant or with young children. Participants' mobility may vary in their status. The FI Code and its detailed explanation of each transaction are also included in our data, which allow us to understand what type of food the participant purchased. We include a CVV dummy variable to indicate that the purchase was with a fruits and vegetables cash-value voucher. CVV equals one if a participant's purchase was with a fruit and vegetable voucher. Participants may travel further to make purchases with fruit and vegetable vouchers to obtain a better selection and acquire fresher fruits and vegetables by shopping for such items at a supermarket. Although all program vendors are required to stock fruits and vegetables, small vendors often only carry a limited selection.

Adding the participant category variables multiplied by the food desert dummy variable captures the interaction effect between food deserts and those category variables. We seek to obtain a more precise estimator for the food-desert dummy variable when we include those control variables. The equation for the model 2 specification is the following:

$$(2) \qquad M_2=\beta_0+\beta_1\cdot FD+\beta_2\cdot CVV+\beta_3\cdot CatI+\beta_4\cdot CatB+\beta_5\cdot CatP+\beta_6\cdot CatN$$
$$+\beta_7\cdot IFD+\beta_8\cdot BFD+\beta_9\cdot PFD+\beta_{10}\cdot NFD+\mu_2$$

where these variables are defined in Table 2.

The results are presented in the third column (regression 1) of Table 8. Food-desert participants are estimated to travel 0.855 miles further on average than their counterparts based on this model. This result is highly statistically significant and closely comparable to the result from the simple linear model.

The baseline comparison group for participant category dummy variables is Child. The main significant result of interest is that post-partum women travel 0.115 miles further compared to women with children, although the effect is smaller in food deserts. The coefficients for participant's status interacted with the dummy variable for food desert are small and are not economically significant, indicating that the impact of participants' status on travel distance is not much affected by whether the participant visits a food-desert clinic..

Participant demographics such as age, race and income could have a significant impact on a participant's mobility. As noted, we do not have the individual demographic information in the dataset. The closest information we have is the demographic variables at the census tract level. Therefore, we use these aggregate variables to control for impacts of demographic features on the travel distance of a participant. Adding these variables can help to alleviate concerns over omitted variables bias. Table 7 contains the mean values of demographic variables for the food-desert participants and their counterparts.

Table 7. Summary of Demographic Variables by FD Status

FD	under5 %	pop517 %	Asian %	Hispanic %	African-American %	MHI $ 000	Poverty %	Redeemed Value $
0 (Control)	10.09	19.03	8.40	66.86	2.62	43.57	21.30	18.16
1 (Treatment)	7.78	18.78	14.00	39.48	24.49	51.34	14.97	18.49

Percent of population under the age of five (under5) is about two percent higher for the control group than for the treatment group. The difference in percent population between ages five and seventeen is negligible between the two groups. However, there are larger differences in the race distribution between food-desert and non food-desert areas, especially for African

American households. There are only 2.62% African American households on average in the non food-desert control areas, whereas African American percentage of the population in the treatment food deserts is 24.49%. There is a higher share of the Hispanic population in control than treatment areas, 66.86% vs. 39.48%. There is little difference in the incidence of Asian population between two groups.

We also include variables to measure incomes and poverty rates in the Census tract. The mean household income (MHI) is higher in food deserts compared to non-food-desert areas. The poverty rate is also higher in control areas vs. treatment areas (21.30% vs. 14.97%).

The dollar value of the FI may also be relevant for explaining participants' travel patterns. Despite participants' insensitivity to price, motivation may still remain to travel further to a preferred store to redeem high-value FIs. The treatment group has a slightly higher mean redemption value, \$18.49, than the control group, \$18.16.

In this most comprehensive model, model 3, we seek to explain travel distance as a function of the food desert status of a participant, a suite of control variables including the FI and CVV dummy variables, participants' program status variables, year and season dummy variables, the demographic variables for the clinic's Census tract, and the FI redemption value. The full model, thus, is as follows:

$$
\begin{gathered}
M_3=\beta_0+\beta_1\cdot FDi+\beta_2\cdot CVV \\
+\beta_3\cdot CatI+\beta_4\cdot CatB+\beta_5\cdot CatP+\beta_6\cdot CatN+\beta_7\cdot IFD+\beta_8\cdot BFD+\beta_9\cdot PFD+\beta_{10}\cdot NFD \\
+\beta_{11}\cdot y2011+\beta_{12}\cdot winter+\beta_{13}\cdot spring+\beta_{14}\cdot summer \\
+\beta_{15}\cdot under5+\beta_{16}\cdot pop517+\beta_{17}\cdot Asian+\beta_{18}\cdot Hispanic+\beta_{19}\cdot Afr.\ Am. \\
+\beta_{20}\cdot MHI+\beta_{21}\cdot poverty+\beta_{22}\cdot redeemed+\mu_3
\end{gathered}
\tag{3}
$$

The results are listed in the second column of Table 8. The additional variables cause R-squared to increase from 0.052 to 0.102. There continues to be positive and significant association between travel distance and food desert dummy variable, but the estimate of additional travel distance for food-desert participants is only 0.27 miles relative to control participants in model 3.

Most of the demographic variables are statistically significant, but the effects are not large. For example, a one percentage point increase in the population of age under five is associated with an additional 0.02 miles in travel distance. One more percentage point of African American population is associated with additional 0.004 miles of travel distance.

6.2 Peer Group Fixed Effects

A fixed effects model is a statistical model that represents the observed travel distance in terms of a suite of explanatory variables that are treated as if the distance were non-random. The travel distance of a participant may be highly correlated with vendor's size as measured by its peer group since the distance partially depends on the location of the vendor. Thus, the individual-specific effect of a participant is correlated with our independent variable. The fixed-effect coefficients soak up all the across-group actions. The within-group action remains, which is what we desire. Use of the fixed effect model greatly reduces the risk of omitted variable bias.

The peer group fixed effects model consists of the same three specifications as the OLS models. The first only includes food-desert dummy variable as an explanatory variable.

(4) $$M_{4\,i,j} = \beta_0 + \beta_1 \cdot FD_{4\,i,j} + \mu_{4\,i,j} + v_{4\,i} + u_4$$

where j denotes the peer group fixed effects. The results of estimating (4) are as follows:

$$\widehat{M_4} = -0.103 + 0.842 * FD$$

Food-desert participants are estimated to travel 0.842 miles further compared to participants at control clinics. This estimated magnitude is close to the OLS model estimate.

In the second specification, the food desert dummy variable is combined into a fixed-effects regression model with participants' program status, the CVV dummy variable, year and seasonal dummy variables. The results are provided in column five (regression (3)) in Table 8. Compared to control participants, food-desert participants are estimated on average to travel 0.847 miles further to redeem their FIs in this model.

The last specification contains all the explanatory variables, including demographic variables. The results are in column five (regression 4) in Table 8. In this specification, food-desert participants are estimated to travel only 0.211 miles further on average than non-food-desert participants.

Each model thus finds a statistically significantly longer travel distance to redeem WIC vouchers for participants who attend a WIC clinic located in a food desert. The amount of the additional travel distance is somewhat sensitive to model specification. The simpler model specifications consistently indicate that food-desert participants travel about 0.85 miles further to shop than participants at the control clinics. However, the estimated incremental distance is much less, about 0.25 miles, for the full model containing demographic variables and year and season fixed effects.

Table 8. Regression Results

Variables	Variable Description	(1) FD+dummies OLS	(2) Full OLS	(3) Peer group fe FD+dummies	(4) Peer group fe full
FD	Food-desert dummy	0.855***	0.271***	0.847***	0.211***
		(0.00897)	(0.0128)	(0.00888)	(0.0121)
CVV	Fresh vegetables and fruits	0.0391***	0.0341***	-0.0966***	-0.0963***
		(0.00171)	(0.00183)	(0.00165)	(0.00173)
CatI	Infant, birth to 12 months	-0.0163	-0.0203*	0.00544	-0.00336
		(0.0111)	(0.0115)	(0.00990)	(0.0104)
CatB	Breastfeeding mom	-0.0302*	-0.0322*	-0.105***	-0.104***
		(0.0169)	(0.0165)	(0.0146)	(0.0142)
CatP	Pregnant woman	-0.0349***	-0.00875	-0.0705***	-0.0476***
		(0.0127)	(0.0123)	(0.0112)	(0.0109)
CatN	Post-partum woman	0.115***	0.113***	0.0791***	0.0898***
		(0.0145)	(0.0140)	(0.0130)	(0.0127)
IFD	Infant*food-desert	-0.0225	0.0265*	-0.0353**	0.00451
		(0.0155)	(0.0149)	(0.0150)	(0.0141)
BFD	Breastfeeding mom*food-desert	0.0152	0.0467**	-0.0207	0.0239
		(0.0240)	(0.0230)	(0.0228)	(0.0213)
PFD	Pregnant*food-desert	0.0559***	0.0360**	0.0220	0.00176
		(0.0172)	(0.0163)	(0.0168)	(0.0155)
NFD	Post-partum*food-desert	-0.0757***	-0.0662***	-0.0843***	-0.0929***
		(0.0194)	(0.0184)	(0.0189)	(0.0177)
y2011	Year dummy 2011		-0.0600***		-0.0682***
			(0.00420)		(0.00386)
winter	Season dummy		0.0114***		0.0170***
			(0.00297)		(0.00273)
spring	Season dummy		0.0479***		0.0529***
			(0.00338)		(0.00310)
summer	Season dummy		0.0177***		0.0172***
			(0.00270)		(0.00249)
under5	Population under age 5 as percent of total population		0.0219***		0.0197***
			(0.00368)		(0.00332)
pop517	school age population, ages 5-17, as percent of total population		-0.00157*		0.000966
			(0.000856)		(0.000792)
Asian	Asian population (of one race) as percent of total population		-0.000344		0.0116***
			(0.000925)		(0.000879)

(continued Table 8)

Hispanic	Hispanic population as percent of total population		-0.0167***		-0.0120***
			(0.000382)		(0.000356)
Afr. Am.	African-American population as percent of total population		0.00382***		0.00975***
			(0.000379)		(0.000380)
MHI	Median household income		0.00496***		0.00193***
			(0.000678)		(0.000643)
Poverty	Percent all population in poverty (with income in past 12 months below poverty level)		-0.00785***		-0.00919***
			(0.000836)		(0.000768)
Redeemed	The amount redeemed each transaction in dollar value		0.000730***		-0.000171**
			(7.49e-05)		(6.90e-05)
Constant		-0.113***	0.782***	-0.0702***	0.517***
		(0.00703)	(0.0704)	(0.00620)	(0.0649)
Observations		6,964,929	6,964,929	6,964,929	6,964,929
R-squared		0.052	0.102	0.190	0.240

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.3 Multinomial Logit and Vendor Choices

To gauge participants' dependency on program vendor types, we constructed a multinomial logit model to estimate the probability of participants shopping at each type of vendors. Saitone, Sexton, and Volpe (2015) argue that nearly all of the available cost savings associated with sales at larger vendors were achieved with vendors operating six or more registers. Thus, we decompose vendor types by size into the following three groups: A50 vendors defined by federal regulations as making at least half of their food sales through the WIC program, small vendors defined as operating from one to five cash registers and large vendors as those operating six or more cash registers.

A-50 vendors emphasize WIC Program sales and tend to be located in proximity to program participants (e.g., near WIC clinics) and to make purchasing easy and non-stressful, for example, by making authorized products easy to locate and emphasizing convenient checkout. Counterbalancing incentives that favor making purchases at larger vendors are their wide selection of WIC-eligible products and favorable prices of non-WIC products, which provide participants the convenience of one-stop shopping (Sexton and Saitone 2012). If food-desert participants are more likely to shop at high-cost small vendors, disqualifying those vendors from the WIC program is more likely to cause food access issues for food-desert participants.

Table 9 below shows the redemption volume at each type of vendor by control, treatment group and total, respectively.

Table 9. FD and Vendor Types

choice	FD=0	Percent	FD=1	Percent	Total	Percent
A50	1,996,327	66.2	1,018,181	33.8	3,014,508	43.3
small	384,576	64.8	209,380	35.3	593,956	8.5
large	2,199,678	65.6	1,156,787	34.5	3,356,465	48.2
Total	4,580,581	65.8	2,384,348	34.2	6,964,929	100

Pearson chi2(2) = 633.2703 Pr = 0.000

In general, large vendors account for the highest share of FI redemption volume (48.19%), in the dataset, followed by A50 and small vendors. Only about 8% of FIs are redeemed at small vendors. About 34% of the FIs in this study are redeemed in food deserts. In Table 10 below, we summarize mean values for important explanatory variables by the three vendor types. The

Hispanic population share is highest at small vendors, while the African American share is highest at A50 vendors. Mean household income is lower and poverty rate is higher for those patronizing small vendors. The higher redemption value for the small vendors reflects the higher prices charged for WIC redemptions by these vendors.

Table 10. Summary of Demographic Data by Vendor Types

choice	under5	pop517	Asian	Hispanic	African-American	MHI	Poverty	Redemption Value
A50	9.28	19.04	10.47	57.99	11.12	45.99	18.89	19.14
small	8.99	17.46	10.84	61.60	10.34	42.05	24.05	24.90
large	9.38	19.11	10.10	56.32	9.16	47.18	18.49	16.33

In the multinomial logit model, the choices as discrete values are regressed on the food desert and CVV dummy variables, WIC participants' status, and their demographic variables. In Table 11, the log odds of the outcomes are presented as a linear combination of the predictor variables. The baseline or reference cell is A50 vendors. Based on the results, we calculate the predicted probability of choosing each type of vendor for treatment and control participants, holding all other variables at their mean values.

Table 11. Multinomial Logit and Relative Risk Ratio Results

VARIABLES	(2) Small vendor Multinomial Logit	(3) Large vendor Multinomial Logit	(5) Small vendor Relative Risk Ratio	(6) Large vendor Relative Risk Ratio
FD	0.711***	0.140***	2.036***	1.151***
	(0.0317)	(0.0175)	(0.064)	(0.020)
CVV	-0.0692***	0.467***	0.933***	1.595***
	(0.00559)	(0.00334)	(0.005)	(0.005)
CatI	-0.277***	-0.0921***	0.758***	0.912***
	(0.0213)	(0.0119)	(0.016)	(0.011)
CatB	0.00970	0.237***	1.010***	1.267***
	(0.0303)	(0.0180)	(0.031)	(0.023)
CatP	-0.125***	0.142***	0.883***	1.152***
	(0.0245)	(0.0143)	(0.022)	(0.016)
CatN	-0.0929***	0.0829***	0.911***	1.086***
	(0.0291)	(0.0165)	(0.027)	(0.018)
IFD	0.111***	0.0638***	1.117***	1.066***
	(0.0354)	(0.0203)	(0.040)	(0.022)
BFD	-0.0692	0.0908***	0.933	1.095***
	(0.0558)	(0.0323)	(0.052)	(0.035)
PFD	0.0433	0.117***	1.044	1.124***
	(0.0422)	(0.0242)	(0.044)	(0.027)
NFD	0.0936**	0.0867***	1.098**	1.091***
	(0.0466)	(0.0266)	(0.051)	(0.029)
y2011	0.459***	-0.0216***	1.582***	0.979***
	(0.00946)	(0.00505)	(0.015)	(0.005)
winter	-0.139***	-0.00193	0.870***	0.998
	(0.00607)	(0.00344)	(0.005)	(0.003)
spring	-0.184***	0.00631	0.832***	1.006***
	(0.00696)	(0.00384)	(0.006)	(0.004)
summer	-0.103***	0.0145***	0.902***	1.015***
	(0.00567)	(0.00314)	(0.005)	(0.003)
under5	-0.0475***	-0.00458	0.954***	0.995
	(0.00510)	(0.00342)	(0.005)	(0.003)
pop517	-0.0939***	0.00244**	0.910***	1.002***
	(0.00226)	(0.00120)	(0.002)	(0.001)
Black	0.00197***	-0.0213***	1.002***	0.979***
	(0.000752)	(0.000448)	(0.001)	(0.000)
Asian	0.0652***	-0.0448***	1.067***	0.956***
	(0.00211)	(0.00134)	(0.002)	(0.001)
Hispanic	0.0301***	-0.0179***	1.031***	0.982***
	(0.000819)	(0.000432)	(0.001)	(0.000)
MHI	-0.0282***	0.0123***	0.972***	1.012***
	(0.00107)	(0.000690)	(0.001)	(0.001)
Constant	-1.088***	1.058***	0.337***	2.881***
	(0.0826)	(0.0438)	(0.028)	(0.126)

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

6.3.1 Relative Log Odds

The results of multinomial logit model are presented in the first two columns of Table 11, denoted by (2) and (3).[4] The likelihood ratio chi-square value of 39002.46 has a p-value < 0.0001, and demonstrates that the model fits significantly better than an empty model, i.e., a model with no predictors. The relative log odds of shopping at small vendors vs. at A50 vendors increases by 0.71 in moving from non-food-desert area to food desert areas. Similarly, the relative log odds of shopping at large vendors vs. at A50 vendors increases by 0.14 in moving from non food-desert to food-desert participants.

6.3.2 Relative Risk Ratios

Because the log odds are hard to interpret, we also display the regression results for the relative risk ratios. The ratio of the probability of choosing one outcome category over the probability of choosing the baseline category is often referred to as relative risk. Relative risk can be obtained by exponentiating the linear equations, yielding regression coefficients that are relative risk ratios for a unit change in the predictor variable. The results are shown in the fourth and fifth columns in Table 11, labeled as (5) and (6). The relative risk ratio switching from FD = 0 to 1 is 2.04 for shopping at small vendors vs. A50 vendors and is 1.15 for shopping at large vendors vs. A50 vendors, indicating food-desert participants' greater propensity to shop at small and large vendors (and less frequently at A50 vendors) compared to the control group.

---

[4] Regression (1) is the log odds of choosing A50 vendors. As the baseline comparison group, the outcome for A50 vendors is dropped. Only the outcomes for small and large vendors are reported.

6.3.3 Margins

The predicted probabilities can also be calculated by the margins command in STATA. Table 13 shows the results of predicted probability of shopping at A50, small and large vendors, by food-desert and non-food-desert participants, respectively.

Table 13. Food Deserts and Vendor Choice

		Delta-method				
	Margin	Std. Err.	z	P>z	[95% Conf.	Interval]
FD	A50					
0	**0.4503**	0.001784	252.49	0	0.446853	0.453845
1	**0.3937**	0.002822	139.51	0	0.388205	0.399268
FD	Small					
0	**0.0720**	0.000713	100.98	0	0.070579	0.073374
1	**0.1234**	0.002219	55.61	0	0.119025	0.127722
FD	Large					
0	**0.4777**	0.001749	273.14	0	0.474247	0.481102
1	**0.4829**	0.002775	174.01	0	0.477451	0.488329

The likelihood of a control participant shopping at an A50/small/large vendor is 45.03% / 7.2% / 47.7%, holding other variables at their mean values. Similarly, the probability of a food-desert participant shopping at an A50/small/large vendor is 39.37% / 12.34 % / 48.29%. Somewhat surprisingly, participants in food deserts are slightly more likely to choose large vendors to redeem their food instruments than control participants. (48.29% vs. 47.77%). Food-desert participants also rely more heavily on small vendors than non food-desert participants, with a marginal probability of about 12% vs. 7%.

7. Policy Implications and Conclusions

In this paper, we have examined the effects of food deserts on WIC participants' shopping behavior in the Greater Los Angeles Area, California. Our results indicate that the food desert has a positive effect on participants' travel distance. Location in a food desert is associated with slightly longer travel to redeem WIC benefits—from 0.25 – 0.85 miles, depending on model specification. Results from the MNL model reveal that food-desert participants are slightly more likely to visit a large vendor than non-food-desert counterparts, but are also more likely to shop at small vendors (12 vs. 7 percent marginal probability). Accordingly, food desert shoppers utilize A50 vendors less often. Also of note is that food-desert participants are slightly more likely to visit multiple vendors than control participants to redeem WIC benefits in any given time period.

The results of this paper do not reveal large differences in the shopping behavior of participants in food-desert areas relative to the control group, which may be contrary to popular beliefs. Food-desert participants do travel further to shop on average than control participants. This may reflect a need to travel further to access suitable shopping options, but it also suggests that that on average food-desert participants have the ability to engage in such travel. Food desert participants also visit large supermarkets with at least as much frequency as their control peers, and are at least as likely to visit multiple vendors. The results, thus, suggest that stringent controls on the behavior of small vendors likely will not have a major impact on participant access in Greater Los Angeles. To the extent our results for GLA extend to other urban food deserts, then perhaps the Program cost savings from eliminating high-price small vendors or constraining their behavior with stringent price ceilings becomes an attractive option.

References

Sage, J., McCracken, V., and Sage, R. (2013). "Bridging the Gap: Do Farmers' Markets Help Alleviate Impacts of Food Deserts?" *American Journal of Agricultural Economics* 95(5): 1273-1279.

Saitone,T.L., Sexton, R.J, and Volpe, R. (2015) "A Wicked Problem? Cost Containment in the Women, Infants and Children Program." *Applied Economic Perspectives and Policy* 37(3): 378-402.

Sexton, R.J. and T.L. Saitone. "The California Women, Infants, and Children Program: Analysis of Cost-Containment Strategies and Recommendations for Improved Program Efficiency." Report prepared for the California Department of Public Health, September 2012, 119 pp.

Ver Ploeg, M., Breneman, V., Farrigan, T. Hamrick, D. Hopkins, P. Kaufman, B. Lin, M. Nord, T. Smith, R. Williams, K. Kinnison, C. Olander, Singh, A., and Tuckermanty, E. (2009). "Access to Affordable and Nutritious Food—Measuring and Understanding Food Deserts and Their Consequences." *US Department of Agriculture, Economic Research Service, Washington, DC:* AP-036.

Mari Gallagher Research and Consulting Group. Women and Children Last (In the Food Desert). (2007). Available at http://www.marigallagher.com/projects/4 (accessed May 02, 2016).

Wrigley, N., Warm, D., and Margetts, B. (2003). "Deprivation, Diet, and Food-retail Access: Findings from the Leeds 'Food Deserts' Study." *Environment and Planning A* 35(1): 151-188.