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ORIGINAL RESEARCH

Disparities in Access to Supplemental Nutrition Assistance Program Retailers Over Time and Space

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Abstract

The largest public assistance program in the United States, the Supplemental Nutrition Assistance Program (SNAP), relies on private retailers for program access. We analyze geo-coded SNAP-authorized convenience and grocery stores in 2000 and 2010 to determine factors associated with their accessibility. Results demonstrate that accessibility was higher in areas with high rates of SNAP income-eligible individuals, but that some spatial disparity persists, particularly in areas with lower initial access and rural areas. Findings highlight the importance of SNAP-authorized convenience stores if markets continue to determine the location of SNAP access points.

Keywords SNAP · Food access · Spatial analysis · Grocery stores · Convenience stores · Disparity

JEL Classification I30 · I38 · L11 · L20

Introduction

Studies have shown that disparities in the food retail environment and accessibility impact consumers' health through their diets (e.g., Black et al. 2014; Caspi et al. 2012; Clary et al. 2017). The entry of a supercenter or convenience store is

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associated with higher rates of obesity, whereas the entry of a supermarket is associated with lower obesity rates (Courtemanche and Carden 2011; Yan et al. 2015). In addition to considering physical accessibility to food, researchers have highlighted the importance of considering its affordability (Caspi et al. 2012), with studies finding that food assistance programs can improve diet quality and improve weight status (Chen et al. 2005; Nguyen et al. 2015).

The Supplemental Nutrition Assistance Program (SNAP), the largest food assistance program in the US, is designed to increase food security and improve nutrition.[1] It provides participants with a monthly benefit to buy food from private retailers, addressing the affordability dimension of food access. SNAP benefits can only be redeemed at retailers that are authorized to receive SNAP. For a store to become SNAP-authorized, 50% of its total gross retail sales must be in staple foods or it must offer three stocking units of three staple food varieties in each of the four staple food categories (or offer 36 staple food items), with one perishable variety in at least two staple food categories: fruits/vegetables, breads/cereals, meat/fish/poultry, and dairy (USDA 2018).

While the USDA has long been interested in SNAP participants' access to grocery stores (Ohls et al. 1999; Ver Ploeg et al. 2009), there has been a lack of research examining the dynamics between program demand and marketplace response—or access to SNAP-authorized stores. One noteworthy exception is Shannon et al. (2016), which examined the geographic and temporal dynamics of SNAP retailers in 2007 and in 2014 across the State of Georgia, finding differences between small and large retailers. Studies have found that the number of SNAP participants is negatively correlated with grocery stores and that improving physical access to stores is associated with greater food security (Dharmasena et al. 2016; Fitzpatrick et al. 2015; Mabli 2014; Mabli et al. 2013; Rigby et al. 2012; Wood and Horner 2015). Studies have also shown that increases in SNAP benefits have a greater effect on food spending than a similar increase in dollars (e.g. Beatty and Tuttle 2014), illustrating the importance of SNAP in reducing food security, but also the importance of examining households' access to SNAP-authorized stores, in addition to any grocery store.

As the geography of poverty changed during the Great Recession, along with increases in SNAP participation and benefits as a result of the American Recovery and Reinvestment Act, it is unclear how the accessibility of SNAP-authorized retailers changed in response to these market changes. Although many low-income households remain clustered in high-poverty neighborhoods, others have dispersed to the suburbs as once-poor inner-city neighborhoods have experienced gentrification (Kneebone 2014). The geography of SNAP participation mirrors these changes in poverty (Slack and Myers 2014), complicating the underlying assumption that all income-eligible individuals have physical access to a SNAP-authorized retailer. For food assistance programs to be effective, they must be effectively integrated with the private food distribution system (Lentz and Barrett 2013).

[1] Before 2008, SNAP was called the Food Stamp Program. The change in title, in part, is to reflect a focus on improving the nutritional intake of participants.

This study examines the accessibility of SNAP-authorized stores in 2000 and 2010 across Ohio, and how these SNAP-authorized stores responded to increases in the number of SNAP income-eligible households and its changing geography. We estimate these separately for grocery and convenience stores, given that these store types may have different service areas and have different effects on diets. We measure access as the number of SNAP-authorized stores within a census tract combined with the number of SNAP-authorized stores within a buffer area from the boundary of the tract weighted by ½. Using this measure of access, we estimate the effect of various tract characteristics that would affect a pre-existing store's decision to become SNAP authorized and a store's decision to enter the market. Overall, the results indicate that the percentage of SNAP-eligible individuals, our main measure of demand, is positively correlated with increases in access to SNAP-authorized grocery and convenience stores. However, the results suggest that SNAP-authorized convenience stores respond to increases in demand in areas with low initial access while authorized grocery stores do not. These findings highlight the disparity in SNAP retailer access, which potentially of impacts the effectiveness and efficacy of SNAP.

Data

Our study focuses on the state of Ohio, which was recently ranked the 3rd highest state for very low food security (Coleman-Jensen et al. 2015), behind only Arkansas and Mississippi. In addition, between 2000 and 2010, Ohio's poverty rate went from below the national average (Ohio 14.7%; National 16.5%) to above it (Ohio 20.4%; National 20.1%); the 46% increase was one of the highest in the country. With a population of 11,536,502 in 2010, Ohio's population only increased 1.6% from 2000. At the same time, the number of Ohioans participating in SNAP increased by 163%, from 610,000 to 1,607,000. While Ohio's population has marginally increased, both the population and poverty have shifted to the suburbs and exurbs (Kneebone 2014).

By focusing exclusively on one state, we do not have to be concerned about policy differences in SNAP participation requirements affecting our results. For example, broad-based categorical eligibility (i.e., when people qualify for SNAP based on qualifications for other assistance programs) was introduced in Ohio in October 2008, while other states (e.g., North Dakota) had already introduced these participation criteria several years earlier. Furthermore, restricting our analysis to one state allows the data to be manageable for more in-depth analyses. Nevertheless, the results have implications across states because all stores face the same criteria to become SNAP-authorized, regardless of state.

The foundation for our empirical methodology relies on Christaller and Lösch's central place theory (Christaller and Baskin 1966; Lösch 1954), or the idea that a food retail store chooses to locate in an area based on threshold and range, i.e. the minimum market size (demand base on population and purchasing power) and the maximum distance a consumer will travel to obtain a good or service. Grocery stores and convenience-oriented stores have different thresholds and ranges, resulting in

different locational strategies (Wood and Browne 2007). In addition, SNAP participation may introduce competing effects: while it increases a consumer's purchasing power (Bitler and Haider 2011), it is also negatively correlated with income, or associated with lower purchasing power.

Previous research has also found that minority neighborhoods have less access to healthy food retail. D'Rozario and Williams (2005) offer a noneconomic retail location theory based on discrimination that they call 'retail redlining' and provide evidence to support this theory in food retail, which subsequent research further supports (Kwate et al. 2013; Meltzer and Schuetz 2012; Schuetz et al. 2012). In addition, the number of chain and large-format stores has decreased in rural areas in recent years (Cho and Volpe 2017). Nevertheless, Eslami and Cunnyngham (2014) found that rural areas had higher participation rates among SNAP eligible households (88% vs. 77% for metropolitan), indicating the importance of addressing the rurality of an area in relation to accessibility.

One of the limitations with our study is our inability to distinguish between pre-existing stores that became SNAP-authorized and new stores that opened SNAP-authorized. Thus, our model needs to include factors that would affect a store's decision to enter an area (i.e., population and purchasing power) as well as a pre-existing store's decision to become SNAP-authorized (i.e., increase in the number of SNAP participants). Although large grocery stores may enter an area SNAP-authorized, because the application process could be more centralized, smaller independent grocery stores and convenience stores may be unwilling to initially incur the time cost of the application process. Instead, these smaller stores may choose to become SNAP authorized later on if they believe SNAP recipients could be part of their customer base. We also chose to include characteristics that have been found to be associated with fewer food retailers to control for any observables that may be affecting a store's decision to enter an area. Thus, we offer the following function for the different factors that would affect the number of SNAP-authorized stores in a given area, including basic controls at the tract level to keep our model as parsimonious as possible (Eq. 1):

$$\begin{aligned} &\textit{Number of SNAP} - \textit{authorized stores}\,(\textit{Access}) \\ &\quad = f(\textit{population}, \textit{SNAP participants}, \textit{area size}, \\ &\quad \textit{distance from urban center}, \textit{racial/ethnic composition}) \end{aligned} \tag{1}$$

Snap-Authorized Store Access Measures

Studies have used various store characteristics to examine food access, such as square footage, store count, and average price prices (Ver Ploeg et al. 2014). Numerous studies have used store counts or store density as a measure of access to examine its effect on diets through their food purchases (e.g., Caspi et al. 2012; Kyureghian et al. 2013). Because we are interested in access to SNAP-authorized stores, we chose to examine access in terms of SNAP-authorized store counts, where a higher number of stores would indicate a higher level of access.

Table 1 Ohio SNAP-authorized retailers

Year	Grocery stores			Convenience stores			Total		
	State	Urban	Rural	State	Urban	Rural	State	Urban	Rural
2000	2074	1798	276	2549	2064	485	5106	4297	809
2002	2027	1767	260	2510	2081	429	4954	4228	726
2004	2012	1770	242	2566	2150	416	4983	4291	692
2006	2016	1784	232	3336	2861	475	5755	5009	746
2008	1985	1752	233	3921	3398	523	6284	5490	794
2010	2102	1854	248	5135	4458	677	7685	6692	993
% Chg.	1.4%	3.1%	− 10.1%	101.5%	116.0%	39.6%	50.5%	55.7%	22.7%

Grocery stores consists of small, medium, and large grocery stores; supermarkets; and superstores. Convenience stores consists of convenience stores and combination grocery/other. The total number of stores include grocery and convenience stores, as well as specialty stores (bakery, meat/poultry, fruits/vegetables, and seafood), non-profit food buying co-op, and direct marketing farmer

The USDA Economic Research Service offers a tract-level measure of food access[2] that identifies areas that are low income and that do not have a large grocery store within a certain number of miles. We created a new measure for this study for three reasons. First, the USDA measure does not focus on SNAP-authorized stores. Second, the measure only examines supermarkets, supercenters, and large grocery stores; it does not include smaller grocery stores or convenience stores. Finally, the USDA measure is binary, while the measure we developed for this study is a continuous variable.

We obtained 2000 to 2010 data on SNAP-authorized stores from the USDA Food and Nutrition Service (FNS). This database provides store names, addresses, and types. Given that grocery stores and convenience-oriented stores have different thresholds and ranges for potential consumers, we separated SNAP-authorized grocery stores (i.e., Large Grocery Store, Medium Grocery Store, Small Grocery Store, Supermarket, Superstore) and convenience stores (i.e., Convenience Stores, Combination Grocery/Other). We chose to focus on 2000 and 2010 to capture the environment before and after the US financial crisis of 2007–2008. In addition, this period had a marked increase in convenience-oriented stores becoming SNAP-authorized, particularly in urban tracts (Table 1).[3] In contrast, authorized grocery stores had a decrease in rural tracts—10.1% from 2000 to 2010. Nevertheless, in both years, most of the SNAP-authorized stores were located in urban tracts—around 87% to 88% for grocery stores and 81% to 87% for convenience stores. We investigated whether changes in the number of SNAP-authorized convenience and grocery stores had similar changes in the total number of convenience and grocery stores but found

[2] http://www.ers.usda.gov/data-products/food-access-research-atlas/.

[3] The number of SNAP authorized stores across the U.S. increased by 34% from 162,015 stores in FY 2006 to 216,738 in FY 2010 (USDA 2011).

Fig. 1 Number of SNAP-authorized convenience (left) and grocery (right) stores, by tract, 2010

that the correlation coefficient ranged from −0.05 to 0.5 and from 0.14 to 0.49, respectively.[4]

Using data provided by FNS, all SNAP-authorized stores were geo-coded, and then overlaid by 2010 census tract boundaries using the Census Bureau's Tiger shapefiles to calculate the number of stores within each tract.[5] Mapping these tracts illustrate that there were more SNAP authorized convenience stores in tracts along the southern and eastern edge of Ohio, where there were fewer authorized grocery stores (Fig. 1). Tracts with a large number of authorized stores were also clustered in cities and along interstates, particularly I-71, which connects Cincinnati, Columbus, and Cleveland—the three largest cities in Ohio. We use census tracts as the geographic unit to calculate access as it is the most common unit used for healthy food access studies that have a wide geographic scope (Ver Ploeg et al. 2014). However, using an area-based definition can introduce the modifiable areal unit problem (MAUP) (Wong 2009). These artificial boundaries of census tracts do not affect immediate access to stores; many have main roads as their boundaries, with stores on both sides.

To help address the use of artificial boundaries, a 'buffer' approach was used to calculate accessibility.[6] We buffered the tract boundary to add stores within a Euclidean distance outside of the tract to stores within the tract.[7] Therefore, to calculate the number of SNAP-authorized stores 'accessible' to a tract, both the stores within the tract and those that are within a 1-mile buffer of the tract *i*, identified as buffer *i* and

[4] We used the Census Bureau's County Business Patterns to obtain the total number of convenience and grocery stores (NAICS codes 445110, 4452, 445120 and 447110).

[5] Please contact authors for details on the geocoding process.

[6] We also ran the regressions separately for rural and urban tracts, given that this should address the largest differences in tract size, and found similar results.

[7] Although we present the results using a buffer created within a Euclidean distance outside of the tract, we also tried using a road network distance for SNAP authorized stores in 2000. There was no change in the sign of the results and the only changes in significance were for population being insignificant for convenience stores and percent employment being insignificant for grocery stores.

weighted by ½, are included.[8] We chose to weight the stores within the buffer area under the assumption that although these stores are accessible, they would not be as easily accessible as those within the tract. SNAP-authorized access measures were calculated for our categories of grocery stores and convenience stores for the years 2000 and 2010 (Eq. 2):

$$access_i = \sum stores_i + \frac{\sum stores_{\text{bufferi}}}{2} \tag{2}$$

Although using this buffer approach should improve our measure of access, we recognize there are limitations to using an area-based measure, such as variation in individual access within these areas, including physical proximity and household resources (Ver Ploeg et al. 2014). In addition, the size of these tracts often vary substantially in size. We include the size of the tract as an independent variable in our analyses to help mitigate this effect, as well as various controls for whether the tract is rural or urban, which is discussed further in the following subsection. Despite these limitations, we chose to use an area-based measure of access because our independent variables are only available as area-based measures.

Independent Variables

To represent our main independent variable of interest, SNAP participants, we used the number of individuals below 125% of the Federal poverty level (FPL), slightly underestimating SNAP income-eligibility.[9] SNAP eligibility in Ohio is more complex than the ratio of income to poverty level, such as household resources or whether someone in the household is elderly or disabled. However, Eslami and Cunnyngham (2014) found that although only 79% of eligible individuals participated in fiscal year 2011, 92% of the benefits available to all eligible individuals were disbursed, indicating that most of the eligible nonparticipants have incomes near the eligibility threshold. In addition, using income-eligible individuals as a proxy mitigates the endogeneity of SNAP participation, or the possibility that a low-income individual could choose to enroll in response to a store becoming SNAP-authorized.[10]

FNS also provided administrative data on the number of SNAP participants in Ohio on a county level, which we used to estimate the relationship between the number of individuals below 125% of the federal poverty line (FPL) and the number of

[8] We conducted a sensitivity analysis for the dependent variable testing the buffer distance of 1 mile. Distances of 0.25, 0.5, and 1.25 were used in place of the one-mile distance. We also conducted a sensitivity analysis for the weight at ¼ and ¾. Results demonstrate no change in direction or significance for the independent variables.

[9] The income eligibility criteria is being at or under 130% of the FPL. As a robustness test, we used 150% of the FPL; it did not alter the significance or direction of the findings.

[10] Although it could be argued that low-income individuals could migrate closer to a SNAP-authorized store, low-income individuals tend to be less mobile (Sampson 2012).

SNAP participants.[11] Although there was a lower share of low-income individuals participating in SNAP in 2000 (33%) than in 2010 (76%), these shares were nearly identical across rural and urban counties; the shares increased from 33 to 75% in rural counties and from 33 to 76% in urban counties. In addition, comparing county-level maps of the number of SNAP participants and low-income individuals illustrates that counties with a high number of SNAP participants had a high number of low-income individuals, although the number of low-income individuals tended to be higher (Online Appendix).[12] Finally, the large correlation coefficient—0.9554—indicates that we have an appropriate proxy.[13]

All of the data for our independent variables are from the Neighborhood Change Database Tract Data, which enables a comparison of tracts over time by normalizing the 2000 data to 2010 boundaries (GeoLytics 2011). In addition to our proxy for SNAP participants, we included the following independent variables: population, unemployment rate, land area in square miles, distance to an urban center in square miles, the percentage of the population that is Hispanic, and the percentage that is Black. We calculated the Euclidian distance from the center of each tract to the center of the closest Census Bureau urbanized area (population of at least 50,000). We also took the quadratic of the distance to urbanized area center measure to represent the different dynamics of grocery stores in urban and rural areas versus suburban and exurban areas, which addresses the overall retail trend of grocery stores exiting the former and being built in the latter. Table 2 provides descriptive statistics for all dependent and independent variables for 2000 and 2010.

A few things should be noted regarding the independent variables. Median income was initially in all of the models but was insignificant for them all, likely due to multicollinearity with the SNAP-eligibility variable. Thus, because SNAP eligibility is a better measure of potential demand for SNAP-authorized retailers, we excluded the median income variable. In addition, given differences between rural and urban areas (e.g., transportation structures), we conduct robustness checks by running separate models for the quartile of tracts closest to the urbanized area center and those in the quartile furthest from the urbanized area center, running the models with a rural dummy variable, and running the models separately for rural and urban counties. No significantly different results were found. Specifically focused on personal transportation, estimations were run with the percentage of residents in the tract who do not own a vehicle. This variable was positive and significant, which may be a positive indication but is likely correlated with the percentage of low-income individuals and potentially other demographic characteristics. The sign and overall relationship between the independent variables with the dependent variables remain the same.

[11] We used the 2000 Decennial Census and the 2010 American Community Survey (5-year estimates) to obtain the number of individuals below 125% of the FPL.

[12] The share of SNAP participants increased from 40 to 79% in urban counties and from 35 to 75% in rural counties.

[13] In the remainder of the paper, SNAP eligibility is used as short-hand for SNAP *income*-eligibility.

Table 2 Descriptive statistics ($N = 2941$)

Variables	Minimum	Maximum	Mean	SD
Dependent variables				
Access to SNAP-authorized groceries, 2000	0	17	2.57	2.04
Access to SNAP-authorized groceries, 2010	0	14	2.51	1.93
Access to SNAP-authorized convenience, 2000	0	35	3.50	3.71
Access to SNAP-authorized convenience, 2010	0	46	6.87	5.74
Independent variables				
% SNAP income eligible, 2000	0	91	15.85	13.62
% SNAP income eligible, 2010	0	95	20.63	16.16
Population, 2000	91	9850	3857.71	1470.78
Population, 2010	37	18,574	3922.65	1767.62
% Unemployment, 2000	0	50	5.79	4.96
% Unemployment, 2010	0	80	10.42	7.36
% Black, 2000	0	100	14.93	25.91
% Black, 2010	0	100	17.71	26.60
% Hispanic, 2000	0	57	2.02	4.09
% Hispanic, 2010	0	59	3.33	5.01
Dist to urbanized center, miles	0	54	12	10.11
Land area, sq mi	0	214	13.89	27.45

Empirical Methodology

To examine the relationship between different types of SNAP-authorized stores and SNAP-eligibility rates in 2000 and 2010, we initially used a tobit model to examine access to authorized grocery and convenience stores by census tract in 2000 and 2010.[14] However, running a spatial dependence test with GeoDa illustrated that both store types exhibited spatial autocorrelation.[15] Thus, we ran a spatial lag model using GeoDa and present these results in the main manuscript instead.[16] In the following equation, $SNAP_i$ is the percentage of SNAP-eligible individuals, x_i is composed of the aforementioned tract-level variables, and ε_i is the error term (Eq. 3):

$$access_i = \beta_0 + \propto SNAP_i + \beta x_i + \varepsilon_i \tag{3}$$

To examine how different SNAP-authorized stores responded to increases in poverty and its changing geography, we take three approaches. First, we use a spatial lag model to examine how the change in access to grocery and convenience stores

[14] We also ran the regression using an OLS model and found similar results that were only slightly different in magnitude.

[15] We ran a Lagrange Multiplier (LM) test and a Robust LM test using GeoDa and obtained very significant results for all of the results. Contact authors for results.

[16] The results for the tobit model are included in the Appendix. The only significant difference for grocery stores in 2000 is distance to urban center. For convenience stores in 2000 and grocery stores in 2010, the only significant difference is the percentage unemployed; the sign and significance levels for convenience stores in 2010 remain the same.

by census tract between 2000 and 2010 is associated with changes in SNAP-eligible customers ($\Delta SNAP_{it}$ in Eq. 4).[17] We include controls of population and employment ($\Delta\beta pop_{it} + \Delta\beta unemp_{it}$) and initial conditions (x_i) for the following: tract size, distance from urbanized area center, and percent minority in 2000. Including these initial conditions allows us to determine whether changes in access predominantly occurred in rural areas or areas with a higher percentage of minorities. Second, we run an OLS model separately for rural and urban tracts. Given that there tend to be fewer chain stores than independent stores in rural areas, the decline in independent stores from 2007 to 2010 could be an indication that access to SNAP-authorized grocery stores in rural areas declined (Cho and Volpe 2017).

$$\Delta access_{it} = \Delta\beta_0 + \alpha\Delta SNAP_{it} + \Delta\beta pop_{it} + \Delta\beta unemp_{it} + \beta x_i + \varepsilon_{it} \quad (4)$$

Because these approaches do not take into account initial access and competitive market conditions, we use a third approach to address these concerns. Areas with high access may be saturated, while areas with low access may have more opportunities for stores to enter. Therefore, we rerun the OLS model for each quartile of initial access in 2000 separately. An analysis of variance between these quartiles shows that the tracts in these quartiles vary significantly ($p < 0.01$) in terms of initial conditions of land area, population, percent minorities, and distance from urban area center. The tracts with the lowest initial access for both SNAP-authorized grocery and convenience stores have the lowest population densities, the lowest percentage of Hispanic and Black residents, and are furthest from an urban area center; tracts with the greatest initial access exhibit the opposite.

Findings

We present the cross-sectional relationships between SNAP-authorized store access and SNAP eligibility for 2000 and 2010 in Table 3. For all sets of findings, we multiply the dependent variable by 100 so that the results are legible. In both years, for access to SNAP-authorized grocery and convenience stores, the coefficient for SNAP-eligible individuals was positive and significant. This indicates that tracts with a higher level of access to SNAP-authorized stores was correlated with a greater number of SNAP-eligible individuals. However, the magnitude from 2000 to 2010 and Table A1 illustrates that the standardized beta decrease, suggesting that the relationship between SNAP-eligible individuals and access to authorized stores weakened over the decade. In addition, comparing the standardized betas, it appears that this variable explains more of the variation for convenience store access than it does for grocery store access. This may be because convenience stores have smaller market areas and are more responsive than grocery stores.

[17] We also ran the regression using an OLS model, which are included in the Appendix. For the change in grocery stores, the only significant difference is the percentage of Hispanic residents in 2000 and land area. Similarly, for change in convenience stores, the only significant difference is the distance to urban center.

Table 3 Spatial lag model results, SNAP-authorized store access, 2000 and 2010

	2000		2010	
	Beta	Std. err	Beta	Std. err
Grocery stores				
Constant	−42.079***	8.961	−14.89	10.184
% SNAP-eligible	1.469***	0.272	0.65***	0.203
Population	0.018***	0.002	0.017***	0.001
% Unemployment	0.566	0.713	−0.336	0.475
% Black	0.332***	0.111	0.437***	0.119
% Hispanic	2.597***	0.541	3.139***	0.505
Dist to urban center, mi	−0.792	0.694	−2.026**	0.796
ist UC*Dist UC	0.036**	0.016	0.055***	0.019
Land area, sq mi	−0.869***	0.094	−0.784***	0.107
Convenience stores				
Constant	−67.425***	10.836	−101.68***	18.663
% SNAP-eligible	3.273***	0.341	2.674***	0.377
Population	0.018***	0.002	0.03***	0.003
Unemployment	−2.414***	0.883	1.361	0.88
% Black	0.506***	0.138	1.299***	0.228
% Hispanic	5.388***	0.689	7.452***	0.96
Dist to urban center, mi	−1.807**	0.865	−2.534*	1.48
Dist UC*Dist UC	0.04**	0.02	0.088**	0.035
Land area, sq mi	−0.237**	0.115	−1.244***	0.197

Significance level *10%; **5%; ***1%

Most of the other variables are significant for both SNAP-authorized convenience and grocery stores in 2000 and 2010; the exemptions are distance to urban center for grocery stores in 2000 and unemployment for grocery stores in both years and convenience stores in 2010. As expected, population is positively correlated to SNAP-authorized grocery and convenience store access. In addition, the combination of the distance variables suggests that SNAP-authorized stores are more likely to be found in areas very close to urban centers. Finally, both the race and ethnicity variables are positive and significant, indicating that areas with higher proportions of racial and ethnic minorities have better access.[18] However, Table A1 shows that the race and ethnicity variables have higher standard betas in 2010 than for grocery stores, suggesting that these variables explain more of the variation for convenience stores.

Figure 2 illustrates the spatial differences in access to SNAP-authorized convenience and grocery stores, with a close-up of Cincinnati. We present the results for changes in accessibility and SNAP eligibility between 2000 and 2010 in

[18] Given that Shannon et al. (2016) found differences according to the size of the retailer (e.g., small vs. large retailers), and that supercenters sell a wider variety of items (including non-food products), as a robustness check, we estimated the model for only supermarkets and supercenters; the results were similar in direction and magnitude.

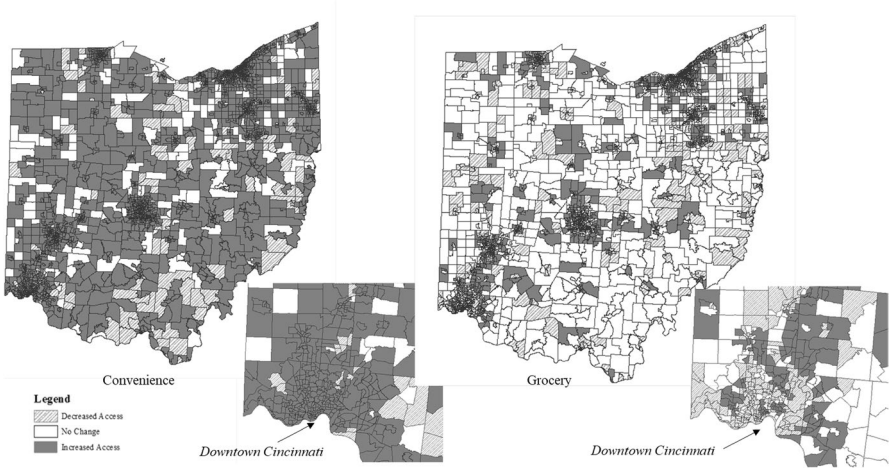

Fig. 2 Changes in SNAP-authorized convenience (left) and grocery (right) access, by tract, 2000–2010

Table 4 Spatial lag model results, change in SNAP-authorized store access, 2000–2010

	ΔGrocery		ΔConvenience	
	Beta	Std. err	Beta	Std. err
Constant	6.78	4.574	53.111***	9.488
Δ% SNAP-eligible	0.398**	0.167	0.759**	0.314
ΔPopulation	0.01***	0.002	0.001	0.003
Δ% Unemployment	−0.306	0.329	0.289	0.618
% Black	−0.216***	0.07	0.536***	0.132
% Hispanic	−0.627	0.404	1.714**	0.76
Dist to Urban Center, mi	−0.648	0.539	−0.781	1.018
Dist UC*Dist UC	0.002	0.013	0.045*	0.024
Land area, sq mi	0.104	0.072	−1.091***	0.138

Significance level *10%; **5%; ***1%

Table 4. The betas indicate that increases in the percentage of SNAP eligible individuals is associated with increases in convenience and grocery store access, and that changes in employment did not impact either. However, unlike the cross-sectional model, the changes in SNAP-authorized grocery store access do not mirror changes in convenience store access for the remaining variables. Increases in total population is associated with increases in grocery store access but not associated with changes in convenience store access. Higher initial proportions of Black and Hispanic residents are associated with increases in access to SNAP-authorized convenience stores, while SNAP-authorized grocery store access decreased areas with high initial proportions of Black residents, suggesting disparities in the changing food environment.

Table 5 OLS results, change in SNAP-authorized store access by rural and urban, 2000–2010

	ΔGrocery—rural			ΔGrocery—urban		
	Beta	Std. err	Std. beta	Beta	Std. err	Std. beta
Constant	−18.49	13.1		42.26***	9.048	
Δ% SNAP-eligible	−0.552	0.541	−0.045	1.112***	0.314	0.077
ΔPopulation	0.006	0.005	0.052	0.025***	0.003	0.152
Δ% unemployment	2.051*	0.929	0.098	−0.165	0.622	−0.006
% Black	0.539	0.772	0.03	−1.824***	0.127	−0.297
% Hispanic	−1.422	2.074	−0.03	−6.385***	0.75	−0.164
Dist to urban center, mi	1.275	1.117	0.191	0.712	1.206	0.036
Dist UC*Dist UC	−0.028	0.021	−0.221	−0.063*	0.031	−0.119
Land area, sq mi	−0.097	0.094	−0.052	−1.241*	0.594	−0.046
	ΔConvenience—rural			ΔConvenience—urban		
	Beta	Std. err	Std. Beta	Beta	Std. err	Std. Beta
Constant	95.78***	24.247		400.3***	15.616	
Δ% SNAP-eligible	0.445	1.002	0.02	2.777***	0.55	0.108
ΔPopulation	−0.006	0.01	−0.029	−0.008	0.006	−0.027
Δ% unemployment	0.723	1.719	0.019	0.171	1.079	0.004
% Black	0.901	1.429	0.028	2.605***	0.22	0.245
% Hispanic	4.728	3.839	0.054	5.477***	1.295	0.081
Dist to Urban Center, mi	−0.668	2.067	−0.054	−10.18***	2.08	−0.293
Dist UC*Dist UC	0.0278	0.038	0.119	0.190***	0.053	0.208
Land area, sq mi	−0.367*	0.174	−0.107	−4.381***	1.028	−0.093

Significance level *10%; **5%; ***1%

By running these regressions separately for rural and urban areas, we find that most of the tract characteristics do not have an effect on access in rural tracts but do for urban ones (Table 5). In rural tracts, only increases in employment are associated with increases in SNAP-authorized grocery store access and smaller (larger) tracts are associated with increases (decreases) in convenience store access. In contrast, in urban tracts, increases in the percentage of SNAP eligible individuals is associated with increases in access to authorized grocery and convenience stores. However, similar to the results for total changes (Table 4), initial proportions of Black and Hispanic residents are associated with higher increased authorized convenience store access, but decreased access to authorized grocery stores.

Table 6 OLS results, change in SNAP-authorized store access by quartile of initial access

	Q1 (lowest)	Quartile 2	Quartile 3	Q4 (highest)
ΔGrocery				
Constant	49.25***	26.09*	46.02***	6.816
Δ% SNAP-eligible	0.344	0.458	0.966*	2.088**
ΔPopulation	0.007**	0.025***	0.034***	0.044***
Δ% unemployment	−0.772	0.596	−3.669***	2.027
% Black	1.005***	0.212	−0.305	−2.401***
% Hispanic	3.850*	3.053*	1.905	−10.06***
Dist to urban center, mi	−3.185***	−0.119	1.424	−2.372
Dist UC*Dist UC	0.055**	−0.026	−0.09*	−0.001
Land area, sq mi	−0.131	−0.548**	−0.908*	0.201
ΔConvenience				
Constant	280.4***	308.7***	378.8***	557.7***
Δ% SNAP-eligible	5.145***	4.655***	1.048	2.124*
ΔPopulation	0.001	0.006	0.02	0.012
Δ% Unemployment	−0.972	−0.749	2.056	−0.445
% Black	4.109***	3.218***	2.431***	0.918*
% Hispanic	12.55**	17.64***	1.508	0.487
Dist to Urban Center, mi	−11.73***	−7.326**	−6.797*	−6.813
Dist UC*Dist UC	0.267***	0.166**	0.096	−0.004
Land area, sq mi	−1.437***	−2.116***	−2.425***	−3.833***

Significance level *10%; **5%; ***1%

To account for market competition, we examine changes in access to SNAP-authorized retailers while controlling for initial access. Table 6 shows the results of changes in grocery and convenience store access between 2000 and 2010, respectively, after separating stores into quartiles according to initial access. The results show that increases in grocery store access are associated with an increase in SNAP eligibility only in areas with the greatest initial access. However, for SNAP-authorized convenience stores, accessibility increased in areas with low initial access (Quartiles 1 and 2) as well as those with the highest level of initial access.

While population continues to be positive and significantly associated with increases in SNAP-authorized grocery access across all areas, regardless of initial access, it was insignificant in all areas for SNAP-authorized convenience stores. In addition, while the results for race and ethnicity are mixed for SNAP-authorized grocery stores, they are positively associated with increases in access to SNAP-authorized convenience stores. For the latter, the proportion of Black residents is significant across all four quartiles and the proportion of Hispanic residents is only significant in the two quartiles with the lowest initial access. For SNAP-authorized grocery stores, increases in access are positively correlated with the percentage of Black and Hispanic residents in areas with the lowest levels of initial access; the case is the opposite in areas with the highest initial

access. However, it is important to note that quartiles with greater initial access had a significantly greater percentage of minority residents.

Discussion

In this analysis, we examine how the food retail industry responded to changing rates and geography of SNAP eligibility. Overall, areas with a higher percentage SNAP-eligible population are positively and significantly associated with higher access to SNAP-authorized grocery and convenience stores, although the correlation is markedly stronger in 2000 than 2010. Furthermore, increases in access to authorized grocery and convenience stores responded to the increases in, and changing geography of, poverty, although the explanatory power was greater for authorized convenience stores. After taking into account initial access, we find that grocery stores only responded to increasing SNAP eligibility in places with initially high levels of access, while convenience stores responded in areas with low initial access.

Part of these results could be from overall changes in the food retail environment, when a greater number of pharmacies and small general merchandise stores, both of which are classified as "convenience" in this study, began to carry food products (Harris et al. 2002; Martinez 2007). From 2010 to 2015, SNAP-authorized convenience retailers increased by 36%, from 127,762 firms to 173,427 firms; they are now 66% of the total redemption sites for SNAP (USDA 2011, 2016a). As credit card use became more prevalent and the transition to EBT cards was finalized by 2004, more stores may have chosen to become SNAP authorized. Further, the incentives posed by the American Recovery and Reinvestment Act (which increased benefits for participants) and the increased number of SNAP participants may have incentivized pre-existing stores to become authorized.

Our results also suggest that there was greater access to SNAP-authorized convenience and grocery stores in both 2000 and 2010 in tracts with a greater proportion of Black and Hispanic residents. The results for SNAP-authorized convenience store are in line with other studies that find similar results for all convenience stores (e.g., Freedman and Bell 2009), but the SNAP-authorized grocery stores results are contrary to many studies that highlight less access by minorities (e.g., Rigby et al. 2012). Nevertheless, our results for *changes* in access from 2000 to 2010 indicate that the relationship between race and ethnicity and SNAP-authorized grocery store access is negative, suggesting disparity. This could be the result of an excluded variable bias, or it could be because grocers consider high minority areas to be less desirable, and therefore, are engaging in 'retail redlining' (e.g., Kwate et al. 2013; Meltzer and Schuetz 2012). In contrast, increases in SNAP-authorized convenience stores had a positive relationship with race and ethnicity.

In many ways, as Shannon et al. (2016) found, the market is being efficient, with retailers responding to the demand of potential SNAP participants. While we found similar results overall, our results indicate that this is not the case everywhere. Our study suggests that retailers are responding differentially given rural-ness, initial access, or initial racial makeup. Wilde (2012) estimates that 10% of food purchased for in home consumption is purchased with SNAP benefits, illustrating its

importance in the food retail industry. Retail location can impact the effectiveness of SNAP's ability to address nutrition and food security. From a public health perspective, the differences between outlet types is not inconsequential, with smaller outlets tending to carry less variety, lower quality, and higher priced products, as distribution streams and economies of scope and scale are vastly different between larger grocers (e.g., supercenters) and convenience retailers. Further, spatial disparities in food access related to the racial and ethnic make-up of a neighborhood may amplify individual deprivation (e.g., low income or lack of transportation), resulting in poorer health outcomes (Macintyre et al. 2008). As federal, state, and local governments and citizen groups continue to increase their focus on place-based solutions that are meant to alter the food environment to increase healthy food access, an important issue to address is where and *what types* of SNAP-authorized retailers fit in these place-based strategies.

Policy Implications

In December 2016, the USDA set new standards that ensure a minimum number of products are on the shelves for SNAP-authorized stores (USDA 2016b). Prior to 2016, a store could become SNAP-authorized by offering only three varieties of the four staple food categories, or by offering 12 staple food items (USDA 2014). The standards include a provision that considers stores in areas with limited access to food that do not meet the eligibility requirements, although it remains unclear how access to SNAP-authorized stores will be affected by these changes (Oliveira et al. 2018). SNAP-authorized convenience stores have grown considerably since the mid-2000s and have been a target in recent debates, partly because these retailers have the most cases of fraud. Convenience retailers tend to offer fewer selections of lower quality products at higher prices (Stewart and Dong 2011). However, convenience stores and pharmacies that carry food locate in low-income, minority, and rural neighborhoods that have less access to supermarkets and supercenters (Freedman and Bell 2009; Larson et al. 2009). Residents in rural areas may face increased transportation costs or higher prices, as well as less variety and lower quality food items than in suburban and exurban communities where new superstores are generally built (Sharkey 2009).

Convenience-oriented retailers—including convenience stores, gas stations with convenience stores, drug stores, and general merchandize stores ("dollar stores")—that are SNAP-authorized have increased substantially since the mid-2000s. In Ohio, this is the store format that increased 101.5% in SNAP authorization during our study period. Although the majority of SNAP participants identify a supermarket as their primary location for food shopping (Mabli et al. 2013), in a study of the Twin Cities, Shannon (2014) found that more SNAP benefits are redeemed at convenience stores and small groceries in low-income areas, particularly when compared to middle-class, suburban neighborhoods. Furthermore, although 84% of SNAP benefits were redeemed at supermarkets and supercenters, only 64% of the transactions occurred at these stores, compared to 4% and 15%, respectively, for convenience stores (Castner and Henke 2011). This suggests that although SNAP participants

redeem most of their benefits at these larger food retailers, convenience stores continue to play an important role, albeit likely a different role.

Our results suggest it may be more useful to focus on convenience retailers that respond to changes in poverty, particularly in high-need and minority neighborhoods. Many localities have adopted this approach through "healthy corner store" program efforts, which provide technical and resource support to increase healthy offerings at convenience-oriented stores (e.g., Syrett and Vaughan 2014; Chrisinger 2015). Convenience stores, particularly independently owned stores, often lack access to the distribution infrastructure and the economics of scope and scale that would enable them to carry a variety of high-quality, low-priced goods (Laurison 2014). Public health interventions can help to overcome these barriers. One such program is the Food Trust's Healthy Corner Store Initiative, in partnership with the Philadelphia Department of Public Health's Get Healthy Philly initiative, which has over 600 stores participating citywide (Almaguer Sandoval and Aquilante 2014).

Our findings suggest it could also be useful to offer incentives to develop non-traditional stores (including mobile options), where programs such as Farmers' Markets SNAPS Support Grants and the Food Insecurity Nutrition Incentive Grant Program provide additional considerations for applicants targeting high-need areas. Finally, some localities have provided opportunities for low-income residents to access better food environments through specialized bus routes designed to meet the shopping needs of residents or via taxi vouchers.

Limitations

It is important to note that this study is not without limitations. Foremost, we only modeled the access to stores that are SNAP-authorized; we do not have a comparable database for non-SNAP-authorized retailers. Thus, we do not know whether a store is new or a pre-existing store that became SNAP authorized, as retailers can make that decision at any point in time. However, both situations increase access for SNAP purchases. In addition, we do not have any data on the store products, variety, quality, or pricing, which could provide better or worse access to a SNAP program participant. Using tract-level data prevents year-to-year estimations, as we only have explanatory variables for 2000 and 2010.

Conclusion

This study explored the dynamics of different types of SNAP-authorized stores over time and space, given the impacts of the Great Recession on poverty and SNAP participation, and the changing market structure of the SNAP retailing sector. The purpose is to provide additional insight on policies that impact nutrition and food security outcomes, particularly given current debates about the SNAP program. While SNAP has always relied on the private marketplace to offer services, the initial results show that the market appears to be effective in many ways. However, our findings suggest that stores may not be equally responding given the racial and

ethnic make-up of an area (with mixed results), its location, and initial levels of access, all of which can result in disparities among food environments. Disparities in the food environment have the potential of impacting the effectiveness of SNAP. Further, our findings highlight the potential importance of SNAP-authorized convenience stores. Finally, given the geographic reality of the marketplace and that private retailers stand to reap benefits from the SNAP program, our findings raise questions about the locations (and retail types at those locations) at which participants access the program.

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