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Population Density, Poverty, and Food Retail Access in the United States: An Empirical Approach[1]

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Abstract

This article uses a random sample of census block groups to describe the adequacy of the local food retail environment in the continental United States. It builds upon simple empirical relationships between population density, poverty rates, vehicle access, and proximity to the nearest supermarket. In contrast with the conventional wisdom, the results show that high-poverty block groups had closer proximity to the nearest supermarket than other block groups did, on average: 85.6% of high-poverty block groups had a supermarket within 1 mile, while 76.8% of lower-poverty block groups had a supermarket within this distance. Population density is a strong predictor of proximity to the nearest supermarket. Block groups with very high population density generally had very close proximity to a nearest supermarket. In block groups lacking a nearby supermarket, rates of automobile access generally were quite high (more than 95%), although this still leaves almost 5% of the population in these areas lacking both an automobile and a nearby supermarket.

Keywords: food retail, food access, food deserts, poverty, community food security

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Introduction

The United States in recent years has faced public concerns about unhealthy eating patterns, low consumption of fruits and vegetables, high rates of overweight and obesity, and household food insecurity. These concerns have generated a lively policy debate about the adequacy of the food retail environment, especially in low-income areas, and whether and how public policy could intervene to improve the retail environment in underserved areas (USDA Economic Research Service 2009; Rose 2010; Gittelsohn and Lee 2013).

These policy discussions have led to research that has attempted to define which areas may be underserved and have inadequate food retail. Such areas sometimes have been called "food deserts," although use of this term may be declining. Informally, the term "food desert" may be used to describe neighborhoods that lack healthy food resources. More formally, USDA's Economic Research Service classifies a census tract that meets a particular definition of low income and distance from the nearest supermarket as a "food desert" (Economic Research Service 2013). To understand the implications of alternative definitions, this article describes and compares three approaches that have been used to identify geographic areas with inadequate food retail:

- a low-income low-access approach, which identifies geographic areas that are low-income and lack a supermarket within a specified distance;
- a low-vehicle low-access approach, which identifies geographic areas that have low rates of vehicle access and lack a supermarket within a specified distance;
- a relative distance approach, which identifies geographic areas that have worse-than-usual proximity to a supermarket, compared with other neighborhoods that have similar population density and vehicle access rates.

These three approaches have been used in research applications and widely-circulated online tools. A low-income low-access approach was the primary approach used in USDA's online food desert atlas and still is one approach used in an updated version of this online tool, called the Food Access Research Atlas (FARA) (Economic Research Service 2013). A newer low-vehicle low-access approach also is used in the updated online FARA tool (Economic Research Service 2013). A relative distance approach has been used in the definition of areas with limited supermarket access (LSA) by The Reinvestment Fund, one of several notable non-governmental research initiatives using alternative definitions of adequacy (The Reinvestment Fund 2011).

These tools are important because they may be used as inputs to policy decisions about subsidies or tax breaks to encourage retailers to locate in underserved locations or zoning rules to guide retailer location choices. However, retailers' location decisions respond primarily to market incentives rather than policy initiatives. Food retailers choose locations that they judge will be profitable. The profitability of a particular location depends on (a) the number and buying power of potential customers in nearby residential neighborhoods, (b) the nature of competition from other retailers, and (c) land, labor, and capital costs, which vary from place to place. Retailers cannot afford to build supermarkets in locations with too few customers or too many competitors.

The three research approaches lead to distinct conclusions about the adequacy of food retail conditions nationally and about which particular geographic areas lack adequate retail. Although they have similar purposes, the approaches differ in the underlying household-level circumstance or condition that motivates the methodology; they differ in implicit assumptions about the relationships between poverty, vehicle access, population density, and proximity to supermarkets; and they differ in their method for aggregating data from basic units (such as a census block group) to larger geographic units (such as a census tract).This article compares and contrasts the three approaches using a common data source, a random sample of more than 33,000 census block groups in the continental United States.

Using this data source, this article addresses four empirical questions about characteristics of small geographic areas (census block groups):

1. What is the empirical relationship between poverty and proximity to supermarkets?
2. What is the empirical relationship between population density and proximity to supermarkets?
3. What is the empirical relationship between vehicle access and proximity to supermarkets?
4. What is the average proximity to a supermarket for geographic areas with particular levels of population density and vehicle access rates?

These concrete empirical questions are important for two reasons. First, the basic relationships among poverty, population density, vehicle access, and proximity to supermarkets are interesting in their own right; in some cases, these relationships are surprising and contradict the conventional wisdom. Second, these empirical questions help in making choices among the three research approaches and in developing improved methods for identifying areas with inadequate food retail access.

This article contributes to a research literature that also includes several other important lines of work. The three approaches here focus on proximity to supermarkets, using retailer data that are available at the national level. Other research addresses different retail formats, including healthy food initiatives in smaller stores, using retailer data that are only available in particular locations (Gittelsohn, Rowan, and Gadhoke 2012). The three approaches here focus on the nearest supermarket, while other research measures distances to potentially more distant retailers patronized by food consumers (USDA Economic Research Service 2012; Apparicio, Cloutier, and Shearmur 2007; Cole 1997).The three approaches here merely describe food retail conditions, while other research seeks to measure the relationship of these conditions to diet and health outcomes (Gibson 2011; Leung et al. 2011; Chen, Florax, and Snyder 2010). For this article, it was sufficient to better understand the geographic conditions and computational methods in high-profile online tools that are used to identify areas with inadequate proximity to the nearest supermarket.

Background

USDA has published two reports measuring access to affordable and nutritious food nationwide (USDA Economic Research Service 2009; USDA Economic Research Service 2012). Retail access conditions depend to a large extent on competition in economic markets. An earlier

literature in economics paid close attention to the relationship between the number of retailers in a particular area and their degree of market power (Fik 1988, Benson and Faminow 1985, Cotterill 1986). A line of research tracing back to Huff (1964) considered the question of how large each retailer's catchment area would be if consumers sought to shop at the closest retailer. In part responding to changes in the diversity of retail formats, some more recent research has focused on the relationship between market power and the mix of services that retailers offer (Bonanno and Lopez 2009).

This type of economic analysis adds new insight to existing lines of research on inadequate food retail access. For example, Broda, Leibtag, and Weinstein (2009) note that low-income consumers differ from other consumers not only in their more frequent use of small retailers (which may have higher food prices and locations close to home) but also in their more frequent use of superstores or supercenters (which may have lower food prices and locations farther from home). Bitler and Haider (2011) discuss both the supply and demand for food retail services, recognizing that in some cases it is a market equilibrium outcome to have only a small number of retailers in a particular geographic area.

This study focuses on three high-profile existing approaches to identifying geographic locations with inadequate supermarket access. The three approaches differ in their implicit assumption about the underlying household-level condition that is most important.

The Low-Income Low-Access Approach. In an online mapping tool and accompanying data resources, USDA's Food Access Research Atlas (FARA) identifies census tracts as having inadequate food retail if they meet both a low-income definition and a low-access definition (Economic Research Service 2013).

- Low-income tracts satisfy an absolute poverty standard or a relative income standard. The absolute standard is having a poverty rate of at least 20%, based on the federal government's poverty thresholds. The relative standard is having census-tract median income at or below 80% of the median income in the corresponding metropolitan area or (for non-metropolitan areas) the entire state. This second standard varies across geographic locations.
- Low-access tracts have at least a third of the population or at least 500 people with low access. Low-access, for ERS, means low proximity to the nearest supermarket, defined using a different distance threshold in urban areas (at least 1 mile from a supermarket) and rural areas (at least 10 miles from a supermarket). Estimates are also given for alternative distance thresholds, but we focus on the 1- and 10-mile thresholds.

In this approach to classifying census tracts, some complexity arises from the need to aggregate up to the census-tract level, but the implicit underlying concept is clear. A person qualifies as having inadequate food retail access if he or she is low-income (based on having income below either the poverty line or 80% of area median income) and lives farther than the threshold distance from the nearest supermarket (where the threshold distance is 1 mile in urban areas and 10 miles in rural areas). This approach does not explicitly refer to vehicle access, but both the low-income standard and the distinction between urban and rural areas may be motivated by concern for those who lack vehicles.

The Low-Vehicle Low-Access Approach. USDA's FARA tool recently has added more information so that a vehicle-based measure can be constructed. A tract is identified as having low vehicle availability "if more than 100 households in the tract have no vehicle available and are more than 0.5 miles from the nearest supermarket" (Economic Research Service 2013).

The Relative Distance Approach. The Reinvestment Fund (TRF), a non-governmental organization prominent in community food security research, identifies areas with limited supermarket access (LSA). Like USDA, TRF makes the results available in a popular online mapping tool. TRF uses a relative distance-to-supermarket concept somewhat akin to a relative income threshold in poverty measurement. A particular block group has low relative access if its distance to the nearest supermarket is longer than a threshold distance, which varies across 13 comparison-group strata, defined by combinations of population density and vehicle access rates.

For each comparison-group stratum, the threshold distance for determining whether the block group has limited access is based on the distance to the nearest supermarket for higher income block groups in the stratum that are presumably not deprived. TRF computes the benchmark distance as the median distance to the nearest supermarket for those block groups with higher income (based on area median income above 120% of median income for the metropolitan area or state). Several findings are useful for understanding TRF's concept of inadequacy:

- The 4 rural strata with the lowest population density have 11.7% of the U.S. population. All of these strata have high vehicle access in TRF's classification. In these strata, the adequate benchmark distance ranges from 5.5 miles to 17.5 miles. This distance is roughly comparable to the 10-mile threshold used by USDA's FARA in rural areas.
- The 5 urban strata with the highest population density have 50.3% of the U.S. population. All but one of these strata have medium or high vehicle access in TRF's classification. In these strata, the adequate benchmark distance ranges from 0.15 miles to 1 mile.
- Only 1 of the 13 strata has low vehicle access in TRF's classification. It has a high population density and represents 6.6% of the U.S. population. Its adequate benchmark distance is just 0.29 miles.

In TRF's approach, the threshold distance varies across the comparison-group strata. For some locations, the threshold distance is larger than five miles, recognizing that many residents have vehicles. In other locations, the threshold for inadequate retail access may be as small as 0.15 miles or 0.29 miles, which is shorter than the threshold distance to supermarket used in other approaches with which we are familiar. With such small threshold distances, many locations may be classified as having inadequate access.

Conclusions about retail adequacy for census tracts necessarily build on conclusions about retail adequacy for smaller geographic units. In small areas, such as a census block group or a 1-km or 0.5-km grid square, the research literature generally treats resident households as if they share the same food retail environment. Building on the identification of small geographic units where households have inadequate access, one can determine which larger geographic areas (such as census tracts or counties) have sufficient numbers of such households or individuals to qualify as areas with limited supermarket access. For these larger geographic units, it is clear that research methods must acknowledge the internal heterogeneity in food retail access.

Conclusions about retail adequacy in small geographic units necessarily build on a concept of adequacy at the household level. It is useful to make this household-level concept explicit rather than having readers derive it implicitly from definitions of adequacy for geographic areas. To define adequacy at the level of the household, much of the literature focuses on the presence of supermarkets within a specified threshold distance from home. A sensible threshold distance may depend on whether a household has a vehicle. A common threshold distance is 0.5 miles or 1 mile for people who lack a vehicle and a longer distance for people who have a vehicle. As an illustrative example, one could say a household has inadequate access if (a) it lacks a vehicle and lives more than 0.5 miles from the nearest supermarket or (b) it has a vehicle and lives more than 10 miles from the nearest supermarket (Figure 1). This framework easily may be adapted for other threshold distances, such as 1 mile for households that lack a vehicle.

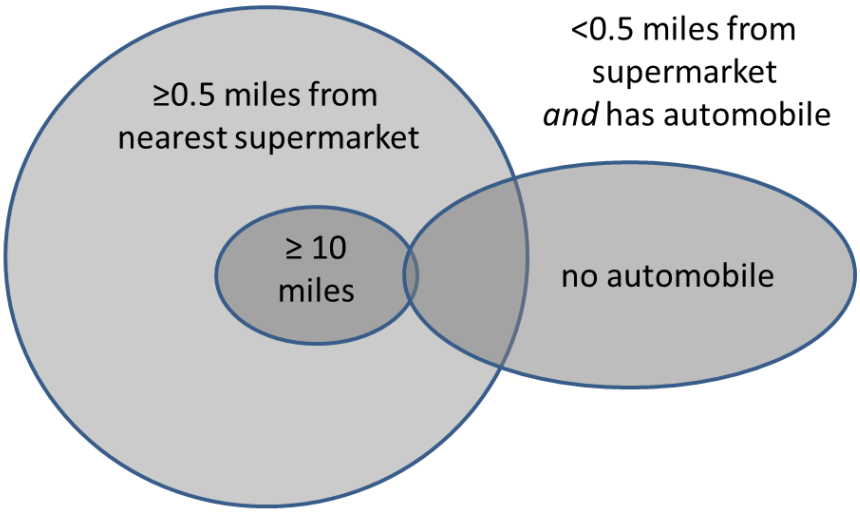

Figure 1. A Concept of Inadequate Food Retail Access at the Household Level.

Note. The circle at left represents households located at least 0.5 miles from a supermarket. A subset of these households are located at least 10 miles from a supermarket. The oval at right represents households with no vehicle. Darker shading in the intersection represents inadequate food retail access.

Data and Methods

This study used geographic information for all census block groups within 91 counties in 27 States. The counties were chosen by USDA's Economic Research Service in connection with the Food Acquisition and Purchase Survey (FoodAPS), a new national food expenditure survey (Kirlin and Denbaly 2013). For FoodAPS, Mathematica Policy Research, Inc., selected a slightly different list of 108 counties within 50 primary sampling units (PSUs) in the same 27 States. Within the PSUs, the FoodAPS survey sampled approximately 5,000 households in 400 secondary sampling units (SSUs). None of the FoodAPS household data or SSU identifiers were used in this article, which only needed geographic-level data.

The sample size was 33,604 block groups (after excluding 3 block groups that had implausibly high population densities, which we attributed to incorrect land area estimates). The analysis block groups belonged to 11,747 census tracts in 91 counties in the 50 PSUs. The block-group analysis file included two types of variables: (a) variables that were originally acquired at the block-group level (such as Census Bureau demographic characteristics for block groups) and (b) variables that describe the retail environment at varying distances from the population-weighted centroid of the block group.

This study used the same 2010 retailer location data that USDA/ERS used in FARA, combining information from TDLinx and USDA/FNS Store Tracking and Redemption System (STARS). Nielsen TDLinx is a commercial database of retailers selling consumer packaged goods (including food). FNS uses STARS to monitor and manage SNAP-authorized retailers. Our analysis is based on counts of retailers located within a specified distance from the population-weighted block-group centroid. FARA, by contrast, is based on 0.5-km square grids rather than concentric circles. In FARA, the entire country was divided into 0.5-km square grids and then population data was allocated to these grids. The distance to the nearest supermarket was measured for each grid cell by calculating the distance between the geographic center of the 0.5-km square grid that contains estimates of the population and the center of the grid with the nearest supermarket. This study used block groups rather than 0.5-km square grids, because we lacked access to 0.5-km grid data, and block groups were judged to be adequately disaggregated.

At the block-group level, this study made no assumption that residents shopped within the block group itself. Instead, residents were assumed to shop anywhere in the retail environment that surrounded the block-group centroid. We estimated counts for supermarkets and superstores at linear distances of 0.5 miles, 1 mile, 5 miles, 10 miles, and 20 miles from the population-weighted centroid of the block group. The commonly-used conventions (such as a 0.5-mile or 1-mile radius in urban areas or a 10-mile radius in rural areas) are special cases that can be analyzed using this data source.

For clarity, in the initial analysis of underlying relationships across block-group variables, this study used an absolute poverty standard for defining high-poverty areas. A high-poverty block group was defined as one with $\geq$ 20% of the population in poverty. The analysis used 4 population density levels, ranked from least to most dense: low, 0-1k persons per square mile; medium, 1k-5k persons per square mile; high, 5k-10k persons per square mile; very high, 10k+ persons per square mile. We removed from the analysis 3 outlier block groups with implausible population density greater than 300k persons per square mile (a density much greater than that of Manhattan). Block groups in rural census tracts are predominantly in density level 1. Block groups in urban census tracts are more numerous, and they are split evenly between density levels 2, 3, and 4.

The first four sections of the analysis address the four empirical questions noted in the introduction, describing the relationships among variables related to food access at the block-group level. The final section of analysis discusses issues of aggregation from a detailed geographic level (block group) to a broader geographic level (census tract).

Results

Poverty and Proximity to Supermarkets

First, consider the relationship between poverty and proximity to supermarkets. 26.1% of block groups were high-poverty, and these block groups contained 25.4% of the population. Because census block groups by design have roughly similar population sizes, weighting block groups by population made only small differences to the empirical results, so this article reports unweighted counts of block groups. High-poverty block groups (one quarter of all block groups) contained 60.6% of poor people. Lower-poverty block groups (three quarters of all block groups) contained the remaining 39.4% of poor people.

Fewer than 1 out of each 2,000 block groups (0.03%) lacked a supermarket within 20 miles, and another 1 out of 300 block groups (0.32%) lacked a supermarket within 10 miles (Table 1). At the other end of the spectrum, 43.9% of block groups had a supermarket within 0.5 miles, and another 35.2% of block groups had a supermarket between 0.5 miles and 1 mile away. In between the two extremes, 20.6% of block groups had a nearest supermarket between 1 and 10 miles away.

The high-poverty block groups had better access to supermarkets than other block groups did, on average, 85.6% of high-poverty block groups had a supermarket within 1 mile. By contrast, only 76.8% of lower-poverty block groups had a supermarket within this distance. Thus, most block groups had fairly good proximity to a nearest supermarket. Surprisingly, low-income block groups on average had better proximity than high-income block groups did.

Table 1. Frequency of Having a Nearest Supermarket at Each Distance (in Miles) for Block Groups with and without a High Poverty Rate.

	Distance to Nearest Supermarket (in miles)					
Block Group Poverty	0 to 0.5	0.5 to 1	1 to 10	10 to 20	>20	Total
			# Block groups *(row %)*			
Not high poverty	10,029	8,968	5,659	88	6	24,750
	(40.52)	*(36.23)*	*(22.86)*	*(0.36)*	*(0.02)*	*(100.00)*
High poverty	4,655	2,817	1,230	18	5	8,725
	(53.35)	*(32.29)*	*(14.10)*	*(0.21)*	*(0.06)*	*(100.00)*
Total	14,684	11,785	6,889	106	11	33,475
	(43.87)	*(35.21)*	*(20.58)*	*(0.32)*	*(0.03)*	*(100.00)*

Note. High-poverty block groups have a poverty rate greater than or equal to 20

Population Density and Proximity to Supermarkets

Second, consider the relationship between population density and proximity to the nearest supermarket. Among block groups in the lowest-density level, only 6.1% are within 0.5 miles of a supermarket and another 15.8% are between 0.5 and 1 miles of a supermarket (Table 2). By contrast, among block groups in the highest-density level, 72.5% are within 0.5 miles of a supermarket.

Table 2. Frequency of Having a Nearest Supermarket at Each Distance (in Miles) at Each of Four Population Density Levels.

	Distance to Nearest Supermarket (in miles)					
Population Density	0 to 0.5	0.5 to 1	1 to 10	10 to 20	>20	Total
			# Block groups *(row %)*			
Low	229	592	2,821	106	11	3,759
	(6.09)	*(15.75)*	*(75.05)*	*(2.82)*	*(0.29)*	*(100.00)*
Medium	2,567	4,388	2,805	1	0	9.761
	(26.30)	(44.95)	(28.74)	(0.01)	(0.00)	(100.00)
High	4,408	4,255	1,026	0	0	9689
	(45.49)	*(43.92)*	*(10.59)*	*(0.00)*	*(0.00)*	*(100.00)*
Very high	7,495	2,570	268	0	0	10,333
	(72.53)	*(24.87)*	*(2.59)*	*(0.00)*	*(0.00)*	*(100.00)*
Total	14,699	11,805	6,920	107	11	33,542
	(43.82)	*(35.19)*	*(20.63)*	*(0.32)*	*(0.03)*	*(100.00)*

For urban areas, Figure 2 shows block-group poverty rates on the horizontal axis and the natural logarithm of block-group miles to the nearest supermarket, ln(distance), on the vertical axis.

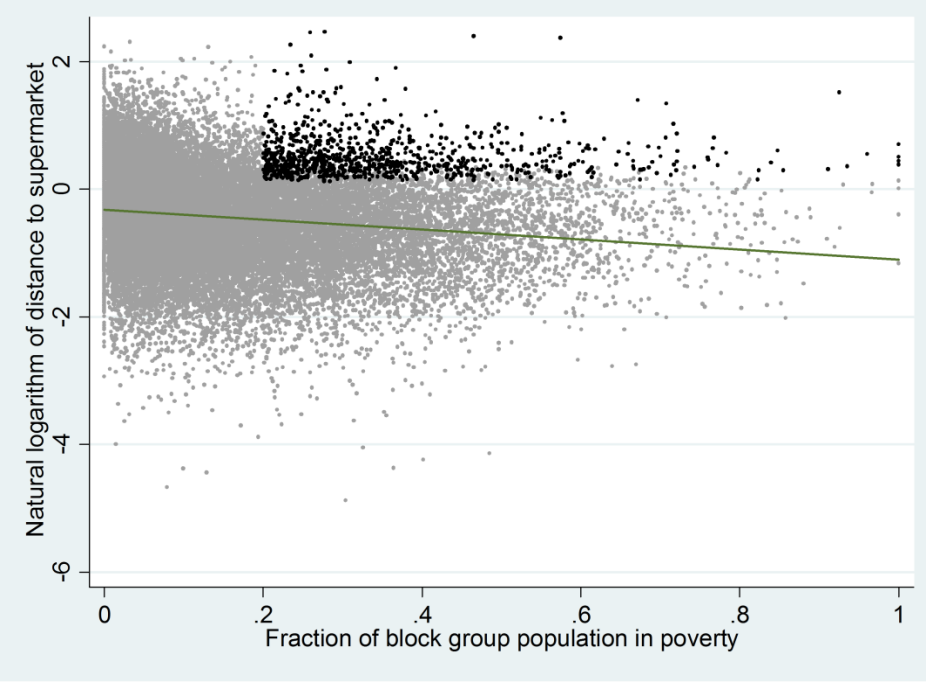

Figure 2. The Natural Logarithm of Distance to the Nearest Supermarket, as a Function of the Poverty Rate, in Urban Areas.

Note. black color indicates the poverty rate is high (greater than 20%) and the nearest supermarket is 1 mile away or farther; the vertical axis shows the natural logarithm of the distance to the nearest supermarket in miles (the logarithmic scale is used for display, because the dependent variable is highly right-skewed).

Block groups further than a mile from a supermarket have ln(distance) greater than zero. In the figure, there is not much correlation between ln(distance) and the poverty rate, and what little correlation exists is negative. The block groups that are both high-poverty and greater than one mile from the nearest supermarket are in the top right quadrant, marked in black. This figure shows that definitional thresholds strongly influence descriptions of supermarket access that are based on distance and poverty rates.

The block groups marked in black are not a separate cluster in this two-dimensional space. On the contrary, an analyst using a distance threshold slightly different than one mile, or a poverty rate threshold slightly different than 20%, would have generated a much different estimate of the fraction of block groups that suffers from poor supermarket access. Moreover, the block groups illustrated in black are overshadowed by the larger number of block groups in the top left and bottom right quadrants. The block groups in the top left quadrant have poverty rates below 20%, but they are far from the nearest supermarket and they include large numbers of poor people (we noted earlier that almost two fifths of poor people live in block groups with poverty rates below 20%). The block groups in the bottom right quadrant have exceptionally high rates of poverty, and they may face serious problems with the quality of the food environment, but they do enjoy close proximity to the nearest supermarket.

Thus, much more than poverty, population density was a powerful predictor of proximity to a nearest supermarket. Nearly all block groups with very high population density had a nearest supermarket no more than 1 mile away.

Vehicle Access and Proximity to Supermarkets

Third, consider the relationship between vehicle availability and supermarket access. In block groups with a supermarket less than 0.5 miles away, 15.3% of households lacked a vehicle (Table 3). For in-between block groups, with a nearest supermarket between 1 and 10 miles away, 4.7% of households lacked a vehicle. In block groups with a nearest supermarket between 10 and 20 miles away, 4.6% of households lacked a vehicle.

Table 3. Percentage of Households Having No Vehicle, for Block Groups with Nearest Supermarket in Each Distance Category.

	Distance to Nearest Supermarket (in miles)				
	0 to 0.5	0.5 to 1	1 to 10	10 to 20	>20
Mean % with No Vehicle	15.34	8.04	4.71	4.55	5.71

Thus, vehicle availability is highest in the areas where vehicles are most needed. Yet, lack of a vehicle may be a problem for a small but non-negligible fraction (almost 5%) of those households that are at least 1 mile from the nearest supermarket.

Proximity to Supermarkets Based on Area Characteristics

Fourth, consider the proximity to supermarkets in block groups with particular levels of population density and vehicle access. This fourth empirical question helps us to understand relative distance methods, such as TRF's approach to identifying LSAs, which was described in the background section.

This article's relative distance analysis, loosely motivated by TRF's approach, used the same 4 population density levels as in our earlier results. We defined a block group as "high vehicle" if the rate of vehicle access was greater than 80%, and "low vehicle" otherwise. We stratified all block groups into low-income (having a high poverty rate or low relative income or both) and not-low-income categories. TRF uses only higher-income areas (defined as having median income above 120% of the poverty guideline) to establish adequate benchmark distances.

In our analysis, as in TRF (2011), the low-density block groups had high vehicle access rates (Table 4). The mean distance to the nearest supermarket among these predominantly low-density block groups was about 4 miles (4.18 miles in low-income block groups and 3.93 miles in other block groups). By contrast, for block groups with the highest population density level, the mean distance to the nearest supermarket was much smaller, ranging from 0.37 to 0.57 miles depending on vehicle access and low-income status. These benchmark distances are similar to the results TRF (2011) found for high-density areas.

Table 4. Benchmark Distances for Several Population Density and Vehicle Access Categories.

Population Density	**Mean Distance in Miles** ***(% of all block groups)***			
	Not Lower Income		Lower Income	
	High Vehicle	Low Vehicle	High Vehicle	Low Vehicle
1 (lowest density)	3.93 *(13.0)*	-	4.18 *(7.5)*	-
2	1.13 *(35.4)*	-	0.97 *(15.7)*	0.87 *(4.6)*
3	0.76 *(30.3)*	-	0.75 *(19.8)*	0.71 *(6.3)*
4 (highest density)	0.57 *(15.4)*	0.37 *(4.3)*	0.57 *(25.1)*	0.42 *(20.1)*

Note. Empty cells indicate that few people live in areas with that combination of population density and vehicle access.

Thus, although our relative distance approach did not seek exactly to replicate the TRF approach, we observed the same patterns that TRF observed. High-population-density areas tend to have short benchmark distances of much less than 1 mile, which means that such block groups generally are within one mile of a supermarket.

Aggregating to the Census Tract

In urban areas, a block group generally is sufficiently small that the population-weighted centroid can be treated as the location where people live. We recognize that rural block groups are larger, but, in this study, we nonetheless use the population-weighted block group centroid as an approximation of the location where residents live. In yet larger geographic units such as census tracts, one always must recognize that the food environment is different for residents of different neighborhoods within the unit. Building on the basic block-group level results in the previous section, we next investigate issues of aggregating to the census-tract level in the low-income low-access approach. Some of the lessons from this analysis may apply to other approaches as well.

FARA identifies census tracts that are both (1) a low-income tract and (2) a low-access tract (meaning that the households have poor proximity to the nearest supermarket). It is comparatively straightforward to define a low-income census tract, using the same approach as was used previously to define a low-income block group. Low income, in FARA, means having a poverty rate of at least 20% (as in the previous section) or having low median income relative to other parts of the same metropolitan area or state. While the previous section showed that 26% of block groups had high poverty, 42.2% of census tracts qualify as low-income using this more expansive definition (Table 5).

Table 5. Joint Frequency for Census Tracts Having Low Income and Low Access.

	Access Status		
	Not Low	Low	Total
Income Status			
		# Census Tracts	
		(row %)	
Not Low Income	4,672	2,111	6,783
	(68.88)	*(31.12)*	*(100.00)*
Low Income	4,073	879	4,952
	(82.25)	*(17.75)*	*(100.00)*
Total	8,745	2,990	11,735
	(74.52)	*(25.48)*	*(100.00)*

Note. The ERS Food Access Research Atlas (FARA) classifies a tract with both low income and low access as a "food desert."

It is more difficult to define low access at the census-tract level than at the block-group level. The issue is that supermarket access is an attribute of a very specific geographic location, such as a block-group centroid (in the previous section) or a small 0.5-km square grid cell (in USDA's FARA estimates). In contrast with a block group, a census tract is too large an area for the distance from the census-tract centroid to be a useful concept. Hence, FARA based its tract-level definition of low-access on a particular aggregation: a low-access census tract is one in which at least 500 people reside in low-access grid cells, or 33% of the tract population resides in low-access grid cells, or both. While the previous section showed that 20.9% of block groups had no supermarket within 1 mile, this census-tract analysis found that 25.5% of census tracts qualify as low access using this approach (Table 5). It is common to have low-access census tracts that include some neighborhoods with adequate food retail access.

Overall, 879 out of 11,735 census tracts (7.5% of all census tracts) met both the low-access and low-income criteria. Low-income census tracts are less likely than other census tracts to be classified as low-access tracts. Of those census tracts classified as having low income, 17.8% had low access. Of census tracts that were not low-income, 31.1% had low access (Table 5). To summarize, the census-tract level analysis was more likely than the earlier block-group level analysis to classify a geographical area as an area with inadequate food retail. Yet, the basic relationship between income status and food retail access status remained the same. Low-income census tracts have comparatively good access to supermarkets.

Discussion

There is substantial policy interest in classifying geographic areas according to the adequacy of the local food retail environment and in measuring the prevalence of poor access conditions. Three leading approaches share some similarities in methods and motivation, but they differ in key respects and lead to substantially different conclusions about food retail adequacy.

The approaches studied here each measure the distance to the nearest supermarket and compare it to a threshold distance thought to indicate an acceptable burden for grocery shopping. In the low-income low-access approach, USDA Economic Research Service (2009) used time-based measures for walking and driving to develop estimates of walkable and drivable distances. For walking, the authors assumed a walking speed of 2 miles per hour and a 15-minute walking time to arrive at a 0.5 mile radius for "high" access (in urban areas). Others (Algert, Agrawal, and Lewis 2006, Apparicio, Cloutier, and Shearmur 2007, California Center for Public Health Advocacy, PolicyLink, and UCLA Center for Health Policy Research 2008) have used similar definitions of walkability. For driving, USDA's Economic Research Service assumed a driving speed of 40 miles per hour and a 15-minute drive to arrive at a 10 mile radius for "high" access in rural areas. Clearly, if one uses a smaller threshold distance, one is systematically more likely to classify a particular location as having inadequate food retail conditions. Conversely, if one uses a larger threshold distance, one finds fewer such areas. Hence, a lot depends on the choice of threshold distance. The findings show that the choice of the threshold point could make a sizable difference in the number of locations that are designated as limited access.

Each approach implicitly sought to take account of the fact that a reasonable threshold distance may be different for households with and without vehicles, but the methods for taking account of vehicle availability differed considerably. If the population of concern is people who live further than a threshold distance and lack a vehicle, then FARA's vehicle-based measure seems to be the most direct approach.

Using low-income status at the census-tract level has some shortcomings as a method for identifying this population. Because low-income areas are more likely than other areas to have a supermarket nearby, the low-income low-access approach actually excludes many areas that are not low-income, but which have particularly long distances to the nearest supermarket. Recall from the first section of results that almost 40% of poor people live in neighborhoods that are not high-poverty neighborhoods. One could argue that the low-income low-access approach excludes one of the most commonly deprived populations, which is poor people in non-poor neighborhoods that lack a supermarket.

Similarly, the relative distance approach would be an indirect way of identifying areas where people lack a vehicle and live too far from a supermarket. In some areas with large threshold distances, it seems possible that households without a vehicle would face great hardship. In other areas, a threshold distance of less than 0.5 miles may be too short. In such areas, many residents without vehicles may be classified as having limited supermarket access even if they are well-satisfied with nearby supermarkets at distances of between 0.5 miles and 1 mile.

We conclude that neither the low-income low-access approach (with access based only on distance) nor the relative distance approach serves well as a method for accounting for vehicle access, but we recognize that there may be other motivations for these approaches. It could be that low income is not intended as a proxy for low vehicle availability, but instead there is a more direct reason why people in low-income neighborhoods without a supermarket should be at greater disadvantage than people in other neighborhoods without a supermarket. For example, community development in low-income neighborhoods could be the policy goal. Likewise, there could be a more direct motivation for the relative distance approach, such as concerns over equity of access.

Our results suggest some recommendations for future work in measuring food retail adequacy. First, it is good to state explicitly the household-level or individual-level condition that represents inadequate food retail access. For example, the underlying household-level condition might be one of the three conditions studied in this article: (1) poverty plus lack of a nearby supermarket, or (2) lack of a vehicle plus lack of a nearby supermarket, or (3) lack of a supermarket as close as one typically expects in neighborhoods with similar population density. Alternatively, the household-level condition might address issues beyond those covered here, such as lack of fresh fruits and vegetables at a particular price point. Second, when it is necessary to aggregate from granular geographic data to larger areas such as census tracts or counties, it is good to do so in a fashion that preserves the underlying information about the extent of hardship. Current methods of aggregation may cautiously classify some census tracts as having inadequate access even if many block groups or smaller geographic units contained in the census tracts have adequate food retail access.

The research literature on food retail adequacy may have policy implications. In particular, policy-makers may choose to target areas for subsidies or tax incentives to attract additional commercial supermarkets, or they may use zoning rules to guide retailer location decisions. When research on food retail adequacy is used in this fashion, it is especially important that the choice of threshold distance and assumptions about vehicle adequacy match actual consumer behavior. For example, if one assumed that low-income households in a particular community seek to shop for groceries within a 0.5-mile radius, when in fact vehicle availability rates are high and households in this community usually patronize lower-priced retailers at greater distances, then it could be a substantial policy error to subsidize the introduction of a new supermarket. To determine locations where market outcomes have been unsatisfactory and where a new supermarket may be encouraged, it is good first to recognize and assess population density, vehicle availability, and the proximity of other supermarkets.

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