Measuring utility-based access to nutrition in Utah County, UT using passive mobile devices and NEMS-S data

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Introduction

Equitable access to adequate nutrition is a critical concern in many communities. However, prevailing methods to measure access using distance thresholds are overly simplistic and lack behavioral support: people do not always patronize the nearest grocery store, if more affordable or preferable options exist. Simply considering the proportion of the population living within a given distance of any grocery store ignores these nuances and could lead to ineffective policy interventions.

Objectives

In this research, we present an initial attempt to estimate a grocery store destination choice model for residents in Utah County, Utah using passive mobile device location data paired with a recently collected NEMS-S data set representing the local food environment. This model allows us to infer the relative importance of

1. Travel distance from home neighborhood to grocery store
2. Observed behavioral preference for store size and amenities

We then use this model to evaluate access to grocery stores in Utah County.

Methods

Utility-based access is based in destination choice theory. If a person living in block group i is choosing to travel to a grocery store, the *utility* of a particular store j is

$$U_{ij} = \beta d_{ij} + \gamma X_j$$

Where d_{ij} is the distance or travel cost between i and j, X_j is a vector of attributes of the store (size, brand, etc.), and β, γ are estimated coefficients. The total benefit (or access) to all options J is the log-sum of the utility of everything in the choice set,

$$\ln \sum_{j \in J} \exp(U_{ij})$$

We estimate the coefficients for this measure using three data sets:

1. A NEMS-S survey (Glanz et al. 2007) conducted on grocery stores in Utah County, Utah during Spring 2021 provides attributes of the stores including their size and amenities.
2. Mobile device records obtained from StreetLight Data reveal the home block group of visitors to these grocery stores.
3. Travel paths between block group centroids and grocery stores obtained from OpenStreetMap via `opentripplanner` (Morgan et al. 2019)

To construct the estimation data set, we sample from the mobile device data to obtain simulated observed "trips" to grocery stores. Alternative options are sampled randomly from the other stores — this results in unbiased but somewhat inefficient estimates. Models are estimated using the `mlogit` package for R (Croissant 2020).

Results

The estimated coefficients are intuitive and highly significant considering standard confidence intervals. People are less likely to go to stores that are further away by car, or to stores that are convenience stores or ethnic markets rather than traditional grocery stores. They are more likely to go to larger stores (as inferred from the number of cash registers), or stores that include other kinds of merchandise such as home goods or clothing, all else equal.

Table 1: Store Choice Utility Coeffcients

	Base	Attributes	Size
Drive time	-0.206 (-73.226)	-0.210 (-67.477)	-0.217 (-65.236)
Convenience Store	-3.077 (-12.663)	-2.285 (-9.167)	-1.588 (-6.290)
Other non-standard	-2.684 (-17.033)	-1.617 (-9.703)	-1.052 (-6.215)
Has pharmacy		0.660 (13.741)	0.286 (5.235)
Ethnic market		-1.704 (-13.312)	-0.990 (-7.510)
Has other merchandise		1.670 (33.469)	1.039 (17.092)
Number of registers			0.079 (28.279)
Number of self-checkout			0.022 (6.888)
Num.Obs.	5,848	5,848	5,848
Log Likelihood	-7,729.8	-6,592.4	-6,086.4
McFadden Rho-Sq	0.449	0.530	0.566

t-statistics in parentheses.

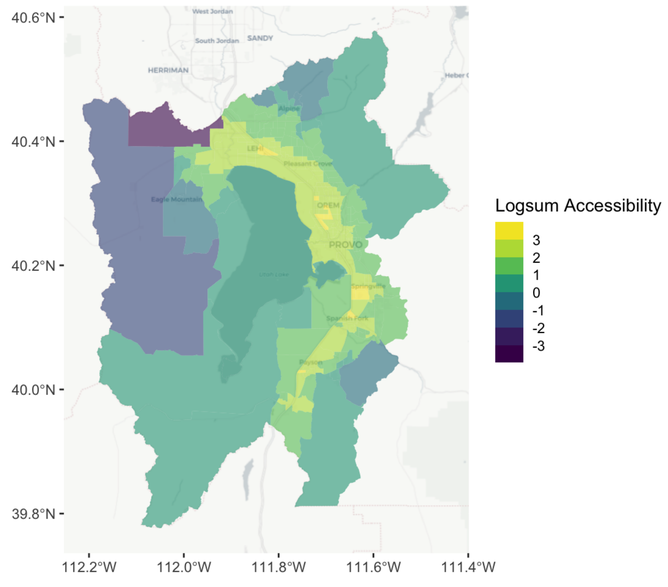

Figure 1: Access to grocery stores based on the 'Size' model.

When the model coefficients are applied to all block groups in the region, the comparative nutrition accessibility picture becomes clear. Large retail areas show the highest comparative accessibility, while outlying regions show comparatively less.

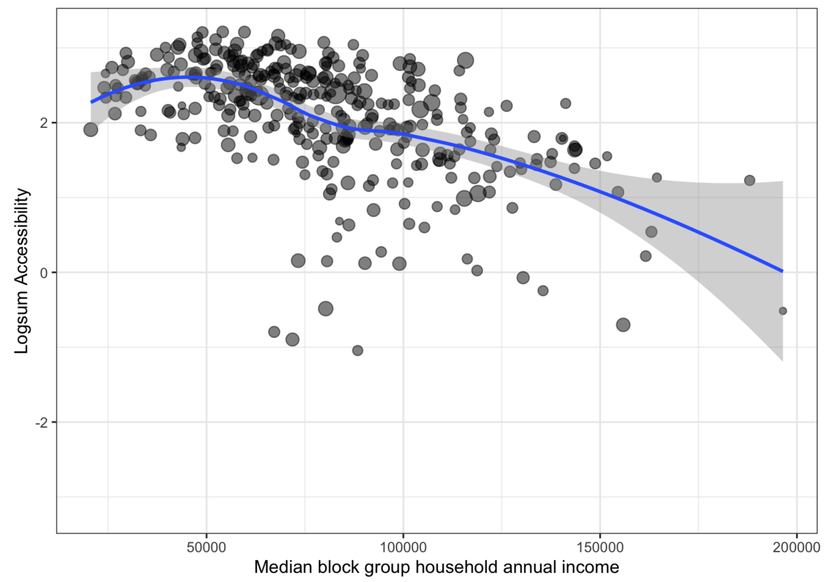

Figure 2: Correlation of income and logsum-based access to grocery stores.

There is not a clear relationship observable between utility-based access to grocery stores and traditional sociodemographic characteristics revealed by this model. But these preliminary results do not yet consider the improved mobility that high-income households have. Further research is required.

Next Steps

The driving time is the only current travel impedance term. This will be expanded to include other modes of travel, weighted by the mode availability of the agents.

The NEMS-S contains considerably more attributes than those included in these preliminary results: produce price and variety, dairy offerings, etc. Investigating the effect of these variables on store choice is a major next step.

Neighborhoods with different socioeconomic characteristics are likely to show different preferences in their grocery store choice; the model should be segmented to allow for flexibility and accuracy in these preferences.

References

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