Accessibility, network structure, and consumers' destination choice: a GIS analysis of GPS travel data

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Abstract

Based on GPS travel data in the Twin Cities, this paper analyzes the impacts of travelers’ interactions with road network structure and clustering of services at the destinations on their retail destination choice. The results reveal that higher accessibility and diversity of services around destinations are more attractive. The diversity and accessibility of services in an area are often highly correlated. Furthermore, a destination reached by a route with greater circuity, discontinuity, and roadness damps its appeal.

GPS data in the Twin Cities

- Collected to study commuters’ travel behavior before and after the opening of the new I-35W Bridge.
- Subjects’ selection criteria: (1) legal drivers; (2) are likely to be affected by the opening of the new I-35 W Bridge; (3) age 25-65; (4) drive along to work; (5) have a full-time job and follow a common work schedule.

Select alternative destinations for trips

1. Catalogue home-based retail trips into groups based on travel time.
2. Calculate the probability of trips in each category.
3. Decide the size of choice set (using 10 in this case).
4. Use Monte Carlo Simulation to simulate the number of trips for each group.
5. Calculate network vehicle travel distance buffers by travel time from travelers’ homes.
6. Randomly select 9 centroids from these buffers as alternative destinations.

Hypothses

- A destination with greater accessibility and diversity of services, all else equal, is more attractive.
- A destination reached via a more circuitous or discontinuous route, all else equal, is less attractive.

The model formulation

Dependent variable: destination choice
Independent variables:

Land use
- Accessibility (ln): total number of services within 10 minutes’ walking from a parking destination.
- Diversity of services: the entropy at destination k equals

\[ H_k = \frac{1}{k} \sum p_{ks} \ln(p_{ks}) \]

Where \( p_{ks} \) is the proportion of service type \( s \); \( S \) is the total number of services at destination \( k \).

Road network structure of the routes
- Circuity (ln): ratio of network travel distance to Euclidean distance.
- Discontinuity (ln): total number of changes of road hierarchy (by 5 mph road speed) along the shortest travel time path divided by trip length.
- Travel time (ln): for actual trips, the travel time is the time recorded by GPS. For alternative trips, it is the shortest vehicle travel time on the network.
- Roadness (ln): sum of the total number of roads along a route. A road is defined based on every consecutive intersections. If the acute angle of every three intersections is [170°, 180°], they constitute one road; else two roads.

Conclusions

The study uses GPS travel data in the Twin Cities and GIS analysis to examine the impact of destination accessibility and road network structure on travelers’ destination choice for non-work non-home trips. We hypothesize that a destination's accessibility, diversity of services, and road network topology influence travelers’ destination choice. The results have confirmed our hypotheses. Cumulative accessibility and diversity of services in the adjacent walking zones, all else equal, promote a destination's appeal. In addition, a destination reached via a route of greater circuity, discontinuity, and roadness lessens its attractiveness to visitors. The results indicate that both land use patterns and road network structure affect individuals’ retail destination choice.