Demand Theory

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Questions

• Who, what, where, when, why, how?
  • Who is traveling or what is being shipped?
  • Where are the origin and destination of those trips, shipments?
  • When do those trips begin and end (how long do they take, how far away are the trip ends)?
  • Why are the trips being made, what is their purpose?
  • How are the trips getting there, what routes or modes are they taking?

Answers

• What are the answers to those questions a function of?
  • Cost: Money, Time spent on the trip,
  • Cost: Money and Time of alternatives.
  • Benefit (utility) of trip (e.g. the activity at the destination)
  • Benefit of alternatives

Rationale

• Why do we want to understand those questions:
  • How much “induced demand” will be generated if a roadway is expanded?
  • How many passengers will be lost if bus services are cut back?
  • How many people will be “priced off” if tolls are implemented?
  • How much traffic will a new development generate?
  • How much demand will I lose if I raise shipping costs to my customers?

Derived Demand

• What happens if we change
  • It is often said that “travel is a derived demand”. There would be no travel but for the activities being undertaken at the trip ends. Travel is seldom consumed for its own sake, the occasional “Sunday Drive” or walk in the park excepted.

Budgets

• On the other hand, there seems to be some innate need for people to get out of the house, a 20-30 minute separation between the home and workplace is common, and 60 - 90 minutes of travel per day total is common, even for nonworkers.
• What we know:
  • The more expensive something is, the less of it that will be consumed. E.g. if gas taxes were doubled there will be less vehicle miles traveled overall.
  • Similarly, the longer it takes to get from A to B, the less likely it is that people will go from A to B.
**Demand**

- All this means is that we are dealing with a downward sloping demand curve:

**Induced Demand**

- Induced Demand

**The Shape**

- What we need to estimate is the shape of demand (is it linear or curved, convex or concave, what function best describes it), the sensitivity of demand for a particular thing (a mode, an origin destination pair, a link, a time of day) to price and time (elasticity) in the short run and the long run.

**Measurement**

- Are the choices continuous (the number of miles driven) or discrete (car vs. bus)?
- Are we treating demand as an absolute or a probability?
- Does the probability apply to individuals (disaggregate) or the population as a whole (aggregate)?
- What is the trade-off between money and time?
- What are the effects on demand for a thing as a function of the time and money costs of competitive or complementary choices (cross elasticity).

**ITE Trip Generation Rates**

- Trip Generation - Estimates the number of trips entering or exiting a site at a given time (sometimes the number entering and exiting combined is estimated). ITE Rates are functions of type of development, and square footage, number of gas pumps, number of dwelling units, or other standard measurable things, usually produced in site plans. They are typically of the form Trips = a + b * Area OR Trips = a + b * ln (Area). They do not consider location, competitors, complements, the cost of transportation, or many other obviously likely important factors. They are often estimated based on very few observations (a non-statistically significant sample). Unfortunately, many localities require their use.

**Urban Transportation Planning Models**

- Trip Generation - Estimates the number of trips being produced or attracted to a traffic zone by purpose of trip, as a function of the number of households, dwelling unit type, age of occupants, income, and other easily gathered demographic data, or number of employees by type of employer (office, retail, industrial, other). Purpose can be thought of as a matrix of origin and destination activities, where the less frequent activity pairs (trip purposes) are often aggregated. Trip rates are rarely a function of aggregate accessibility (a function of the money and time cost to reach destinations) and even so, are fairly insensitive to it. In general, activities will be pursued, it is how, when, and where they are pursued which is sensitive to money and time prices.
Urban Models: Techniques

- Aggregate Demand Models
- Discrete Choice Models

Matrix of Interchanges

<table>
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<tr>
<th></th>
<th>Home</th>
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<th>Shop</th>
<th>School</th>
<th>Other</th>
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Prediction Aims

- On Urban Passenger Side Trying to Predict:
  - Trips by Origin Activity,
  - Destination Activity,
  - Origin Zone,
  - Destination Zone,
  - Mode,
  - Time of Day, and
  - Route
- Multidimensional problem.

Trip Generation

1. Trip Generation
2. Trip Distribution
3. Mode Choice
4. Route Assignment

What Affects Trip Generation?

- Trip Type
  - Work to Home unlinked
  - Work to Other, Other to Home linked
  - Home to Other
  - Other to Home
  - Other to Other
  - Home to Work
- Factors
  - How do we predict how many trips will be produced by zone?
  - Work in pairs, develop a list of explanatory factors associated with trip types (i.e., form hypotheses).

Trips at Home End

- For instance trips produced from or attracted to homes in a zone is described as a function of:
  - Th ~ (housing units, household size, age, income, accessibility, vehicle ownership).
- [Clearly accessibility and vehicle ownership require knowing something about the network, and so must be solved recursively.]
**Trips at Work End**

- From or to work:
  - Trips = f (jobs(square feet of space by type, occupancy rate))

  e.g. Demand = Trips/Acre = f(Distance from Center)

<table>
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<td>X_s etc</td>
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<tr>
<td>7</td>
<td>X_m</td>
<td>X_c</td>
<td>X_s etc</td>
</tr>
</tbody>
</table>

**Trips at Shop End**

- From or to shop:
  - Trips = f (number of retails workers, type of retail, square foot, location, competition)

  e.g. Demand = Trips/Store = f(Retail Type)

**PM Peak Period Trips By Purpose (DC 1988)**

- Home-End Trip Generation
  - Cross-classification model:
  - The dependent variable is trips per person.
  - The independent variables are dwelling type (single or multiple family), household size (1, 2, 3, 4, or 5+ persons per household), and person age.
  - Figure 1 shows a typical example of how trips vary by age, in this case for work to home trips, for three person households, in both single-family and multi-family residence types.

- Non-Home-End Trip Generation
  - The trip generation rates for both "work" and "other" trip ends were developed using Ordinary Least Squares (OLS) relating trips to employment by type and population characteristics. The variables used in estimating trip rates for the work-end are Employment in Offices (OFFEMP), Retail (RETEMP), and Other (OTHEMP).__

**Specification**

- **Trips By Age**
  - A typical form of the equation can be expressed as:
    \[ T_i = B_1 \times \text{OFFEMP}_i + B_2 \times \text{RETEMP}_i + B_3 \times \text{OTHEMP}_i \]
  - Where:
    - \( T_i \) - Person trips attracted per worker in the ith zone
    - OFFEMP - office employment in the ith zone
    - RETEMP - retail employment in the ith zone
    - OTHEMP - other employment in the ith zone
    - \( B_1, B_2, B_3 \) - model coefficients
Activity Analysis

Frequency: How many times the trip is made per day

Scheduling order in which the trip is made:
- Activity-Home, work, shop, other (Non-Discriminatory)
- Schools, church, visit friends, recreation, out of town (Discriminatory)

Factors: HHM, HHML, and HHMHL
- There are a function of sex, age, employment, state, income, and availability.
- Important things to note in household are the household size (not predictable), household structure is predictable.
- Location availability and time zone feedback.
- Dwelling unit types are obtained from the household pattern and are an indicator of the income, size, household structure. They are single units and multifamily types.
- Time of day: The time of the day can be derived from the pattern and duration of activities.

Como Case

- [See Handout]