Accessibility (continued) & Basics of Travel Demand

Day 6

11.953

Content

- Quick Review of Major Concepts from Last Week
  - Accessibility measures via Gravity Model and Utility-based Model
- Conclusions from Accessibility Lecture
  - "Composite Measures," Deciding on a "Best Measure", Accessibility as *raison d'etre*?
- Travel Demand
  - Basic Characteristics
  - Primary Drivers
  - Influencing Factors
  - International Comparisons
  - Implications for the Future…
- Assignment I
- Other Course Logistic Items

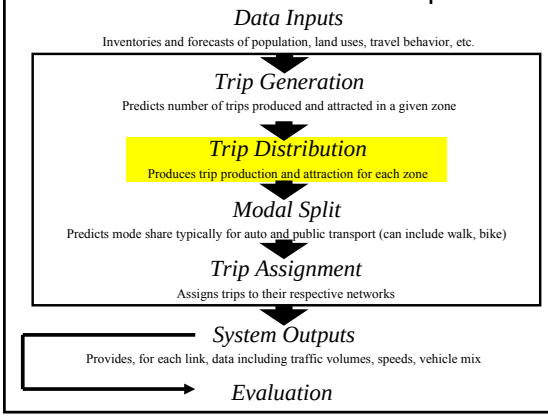
Gravity-based Measures

- Theoretical origins in physics,
- Improvement over distance-based measures, partly because they attempt to better reflect travel behavior realities through their functional form, generally:

$$A_i = \sum_j W_j f(c_{ij}, \beta)$$

- where:
  - W_j represents the opportunities available in a given zone j;
  - $f(c_{ij}, \beta) = \exp(-\beta c_{ij})$ = impedance between zones i and j;
  - c_{ij} represents the travel cost/distance between zones i and j; and
  - β is a travel cost sensitivity parameter.
    - generally enters as a negative exponential function
    - the accessibility measure clearly is highly sensitive to this parameter.
    - Should come from empirical analysis

Back to the "Four Step"



Utility-Based Accessibility: the Logit Model

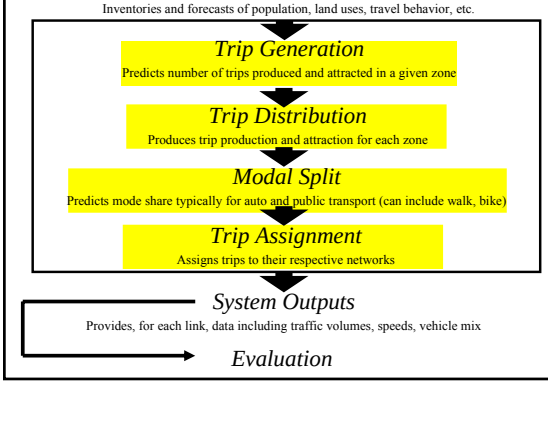
$$P_n(i) = \frac{e^{\mu V_{in}}}{\sum_{j=1}^{j} e^{\mu V_{jn}}}$$

Example: Car or Bus?

- Potential Influencing factors (variables)
  - In-vehicle travel time
  - Out-of-vehicle travel time
  - Traveler income
  - Age
  - Gender
  - Etc.

Normally, Results used to MAKE PREDICTIONS about choices in some future (or alternative)setting

Back to the "Four Step"



Utility-Based Accessibility: The "Logsum" and Nested Logit

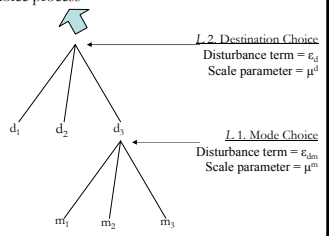
$$P_n(dm) = P_n(m \mid d) P_n(d)$$

"Logsum" at "the root" represents composite benefit ("Expected Maximum Utility") of the entire choice process

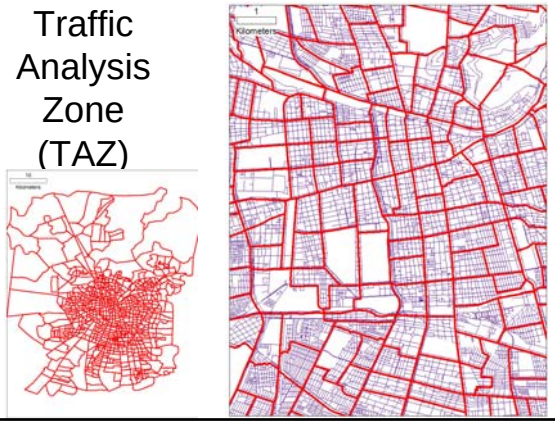
$$P_n(d) = \frac{e^{(V_d + V'_d)\mu^d}}{\sum_{d \in D_n} e^{(V_d + V'_d)\mu^d}}$$

$$V'_d = \frac{1}{\mu^m} \ln \sum_{m \in M_{nd}} e^{(V_m + V_{dm})\mu^m}$$

$$P_n(m \mid d) = \frac{e^{(V_m + V_{dm})\mu^m}}{\sum_{m \in M_{nd}} e^{(V_m + V_{dm})\mu^m}}$$

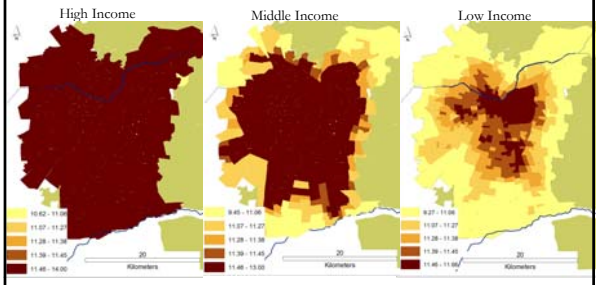


Traffic Analysis Zone (TAZ)



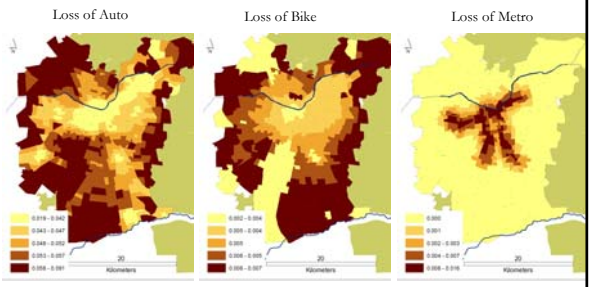
Social Accessibility Levels

Female Adult, Evaluated at Mean Relevant Characteristics for Income Category



Relative Decline in Recreational Accessibility

Middle Income Female



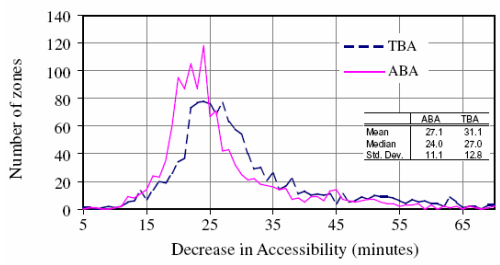
"Utility-based" Measures

- Theoretically appealing
  - Basis in behavioral theory and welfare economics
- Not immediately and easily convertible into meaningful and understandable units
  - Convertible into currency, time, but cumbersome
- Assumes utility linear with respect to income
  - Nonpresence of income effect
- Still *travel-biased* measures
  - Cannot immediately account for non trip-based accessibility (e.g., not traveling; trip-chaining)

"Composite" or "Activity-based" Approaches

- Essentially merging person-based (time-space) with utility-based
- Aims to account for people's activities throughout the day.
- Directly linked to "activity-based" travel research
  - Reflect activity re-scheduling, work-at-home possibilities, etc.
- Data and computationally intensive

Activity-Based Example: Long-Term Impacts of Congestion Pricing



Activity (ABA) versus Trip (TBA)

- Total effects lower (mean and median) for ABA
- ABA accounts for shifting to non-peak, change in activity pattern (e.g., work at home)

Dong et al, 2005.

"Best" Measure?

- No universally-agreed upon criteria
- An "ideal" accessibility measure should reflect:
  - Different preferences among people,
  - Scarcity of people's time *and* money,
  - Range of relevant travel ("impedance") characteristics
    - safety, convenience, comfort, aesthetics, etc.;
  - Range of destination ("opportunity") characteristics:
    - safety, convenience, aesthetics, *diversity*, etc.
  - Relevant traveler characteristics
    - vehicle availability, age, disability status, etc.
  - *And* be "operational," interpretable, easily communicated.

➢ The composite, activity-based approach approaches the theoretical ideal.

See, e.g.: Ramming, 1994; Bhat et al, 2000; Handy and Clifton, 2001; Geurs and van Wee, 2004

Accessibility: Indicator or Variable?

- Examples here have shown accessibility as *Indicator*
  - US Cities accessibility
  - Neighborhood variation (Limanond and Niemeier, 2003)
  - Total User Benefits (Martinez and Araya, 2000)
- Accessibility also used as *variable* (input)
  - As determinant of some behavior or activity, influencing, e.g., residential choice, mode choice, vehicle ownership, etc.
  - Household's worker(s) commute time(s) influencing residential choice
  - distance to bus stops;
  - "neighborhood accessibility";
  - "transit accessibility";
  - number of jobs within certain driving distance;
  - distance to CBD;
  - employment density within certain radii;
  - number of establishments within various radii of home
  - even population density or share of commercial space reflect inherent relative nearness of people, stores, etc.
- And, of course, in combination: e.g., in integrated LUT models

Accessibility as LUT *raison d'etre*?

- The mobility-for-accessibility perspective implies a largely utilitarian perspective
  - we travel to derive accessibility (e.g., "travel is a derived demand")
- But, travel is not always a "means" to an "end,"
  - "travel liking" (due to adventure, variety, independence desires, etc.) and not just for leisure trips, but for routine trips and not just for auto use (see Ory and Mokhtarian, 2005)
  - Extra travel as a means of "information gain" (i.e., better information on products, space, etc.) (Arentze and Timmermans, 2005)
- Travel's role in social class formation
  - E.g., Vasconcellos (1997) details the role of the car in the "making of the middle class."

Basics of Mobility Demand

Relevant Basic Characteristics

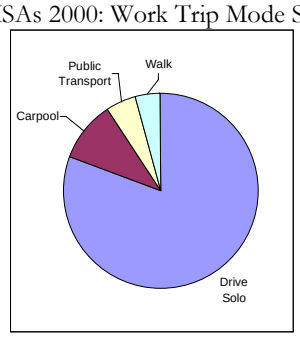
- Purposes:
  - Work, Shopping, Social, Recreational, Business, School, Others
- Origin:
  - e.g., Home-based work, Home-based school, etc. nonhome-based shopping, etc.
- Stage:
  - e.g., Stage 1, 2, etc.
- Mode:
  - car, bus, rail, etc.
- Time of Day:
  - e.g., AM-Peak, Off-peak, etc.
- Tour:
  - combination of trips taken between "anchors" (activity-based modeling); multiple activities in a single tour = "trip chaining"
- Distance, Time, other?

Sources of Data

- Fundamental source
  - Household Origin-Destination Survey
  - Should be calculated for a given Metropolitan Area
- National-level Surveys
  - E.g., Censuses
  - In US: NPTS: 1969, 1977, 1983, 1990, 1995, 2001 (NHTS)
  - 2001 NHTS: 26,000 households, national-level, 24-hour "travel day" diary, plus 28-day "Travel Period" for long-distance travel (see nhts.ornl.gov)

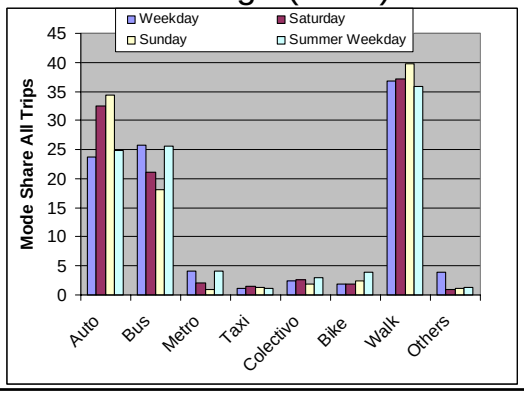
How do people get around?

US MSAs 2000: Work Trip Mode Share



Source: Hanson, 2004.

Santiago (2001)



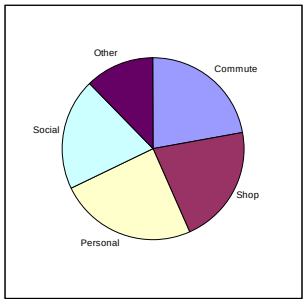
Range of "Developing World" Cities

Image removed for copyright purposes. See Figure 9 in "mobility 2001." World Business Council for Sustainable Development, 2001, p.18.

http://www.wbcsd.org/web/projects/mobility/english_overview.pdf

Source: Various, see WBCSD, Table A-1.

Why do we Travel: Trip Purposes?



Source: U.S. DOE, 2004.

Travel Demand: Relevant Personal Choices

- **Activity choices**
  - result in the number of tours and trips made by a person for a certain purpose
- **Destination choices**
- **Mode choices**
  - car, train, bus, tram, metro, etc.
- **Time-of-day choices**
- **Route choices**

Travel Demand

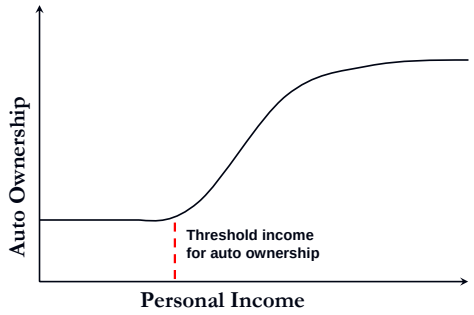
(Activity Choice + Destination Choice + Mode Choice) =

f (Socio-Economics/Demographics, Communication Patterns/Time Routines, Travel Costs (generalized), Modal Availability, Land Use Patterns)

Major Socio-Economic and Demographic Drivers

- Household Income
  - Car ownership
    - although elasticities different at different income levels: e.g., S-curve
  - Longer and more trips
  - Higher demand for speed
    - higher value of time

The Stylized "S-Curve"



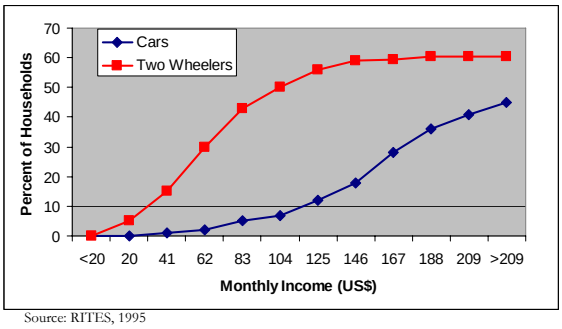
National Motorization Rate Where's the S-Curve?

Figure removed for copyright purposes.
See Willoughby, Christopher. "Managing Motorization." World Bank Report TWU-42, April 2000, p. 8.
http://www.worldbank.org/html/fpd/transport/publicat/twu_42.pdf

Source: Willoughby, 2000, p. 8.

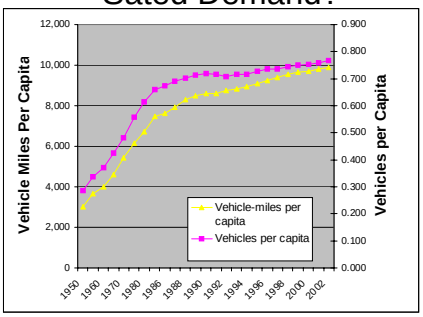
Household-Based S-Curves…

Autos and Motorized Two-Wheelers in Chennai, India (1993)



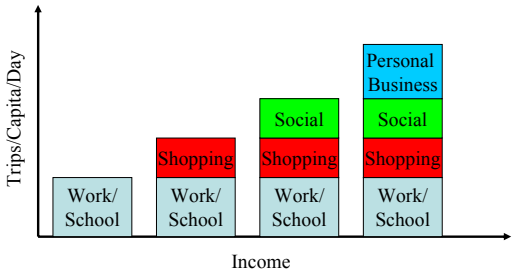
Source: RITES, 1995

U.S. Household Travel: Sated Demand?

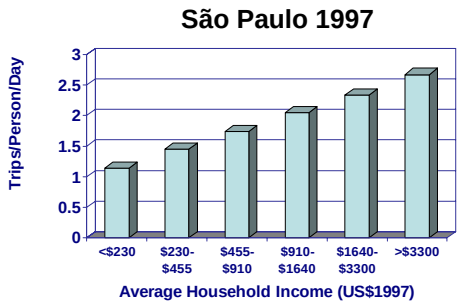


Source: U.S. DOE, 2004.

Income and the Demand for Trips

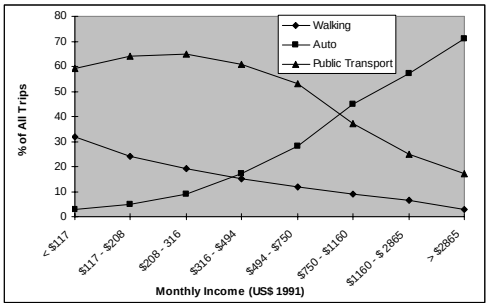


Income and the Demand for Trips



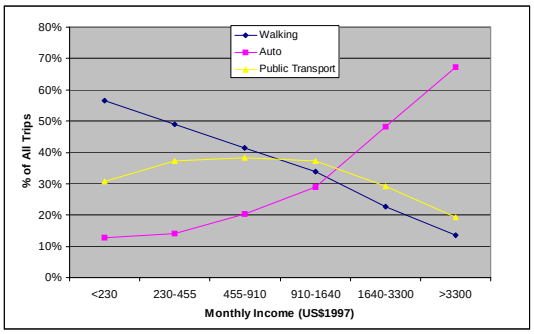
Source: Companhia do Metropolitano de São Paulo, 1999.

Income and Mode Share - Santiago



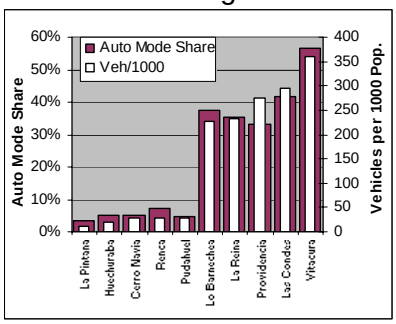
Source: SECTRA, 1991.

Income and Mode Share - São Paulo



Source: Companhia do Metropolitano de São Paulo, 1999.

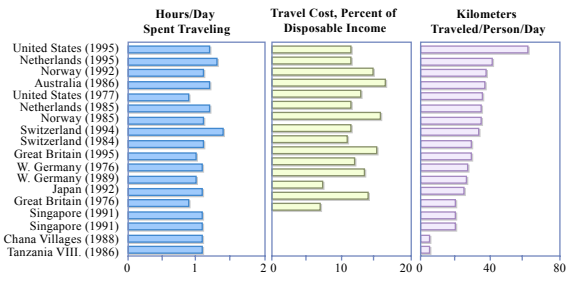
Income, Motorization Rate & Mode Share – Santiago



Source: SECTRA, 1991.

What Does Schafer Say About This?

The Theory of Constant Travel Budgets

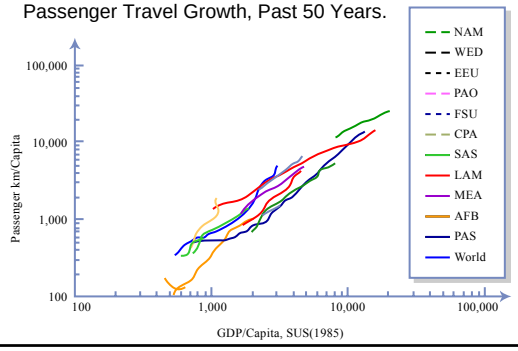


Source: Updated data based on Schafer (1998).

Figure by MIT OCW.

Implies: Increased Income=Increased Travel

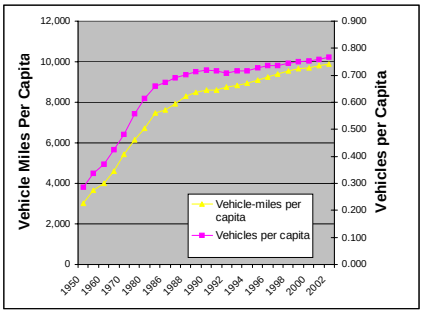
Passenger Travel Growth, Past 50 Years.



Source: Updated data based on Schafer (1998).

Figure by MIT OCW.

How Would Schafer Respond?



Source: U.S. DOE, 2004.

But, be careful with *National* to *Global* Level Averages…