21. Travel Cost Model

1. Introduction

- ➡ Measure values of recreation sites
  - entire sites (beach)
  - characteristics of sites (water quality on a lake)
- ➡ Revealed preference, based on observed behavior (visits to a site)
- ➡ Travel Cost Model
- ➡ Examples of applications
  - ↪ fishing/boating on a lake or lakes
  - ↪ swimming at a beach or beaches
  - ↪ viewing a nature site
  - ↪ hunting
  - ↪ rock climbing
  - ↪ camping in the mountains

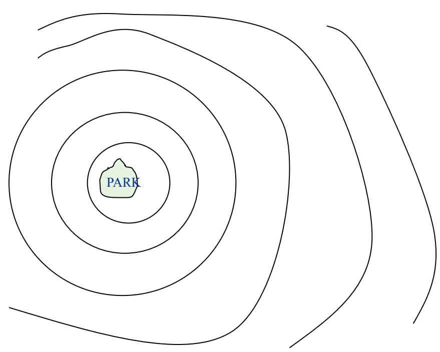
➡Outline

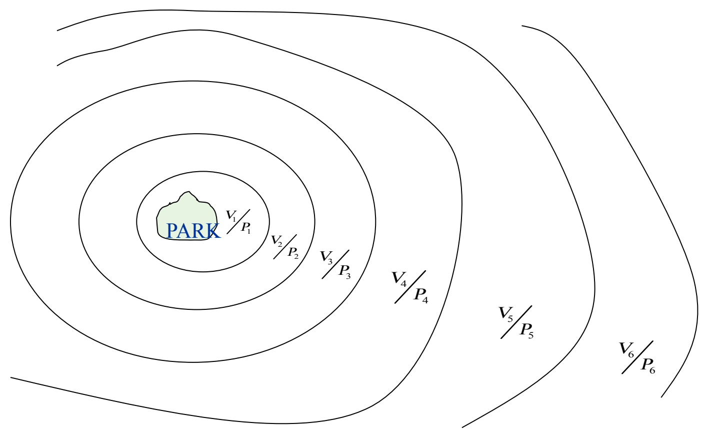
- Intuition and stories
- Modern single site model
  - ↪set-up
  - ↪issues
- Modern multiple site model

2. Intuition and Stories

➡Zonal Travel Cost Model

- Harold Hotelling Letter
- Consider a National Park



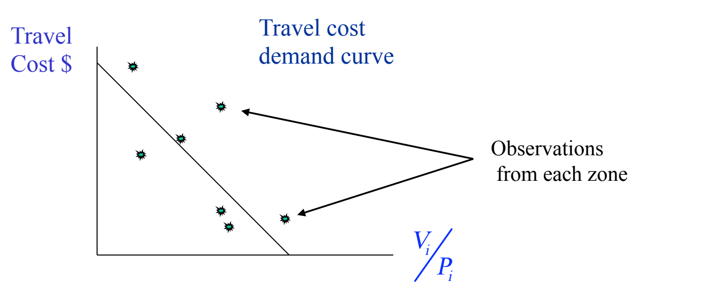


Define:
$V_i =$ No. of visits to park by persons living in zone i
$P_i =$ Population in zone i

What do you observe? Higher rates close in, lower rates far away.

$$V_1/P_1 > V_2/P_2 > V_3/P_3 > \ldots\ldots > V_N/P_N$$

➡Isn't this just the economics of a downward sloping demand curve? A demand curve for recreation trips?



Demand function for recreation trips

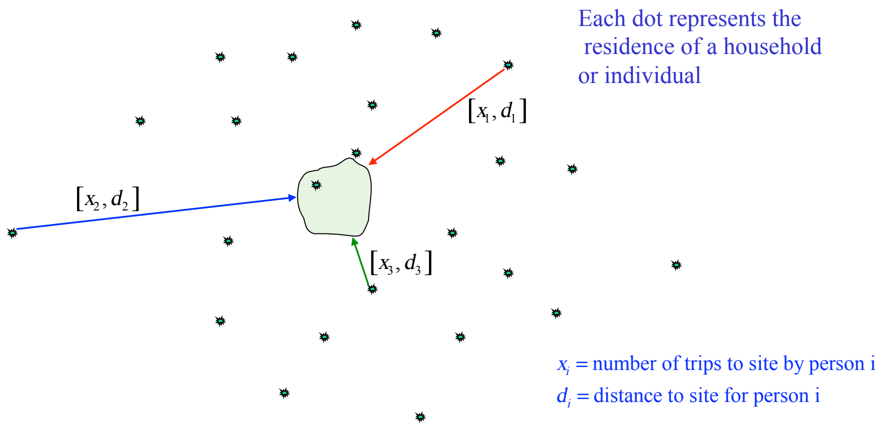
$$V_i/P_i = f(TC_i, Income_i, Education_i, \ldots)$$

Quantity demanded — Price — Shifters

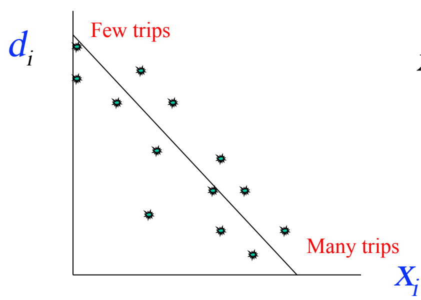
- Estimate with data on visits to park
- Use the demand curve (consumer surplus) estimate to value recreation uses of the park (more on this in the next section)
- Zonal travel cost -- old hat but the principle in modern approaches is the same

3. Modern Single Site Model

- Basic set-up
  - recognizes the same behavior, but works with observations on individuals (not zonal aggregates)



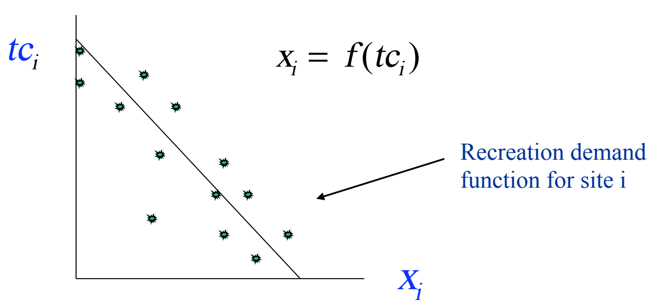
- For each person you know the number of trips made during the season and distance to the recreation site. Again, postulate a travel cost demand curve for recreation.
- Like the Zonal Model we expect the following relationship



$$x_i = f(d_i)$$

$$\left[\frac{df}{dd_i} \right] < 0$$

- Again we are observing the economics of a downward sloping demand function. Substitute (or calculate) travel cost for each distance

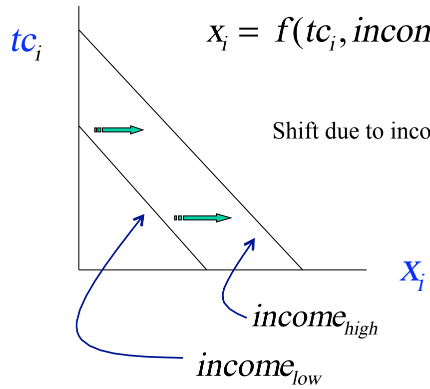


$$x_i = f(tc_i)$$

- Think of travel cost as a surrogate for price

➡Again, we can add shifters. Characteristics that will influence trip taking: income, age, education, experience (eg., fishing), boat ownership

$$x_i = f(tc_i, income_i, fs_i, age_i, ...)$$



➡Price in the model is rather naïve. Can think of more things that make-up the cost of a trip ….fees, time cost and so on. A more common definition of price looks like:

$$price = \begin{pmatrix} travel \\ \cos t \end{pmatrix} + \begin{pmatrix} time \\ \cos t \end{pmatrix} + (fees) + \begin{pmatrix} other \\ related \\ \exp enses \end{pmatrix}$$

Examples:
Lodging, Bait

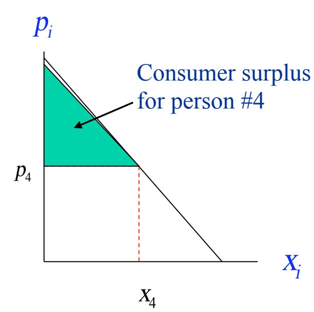
Beware of the hot dog problem!

➡Gather data on trips, location of hometown, and demographics. Calculate price. Then regress trips on tc, demographics. This gives you an estimated demand function.

➡Data set

➡Site value. Calculated in 3 steps using the estimated function

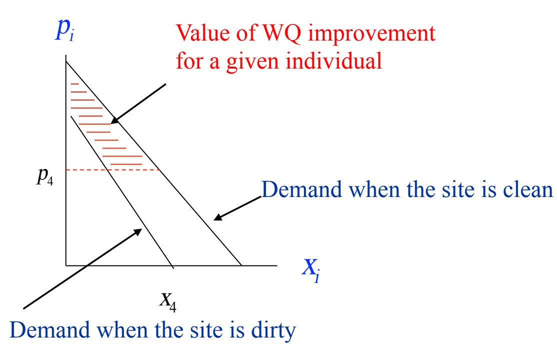
- (1) Calculate the consumer surplus for each individual in the sample. CS for recreation use of the site. For example for person #4 the CS is



- (2) Aggregate to annual values for the population
  - Mean(CS)*Population (eg., Mean(cs)*1,000,000).
- (3)Estimate future values and discount to PV
  - Might have annual values growing w/ population
  - Might have annual values growing w/ income
  - Might have annual values growing due to asymmetric technical change

➡Comments
- Unit-day values (Mean(CS)/x)
- CS for folks near-by vs folks far away

➡Attribute Values
- Examples: water quality, # or trails, beach width



➡In theory you' d like to estimate a demand curve for the site when the water is clean and when it is dirty. Could do it with <u>time series</u> or <u>cross sectional</u> or <u>contingent behavior</u> data. Problem is the number of other variables you need to control for.

➡Comments and Issues

- Measuring the value of time
- The Grandma problem (multiple destinations)
- Substitute sites

$$x_i = f(p_1, p_2, p_3, \ldots.)$$

Enter other site prices

- Nonuse values missed
- Sampling & Pariticipation
- Measuring quality
  - Perceived vs. Actual

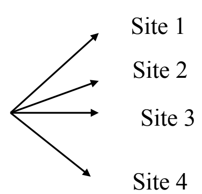
3. Modern Multiple Site Recreation Demand Models

- Systems of Demand equations
- Random Utility Model

➡The Random Utility Model

- Discrete choice model using multinomial logit techniques
- Models and individual's choice of one site from among many possible sites
- The choice of site is assumed to depend on the characteristics of the site, including price (trip cost)

- <u>The RUM Model in deterministic form</u>



Model choice among 4 sites. Estimate the probability of visiting one of these sites as a function of the characteristics of the site.

Individuals pick site w/ Highest utility. So pick site 1 if ...

$$U_1 > U_2, U_3, U_4$$

Consider two scenarios: site loss and quality change at one or more sites:

Site Loss (say site 1 is lost):

If so, choice is now between sites 2, 3, and 4.

How has utility changed as a result of the closure?

@--If person choose site 2, 3, or 4 originally: **no change**.
@--If person choose site 1, then change in utility is

$$\Delta U = MAX(U_2, U_3, U_4) - U_1$$

Quality Change (say wq at site 1 is improved):

How has utility changed as a result of the closure?

Before the quality change person chooses between sites 1, 2, 3 , and 4 with utilities:

- Site 1 U_1
- Site 2 U_2
- Site 3 U_3
- Site 4 U_4

After the quality change person chooses between sites 1, 2, 3 , and 4 with utilities:

- Site 1 U^*_1 ← Note quality change!
- Site 2 U_2
- Site 3 U_3
- Site 4 U_4

If person choose site 1 before cleaning, then utility goes up by

$$\Delta U = U^*_1 - U_1$$

If person chooses site 2,3,or 4 before cleaning, then utility goes up by

$$\Delta U = U^*_1 - MAX(U_2, U_3, U_4)$$

if person chooses site 1 now

$otherwise\ \Delta U = 0.$

To convert to money measures for site closure or quality change divide by coefficient on travel cost!

$$\Delta W = \Delta U / -\beta_1$$

- <u>The RUM Model in stochastic form for estimation</u>

To estimate we assume that each site has the form:

$$U_i = \beta_1 tc_i + \beta_2 wq_i + \beta_3 size_i + \varepsilon_i$$

$$pr_n(k) = pr(U_k > U_i) \text{ for all } i$$

Probability that person chooses site k

$$pr_n(k) = \frac{\exp(\beta_1 tc_k + \beta_2 wq_k + \beta_3 size_k)}{\sum_{i=1}^{4} \exp(\beta_1 tc_i + \beta_2 wq_i + \beta_3 size_i)}$$

This is a special case of the error term having a type 1 extreme value distribution

To estimate, we assume that the error term has some distribution. That will yield a probability of choosing each site and this is loaded into a likelihood function as follows:

$$L = \prod_{n=1}^{N} \prod_{i=1}^{4} pr_n(i)^{t_{in}}$$

$t_{in} = 1$ if individual i visited site n ; and = 0 otherwise.

$$pr_n(k) = \frac{\exp(\beta_1 tc_k + \beta_2 wq_k + \beta_3 size_k)}{\sum_{i=1}^{4} \exp(\beta_1 tc_i + \beta_2 wq_i + \beta_3 size_i)}$$

This is a special case of the error term having a type 1 extreme value distribution

Choose parameters to maximize the likelihood L -- max likelihood estimation.

$$EU = \ln \sum_{i=1}^{4} \exp(\beta_1 tc_i + \beta_2 wq_i + \beta_3 size_i)$$

Site Loss -- loss of site 1

$$\Delta EU / -\beta_1 = \{\ln \sum_{i=1}^{4} \exp(\beta_1 tc_i + \beta_2 wq_i + \beta_3 size_i) \ - \ln \sum_{i=1}^{3} \exp(\beta_1 tc_i + \beta_2 wq_i + \beta_3 size_i)\} / -\beta_1$$

Quality Change -- improved water quality

$$\Delta EU / -\beta_1 = \{\ln \sum_{i=1}^{4} \exp(\beta_1 tc_i + \beta_2 wq_i^* + \beta_3 size_i) \ - \ln \sum_{i=1}^{4} \exp(\beta_1 tc_i + \beta_2 wq_i + \beta_3 size_i)\} / -\beta_1$$

This is the expected utility of a trip

site loss

$$EU^{W} = E\{Max(U_1, U_2, U_3, U_4)\}$$

$$\mathrm{EU}^{\mathrm{WO}} = \mathrm{E}\{Max(U_2, U_3, U_4)\}$$

quality change

$$EU^{W} = E\{Max(U_1, U_2, U_3, U_4)\}$$

$$\mathrm{EU}^{\mathrm{WO}} = \mathrm{E}\{Max(U_1^{*}, U_2, U_3, U_4)\}$$