Lecture 13

Travel cost method

Ivan Rudik
AEM 4510

Roadmap

- How do we estimate the value of recreational goods?

Background

Should we separate the Great Lakes and Mississippi?

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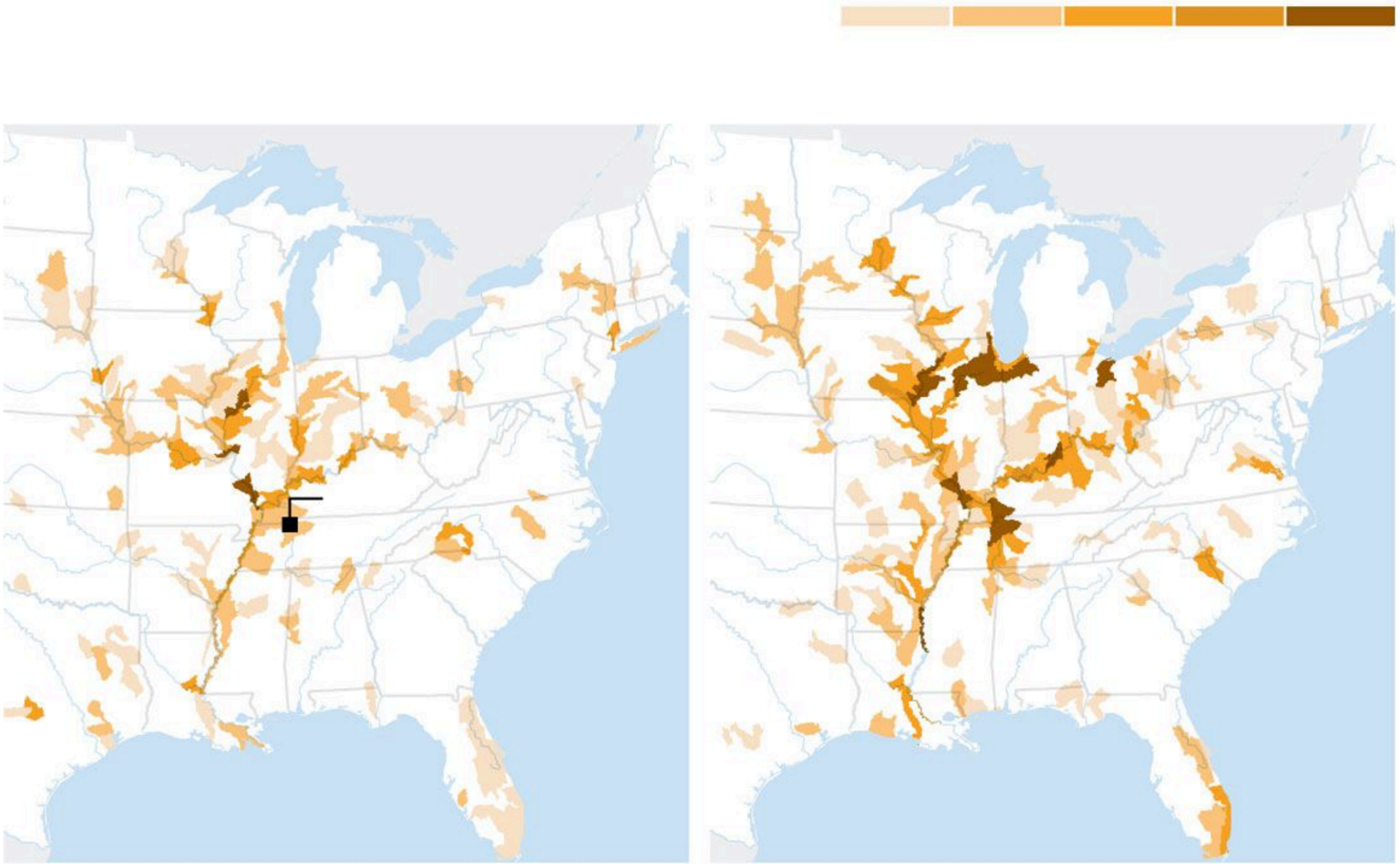

Should we separate the Great Lakes and Mississippi?

The Great Lakes

Carpe diem

Some are worried that Asian carp are poised to invade Lake Michigan

Jul 28th 2012 | From the print edition

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WHEN Eric Gittinger, a biologist, goes to work on the Illinois and Mississippi Rivers, he has to look out. The Asian carp that are swimming up from the South, where they escaped from fish farms decades ago, can leap 10 feet in the air or torpedo themselves twice that distance across the water. Larger fish can weigh 40lb (18kg), and Mr Gittinger gets regularly whacked by them.

Yet what most worries people about Asian carp (in fact, several different invasive carp species) is the fact that they are outeating native fish in the rivers, and now seem poised to invade the Great Lakes. This could harm the $7 billion sport-fishing industry, and damage the ecosystem of the largest body of fresh water in the world.

In 2002 the Army Corps of Engineers (ACE) installed a series of electric barriers 37 miles downriver in the Chicago Sanitary and Ship Canal, an artificial channel that links the lakes with the Mississippi and its tributaries. But people fear they may not be working. Recently, multiple traces of Asian-carp DNA have been found in Chicago's Lake Calumet—far beyond the electric fence (see map), and a stone's throw from Lake Michigan.

Should we separate the Great Lakes and Mississippi?

Benefits from barriers accrue to anglers in the Great Lakes, both commercial and recreational

Costs come from cost of building the barriers plus cost of maintaining them, plus costs of reduced shipping (if any), plus any other costs associated with the barriers

How do we figure out the benefits from recreational anglers?

Why do we need travel cost?

Recreational areas **have value**

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If someone dumped toxic waste in Taughannock does that have zero cost?

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This means that people's WTP to visit can be estimated based on the number of visits they make to sites of different prices

This gives us a demand curve for sites/amenities, so we can value changes in these environmental amenities

Hotelling

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Harold Hotelling proposed the first indirect method for measuring the demand of a non-market good in 1947

Hotelling

> Let concentric zones be defined around each park so that the cost of travel to the park from all points in one of these zones is approximately constant. The persons entering the park in a year, or a suitable chosen sample of them, are to be listed according to the zone from which they came. The fact that they come means that the service of the park is at least worth the cost, and this cost can probably be estimated with fair accuracy.

Hotelling

> A comparison of the cost of coming from a zone with the number of people who do come from it, together with a count of the population of the zone, enables us to plot one point for each zone on a demand curve for the service of the park. By a judicious process of fitting, it should be possible to get a good enough approximation to this demand curve to provide, through integration, a measure of consumers' surplus..

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About twelve years after, Trice and Wood (1958) and Clawson (1959) independently implemented the methodology

Theoretical foundation

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Consider a single consumer and a single recreation site

- Total number of recreation trips: x, to site of quality: q
- Total budget of time: T
- Working time: H
- Non-recreation, non-work time: l
- Hourly wage: w
- Money cost of reaching the site: c; travel time to the site: t
- Expenditures on other market goods: z

Theoretical foundation

This lets us write down the consumer's utility maximization problem:

$$\max_{x,z,l} U(x, z, l, q) \quad \text{subject to:} \quad \underbrace{wH = cx + z}_{\text{money budget}}, \ \underbrace{T = H + l + tx}_{\text{time budget}}$$

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$$\max_{x,z,l} U(x,z,l,q) \quad \text{subject to:} \quad \underbrace{wT = (c + wt)x + z + wl}_{\text{combined money/time budget}}$$

Where now we have one constraint on the dollar value of time

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$$\max_{x,z,l} U(x,z,l,q) \quad \text{subject to:} \quad \underbrace{wT = (c+wt)x + z + wl}_{\text{combined money/time budget}}$$

wT is the consumer's **full income**, their money value of total time budget

$c + wt$ is the consumer's **full price**, their total cost to reach the site

z is their consumption of other goods

wl is the opportunity cost of non-recreation site leisure

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Solve the constraint for z and substitute into the utility function...

Theoretical foundation

$$\max_{x,l} U\left(x, Y - px - wl, l, q\right)$$

Choose trips x and leisure l, this implies an amount of money left over

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and

$$[l] \;\; - wU_z + U_l = 0 \rightarrow \frac{U_l}{U_z} = w$$

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What does this mean?

The value of the marginal recreational trip to the consumer, in dollar terms, is revealed by the full price p

Theoretical foundation

$$U_x - pU_z = 0 \qquad -wU_z + U_l = 0$$

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$$x = f(p, Y, q)$$

This is simply the consumer's **demand curves** for recreation as a function of the full price p, full budget Y, and quality q

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Once we have it, we can compute surplus!

Zonal (single-site) model

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- From a sample of visitors (v_i) at the recreation site, determine zones of origin and their populations (n_i)
- Calculate the per capita visitation rates for each zone of origin $(t_i = (v_i/n_i))$

Zonal (single-site) model

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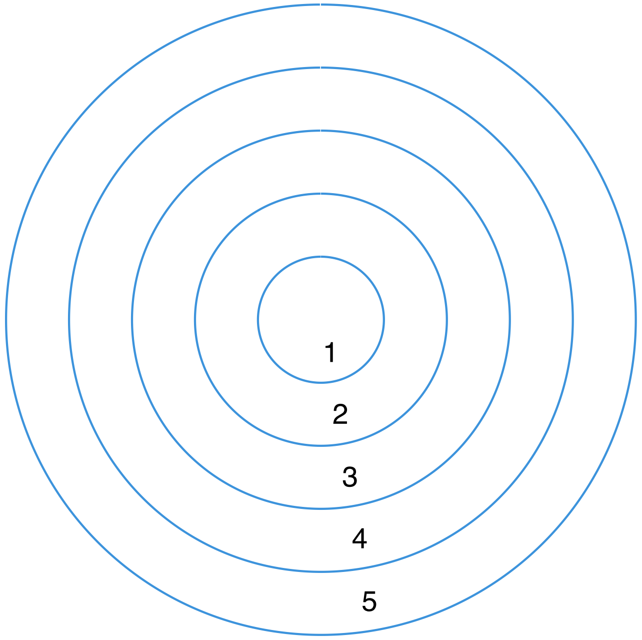
- $t_i = g(tc_i + fee; tc_{si}, s_i) + \varepsilon_i$ where g can be linear

Zonal (single-site) model

Here's a simple example of a set of zones 1-5:



Zonal (single-site) model

Suppose we have the following data:

Zone A	Zone B	Zone C	Zone D	Zone E
Distance: 2	Distance: 30	Distance: 90	Distance: 140	Distance: 150
Population: 10,000	Population: 10,000	Population: 20,000	Population: 10,000	Population: 10,000
Travel cost: 20	Travel cost: 30	Travel cost: 65	Travel cost: 80	Travel cost: 90
Visits per person: 15	Visits per person: 13	Visits per person: 6	Visits per person: 3	Visits per person: 1

If we plot cost by visits per person, we have a measure of the demand curve...

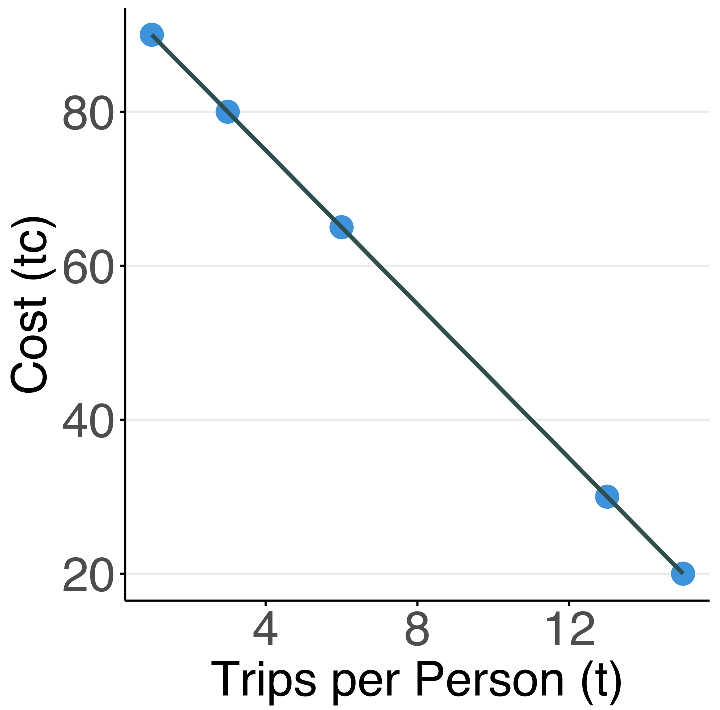
Zonal (single-site) model

This is a very simple example where it happens to be an exactly straight line, most likely the data won't be this perfect

The line is simply:

$$t_i = \beta_0 + \beta_1 tc_i$$

where β_0 is the intercept and β_1 is the slope

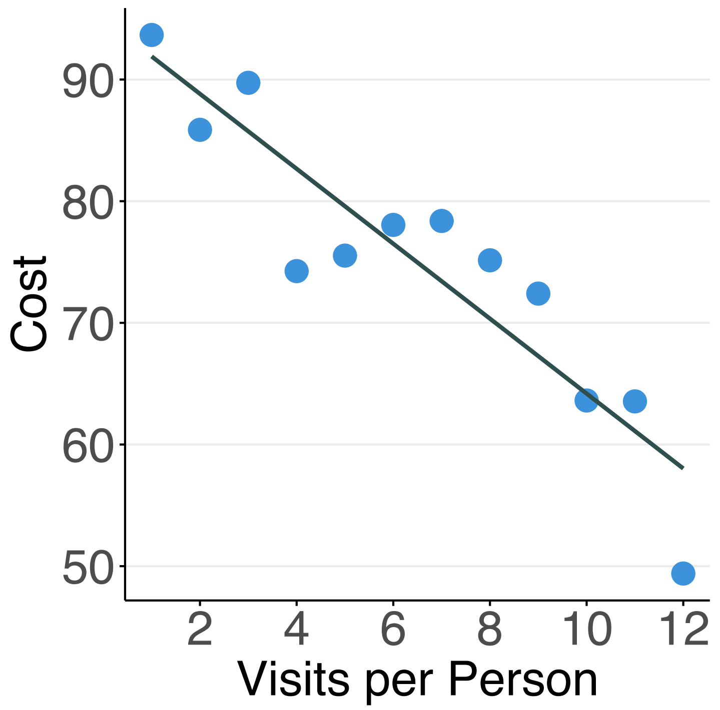


Zonal (single-site) model

The data will most likely look like this, but even this is probably too clean

It ignores things like income, other sites, other household characteristics

For now, we'd continue by fitting a line through the points (OLS/regression)



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The (use) value of the park/site to each zone is given by the area underneath the corresponding demand curve

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What is the right functional form for demand?

How do we measure the opportunity cost of time?

How do we treat multi-purpose trips?

How do we value particular site attributes? Can't disentangle them at a single site

Multi-site model

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What is the benefit of water clarity?

What is the benefit of tree replanting?

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The multi-site model works as follows

Multi-site model

Step 1: Do the single-site estimation for each site:

$$t_{ij} = \beta_{0j} + \beta_{1j} tc_{ij} + \beta_{2j} tc_{sij} + \beta_{3j} s_i + \varepsilon_{ij}$$

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Step 2: Recover all the βs from each step 1 regression so that we have a set of J β_{0j}s for $j = 1 \ldots, J$, β_{1j}s for $j = 1 \ldots, J$, etc

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These βs tell us the slope (β_{1j}) and intercept $(\beta_{0j}, \beta_{2j}, \beta_{3j})$

β_{2j}, β_{3j} capture how the cost of substitute sites and household characteristics matter: they shift demand up and down

Multi-site model

Step 3: Take each set of J coefficient estimates and use them as the dependent variable in a regression on site attributes z:

$$\hat{\beta}_{0j} = \alpha_{00} + \alpha_{01} z_j + \epsilon_{0j}$$

$$\hat{\beta}_{1j} = \alpha_{10} + \alpha_{11} z_j + \epsilon_{1j}$$

$$\hat{\beta}_{2j} = \alpha_{20} + \alpha_{21} z_j + \epsilon_{2j}$$

$$\hat{\beta}_{3j} = \alpha_{30} + \alpha_{31} z_j + \epsilon_{3j}$$

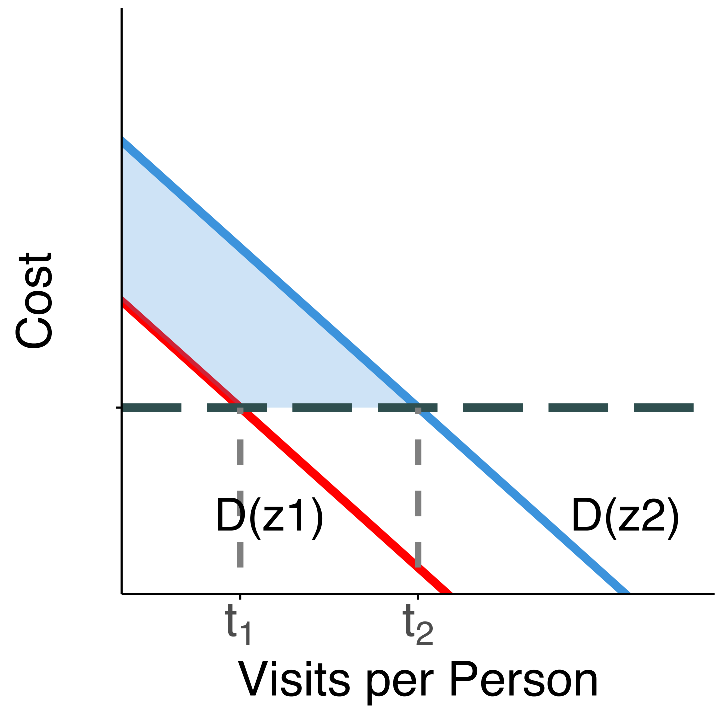
The demand curve shifts with $(\alpha_{00}, \alpha_{01})$ and rotates with $(\alpha_{10}, \alpha_{11})$ as we change site attribute z

Valuing attributes with a multi-site model

If we improve the quality of a site from z_1 to z_2, demand for that site shifts up

The gain in CS, holding the cost fixed, is given by the blue area

Once we estimate demand curves, we can see how welfare changes when we alter quality characteristics!



Multi-site example

Household	Site	Trips	Income	Travel cost	Other-site cost	Water clarity
1	1	4	40450	38.9	16.4	0.51
2	1	5	60304	29.8	37.5	0.51
3	1	5	66681	42.2	67.2	0.51
4	1	5	52886	11.0	51.3	0.51
5	1	5	69282	15.7	7.7	0.51
6	1	5	36948	4.3	48.0	0.51
7	1	6	60866	5.3	91.0	0.51
8	1	5	35557	65.0	160.6	0.51

First stage estimation

Intercept	Own price	Cross price	Income (per $10,000)	Site
2.994	-0.016	0.011	0.321	1
2.448	-0.012	0.010	0.397	2
2.365	-0.020	0.011	0.450	3
2.325	-0.019	0.012	0.438	4
2.045	-0.014	0.014	0.450	5
-0.236	-0.007	0.010	0.321	6
2.665	-0.021	0.012	0.395	7
-0.346	-0.004	0.010	0.324	8
2.983	-0.013	0.011	0.315	9
-0.103	-0.009	0.010	0.302	10
2.060	-0.010	0.012	0.423	11
0.150	-0.008	0.010	0.252	12
-0.251	-0.007	0.009	0.327	13
-0.015	-0.006	0.010	0.276	14
2.549	-0.015	0.013	0.365	15
-0.302	-0.008	0.010	0.327	16
2.370	-0.017	0.011	0.433	17
-0.090	-0.007	0.009	0.313	18

Second stage

Term	Estimate	Demand parameter
Water clarity	47.956	Intercept
Water clarity	-0.171	Own price
Water clarity	0.024	Cross price
Water clarity	1.648	Income (per $10,000)

The estimates column tells us how a change in water clarity (from 0 to 100%), shifts or rotates our demand curve

The income effect is scaled to a $10,000 change in income.

Clearer water $\rightarrow$ more demand, more responsive to price, attracts higher-income people more