N12. Notes on Public Transit

A Model of Mode Choice

- Assume consumers choose modes of transit $i \in \{1, 2, ...N\}$. (Example $i = 1$ automobile, $i = 2$ bus, etc.)

- Individuals face different choice sets:

—Let x_{ij} be the time cost of mode i for consumer j.

—Let c_{ij} be the monetary cost of mode i for consumer j

- Individuals have same preferences.

—α is value of time

—β_i is psychic cost of mode i

- Individual j picks mode i to minimize cost

$$\min_i \left\{ \alpha x_{ij} + c_{ij} + \beta_i \right\}$$

- The demand for mode $i = \#\{$ of j where i solves above problem

Example

- Two modes. $i = 1$ car, $i = 2$ bus

- Note that only $\beta_2 - \beta_1$ matters, so set $\beta_1 = 0$ and let $\beta = \beta_2$.

- An individual takes the bus if and only if

$$\alpha x_1 + c_1 \geq \alpha x_2 + c_2 + \beta$$

or

$$\begin{aligned} -\left[c_2 - c_1\right] &\geq \alpha\left(x_2 - x_1\right) + \beta \\ -\Delta c &\geq \alpha \Delta x + \beta \end{aligned}$$

- Plot data on Δc_j and Δx_j for individuals.

- Estimate α and β.

- Then can use this to consider experiments. Suppose add a subsidy of $\sigma > 0$. Then

$$\Delta c_j' = \Delta c_j^{\circ} - \sigma$$

What is effect on demand?

Generalizations

- Unobserved consumer heterogeneity

—Logit error terms ε_{ij}

—Random coefficients

—See Nobel prize winning work of Daniel McFadden

- Richer model of demand (time cost varying by mode, etc.)

- Selection issues?

- Short-run vs. Long run?

Economics of Public Transit

- Natural Monopoly?

—Graphical discussion of what natural monopoly is

—Optimal pricing under natural monopoly

(i) case of break-even contraint for government (second best)

(ii) no break-even constraint. $P = MC$

A Richer Model with Endogenous Quality

- Let $x \geq 0$ denote product quality (frequency of service is key for public transit)

- Let p be price of the produce. Consumers care about $n = p - x$, price net of value

- Let $D(p-x)$ be demand per person at the net price. Assume $D' < 0$.

- Assume m individuals to $mD(p-x)$ is total demand at net price $p - x$.

Cost Structure

- Let $f(x)$ be the fixed cost to provide quality x. Assume $f(0) > 0$, $f'(x) > 0$.

- Let c be marginal cost.

- So if x is contrained to be 0 then problem is simple case covered earlier.

Problem with no break-even constraint

$$\begin{aligned} & \max_{p,x} \text{Consumer Surplus - Total Cost} \\ = \; & \max_{p,x} \; [\text{area under demand}] - mD(p-x)c - f(x) \end{aligned}$$

- Clear that given x, set $p = c$ (price equal marginal cost)
- Now pick x. Graphical argument
- Clear optimal x is increasing in market size m

Problem with break-even constraint

- Clear in optimum firm breaks even

- So problem boils down to maximizing consumer welfare or

$$\min_{p,x} p - x$$

$$\text{subject to } mD(p-x)(p-c) \geq f(x)$$

- Clear optimal x is increasing in m..

- Logic here is that subsidies are contributing to fixed cost. In the analysis above consumers pay at least marginal cost

- Subsidize marginal cost?

—Some economic justification if congestion externality for driving and can't set congestion tax.

—Always more efficient to use congestion tax if can do it

- Fare box ratios (percentage of operating cost covered by fares)

Bus	32%
Heavy Rail	57%
Light Rail	34%
Commute Rail	49%
All Public Transit	38%

Hiawatha Light Rail

- Construction FundingConstruction funding: (in millions $)

Federal Transit Administration - $334.3

State of Minnesota - $100

Metropolitan Airports Commission - $87

Hennepin County Regional Rail Authority - $84.2

Federal Grant for Congestion Mitigation & Air Quality - $49.8

Transit capital grant - $39.9

Minnesota Department of Transportation - $20.1

TOTAL $715.3

- Ridership

24,600 a day by 2020 (optimistic)

12,300 round trips

Construction cost per round trip=$60,000

- Public Transit in Twin Cities metro area

—250,000 trips a day

—10,000,000 total trips, 2.5% share. (no surprise few notice the strike)