Delay Due to Highway Congestion

- Estimates from Texas Transportation Institute
- 40 hours per person per year for California cities
Preview

☐ Paper Rubric
☐ A model of highway congestion
☐ What can be done
Highway Capacity

☐ One lane from A to B
☐ Distance is 10 miles
☐ Speed limit is 60 mph
☐ At 60 mph, 10 minutes
☐ How many cars make the trip during a 10 minute interval?
10 miles between cars

1 car per period
5 miles between cars

2 cars per period
2 miles between cars

6 cars per period
no space between cars

2,640 cars per period
(5,280ft x 10/20ft)
Traffic Time and Travel Volume

10 minutes

2,640 travelers per period
What’s Wrong With This Picture?

minutes

10

2,640 travelers per period
A Better Picture

minutes

2,640 travelers per period

10
Freeway Travel Time from A to B

minutes

no congestion

congestion

f(n)

n, travelers per period
The Cost of Traveling from A to B

- $n$ is travelers per period
- Travel time on freeway: $f(n)$
- Value of time: $v$
- Cost of traveling from A to B

$vf(n)$
The Demand for Travel

☐ Commuters have alternatives
  ■ Mass transit
  ■ Commute at different hours

☐ Given alternatives, each commuter has a willingness to pay to travel on highway during a particular period

☐ If WTP > cost, commute on highway
A Demand Curve for Travel

Order commuters by willingness to pay

$/trip

commuters
Equilibrium

$/trip  

private cost  

demand

\[ n^e \]
Total Cost for Freeway Drivers

Cost if n-1 travelers on freeway:
\[ v(n-1)f(n-1) \]

Cost if n travelers on freeway:
\[ vnf(n) \]
Marginal Cost

Increase in cost from one more traveler on the freeway:

\[ v(n)f(n) - v(n-1)f(n-1) \]

\[ = v(n-1)f(n) + vf(n) - v(n-1)f(n-1) \]

\[ = v(n-1)[f(n)-f(n-1)] + vf(n) \]
Marginal Cost

\[ = v(n-1)[f(n)-f(n-1)] + vf(n) \]

- External cost
- Internal cost (private cost)
The Calculus of Marginal Cost

\[ C(n) = nvf(n) \]

\[ C'(n) = nvf'(n) + vf(n) \]

- external cost
- internal (private) cost
Marginal Social Cost

MSC

$/$trip

$v(n-1)[f(n)-f(n-1)]$

vf(n)

n
Optimum vs Equilibrium

$/\text{trip}

MSC

vf(n)

n^o

n^e

n
Achieving Optimum through Congestion Toll

MSC

vf(n)

$toll, \ p$

$/\text{trip}$

$n^o \quad n^e$

$n$
Gain to Society

$/trip

MSC

vf(n)

Reduction in cost

Reduction in benefit

n

n^o

n^e
Winners and Losers

- Commuters?
- Government?
An Application: SR91

- State Road 91
- Express lanes in median (4 lanes)
- 10 mile stretch from Riverside to Anaheim
- Toll depends on time of day
- Toll recorded from transponders
Location of SR91X
Heading East -- Evening Rush Hour
Express Lanes
History of SR 91X

- OC having difficulty funding new highways
- Legislature allowed private developers to construct toll highway in median of SR 91
- Opened in 1996
Tolls - 2000

- **Wednesday- Westbound**
  - 12 a.m. – 4 a.m. $0.75
  - 4 a.m. – 5 a.m. $1.65
  - 5 a.m. – 6 a.m. $2.90
  - 6 a.m. – 7 a.m. $3.00
  - 7 a.m. – 8 a.m. $3.30
  - 8 a.m. – 9 a.m. $3.00
  - 9 a.m. – 10 a.m. $2.25
  - 10 a.m. – 7 p.m. $1.50
  - 7 p.m. – 12 a.m. $0.75
Overhead antennas "read" the Fastrack transponder mounted on the windshield and the computer's account is automatically debited as the vehicle enters the express lanes.
Findings About Use

- Proportion of commuters using rises with income
- Proportion is higher for females
SR 91 Revenues and Costs

- Toll Revenue is covering maintenance and construction costs
- Sold back to public in 2002
  - Original franchise had “non-compete” clause which prohibited expansion in capacity
  - Public authority planning capacity enhancing changes
Congestion tolls can finance road construction and maintenance
Conclusion

- When road has limited capacity, may have congestion
- With congestion, additional travelers impose cost on others
- Individuals ignore those costs
- Too much traffic on roadway
- Toll internalizes external cost
Next Time

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Chapter 8
Transportation
“Fiscal Realities”
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