Pricing of Transportation Services: Theory and Practice II

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Transportation Systems Analysis: Demand & Economics

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Review and Outline

● Review of Previous Lecture:
  – Review of cost and demand concepts
  – Public sector pricing in theory
  – Issues with marginal cost pricing
  – Congestion pricing in theory

● Outline of this Lecture:
  – Public sector pricing in practice:
    • **Congestion pricing**
    • Pricing vehicle emissions
    • Public Transportation
  – Private sector pricing in theory and in practice
  – Appendix: Examples of congestion pricing
Characteristics of the congestion problem

- Severity
  - Magnitude: between Lyon and Paris on 16 Feb 1980, a traffic jam (queue) of 109 miles (176 km) (Guinness Book of World Records, 2007)

- Economic cost
  - Urban Mobility Report (TTI, 2004): 2002 cost of congestion in U.S. (lost time, excess fuel, increased VOC) was US$63.5 billion

- Unpredictability
  - It’s estimated that over half the delays on freeways in the U.S. are due to non-recurrent events (accidents, breakdowns, etc.)
Congestion Pricing in Practice (cont.)

- Concerns over congestion pricing
  - “Driving should be free”
  - Equity
  - Use of revenues
  - Privacy/Confidentiality
Congestion Pricing in Practice (cont.)

- Ideal features of a congestion pricing scheme
  - Sensitivity to true marginal costs of auto use
    - By level of congestion
    - By time of day
    - By direction of travel
    - By area of travel
  - Transparency
  - Predictability
Congestion Pricing in Practice (cont.)

● Short-term reactions to congestion pricing
  – Suppress trips
  – Change departure time
  – Change mode
  – Change destination/chain trips
  – Change route
  – Carpool (share costs, exploit exemptions)

● Long-term reactions to congestion pricing
  – Land use / activity system change
Examples of Congestion Pricing

- Singapore Area Licensing Scheme (ALS) and Electronic Road Pricing (ERP)
- Trondheim toll ring
- Autoroute A1 (Paris – Lille)
- California SR-91 (“value pricing”)
- London congestion charging scheme
- Stockholm Congestion Charge
- New York City: tried but defeated politically
Examples of Congestion Pricing (cont.)

- Lessons learned:
  - Pricing does cause travelers to change their behavior
    - But wide variety of price levels / system impacts
  - Almost all pricing schemes to date are blunt
    (not very sensitive to congestion costs or levels)
    - Cordon or individual facility based
    - Limited variation by time of day (e.g. peak/off-peak)
  - Public acceptance is key to success
    - Perception of current traffic problems
    - Promise to use proceeds to fund local improvements
      or perception of choice options
    - Addressing confidentiality concerns
    - Political leadership
Outline

● Public sector pricing in practice:
  – Congestion pricing
  – Pricing vehicle emissions
  – Public Transportation
● Private sector pricing in theory
● Private sector pricing in practice:
  – Amtrak
  – Airlines
● Appendix: Examples of congestion pricing
Pricing Vehicle Emissions

- Increasing concerns over the **externalities** associated with the automobile:
  - Noise
  - Accidents
  - Petroleum Usage
  - Emissions
    - $\text{CO}_2$
    - $\text{NO}_x$
    - Particulates
Pricing Vehicle Emissions (cont.)

- Governments are looking for ways to reduce output of CO$_2$ and toxic emissions
- How to make these reductions while minimizing the overall welfare cost?
- Many available policy options:
  - Regulation/Standards (forcing technology)
  - Pricing
  - Taxes
  - Other rule-based approaches
Pricing Vehicle Emissions (cont.)

- Amount of emissions depends on
  - Amount of driving
  - Type of driving
  - Physical characteristics of vehicles and fuels
  - Vehicle maintenance

- Effect of changes will **not** be instantaneous – need a dynamic model

- Because drivers respond both to speeds and costs, should be considered simultaneously with congestion
Pricing Vehicle Emissions: EU Study*

- Reducing CO₂ emissions
  - Dominated by transport emissions
  - Projected to rise 40% in EU from 1990 to 2010

- Most cost-effective instrument would be **tax on carbon content of fuel**
  - Affects all behavioral “leverage” points
  - Allow consumers to equalize marginal costs appropriately

- But…taxes already high, and alternatives often limited, so is quite difficult politically

Pricing Vehicle Emissions: EU Study (cont.)

- Also – consumers appear to have high “discount rate” on purchasing fuel efficiency
- Found that to achieve 10% reduction in CO₂ emissions compared to baseline required 26% increase in fuel prices
  - Despite “myopia”, more than half came from technical improvements in vehicle fuel consumption
  - Modest reduction in mileage and car ownership
  - Moderate increase in speeds
Pricing Vehicle Emissions: EU Study (cont.)

- What about other options?
  - Standards
  - “Feebate” (taxes and subsidies on certain cars)
  - Feebate and fuel tax
  - Road pricing
- Best result appears to be combination of fuel taxes with differentiated purchase taxes (subsidies)
Outline

- Public sector pricing in practice:
  - Congestion pricing
  - Pricing vehicle emissions
  - Public Transportation pricing
- Private sector pricing in theory
- Private sector pricing in practice:
  - Amtrak
  - Airlines
- Appendix: Examples of congestion pricing
Public Transportation Pricing

- Current state:
  - Low fares cover under 50% of operating expenses. No contribution to capital expenses
  - High level of subsidy
Arguments for Low Fares

- The vicious cycle
- Economies of scale
- Second best pricing
- Equity considerations
The Vicious Cycle

- Assumes that after multiple fare increase the demand is elastic, $|E| > 1$
- Estimated elasticities $\sim (-0.4)$

Outline

- Public sector pricing in practice
- **Private sector pricing in theory**
  - Basic idea
  - Relation to marginal cost pricing
  - Price discrimination
  - Segmented pricing
  - Revenue-maximizing Price
- Private sector pricing in practice:
  - Amtrak
  - Airlines
- Appendix: Examples of congestion pricing
Private Sector Pricing

- Private firms maximize profit
- Profit = Total Revenue – Total Cost
- Max \( R(Q) – C(Q) \)

- Firms should set prices such that

\[
MR(Q) = MC(Q)
\]
Profit-Maximizing Price

- Total revenue
  \[ R(Q) = p \cdot Q = D^{-1}(Q) \cdot Q \]

- Marginal revenue
  \[ MR(Q) = p + Q \cdot \frac{\partial p}{\partial Q} = p + Q \cdot \frac{\partial D^{-1}(Q)}{\partial Q} \]

- Therefore
  \[ p = MR(Q) - Q \times \frac{\partial D^{-1}(Q)}{\partial Q} \geq MC(Q) \]

\[ \frac{p - MC(Q)}{p} = \frac{Q}{p} \cdot \frac{\partial D^{-1}(Q)}{\partial Q} = \frac{-1}{\frac{\partial Q}{\partial D^{-1}(Q)} \cdot \frac{p}{Q}} = \frac{-1}{E_{Q|p}} \]
Profit-Maximizing Price (cont.)

- Under competition

\[ Q \cdot \frac{\partial D^{-1}(Q)}{\partial Q} \approx 0 \]

because the firm is a price-taker (its output does not affect market prices); hence:

\[ p = MC(Q) \]

i.e., in a competitive market prices are likely to be close to marginal costs \( \Rightarrow \) social optimum.
Price Discrimination

- In a fully competitive market, if a firm tries to charge prices higher than marginal cost, it will be undercut.

- In a less competitive market, firms maximize profits by charging different prices ($P > MC$) to different customers.
Price Discrimination (cont.)

- First buyer willing to pay $p_1$ for $Q_1$, the firm charges $p_1$ and the revenue is $p_1 Q_1$
- Second buyer: $p_2$ for $(Q_2 - Q_1)$, the firm charges $p_2$
- Second buyer cannot sell his/her parts to the first buyer
- Monopolistic firm will produce $Q^*$ where the marginal buyer is not willing to pay above the MC
- Price discrimination is economically efficient, but all the consumer surplus is extracted by the monopolist
Segmented Pricing

- Market for travel can be subdivided into different segments with different price sensitivities

- Various strategies of segmented pricing can increase revenue (e.g. regular commuters vs. business travelers)

- Revenue potential can be increased if price increases can be implemented for inelastic segments (i.e. business travelers) and vice versa
Segmented Pricing: Example

- Determination of the level of toll for a tunnel
- Separate price sensitivity for occasional travelers and commuters
- Offer discounts to commuters and charge high toll for occasional travelers
- More potential for profit maximization by attracting price-sensitive drivers without reducing the price for less price sensitive ones
- Concern for exceeding available capacity due to number of drivers paying the lowest toll
Revenue-Maximizing Price

- Often used when price changes have a negligible effect on cost
- Pricing changes to maximize revenue should be aimed at achieving and maintaining a price elasticity of -1
- Appropriate when marginal or variable cost is small compared to average cost
- Cost structures of most transportation services include some variable component
Revenue-Maximizing Price (cont.)

- So, a price increase that causes a demand decrease is generally associated with decreasing total cost and vice versa.
- A price reduction is profitable only if the increase in revenue is greater than the increase in total variable cost.
- If the cost structure includes a relatively small variable cost, revenue maximizing price should be set to maintain demand in the range where price elasticity is slightly smaller than -1.
Revenue-Maximizing Price (cont.)

- If demand is highly elastic, a price reduction should be implemented to keep the price elasticity in the elastic range and bring it closer to \(-1\)
- But large price reductions may increase demand well beyond capacity
- Adding capacity would require significant incremental costs that may be infeasible
- So, pricing strategy should be to raise prices in inelastic markets and vice versa if there is enough capacity available
Profit Maximizing Price, Competition, and Price Discrimination

● In an imperfectly competitive market
  – The firm will set the price above marginal cost
  – Its extent will depend on the price sensitivity

● In case of segmented pricing (or price discrimination)
  – If the price charged to one customer does not affect the quantities purchased by others then this pricing rule applies to each individual customer or segment
  – The less sensitive the customer is to price, the more he/she will pay relative to others
Profit Maximizing Price, Competition, and Price Discrimination (cont.)

- Perfect competition makes price discrimination difficult
  - As competitors will undercut any firm charging more than the marginal cost
- Price discrimination is a sign that competition is imperfect
- In a perfectly competitive market, the prices all firms charge to all customers should be the same
Outline

● Public sector pricing in practice
● Private sector pricing in theory
  – Basic idea
  – Relation to marginal cost pricing
  – Price discrimination
  – Segmented pricing
  – Revenue maximizing
● Private sector pricing in practice:
  – Amtrak
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Example: Pricing at Amtrak

Strategy

- Objective is to maximize revenue
  - Consistent with a fixed cost structure

- To achieve the objective, Amtrak must have knowledge of passenger price sensitivity and competition

- Amtrak’s pricing strategy
  - To raise prices in inelastic markets and to lower prices in elastic market with excess capacity to meet increased demand
  - Else extra demand will need excess capacity
Example: Pricing at Amtrak

● Main alternatives are travel by car, air or bus

● Monitor changes in the price of gasoline and air travel and respond accordingly
  – For example, Amtrak will follow an airline fare increase by a corresponding fare increase for its service

● Revenue gains by changing fares in a competitive market, i.e. travel between end points, may be offset by revenue losses in less competitive markets, i.e. travel involving intermediate points along the same route
Example: Pricing at Amtrak
Segmented Pricing and Yield Management

- Pleasure travelers vs. business travelers
- Offer discounts to early purchasers of tickets
- The danger of segmented pricing
  - Lower fare passengers may largely take the available inventory (if it is fixed)
- So, yield management system is used to adjust seat inventory (seat allocation among different price levels based on expected demand)
- Yield management can only be applied to reserved trains (as it depends on advance bookings)
Example: Pricing at Amtrak
Effectiveness of Pricing Decisions

• Measuring price elasticities based on two sources
  – Previous price changes and their effect on demand and revenue
  – Explicit experiments designed to investigate price sensitivities

• Pricing experiments can only be conducted in certain markets characterized by
  – Relatively low demand with excess capacity even at minimal train frequency
Example: Airline Pricing

● Deregulation in the industry since 1978
● Successful experience
  – Average lower fares
  – Increase in air travel
● More variation in fares across segments
  – Due to differences in airline costs and to price discrimination

● Much more on this in Prof. Belobaba’s upcoming lectures
Conclusions

- Pricing and investment policies for transportation services are often far from optimal
- Marginal cost pricing difficult in transportation sector
- Dissatisfaction with the outcome of public transportation services
- Increasing use of price discrimination (segmented pricing)
- Knowledge of demand and price sensitivities is critical
Appendix

Examples of congestion pricing
Applied Examples of Congestion Pricing

- Singapore Area Licensing Scheme (ALS) and Electronic Road Pricing (ERP)
- Trondheim (Norway) Toll Ring
- Autoroute A-1, Paris – Lille, France
- California SR91 “Value Pricing”
- London Congestion Charging Scheme
- Stockholm Congestion Tax
- New York City (tried, but failed)