Pricing of Transportation Services: Theory and Practice II

Moshe Ben-Akiva

1.201 / 11.545 / ESD.210
Transportation Systems Analysis: Demand & Economics

Fall 2008

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

Congestion Pricing in Practice

- Characteristics of the congestion problem
  - Severity
    - Avg. speed: Manhattan: 6 mph (Traffic Congestion Mitigation Commission of NYS DOT, Interim Report for Public Comment, 2007); London: 9 mph (Transport for London Congestion Charging Group, Impacts Monitoring – First Annual Report, 2003)
    - 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
    - CO_2
    - 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 CO_2 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

*: Jansen, Heinz and C. Denis (1999), "A welfare cost assessment of various policy measures to reduce pollutant emissions from passenger road vehicles", *Transportation Research D*, Vol. 4, pp379-396.

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 CO_2 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

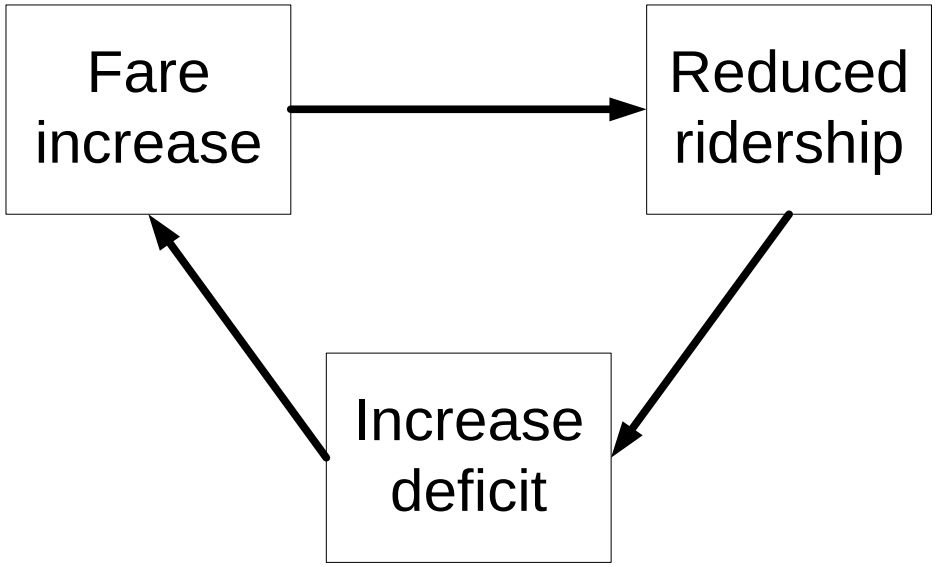
Public Transportation Pricing

- 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 ~(-0.4)

Source: Goodwin, P (1992) Review of New Demand Elasticities With Special Reference to Short and Long Run Effects of Price Changes, *Journal of Transport Economics*, Vol. 26, No. 2, pp. 155-171.

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

$$\mathrm{MR}(Q) = \mathrm{p} + Q \cdot \frac{\partial \mathrm{p}}{\partial Q} = \mathrm{p} + Q \cdot \frac{\partial \mathrm{D}^{-1}(Q)}{\partial Q}$$

- Therefore

$$\mathrm{p} = \mathrm{MR}(Q) - Q \times \frac{\partial \mathrm{D}^{-1}(Q)}{\partial Q} \geq \mathrm{MC}(Q)$$

$$\frac{\mathrm{p} - \mathrm{MC}(Q)}{\mathrm{p}} = -\frac{Q}{\mathrm{p}} \cdot \frac{\partial \mathrm{D}^{-1}(Q)}{\partial Q} = \frac{-1}{\frac{\partial Q}{\partial \mathrm{D}^{-1}(Q)} \cdot \frac{\mathrm{p}}{Q}} = \frac{-1}{\mathrm{E}_{Q|\mathrm{p}}}$$

Profit-Maximizing Price (cont.)

- Under competition

$$Q \cdot \frac{\partial \mathrm{D}^{-1}(Q)}{\partial Q} \cong 0$$

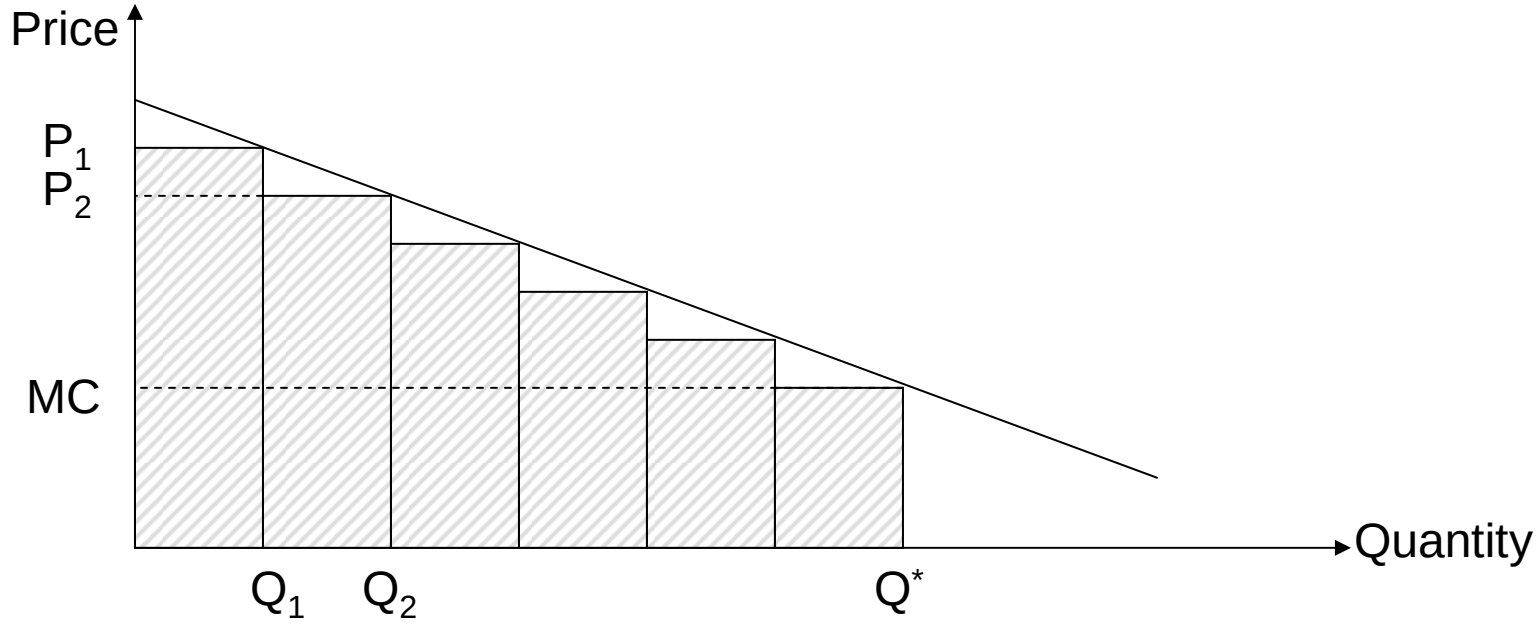
because the firm is a price-taker (its output does not affect market prices); hence:

$$\mathrm{p} = \mathrm{MC}(Q)$$

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 (> 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 that -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
  - Airlines
- Appendix: Examples of congestion pricing

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 Competition

- 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
- Stockohlm Congestion Tax
- New York City (tried, but failed)

1.201J / 11.545J / ESD.210J Transportation Systems Analysis: Demand and Economics
Fall 2008