Congestion Pricing on Highways: Expectations and Results

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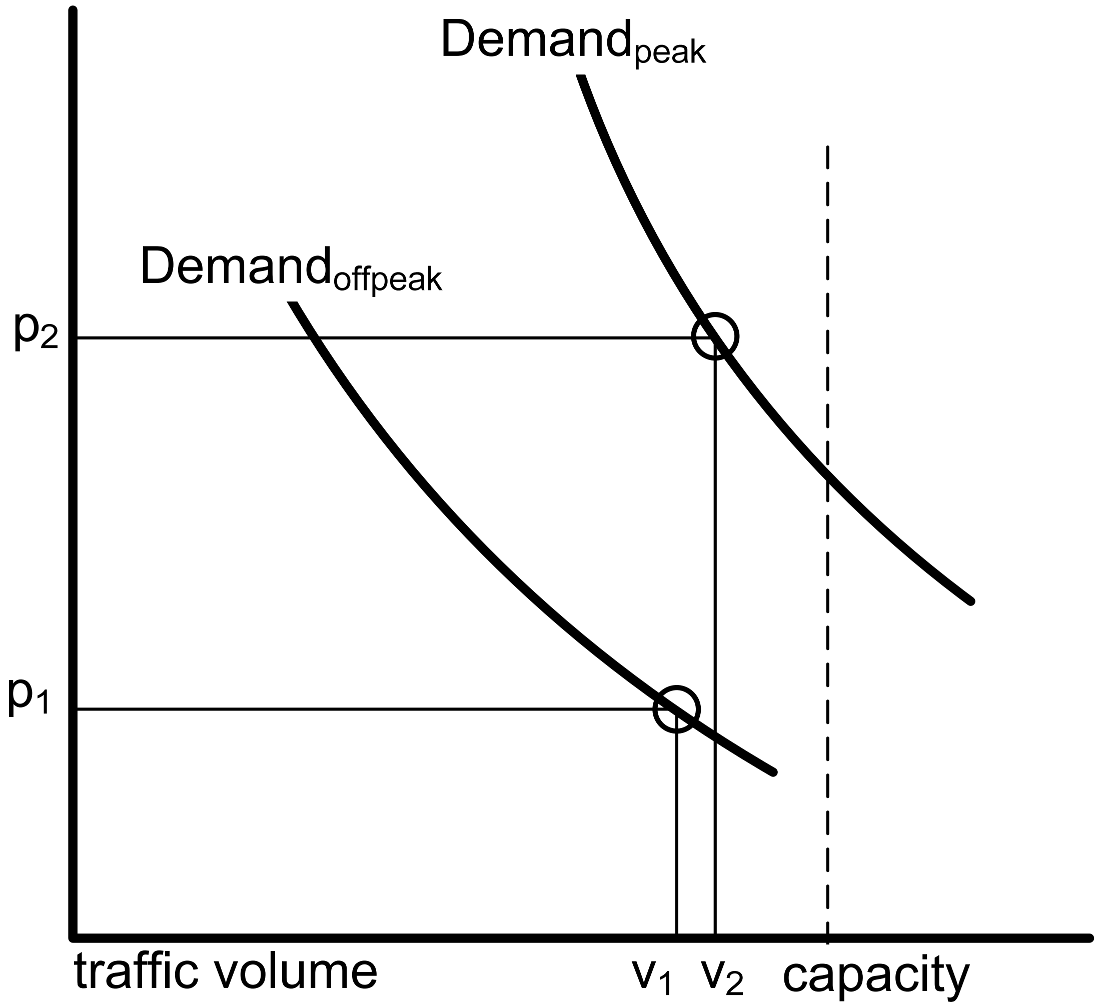
History

- congestion pricing was understood before Adam Smith
- toll roads existed before there were cars
- peak pricing is applied in many familiar sectors (hotels, power, entertainment, sports)
- marginal cost pricing has long been well known and known to apply to highway congestion
- advent of electronic cargo tag (transponder) improved the feasibility of pricing, but ETC was slow in coming to highways
- implementation has occurred incrementally and in dispersed locations
- countertrend is to avoid charging users because that focuses the political resistance (a small diffused tax causes less opposition)
- user charges tend to be preferred by consumers because they escape the charge if they don't consume
- both the number and breadth of applications as well as general interest have been growing geometrically the past 5-10 years

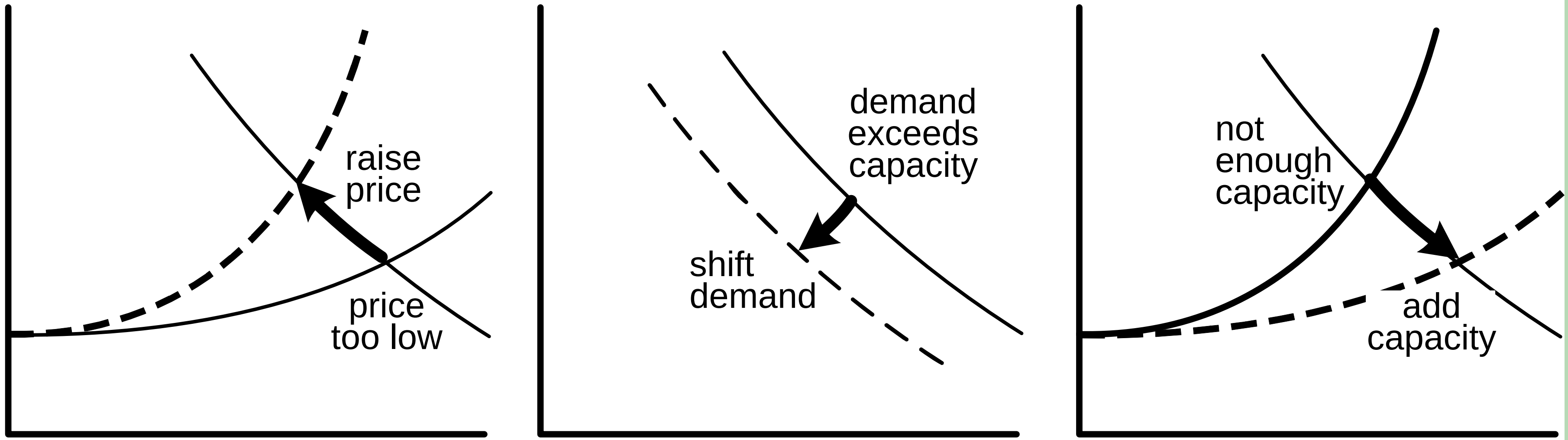
Demand-Based Pricing

- demand fluctuates (demand *curve* moves back and forth)
- capacity is fixed over a longer duration than demand varies
- rationing of capacity in the absence of other mechanisms is queuing, or delay
- other mechanisms: capacity reserves, flexible capacity, server technology (supermarkets), discriminatory pricing, secondary markets, metering

Objective of Peak Pricing



Alternatives for Congestion Mitigation

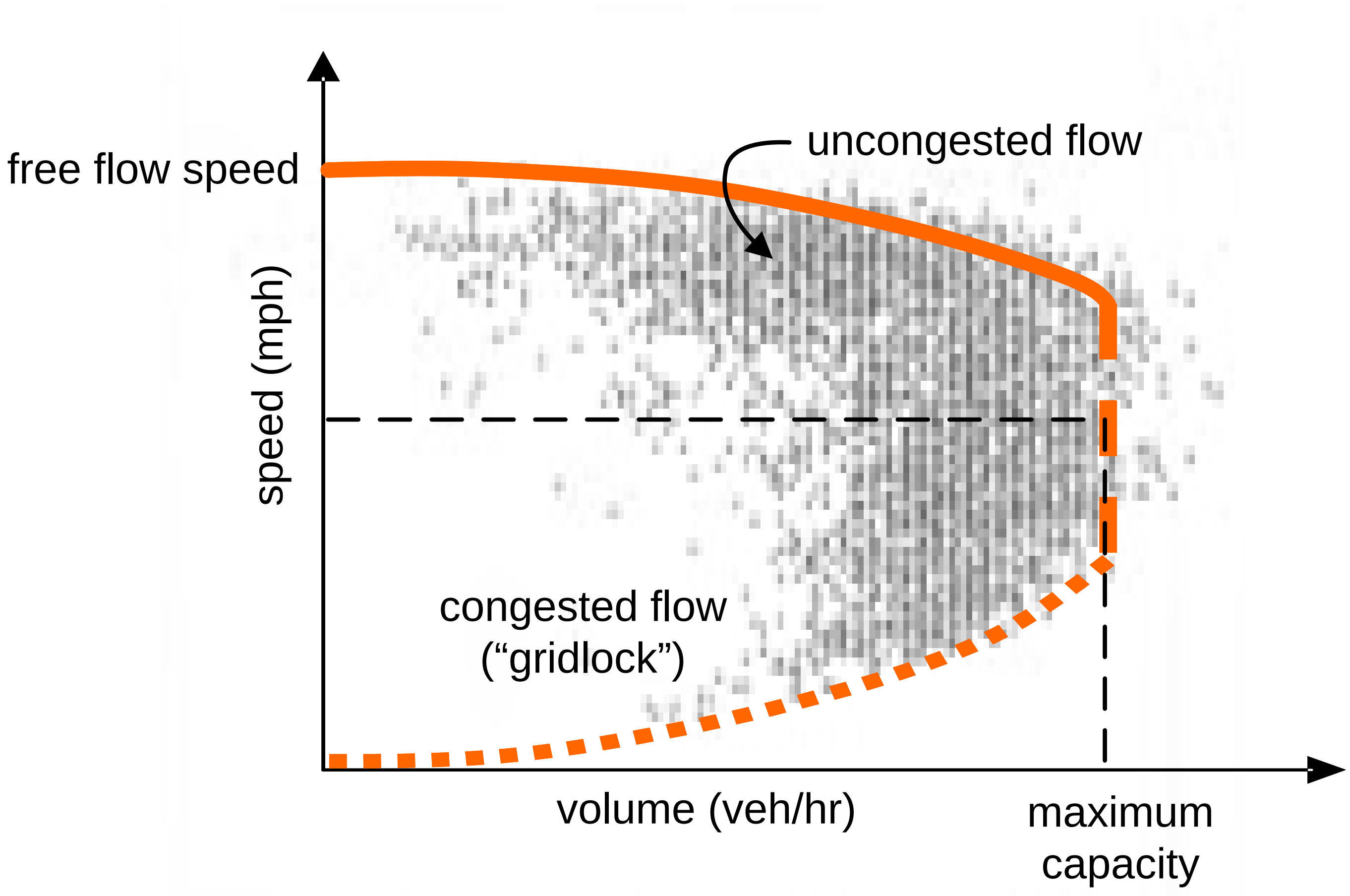


- Increase peak price
- Shift the peak demand curve through related markets
- Add more capacity

Pain Avoidance

- political choice is guided by avoidance of pain
- physical capacity increases seemed easy until urban areas choked up with traffic and the destruction became evident; land and construction costs became large; building to the 30^{th} highest hour at a price of close to zero became unsustainable
- indirect mechanisms that aimed to increase the attractiveness of substitutes (price, comfort, ease of access) have been endless in number and largely ineffective in reducing highway congestion (ridesharing, HOV lanes, transit, employer sanctions, ECO, TCM, flextime, etc.)
- little or no ability to redirect travelers to other times or facilities (no trucks?)
- parking pricing is the exception, it being a complementary good rather than a substitute
- ramp metering on freeways has some effect on reducing hypercongestion

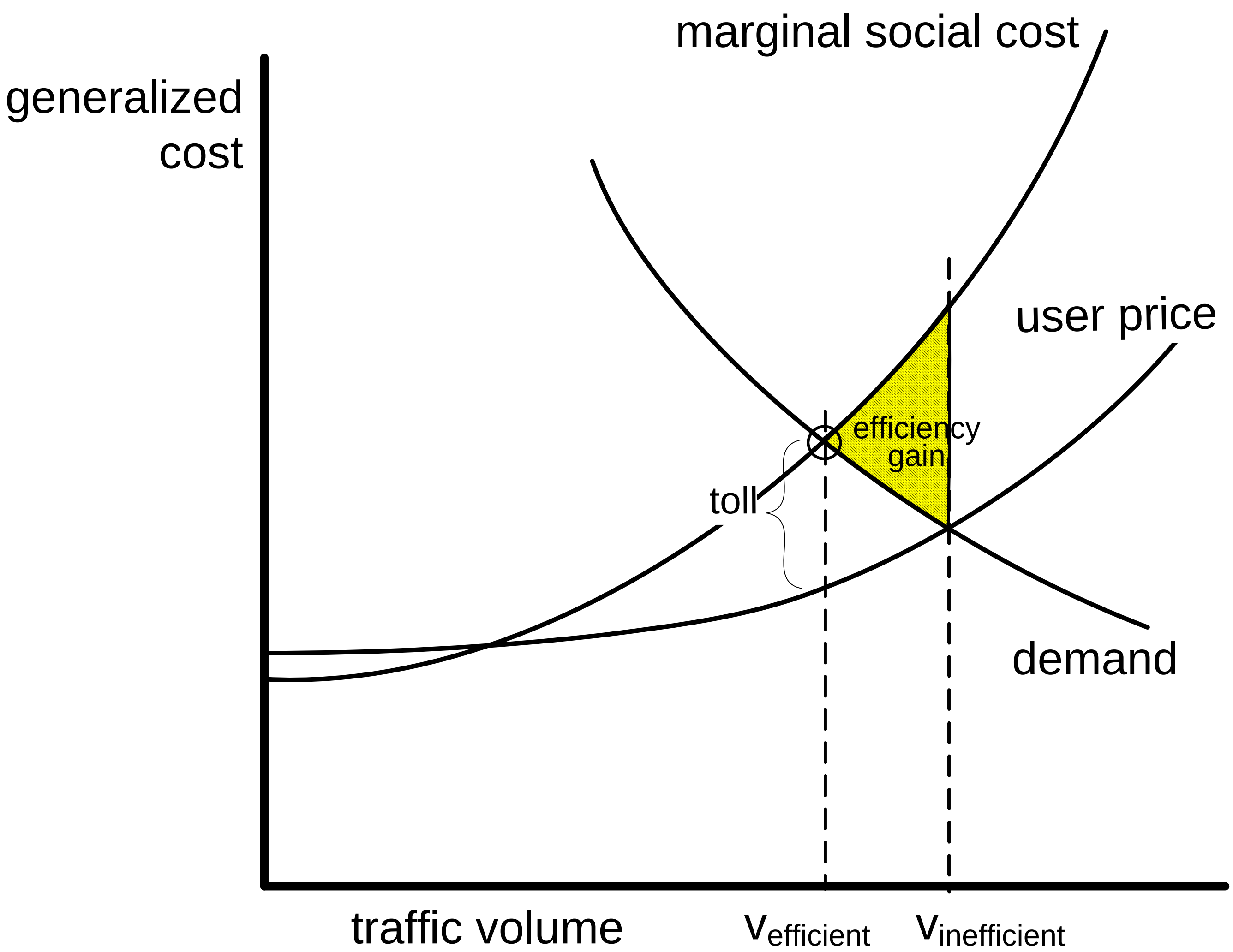
Capacity Loss from Hypercongestion



Congestion Pricing

- last resort to everyone but economists
- Marginal Cost Pricing (MCP)
  - long known by economists to apply to transportation
- only variable costs are relevant
- theory of marginal cost pricing
  - generalized cost to user
  - p = MSC
  - marginal social benefits = demand curve (benefits are internal to users)
- efficiency gain can be decomposed into
  - delay savings for users paying the toll
  - loss of consumer surplus for *vehicles* tolled off

Highway Congestion Pricing Theory



Components of Price and Social Cost

user price	marginal social cost
fuel	fuel
fuel and other excise taxes	
other vehicle operation	other vehicle operation
vehicle wear	vehicle wear
accident risk	accident risk
average travel time	(average travel time)
	marginal travel time
	pavement damage
	traffic services (police)
	emissions (air, water, noise)

Long Run Considerations

- pricing versus investment
  - tolls create revenues above SRMC that can be used to pay for the (fixed) capital costs
  - if facilities are not generating congestion tolls at least some of the time, or if the tolls are not enough to pay the long run costs, then the facility is overbuilt (too much capacity)
- passenger car equivalents (PCE)
  - the toll should be based upon the share of capacity used up by the vehicle
  - trucks, for example, are larger than cars, accelerate more slowly, and require more space in front and back
  - e.g., if toll is $0.20 per VMT for cars, and truck has a PCE = 2.5, then truck toll would be $0.50 per VMT

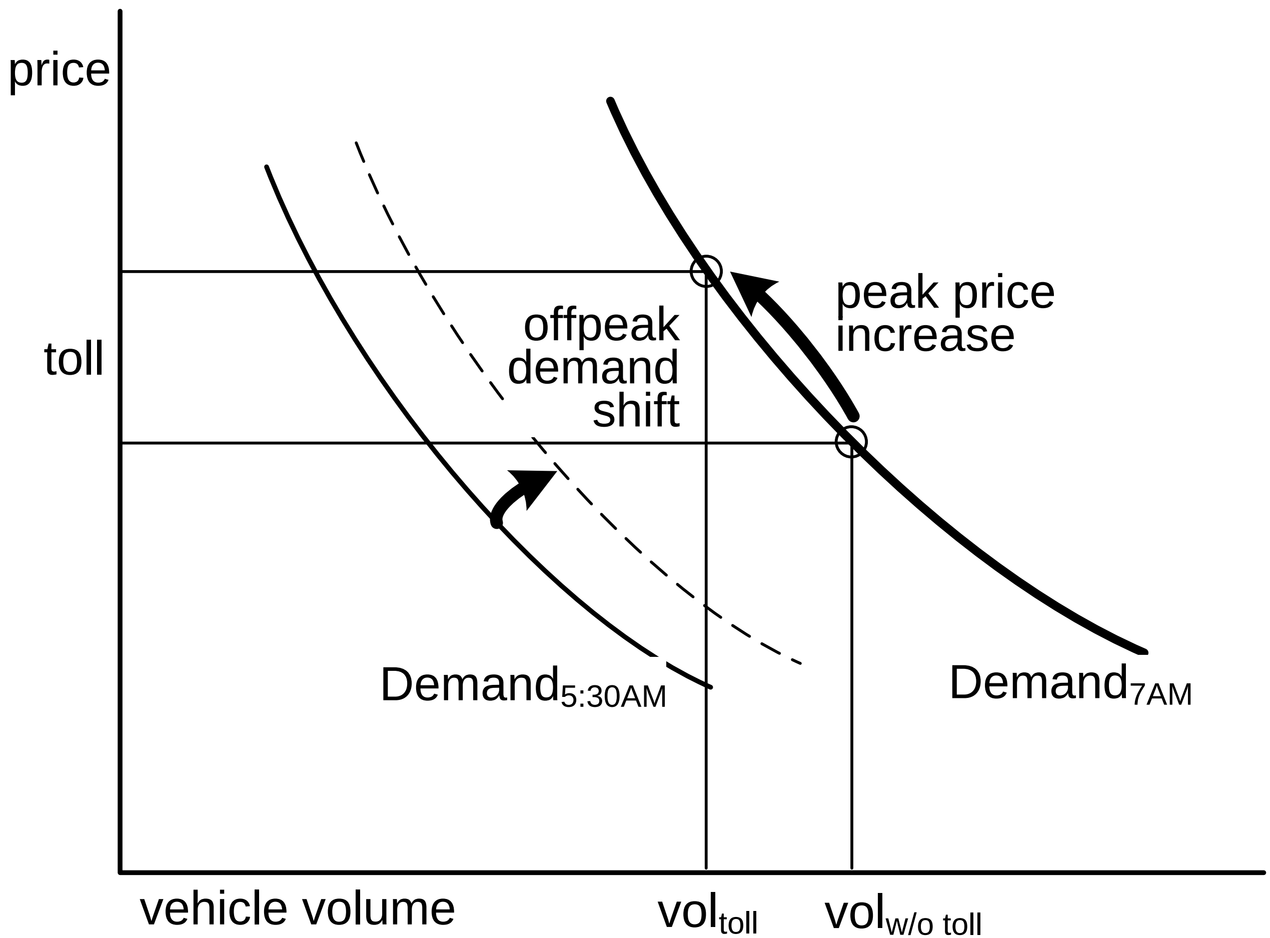
Behavioral Responses to Congestion Pricing

The peak traveler whose daily travel route goes from congested and slow to free-flowing and tolled can minimize the impact of the toll by a range of behavioral changes:

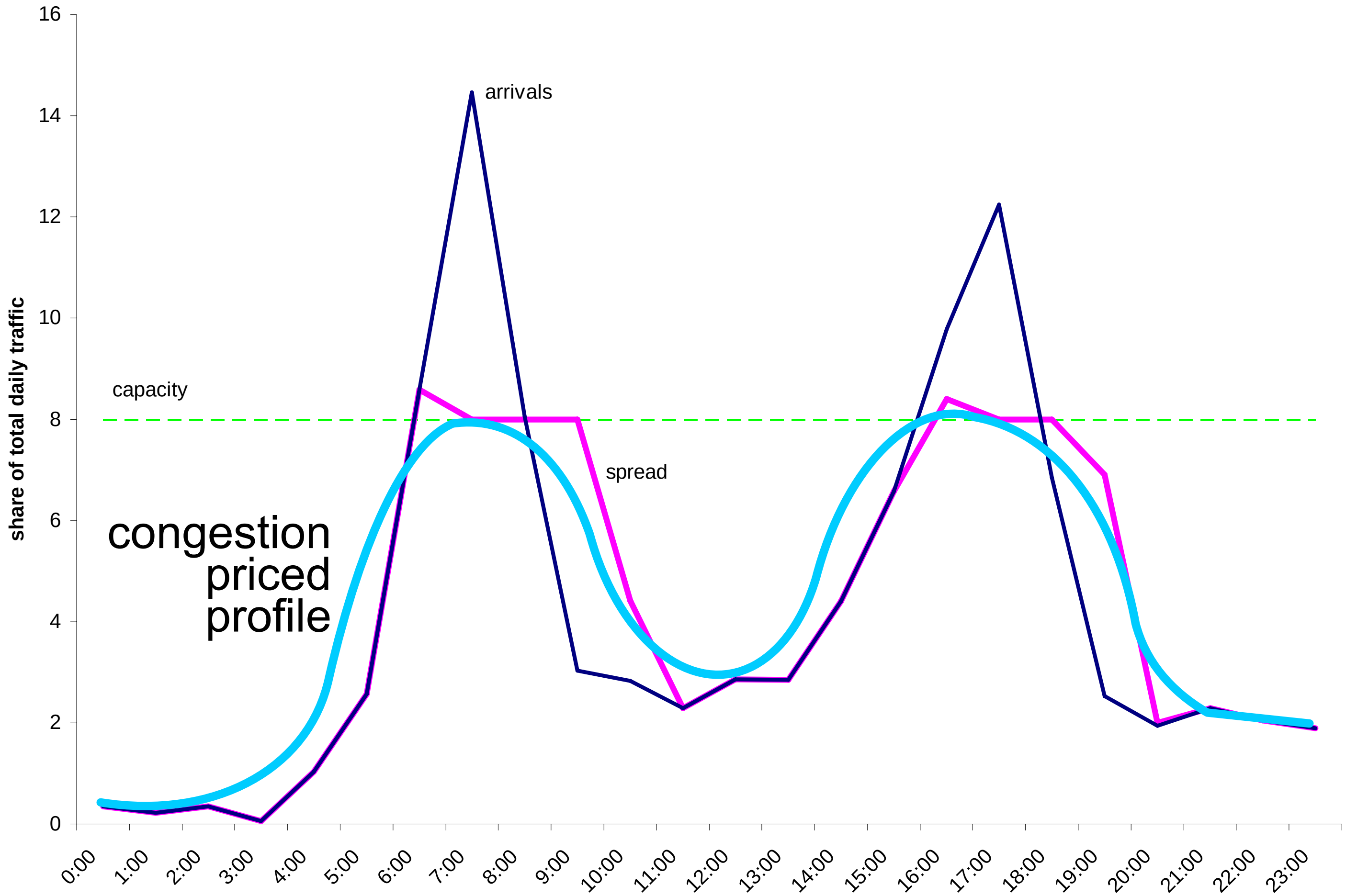
- join in a carpool or vanpool
- switch to bus transit or private express bus on the same highway
- switch to rail or other transit in its own right-of-way
- shift the time of the trip to a lower toll period (schedule shift)
- switch to an untolled route (diversion)
- reduce the number of tolled trips by combining purposes (trip chaining)
- forgo the trip entirely (telework)
- relocate residence or adopt a temporary residence such as an apartment in town to reduce the number of commutes or the direction of peak travel
- change work site (change job or use satellite office)

The overall demand elasticity for VMT with respect to the generalized price (including time) is in the -0.8 to -1.2 range in the short run, and about twice as high in the long run.

Interrelated Demand Periods



Temporal Shift in Demand



Benefits of Pricing

- The efficient toll makes the price to the user equal to marginal social cost at the optimum volume.
- In principle, the efficient price accounts for all social costs, including pollution and road damage, but for congested roads the main concern is making the user face the marginal travel time for everyone rather than only the average time.
- Pricing creates direct incentives in the primary (congested) market, therefore it is the most effective treatment.
- It stimulates the development of viable and worthwhile alternatives (higher occupancy, use of other modes).
- Revenues are generated that may be used to facilitate adjustments, reduce general taxes, or correct equity.
- Tolls imposed at times and places where congestion exists provide the clearest signals to users that the service should be regarded as costly

Benefits of Pricing (cont'd)

- Pricing saves travel time by moving the traffic at higher speed.
- It saves time additionally by making trip times more reliable, so that less cushion is needed in order avoid being late.
- Pricing saves running costs such as fuel (steadier more efficient speed, less acceleration) and vehicle wear, as well as emissions.
- Pricing stimulates the maximum range of behavior changes the user can consider as alternatives to individually paying the toll, such as car and vanpooling, bus, rail transit, teleworking, alternative route, schedule shift, trip chaining, etc.
- It leaves the choices to the persons best able to evaluate the benefits of travel versus its costs to society.
- Pricing can be fine-tuned to any situation, as opposed to, say, the number of people in the same vehicle that constitute "high occupancy."
- Tolling may reduce minor accidents and may increase the severity of accidents that do happen.

Benefits of Pricing (cont'd)

- It provides a valid signal for expansion if users are willing to pay tolls that cover the additional investment in capacity.
- Optimal investment in system capacity and the resulting congestion levels depend on the value of travelers' time (and of reliability to shippers), as well as on the cost of expanding capacity.
- Pricing can be implemented with remote electronic identification and toll collection technology so that no further delay is added; collection and billing costs are higher than with simple excise taxes, but compliance is high and cost per transaction will decline with universal pricing.
- Efficient prices will vary widely by time and place, but charging road and highway users for the delays they cause will—unlike transportation planning—automatically seek the right levels of system usage and congestion.

Downside

- the revenues generated from congestion pricing are transfers (neither costs nor benefits to society), but they are large and exceed the net efficiency gains
- using the revenues inefficiently has the potential to dissipate the gains from pricing
  - reduce other taxes
  - expand transit and other alternatives
  - compensate low income (redistributional equity)
- collection and enforcement costs so far have been somewhat larger than estimated, but can be expected to shrink with time
- network effects are potentially disruptive if not effectively considered

Types of Highway Pricing

- Implementation so far of congestion pricing has not come very close to the ideal, but some are quite effective.
- Some examples from around the world:
  - Facility Tolls
  - HOV/HOT “Managed” Lanes
  - Cordon Rings
  - Comprehensive VMT Charging
- Recurring and non-recurring congestion

High-Occupancy Toll (HOT) Lanes

- evolutionary dead-end, perhaps unique to highways
  - attempt to salvage HOV lanes
  - politically, travelers have a misplaced high value on choice
- two-class service: “standard” and “premium” (also referred to as “value pricing”)
- The Good
  - an improvement on HOV lanes
  - a foot-in-the-door for road pricing
- Not So Good
  - a loss of capacity comes with physically separating lanes
  - hypercongestion is increased on the “free” lanes
  - multi-class service can only be superior to single-class service if *both* services are priced *and* users are heterogeneous

Actual and Proposed Tolls (per VMT)

	toll ($)	area	radius	$/mile	1-way trip length	$/mile	remarks
Cordon							no tolls offpeak or weekends
London	$ 15.80	15.0	2.19	$ 3.62	12	$ 0.66	good all day; LOS standard
Bergen	$ 2.45	7.0	1.49	$ 1.65	8	$ 0.31	per crossing; not LOS-based
Oslo	$ 3.27	24.7	2.81	$ 1.16	8	$ 0.41	per crossing; not LOS-based
Singapore	$ 3.00	18.5	2.43	$ 1.23	12	$ 0.25	per crossing each way; LOS constraint
Stockholm	$ 2.88	11.4	1.18	$ 2.43	12	$ 0.24	per crossing; max/day = $8.40
Facility	toll ($)	length	one-way	$/mile	length	$/mile	no LOS criterion; tolls 24/7
Golden Gate	$ 5.00	1.7	2.94	$ 1.47	20	$ 0.25	1-way; no TOD
Chesapeake Bay	$ 12.00	23.0	0.52	$ 0.52	50	$ 0.24	no TOD
NYC (PANYNJ)	$ 6.00	1.36		$ 4.40	16	$ 0.38	4 bridges and 2 tunnels base rates
NYC discount	$ 2.00	1.36		$ 1.47	16	$ 0.13	TOD differential
Tappan Zee (trucks)	$ 9.50	15	0.63	$ 0.32	30	$ 0.32	inbound; TOD for trucks only
System							no LOS target; toll 24/7
NY Thruway	$ 18.50				496.7	$ 0.04	no TOD
lower portion	$ 0.75				20.9	$ 0.04	no TOD
MassPike	$ 12.20				270.2	$ 0.05	no TOD
HOT Lanes							general purpose plus tolled lanes; no toll offpeak
SR-91 Riverside	$ 9.50	10.0		$ 0.95	20	$ 0.48	LOS standard
Minneapolis	$ 4.00	10.4		$ 0.38	20	$ 0.20	maximum toll is $8, rarely occurs
I-15 San Diego	$ 4.00	8.0		$ 0.50	20	$ 0.20	dynamic LOS
Network (proposed)							universal efficient congestion pricing
Netherlands							no ranges proposed
United Kingdom						$ 2.65	maximum 80 pence/km for v/c>1.0
Oregon VMT pilot						$ 0.10	during two 2-hr peak periods
USA (FHCAS '82)						$ 0.32	Appendix E congestion only
							all tolling is differentiated by vehicle class

Equity Impacts and Public Acceptance

- who pays, who benefits directly, and what is done with the revenues?
- mildly regressive at worst without recycling revenues, easily progressive if chosen
- competition for revenues: more roads, more transit, reduced general taxes, help the poor
- coming next: open road tolling (ORT), “high-performance highways” (FHWA)

Toll Road Concessions

- Public sector has invested in roads for 100 years—heavily in the last 50—and the effort has been a great success in terms of demand and related investment; yet we struggle to raise funds to maintain the system.
- Private firms have purchased long-term leases (50-99 years) to build and operate new toll roads, or to operate existing toll roads, with lessor setting the toll rates (within constraints)
- Concept has become controversial.

Recent US Examples

- Chicago Skyway: 7.8 miles leased for $1.83 billion for 99 years
- Indiana Toll Road: 175 miles, leased for $3.8 billion for 75 years
- Pennsylvania Turnpike: Governor claims road is worth $18 billion for 30 years.
- Congressmen Oberstar/Defazio have warned states about entering such leases if they don't serve the public interest.
  - "are we outsourcing our political will??"
- Texas legislators have put a freeze on new agreements
- Indiana governor has withdrawn several lease proposals in the face of a backlash.
- SR-91 Express Lanes was initially a private franchise

Summary of Pricing

1) For congestion, pricing should be the first resort, not the last. Nothing treats the problem of congestion so directly or as effectively as setting the right price. The evidence is clear, although that doesn't mean pricing is easy.
2) It is possible to eliminate most congestion in the short run with pricing, but the result is not necessarily efficient in the long run; some portions of the highway system where congestion now exists are worth adding capacity to, on benefit-cost grounds.
3) Although systems of universal pricing have been considered and have been or are being developed (UK and Netherlands), none have been implemented.
4) Technology of varying sophistication is available (London went low tech with cameras, Florida has piloted ORT, Germany used GPS).
5) HOT lanes demonstrate that pricing works, but their performance is far below that of full pricing. The option of offering a choice is very popular but probably not economically efficient.