Outline

1. Forms of road pricing & existing schemes
2. Goals of road pricing & existing toll structures
3. Truck-only facilities
4. Acceptability of road pricing (to goods transporters)
Outline

1. Forms of road pricing & existing schemes
2. Goals of road pricing & existing toll structures
3. Truck-only facilities
4. Acceptability of road pricing (to goods transporters)
# Forms of road pricing

<table>
<thead>
<tr>
<th>Type of scheme</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Facility-based</strong></td>
<td></td>
</tr>
<tr>
<td>High occupancy toll (HOT) lanes</td>
<td>US: 12 in operation</td>
</tr>
<tr>
<td>Express toll lanes</td>
<td>Orange County State Route 91</td>
</tr>
<tr>
<td>Individual highways</td>
<td>Highway 407; Many highways in the US, Europe, China ….</td>
</tr>
<tr>
<td><strong>Area-based</strong></td>
<td></td>
</tr>
<tr>
<td>Cordons</td>
<td>Norwegian cities; Stockholm; Gothenburg (2013)</td>
</tr>
<tr>
<td>Zones</td>
<td>London; Milan</td>
</tr>
<tr>
<td><strong>Road networks</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Singapore: some expressways, arterials</td>
</tr>
<tr>
<td></td>
<td>Heavy Goods Vehicles: Switzerland, Austria, Germany, Czech Republic, Slovakia</td>
</tr>
<tr>
<td><strong>Regional</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>US pilot tests: Oregon, Puget Sound, U. of Iowa, and others</td>
</tr>
<tr>
<td><strong>National</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Britain (2004-2007)</td>
</tr>
<tr>
<td></td>
<td>The Netherlands: Dutch Mobility Plan (2010)</td>
</tr>
</tbody>
</table>
Road pricing in Canada

- Wholly facility-based.
- Only 19 tolled links. Twelve (11 bridges, 1 tunnel) connect Ontario and US.
- Highway 407 accounts for over half total traffic volume.
- The most recent facilities were all built as public-private partnerships.
Orange County State Route 91 (1995)
Highway 407 (1997)

Singapore Electronic Road Pricing (1998)

Started in 1998 with 33 gantries
Increased over the years – presently 66 gantries

http://www.internationaltransportforum.org/jtrc/RoundTables/RTfeb10Chin.pdf

Stockholm Congestion Charge (2006)

Milan Ecopass (2008)

Outline

1. Forms of road pricing & existing schemes
2. Goals of road pricing & existing toll structures
3. Truck-only facilities
4. Acceptability of road pricing
Main goals of road pricing

1. Demand management
   - Relieve congestion
   - Reduce road damage, accidents, pollution, noise
   - Promote use of public transit

2. Revenue generation

   Mobility versus accessibility

   *Mobility*: speed
   
   *Accessibility*: travel time to desirable destinations
   
   Mobility enhances accessibility, ceteris paribus. But road pricing can induce changes in destination and travel distances.
Basic model of congestion pricing (Walters, 1961)

Benefit, cost per trip [\$]

Number of trips, \( V \)

Social trip cost (includes congestion delay)

Social optimum

No-intervention equilibrium

Demand

\( p_O \)

\( p_E \)

\( V_O \)

\( V_E \)
Basic model of congestion pricing (Walters, 1961)

- **Benefit, cost per trip [$]**
- **Toll revenue**
- **Social trip cost (includes congestion delay)**
- **Efficiency gain from toll**
- **Social optimum**
- **Private trip cost**
- **No-intervention equilibrium**
- **Demand**

- **$p_O$**
- **$p_E$**
- **$V_O$**
- **$V_E$**

The graph illustrates the basic model of congestion pricing with the following key components:

- *No-intervention equilibrium* ($p_O$, $V_O$): The market without tolls, where the private trip cost equals the social trip cost.
- *Social optimum* ($p_E$, $V_E$): The point where the social trip cost is minimized, indicating the optimal number of trips and toll level.
- *Toll revenue*: The area under the demand curve and above the private trip cost line up to the social optimum.
- *Efficiency gain from toll*: The area above the social trip cost line and below the demand curve up to the social optimum.

The diagram shows how congestion pricing can improve efficiency by altering the number of trips and the toll level to match the social optimum.
Prescription for demand management

Tolls should vary with amount of congestion and other external costs that a vehicle imposes:

**Road characteristics:** capacity, safety design standards …

**Direction of movement:** e.g. inbound vs. outbound

**Time:** time of day, day of week, season

**Vehicle characteristics:**

- Size, maneuverability, axle weight, fuel type & emissions levels
- Congestion measured by Passenger Car Equivalents (PCEs)
  - Single-unit trucks: 1.9. Combination vehicles: 2.2 (Parry, 2008)

**Complications in setting tolls**

- Parts of the road network are not tolled
- Inability to vary tolls sufficiently by time of day, vehicle type,
Further complications for freight transport

National Cooperative Freight Research Program (2011)

Multiple decision-makers
Shipper, receiver, third-party logistics provider, dispatcher/fleet manager, driver

Multiple types of trucking service
Local delivery, drayage, less than load (LTL), private fleet, for-hire, self employed, owner operator, specialized

Other
Trucking industry varies in its familiarity with toll roads, toll reimbursement policies
Multiple dimensions of responses: Frequency of use, route, time-of-day, productivity increases and cost transfers
Response to tolling by commercial vehicle operators is constrained by demands of shippers/receivers
Values of travel time

Small and Verhoef (2007), Forkenbrock and March (2005), Hensher (2011)

**Passengers**

$5-40/hr. Mean ≈ $12/hr.

**Trucks**

Depends on:

- Type of vehicle & load
- Importance of punctual delivery
- Drivers’ wage rates
- Work hour constraints
- Type of trucking service
- Higher in congested conditions than free-flow conditions

Mean ≈ $50/hr. Range up to $200/hr.

Value of reliability: comparable
### Toll rates on Highway 407 (effective Feb. 1, 2012)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Transponder or Video Recorded</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light Vehicle: 5000kg &amp; under</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Regular Zone Rate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Period</td>
<td>Mon-Fri: 6am-7am, 9am-10am, 3pm-4pm, 6pm-7pm</td>
<td>24.20¢ /km</td>
</tr>
<tr>
<td>Peak Hours</td>
<td>Mon-Fri: 7am-9am, 4pm-6pm</td>
<td>25.20¢ /km</td>
</tr>
<tr>
<td><strong>Light Zone Rate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(to west)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Period</td>
<td>Mon-Fri: 6am-7am, 9am-10am, 3pm-4pm, 6pm-7pm</td>
<td>22.60¢ /km</td>
</tr>
<tr>
<td>Peak Hours</td>
<td>Mon-Fri: 7am-9am, 4pm-6pm</td>
<td>23.55¢ /km</td>
</tr>
<tr>
<td><strong>Midday Rate</strong></td>
<td>(entire highway) Weekdays 10am-3pm</td>
<td>21.00¢ /km</td>
</tr>
<tr>
<td><strong>Off Peak Rate</strong></td>
<td>(entire highway) Weekdays 7pm-6am, Weekends &amp; Holidays</td>
<td>19.35¢ /km</td>
</tr>
<tr>
<td><strong>Heavy Single Unit Vehicle</strong></td>
<td>Over 5000kg</td>
<td>Double</td>
</tr>
<tr>
<td><strong>Heavy Multiple Unit Vehicle</strong></td>
<td>Over 5000kg, Trucks or tractors with one or more trailers</td>
<td>Triple</td>
</tr>
</tbody>
</table>

Toll rates in the United States

Holguín-Veras et al. (2006)

70% of facilities have Electronic Toll Collection (ETC) systems, but only 6% employ time variation
Large discounts for frequent users
Bus tolls lower than corresponding PCEs

Tolls for large trucks
  Well above PCEs
  Increase significantly with population density (unlike for cars)
  Appear to vary with pavement damage
Authors conjecture that toll authorities adopt welfare-maximizing tolls for most vehicle types, but pursue revenue generation for large trucks.
Toll rates in the United States

<table>
<thead>
<tr>
<th>Type of facility</th>
<th>Mean cost per vehicle-mile: Ratio of truck to passenger vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Toll roads</strong></td>
<td></td>
</tr>
<tr>
<td>Interstate</td>
<td>3.64</td>
</tr>
<tr>
<td>Non-interstate</td>
<td>3.18</td>
</tr>
<tr>
<td><strong>Toll bridges &amp; tunnels</strong></td>
<td></td>
</tr>
<tr>
<td>Interstate</td>
<td>4.79</td>
</tr>
<tr>
<td>Non-interstate</td>
<td>5.24</td>
</tr>
</tbody>
</table>

Author’s calculation using 2011 data at: http://www.fhwa.dot.gov/policyinformation/tollpage
# Toll rates in Singapore

Effective May 7 to August 5, 2012

<table>
<thead>
<tr>
<th>Vehicle categories</th>
<th>Toll ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorcycles</td>
<td>0.5</td>
</tr>
<tr>
<td>Passenger / Light goods vehicles / Taxis</td>
<td>1.0</td>
</tr>
<tr>
<td>Heavy goods vehicles / Small buses</td>
<td>1.5</td>
</tr>
<tr>
<td>Very heavy goods vehicles / Big buses</td>
<td>2.0</td>
</tr>
</tbody>
</table>

| Tolled elements | |
|-----------------| |
| Arterial roads  | |
| Expressways     | |
| CBD             | |

| Time of day variation | |
|-----------------------| |
| In 30 min. or 5 min. intervals | |

| Time of week variation | |
|------------------------| |
| Arterial roads & expressways: Weekdays only | |
| CBD: Weekdays, Saturdays | |

| Goals | |
|-------| |
| Maintain speeds within specified range: | |
| Expressways: 45-65 km/hr | |
| Arterials: 20-30 km/h | |

| Rate of toll review | |
|---------------------| |
| Quarterly | |

## Primary & secondary goals of schemes

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Revenue generation</th>
<th>Congestion relief</th>
<th>Pollution reduction</th>
<th>Transit promotion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional toll roads</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norwegian toll rings</td>
<td>1</td>
<td></td>
<td>2 (recently)</td>
<td></td>
</tr>
<tr>
<td>HOT lanes</td>
<td>2</td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Singapore</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>London</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Stockholm</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Milan Ecopass</td>
<td></td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>European Heavy Goods Vehicle systems</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>US Vehicle Miles Traveled fee (proposed)</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Relative importance of goals

Congestion relief benefits

Increase with amount of infrastructure that is tolled
Sensitive to degree of time variation in tolls

Environmental benefits

Pollution reduction & climate change benefits dominated by congestion relief (Anas and Lindsey, 2011)
Caveat: Growing awareness of health costs of driving (Lin and Yu, 2008; Currie and Walker, 2009; Taylor, 2012).

Revenue generation

Revenue benefits can dominate direct benefits from congestion relief (de Palma, Lindsey & Proost, 2007).
Outline

1. Forms of road pricing & existing schemes
2. Goals of road pricing & existing toll structures
3. Truck-only facilities
4. Acceptability of road pricing
Truck facilities: Practice

Existing
Clarence Henry Truckway in New Orleans (no tolls)
New Jersey Portway (no tolls)
Pier Pass peak-period fee at Ports of Los Angeles and Long Beach

Underway, proposed or cancelled
Interstate 70 (I-70) (Ohio, Indiana, Illinois, Missouri)
Southern California (four highways)
Interstate 81 (I-81) in Virginia
Interstate 10 (I-10) from Florida to California
NAFTA corridor from Laredo, Texas to Toronto
Trans Texas Corridor (canceled)
Potential advantages

Poole and Samuel (2004), AASHTO (2010), Bucklew (2011)

Less congestion and greater safety for light vehicles
Reduce travel times & improve reliability
Reduce accidents, emissions, noise, road damage
Economize on road construction & maintenance costs
Enable more round trips per vehicle per day
Facilitate use of Long Combination Vehicles
Criteria for candidate locations

Fekpe (2007)

Annual Average Daily Traffic (AADT) at least 100,000

Truck volumes 25%+

Heavy congestion: Level of Service (LOS) E or F

Truck-involved fatal crashes equal to or above national average

Existence of freight intermodal terminals and processing centres close to freeways and interstate highways
Constraints and potential drawbacks

Constraints

Lane capacity indivisibilities
Lack of continuous right-of-way
Complete vehicle separation impractical or infeasible

Potential drawbacks

Limited access may increase total travel distance
Lane weaving to access and exit truck lanes
Increase in emissions, noise, vibration near truck corridors
Design questions

How to create
   Convert existing lanes, or build new lanes?

Separation
   Separate lanes, or separate corridors?

Access rules
   Truck-only, auto only, mixed use?

Location of truck lanes
   Right-hand lane(s), or left-hand lane(s)?
Evidence on benefits

Diverse studies of:
- Passenger Car Equivalents of trucks
- Effects of lane restrictions
- Effects of differential speed limits

Mixed results

PCE of trucks varies with:
- Mix of cars and trucks
- Terrain
- Weather

Crash rates for trucks compared to cars
- Lower: overall, rear-end
- Higher: fatal, sideswipe

Car drivers
- Dislike presence of trucks
- Increase headways which reduces capacity
Reason Foundation study

Samuel, Poole and Holguín-Veras (2002)

Proposal for network of toll truckways.

• Assumed trucks pay a toll of up to half their cost savings (lacked data on willingness to pay)
• Tolls sufficient to cover full costs of the truckways
• Truckers would receive rebate for federal and state fuel taxes, as well as for other truck user taxes
Evidence on benefits

Abdelgawad et al. (2011)

Study of 400 series highways in GTA. Used microscopic traffic simulation methods.

Scenarios
1. Convert one lane of traffic in each direction on Highway 401 into an exclusive truck lane.
2. Construct a 4-lane exclusive truck highway

Results
- Travel time savings for trucks in congested segments
- Diversion of traffic from arterial road system dilutes potential time savings on parallel roadways
Outline

1. Forms of road pricing & existing schemes
2. Main goals of road pricing & existing toll structures
3. Truck-only facilities
4. Acceptability of road pricing
Traditional objections to road pricing

1. Paying for something that was free

   Canadian roads traditionally provided publicly without direct user charges.

2. Double taxation

   Most road-pricing schemes not revenue neutral.

   Proposed exceptions for national schemes:
   - The Netherlands planned to eliminate fixed vehicle charges.
   - The UK has considered lowering fuel taxes if a national scheme is introduced.
Traditional objections to road pricing

3. Inequitable

*With respect to income*

Higher-income groups more likely to gain because willing to pay more for travel time savings.

Counterarguments: Depends on travel volume, mode choice, use of toll revenues.

*With respect to location*

Location relative to tolled facilities

Boundaries of area-based schemes

Toll differentiation on road networks

Tolling of residential streets, private roads
Traditional objections to road pricing

Other objections

System complexity
Invasion of privacy
Loss of retail business
Other revenue sources cheaper to collect
Attitudes of freight stakeholders: London

Altshuler (2010)

Truckers sought an exemption from the London congestion charge. Ken Livingstone, the mayor, accommodated them by reducing the charge for heavy trucks from £15 per day to £5: the same as for cars.
Attitudes of freight stakeholders: Germany

Broaddus and Gertz (2008)

The German HGV scheme was introduced with little opposition. Reasons:
1. Car owners welcomed the toll as a way to reduce HGV traffic on autobahns.
2. Firms anticipated improved infrastructure quality and travel time reliability.
3. Truckers saw the toll as a way to make foreign haulers pay for their use of German roads.
**Attitudes of freight stakeholders: US**

Poole (2011)

Regarding tolls for planned trucks lanes on I-70: part of an 800-mile reconstruction project spanning Ohio, Indiana, Illinois & Missouri.

Attitudes of the trucking community:

1. Cars should pay tolls as well as trucks
2. Tolls should be all-electronic
3. Use of dedicated truck lanes should be voluntary
4. Tolls should end when project costs have been paid off

Poole disagrees with positions 3 and 4.
Attitudes of freight stakeholders: US

National Cooperative Freight Research Program (2011) study of truck tolls

“The findings were overwhelmingly negative across all strata of the trucking industry: there is not a single segment of the trucking industry which showed any positive attitudes about toll roads or the benefits they might offer, either in congestion relief, time savings or reduced shipping cost.”

Reasons for opposition

1. The highway system “has already been paid for”
2. Tolls perceived as double taxation on top of fuel taxes
3. Revenues not earmarked for the toll highway
4. Tolls used as a cash cow to generate revenue
5. Shippers want rate quotes that include all accessorial charges and prefer to delegate route choice decisions to carriers
6. Drivers may not value even large time savings if they cannot use them productively
Attitudes of freight stakeholders: US

National Cooperative Freight Research Program (2011) cont.

Less resistance to tolls
• If drivers familiar with toll roads
• Where toll roads offer value for money in terms of road quality, time savings, reduced fuel consumption, facilitate compliance with hours of service limits, allow heavier loads, or allow longer combination vehicles

Options to increase acceptability
1. Free distribution of transponders, simplify creating accounts, flexibility in payment terms.
2. Long “ramp up” period (e.g. 10 years) for phasing in full tolls
3. Cross subsidies between automobiles and commercial trucks
Summary: Differences between trucks and cars

<table>
<thead>
<tr>
<th>Difference</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impose higher costs: congestion, accident hazard, emissions, road damage, noise</td>
<td>Should pay higher tolls</td>
</tr>
<tr>
<td>Different operating characteristics: speed, acceleration, maneuverability</td>
<td>Argument for truck-only lanes or roads</td>
</tr>
<tr>
<td>Higher values of time &amp; reliability</td>
<td>Higher willingness to pay for congestion relief</td>
</tr>
<tr>
<td>Higher vehicle operating costs</td>
<td>Higher willingness to pay for well-maintained roads</td>
</tr>
<tr>
<td>Less flexibility to re-route or reschedule trips for urban deliveries</td>
<td>Less benefit from changes in behaviour</td>
</tr>
</tbody>
</table>
Thank you!

Robin Lindsey  
Operations and Logistics Division  
Sauder School of Business  
University of British Columbia  
2053 Main Mall  
Vancouver  
British Columbia V6T 1Z2  

1 (604) 822-3323  
Robin.Lindsey@sauder.ubc.ca
References


References


References


References


Further reading


