Høgskolen i Molde
Vitenskapelig høgskole i logistikk

PhD Logistics

Trial Lecture

The incentive Properties of different forms of Urban Transport Financing and Regulation

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Table of Content

Scope of Presentation

The Definition of Incentive Schemes

The conscious use of rewards and penalties to encourage good performance in the public utility sector. (*Laffont and Tirole, 1993*)

The Advantage of Incentive Schemes (*Sappington, 2002)*

- give businesses and individuals choice about how to comply
- lowers the total compliance cost
- stimulates innovative approaches
- pre-empt conflict with stakeholders
- Mainly useful for reaching social desirable goals

Different kinds of incentives

- Quality incentive
- Patronage incentive
- Environmental incentive
- Innovation incentive
- Revenue incentive
- Productive incentive
- Financial incentive
- Economic incentive

Scope of Presentation

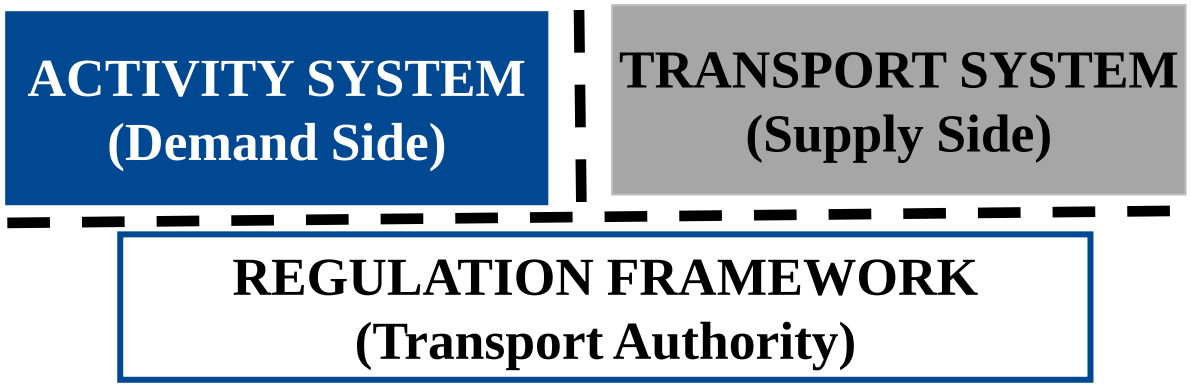
Transport Demand Management (TDM) Policies

----provides incentives and controls to users through pricing and regulation instruments. *(Orski,1990; Meyer,1999; Ferguson, 2000; Ison and Rys, 2008)*

Transport Supply Management (TSM) Policies

----involves the regulations and financing on the supply side.

Figure 1:the category of urban transport policy



Scope of Presentation

Transport Demand Management (TDM) Policies

TDM is any policies or set of policies aimed at influencing people's travel behavior in such a way that alternative mobility options are presented and/or congestion is reduced (Meyer, 1997).

Table 1 The menu of transport demand management policies

Financing	Regulation
• Vehicle & fuel taxes • Parking charges • Cordon toll for financing urban road	• Land use and transport strategies • On-street parking restrictions • Carpool and vanpool programs • Alternative working patterns • Restrict number of license plates
• Congestion pricing	

They provide positive / negative incentives to users :

☺ shift modes — walk, cycle, take transit or rideshare instead of driving.

☺ make fewer trips — telework, shop online or use the telephone.

☺ drive more efficiently — shop locally, avoid peak periods and congested routes.

Scope of Presentation

Transport Supply Management (TSM) Policies

----the use of policies, programs and regulations to influence supply decisions on quantities and qualities of urban transport infrastructure and services.

Table 2: The menu of transport supply management policies

Infrastructure	Non-infrastructure good
• High-occupancy vehicle priority lanes • Bicycle and pedestrian facilities/programs • Park and Ride (P & R) Facilities • **Public Private Partnership (PPP)** • Infrastructure access charge	• **Bus Service contract**

Strength from incentives (*Small and Verhoef, 2007; Veselá, 2006*)

►have rich experience and knowledge with price setting, price sensitivity, public perceptions, marketing, and the role of price differentiation.

►have a strong incentive to adopt a whole life costing approach to design.

►have a financial incentive to enhance economic efficiency in road use

Weakness from cost-effective

► may lead to increased costs.

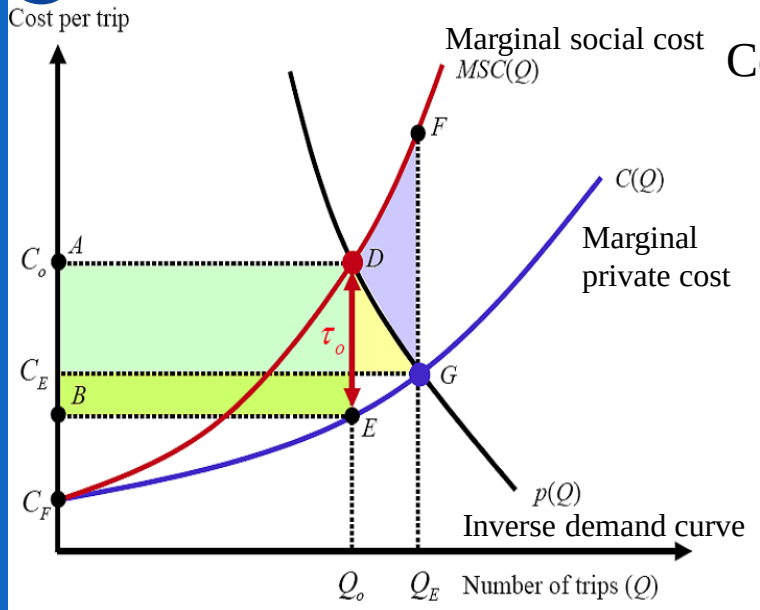
► may entail larger transaction costs

Incentive Mechanism of Congestion Pricing

Cause of road congestion

A driver has little incentive to limit the use of his car because he bears only his private costs on congested roads and does not need to bear the external costs, such as the cost of extra congestion caused by his entrance. (*Richard, et al. 2010*)

Basic Economic Motivation—Marginal Social Cost Pricing



Congestion toll should be imposed on drivers

-----incentivize to travel less;

-----incentivize to change from private vehicles to public transit;

-----incentivize to travel at less congested times;

The traveler should pay directly for the costs they impose on other users as an incentive to use resources efficiently.

Congestion pricing can be viewed as a monetary incentive toward users' behavior modification

Incentive Mechanism of Congestion Pricing

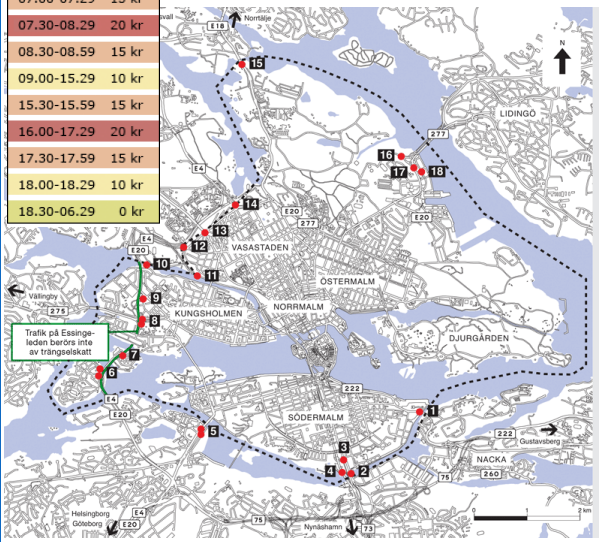
Access Control system

Practice implementation

- London congestion pricing (2003)
- Social experiment of congestion pricing, Stockholm (2006)
- Toll rings in Norwegian cities (1990s)
- Electronic Road Pricing in Singapore (1998)
- PierPASS in Los Angeles
- Credit-based in Dallas, USA
- Tolled express lane in Orange County, USA

In 2003, motorists driving in central London on weekdays between 7:00 am and 6:00 pm are required to pay £5.

Time	(SEK) Amount
06.30-06.59	10 kr
07.00-07.29	15 kr
07.30-08.29	20 kr
08.30-08.59	15 kr
09.00-15.29	10 kr
15.30-15.59	15 kr
16.00-17.29	20 kr
17.30-17.59	15 kr
18.00-18.29	10 kr
18.30-06.29	0 kr



- Reduced delay due to removal of bottlenecks
- Reduced overall traffic 3-5 %
- Increased public transport 6-9 %
- Reduced noise from above ground traffic
- Less pollution
- Improved traffic safety

- 10-20 SEK per cordon crossing
- Depending on time of day
- No charge evenings or weekends
- Taxi, buses, green cars exempt
- Max 60 SEK/day

Incentive Comparison of Bus Service Contract

Cause of service contract

Conflicting objectives and asymmetric information are two basic reasons why the authority chooses to regulate the private operators by means of a fixed-term service contract. (*Laffont and Tirole, 1993*)

Types of contract

Two main types of contracts can be distinguished in the public transport industry: *(Amaral, Medda and Quidort ,2009)*

1. Cost-plus contract (C+)

-- The authority reimburses all costs and pays a specified profit rate.

-- The authority bears all revenue and cost risks.

2. Fix-price contract(FP)

--The authority transfers to the transit operator a fixed payment.

--The operator bears its revenue and cost risks .

--It can be further separated into two kind

- Gross cost contract
- Net cost contract

Incentive Comparison of Bus Service Contract

Net cost contract

----The operator has two sources of income: the commercial receipts from providing services and a fixed transfer from the local authority.

----Any change in the passenger volume affects its profit.

-----It provides a "natural incentive" for allocative efficiency as operators attempt to maximize revenues and not only minimize costs.

Gross cost contract

----Total revenues from fares are collected by the authority

----The operator's sole source of income is the transfer payment from the authority, which is independent on its fare-box revenue.

----Any change in passenger volume does not affect its profit.

Table 3 Comparisons of net cost contract and gross cost contract

	Net cost contract	Gross cost contract
Risk Burden	Both product and revenue risks are borne by the transit operator	Production risk is taken by the operator while revenue risk is born by the authority
Payment	The operator only receives a subsidy equal to the different between the anticipated total operating costs and revenues	The operator pays an agreed prices for the production of a fixed amount of services

Incentive Comparison of Bus Service Contract

Continuous Time Model *(Gautier, and Yvrande-Billon, 2008)*

Duration of contract

A contract that lasts until time T.

Productive effort

The cost of this effort is $\psi(a(t))$

Realized cost functions

With effort, the operator reduces cost by $a(t)$.
That is $\hat{c} = -a(t)$,
At time t, the realized cost is

$$c(t) = c(0) - \int_0^T a(\tau)d\tau$$

Discounted profit function

Total discounted profit flow is

$$\int_0^T e^{-\rho t}\pi(t)dt$$

Incentive Comparison of Bus Service Contract

Cost-plus contract

- At each time *t*, authority pays the cost *c*(*t*) plus a fixed amount of P^{c+}.
- At each time *t*, the profit is

$$\pi_{C+}(t) = P^{C+} - \psi(a(t))$$

- The operator 's incentive to reduce cost can be expressed as :

$$\underset{a(t)}{Max} \int_0^T e^{-\rho t}\left[P^{C+} - \psi(a(t))\right]dt$$

- The optimal effort path

$$a^*_{C+}(t) = 0$$

For all *t*<T, (1) $a^*_{FP}(t) > a^*_{C+}(t) = 0$

Fixed-price contract

- At each time *t*, the authority transfers P^{FP}
- At each time t, the profit is

$$\pi_{FP}(t) = P^{FP} - c(t) - \psi(a(t))$$

- The operator 's incentive to reduce cost can be expressed as :

$$\underset{a(t)}{Max} \int_0^T e^{-\rho t}\left[P^{FP} - c(t) - \psi(a(t))\right]dt$$

- The optimal effort path

$$a^*_{FP}(t) = \psi'^{-1}\left[\frac{1}{\rho}\left(1 - \frac{e^{-\rho T}}{e^{-\rho t}}\right)\right]$$

-----Fixed-price contracts give more incentives to reduce costs than cost-plus contracts do. (*Gagnepain and Ivaldi 2002*)

(2) $\partial a^*_{FP}(t)/\partial t < 0$

------Under a fixed-price contract, the operator's incentive of reducing cost decreases with time to expiration.

Incentive Comparison of Bus Service Contract

The operator has two incentives:

Productive incentive $a_1(t)$ $\quad \hat{c} = -a_1(t)$

Commercial incentive $a_2(t)$ $\quad \hat{x} = f[a_2(t)]$

Cost of these effort is :$\psi(a_1(t), a_2(t))$

Net cost contract	Gross cost contract
• At time *t*, operator receives a fixed payment P^{NC} and fare revenue $\bar{p}x(t)$	• At time *t*, the authority transfers P^{GC}
•The bidder is the firm with the lowest operating deficit. ($c(T) - \bar{p}x(T)$)	•The bidder is the firm with the lowest cost
• At each time *t*, the profit $\pi_{NC}(t)$ is $\pi_{NC}(t) = \bar{p}x(t) + P^{NC} - c(t) - \psi(a_1(t), a_2(t))$	• At each time *t*, the profit $\pi_{GC}(t)$ is $\pi_{GC}(t) = P^{GC} - c(t) - \psi(a_1(t), a_2(t))$
• Operator ‘s objective be expressed as : $\underset{a_1(t),a_2(t)}{Max} \int_0^T e^{-\rho t}\left[\bar{p}x(t) + P^{NC} - c(t) - \psi(a_1(t), a_2(t))\right]dt$	• Operator ‘s objective be expressed as : $\underset{a_1(t),a_2(t)}{Max} \int_0^T e^{-\rho t}\left[P^{GC} - c(t) - \psi(a_1(t), a_2(t))\right]dt$

• The resulting optimal effort under the net cost contract and the gross cost contract can be derived as these two inequalities

$$a_1^{NC}(t) \le a_1^{GC}(t) \qquad a_2^{NC}(t) \ge a_1^{GC}(t) = 0$$

Incentive Comparison of Bus Service Contract

$a_1^{NC}(t) \le a_1^{GC}(t)$ ➡

A gross cost contract provides more incentive to reduce cost than a net cost contract does. (*Roy and Yvrande-Billon*, 2007)

$a_2^{NC}(t) \ge a_1^{GC}(t) = 0$ ➡

The gross cost contract does not provide any incentive to increase the patronage . While, the operator regulated by a net cost contract has incentive to increase the ridership.

Contract renewal is an important source of incentive for operators to keep costs low and improve service levels.

Incentive Comparison of Bus Service Contract

Table 4 The type of bus service contract across European country

City	Contract Type	Incentive	Awarding method	Duration
Amsterdam	Net-cost	Service quality	Competitive tendering	**5**
Brussels	Net cost	Service quality	Direct awarding	**5**
Budapest	Gross cost	Patronage	Direct awarding	**8**
Dublin	Gross cost	Patronage	Negotiation	**5+5**
London	Gross cost	Quality	Competitive tendering	**5+2**
Frankfurt	Gross cost	Environmental	Competitive tendering	**6**
Stockholm	Gross cost	Service Quality	Competitive tendering	6
Paris	Gross cost	Service Quality	Competitive tendering	5-10

- The C+ contract is totally replaced by the FP contract in the urban transport sector due to its very low incentive powers.
- Most contracts are not pure gross cost contracts or net cost contracts

Extended GC contracts--although authorities still use GC contracts, these include relatively large economic incentives for quality and/or passenger improvements.

Extended NC contracts imply that the contract also has incentives for further improvements in service quality (*Longva et al., 2005*) .

- Competitive tendering is a popular mechanism for the provision of local bus services.

Incentive-based subsidy scheme for public transit

Cause of Incentive-Based subsidy Scheme

Compared with the social optimal results, the profit-oriented operator intends to provide lower service levels and charge high fares. To correct this social undesirable behavior, policy instruments should be designed to give the operators incentives to behave in line with social aims. *(Van Reeven ,2008; K. Jansson, et al, 2008; Savage and Small ,2010; Basso and Jara-Díaz ,2010;).*

Although the pre-described net cost or gross cost contracts can tack the production inefficiency problem (or X-efficiency) , they do not guarantee for increased market efficiency in social sense. More elements should be added into the service contracts.

(*Johansen, Larsen and Norheim, 2001*)

The incentive-based subsidy linked to the service levels and/or patronage can be used with the intention to solve production in-efficiency and market inefficiency.

Incentive-based subsidy scheme for public transit

Micro-economic Modeling Framework (*Else, 1985, Sonesson, 2006*).

Step 1 Preparations

(1) Demand (Q) is supposed to depend on price (p) and service quality (A).

The inverse demand function is $p=(Q,A)$ $\partial p/\partial Q \le 0$ *and* $\partial p/\partial A \ge 0$

(2) Cost is a function of trips made, as well as of quality, c=c(Q,A)

(3) To make the operator choose the social desired Q and A, the authority introduces a subsidy system , S (Q,A).

Step 2 Optimization

Authority ---maximize social welfare		Operator---maximize profit	
$W(Q,A)=\int_0^Q p(q,A)dq-c(Q,A)$		$\pi(Q,A)=Q*p(Q,A)-c(Q,A)+S(Q,A)$	
With respect to Q^{W*}	$\frac{\partial W}{\partial Q}=p-\frac{\partial c}{\partial Q}=0$	$\frac{\partial \pi}{\partial Q}=Q\frac{\partial p}{\partial Q}+p-\frac{\partial c}{\partial Q}+\frac{\partial S}{\partial Q}=0$	With respect to $Q^{\pi*}$
With respect to A^{W*}	$\frac{\partial W}{\partial Q}=\int_0^Q Q\frac{\partial p}{\partial A}dq-\frac{\partial c}{\partial A}=0$	$\frac{\partial \pi}{\partial A}=Q\frac{\partial p}{\partial A}-\frac{\partial c}{\partial A}+\frac{\partial S}{\partial A}=0$	With respect to $A^{\pi*}$

Step 3 Optimal subsidy system

$$\frac{\partial S}{\partial Q}=-Q\frac{\partial P}{\partial Q} \qquad \frac{\partial S}{\partial A}=\int_0^Q \frac{\partial p}{\partial A}dq-Q\frac{\partial p}{\partial A}$$

Incentive-based subsidy scheme for public transit

Discussion of the incentive-based subsidy scheme

$$\frac{\partial S}{\partial A} = \int_0^Q \frac{\partial p}{\partial A} dq - Q\frac{\partial p}{\partial A}$$

Average valuation

The marginal valuation of quality by the average user

Marginal valuation

The marginal valuation of quality by the marginal user

If the average valuation does not equal the marginal valuation, the operator chooses a non-optimal quality for a given quantity.

------If the average valuation exceeds the marginal valuation , the operator should be subsidized for quality improvements.

------If marginal valuation exceeds average valuation , the operator should be taxed for quality reduction.

If the marginal valuation equals the average valuation, we only need to subsidize operators based on patronage.

Incentive-based subsidy scheme for public transit

$$\frac{\partial S}{\partial Q} = -Q\frac{\partial P}{\partial Q} \qquad S(Q) = \int_0^Q -Q\frac{\partial p}{\partial q}dq + K$$

A monopoly should be given a subsidy equal to consumer surplus in order to choose the socially optimal level of quantity (Q).

The fixed deduction(K) is an arbitrary constant that must be chosen to let the operator keep one proper profit in the optimum.

To sum up:

With the optimal subsidy, the private operator will choose socially optimal values for Q and A, as well as for price.

With the right economic incentives given by the optimal subsidy, the private operator is expected to be socially efficient.

Incentive-based subsidy scheme for public transit

Practical implementation

Patronage Funding in New Zealand

only related to the patronage and not affected by the quality. (*Hasher, et al, , 2002, 2003, 2004*).

Quality Contracts in Norway

Inter-city rail in NSB
Fearnley et al. 2004

Bus in Hordaland
(*Larsen, 2001; Carlquist, 2001*)

Incentive-based subsidy

Net cost contract

Three mandatory steps

One alternative steps

Incentive-based subsidy scheme for public transit

Step One:

One ideal case is constructed by maximizing SW under relevant capacity and budget constraints with respect to seven design variables:

- Fare levels for the 3 periods of demand ;
- Vehicle-km produced in basic and additional peak service;
- Capacity per vehicle- km in basic and additional peak services

Step two:

The incentive-based subsidy system that linked to:

----number of vehicle kilometers
---- number of vehicle hours
---- number of passengers

are calculated to make the operators replicate the optimal solution.

Step Three:

To avoid the excessive profit arising from marginal optimization, a lump-sum fee is recommended to be charged.

Step Four (Alternative):

One bonus/punish arrangement for punctuality is recommended in addition to the above arrangement.

Incentive-based subsidy scheme for public transit

In summary

There are two types of incentives: one is the revenue-based, and another is subsidy-based.

Such bus service contract with incentive-based subsidy scheme not only combines authority's the welfare maximizing objective with operator's commercial goal, but also provides further incentives for cost reduction and market efficiency.

Table 5 Suggested subsidy rates in NOK for four local transport operators in Hordaland county

Operator	Per vehicle-km	Per vehicle hour (base service)	Per vehicle hour (Additional service)	Per peak hour passenger
GAIA	3.5	130	300	0
VEST	2.5	130	250	0
BNR	1.5	130	250	10
HSD	1.5	130	250	9

Source: Carlquist (2001)

Conclusions

With the wave of deregulation and privatization, any intervention from public authorities should be incentive-based rather than command and control based.

Incentive design in urban financing and regulation transport policies can effectively reduces the conflict of interests between parties and makes agents partially responsible for their decisions.

Incentive subsidy and bonuses (or their inverse, penalties) are generally especially effective in ensuring good performance in terms of outcomes (*Hensher and Houghton 2004*).

For the sake of time, some urban transport policies cannot been discussed here, such as Parking pricing policies in the CBD , Cordon Toll for financing urban road.

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