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Pricing and efficient public transport supply in Mobility as a Service

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'Integrating Public Transport into Mobility as a Service (MaaS)'

Introduction

Welfare economics and Mobility as a Service

Mobility as a Service =
Multi-modal solutions + Sharing economy + Emerging IT

New policy proposals with high relevance for welfare economic appraisal

1. Pricing: New tariff structures – mobility packages, multimodal subscriptions
2. Industrial organisation and institutional setup: New agency in the integrator's role

Early scientific results: mainly demand modelling experiments, without policy optimisation and economic appraisal.

Introduction

Highlights of main messages

- Temporally, spatially and directionally differentiated, usage dependent pricing provides a powerful tool to incentivise efficient mobility
- Subscriptions induce welfare losses for two reasons
    1. Subscription holders face zero marginal fare, while they contribute to crowding more pronouncedly
    2. Non-subscription holders become more reliant on private car use, generating additional externalities
- Emerging IT solutions within MaaS make sophisticated disaggregate pricing policies user friendly
- Industrial organisation of MaaS: economic objective (i.e. profit or welfare orientation) of MaaS integrator has substantial impact of efficiency
- Covid-19: Extreme level of crowding externalities (with heterogeneity in perception) → Correct travel incentives are especially important

What makes pricing efficient in public transport?

Theory of pricing

Theory suggests that the optimal financial incentive internalises the net non-personal social cost of travelling

[Optimal fare] = [net MSC] – [MPC]

... in which the **marginal personal costs** of public transport use can include

- Access and egress (walking) costs
- Waiting time incl. its uncertainty
- In-vehicle travel time cost, incl. crowding discomfort
- Transfer costs

[Optimal fare] = [net MSC] – [MPC]

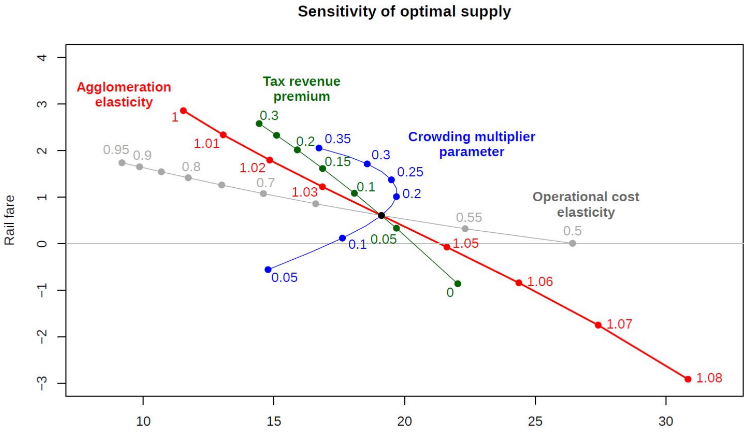
... while the **net marginal social cost** of public transport use contains

1. Without capacity adjustment
   - Crowding discomfort externality imposed on other users (–)
   - Delay externality during boarding and alighting (–)
   - Substitution with underpriced car use (+)
   - Wider economic benefits, including productivity gains (+)
2. With responsive capacity
   - Positive waiting time externality, the Mohring effect (+)
   - Density economies in operational costs (+)
   - Marginal cost of public funds (–)

(–): *Negative* external welfare effect, with a *positive* impact on the optimal fare
(+): *Positive* external welfare effect, with a *negative* impact on the optimal fare

What makes pricing efficient in public transport?

A numerical synthesis



Hörcher, D., De Borger, B., Seifu, W., & Graham, D. J. (2020). Public transport provision under agglomeration economies. *Regional Science and Urban Economics*, 81, 103503.

Non-uniform pricing in public transport

A literature overview

- Subscriptions implement **second-degree price discrimination** in the form of quantity discount

  Brown, S. J., Sibley, D. S., (1986). *The Theory of Public Utility Pricing*. Cambridge University Press.

- Financially constrained **public operators can increase revenues** efficiently with subscriptions

  Carbajo, J. C. (1988). The economics of travel passes: non-uniform pricing in transport. *Journal of Transport Economics and Policy*, 153-173.

- Travel pass provision is a **progressive policy**, low income groups should rely on subscriptions

  Jara-Díaz, S., Cruz, D., & Casanova, C. (2016). Optimal pricing for travelcards under income and car ownership inequities. *Transportation Research Part A: Policy and Practice, 94*, 470-482.

- Road pricing application: Road subscriptions generate **excess congestion and overconsumption**

  Wang, J. Y., Lindsey, R., & Yang, H. (2011). Nonlinear pricing on private roads with congestion and toll collection costs. Transportation Research Part B: Methodological, 45(1), 9-40.

- Subscriptions are harmful in public transport as well, if **crowding externalities** are included in the model

  Hörcher, D., Graham, D. J., & Anderson, R. J. (2018). The economic inefficiency of travel passes under crowding externalities and endogenous capacity. *Journal of Transport Economics and Policy*, 52(1), 1-22.

Unexplored questions in the literature

Modelling objectives

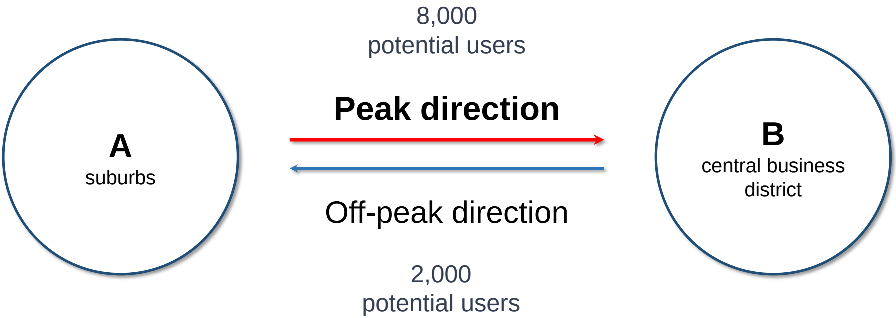
How do PT/multimodal subscriptions perform, if...

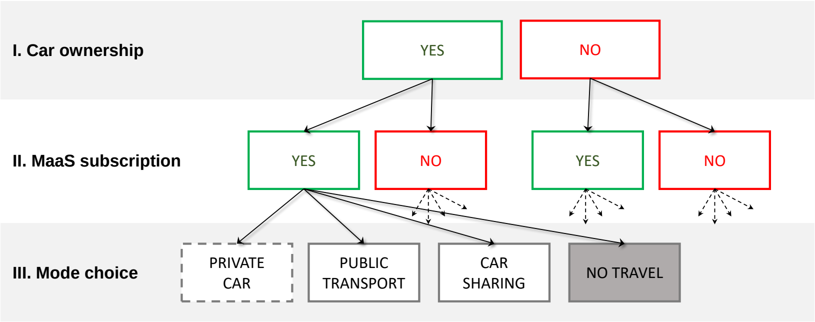
- mode choice is endogenous wrt. private and shared car use?
- car ownership is endogenous?

Explore *supply-side* decisions in Mobility as a Service

1. **Pricing:** How a future MaaS operator should/will set the prices of subscriptions and traditional usage (pay-as-you-go) fees.
2. **Capacity:** It is unclear what capacity policy (e.g. frequency and car sharing fleet size) should complement the pricing reform.
3. **General appraisal:** How new fare and capacity levels will affect (i) the net consumer benefit of urban transport provision, (ii) operational costs and public subsidies to public transport, and (iii) the magnitude of externalities generated by the transport sector as a whole.

Modelling framework





- ⇒ Recursive evaluation: Decisions made based on expected utility (logsum) on lower decision levels, *plus* additional payments.
- ⇒ **Social welfare** = Money value of expected utility on top of the decision tree + Revenues – Operator costs
- ⇒ Repeated for both markets.

Key model features

- Source of externalities: Congestion in road use, crowding in public transport, access/availability costs in car sharing
- Public transport: frequency-dependent waiting time, Mohring effect
- Private car users do pay for parking, shared cars don't
- Car sharing: fixed fleet size shared by the two directional markets
- Benchmarked pricing policies:
  - flat fares (PAYG) in both PT and car sharing
  - flat fares + **rail** subscription
  - flat fares + **car sharing** subscription
  - flat fares + **multimodal** subscription
  - directionally differentiated fares

Scenario 1

The impact of subscriptions at a fixed price

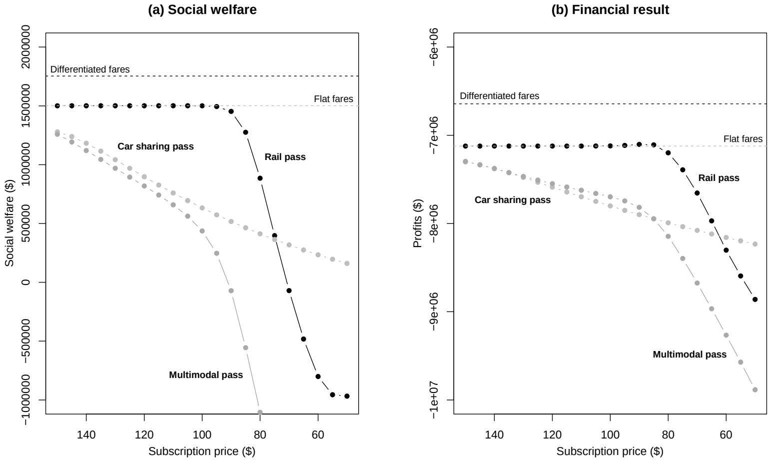
Initial state: optimal flat fares → Subscription introduced at fixed price
PT supply: flat fare at $2.00, 8 trains per hour
Car sharing supply: flat fare at $7.70, 500 cars in fleet

Market	Off-peak		Peak	
Subscription available	No	Yes*	No	Yes*
Rail utility				
– non-pass holders	-7.44	-7.48	-9.7	-9.85
– pass holders	–	-6.48	–	-8.85
Private car use utility	-4.01	-4.01	-6.18	-6.23
Car sharing utility	-8.34	-8.13	-11.34	-11.06
Rail demand				
– non-pass holders	902	429	3578	1306
– pass holders	–	521	–	2351
Private car use demand	846	831	3806	3837
Car sharing demand	250	217	342	331

* *Subscription price set to* $T_1 = \$50$

Schenario 2

Variable subscription prices



Double welfare loss due to subscriptions:

1) Public transport demand intensifies due to pass holders who face zero marginal fare.

2) Non-pass holders shift to unpriced car use

Scenario 3

Profit oriented subscriptions

Table: Profit maximisation with flat fares, non-uniform tariffs, and differentiated pricing. All quantities are expressed in monetary units.

	τ_a^p	τ_b^p	τ_a^s	τ_b^s	T_1	T_2	T_3
Baseline scenario	2.00	2.00	7.70	7.70			
Flat fares	6.62	6.62	8.96	8.96			
Rail subscription	8.58	8.58	8.87	8.87	191		
Car share subscription*	6.62	6.62	8.96	8.96		*High*	
Multimodal subscription	17.65	17.65	18.33	18.33			202
Differentiated pricing	7.17	3.48	11.34	7.80			

	Pr index	W index
Baseline scenario	0.00	1.00
Flat fares	1.00	0.00
Rail subscription	1.12	-0.61
Car share subscription*	–	–
Multimodal subscription	1.35	-0.84
Differentiated pricing	1.16	0.12

Conclusions from modelling exercise

Hörcher, D., & Graham, D. J. (2020). MaaS economics: Should we fight car ownership with subscriptions to alternative modes?. *Economics of Transportation, 22*, 100167.

1. We develop a numerical model of peak commuting in which (long-run) car ownership, (medium run) subscriptions to other modes, and daily mode choice are all endogenous.
2. We test the economic and financial impact of subscriptions to individual modes or both modes together.
3. Subscriptions **harm social welfare** in the presence of externalities, for two reasons
   3.1 **Pass holders face zero marginal fare**, and therefore overconsume in the presence of crowding and access cost externalities.
   3.2 **Non-pass holders** experience worsening conditions on public transport and car sharing → more likely to **switch to private car use**.
4. Subscriptions for rail and the combination of both alternative modes generate extra revenues through **second-degree price discrimination**.
   → *But differentiated fares would do that more efficiently.*

Economic objectives in MaaS provision

The MaaS provider

Lesson from numerical example: the supplier's objective has massive impact on capacity and fares.

Open questions in the MaaS framework

- What level of control should the MaaS provider (integrator) have on supply variables such as capacity and price?
- Ownership structure of the MaaS provider

Operators in the MaaS system

Competition may not prevail due to the *natural monopoly* nature of network industries

Competition between privately and publicly owned firms leads to *ambiguous outcomes*, and potentially *unfair* practices

Policy dilemma: Limit the scope of MaaS to information provision and a platform for digital transactions?

Societal impacts during and after Covid-19

- Substantial rearrangement and general reduction in travel demand patterns
  - Uncertain future evolution path for mobility, but the scale/density advantages of cities are unlikely to disappear
- As long as infection risks remain with us:
  1. Value of crowding is expected to be much higher – social distancing
  2. Public transport faces serious capacity scarcity – efficient use of available resources is crucial
  3. Differentiated pricing has increased relevance
  4. Economic downturn and social challenges – Redistributional concerns and equity are key requirements
- Onging research: demand management with (i) inflow control, queueing, (ii) advance booking, slot reservation (iii) differentiated pricing, (iv) slot auctions, (v) tradeable permit schemes

Conclusions

1. Current MaaS literature: increased focus on **demand modelling** aspects, little attention devoted to **economic appraisal**.
2. Pricing in the MaaS framework – Modelling results
   - Subscription-based tariff products provide false demand incentives, even if mode choice and car ownership are endogenous
   - Differentiated pricing handles peak-time externalities in all modes
3. The **technological solutions** of MaaS enable the implementation of differentiated pricing in a **user friendly way**
4. **Industrial organisation** of MaaS – Often unclear economic objectives, complex bargaining processes if MaaS is more than an information platform
5. **Covid-19:** Increased crowding costs, capacity scarcity, sensitive social environment – MaaS can contribute with effective capacity allocation