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Road Pricing Strategies: analyzing scenarios of Eurovignette's implementation in Barcelona

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0. Index

Introduction

- **Urbanisation rates** have been **growing** gradually since the mid 20th century. Globally, it raised from 30% (in 1960) until 57% (in 2022), although in Europe we have reached 75% already.

- Metropolitan areas struggle to absorb all migration arriving from rural areas, but also from other countries. Housing, trade, job market, and even **transport** have been affected. As downtowns are fulfilled, and prices are prohibitive, new housing promotions tend to be in the periphery, and **larger trips** are then needed to reach central areas. Logistics facilities are also being expelled from central locations (**logistics sprawl),** requiring logistics operators **larger trips** to distribute and deliver.

- The problem is that **urban mobility and freight distribution** have started to be identified as cause of **many externalities**, from air pollution to CO2 emissions, noise, accidents, traffic jams, lack of parking, irregular parking, or public space occupancy, among others.

- Policymakers are not aloof in front of such phenomena and have started reflecting on measures…

Road pricing policy: legal and theoretical framework

- *Directive 1999/62/EC of the European Parliament and of the Council of 17 June 1999 on the charging of heavy goods vehicles for the use of certain infrastructures.*

  1) Establish an internal market in road transport with a level playing field and ensure uniform and non-discriminatory application of rules.
  2) Strengthen the application of the user and polluter pays principles.
  3) Contribute to the financing of road infrastructures.
  4) Tackle congestion and the negative environmental and health impacts of air pollution and noise.

- But this is not something new…

  Pigou (1920) and Knight (1924) started discussing permits, limitations and restrictions to traffic and parking.

Road pricing policy: carrot & stick

Penalty policies to mitigate impacts and externalities	Reduction of road capacity in streets belonging to sensitive urban areas. Restriction of the circulation of vehicles in certain streets. Regulation of parking on public roads. **Urban tolls.** Measures to limit circulation according to license plates. Variable signalling in the city's access. **Progressive taxes according to fuel consumption and vehicle efficiency.** **Implementation of the Euro-vignette for freight road transport.**
Active policies to promote sustainable modes	Subsidized bonds for public transport. Traffic light prioritization to public transport and non-motorized modes. Public systems of bicycles and scooters. Discounts on road tolls for electric vehicles and those with high occupancy. HOV-lanes to facilitate the entrance to big cities.

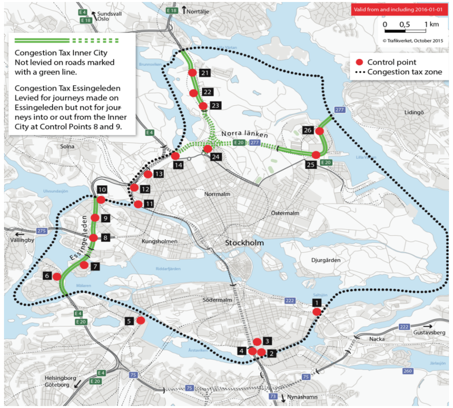
Types of Urban Tolls

Schemes (de Palma & Lyndsey, 2011; Gervasoni & Sartori, 2007)

- Based on specific infrastructure
- Based on geographical areas

Methods (May & Milne, 2000)

- Fixed fee
- Time
- Distance
- Congestion



Types of Urban Tolls

Pricing options:

- Pricing based on specific infrastructure
- Pricing based on perimeter access
- Pricing based on total distance
- Pricing based on total time
- Pricing based on access to specific areas

Additional variables & parameters:

- Day of the week
- Type of vehicle
- Existing congestion
- Season
- Time slots

Best practices

	Singapore (1975)	London (2003)	Milan (2012)
Aim	Reduce congestion in CBD area	Reduce congestion	Reduce congestion & reduce CO_2 emissions
System	Hybrid pricing system based on existing congestion Implemented by public authorities	Congestion pricing by areas Implemented by public authorities	Congestion pricing scheme based on perimeter access Restriction of access to old city centre
Results	1975-2007 Traffic reduction: -21% CO_2 emissions' reduction: -16% Modal shift: -10% car Income (2012): > 285M€	Traffic reduction: -33% CO_2 emissions' reduction: -12% Modal shift: +20% bus, +13% taxi Income: > 325M€	Traffic reduction: -37% CO_2 emissions' reduction: -16% Modal shift: -12.5% car Income (2014): > 21M€

Case study: Barcelona

- 95 km² of surface
- Implementation of LEZ (2020)
- Automatic enforcement system (CCTV)
- Sustainable Urban Mobility Plan (2024) aims at reducing CO_2 up to 30% in 30 years.

Case study: Barcelona

- 7 million of daily journeys within the SIMMB

- Transport modes:

Mode	Journeys	Modal share (%)
Non-motorised	3.294.959	46,40%
Public Transport	2.101.072	28,20%
Private vehicles	1.631.435	25,40%

- Journeys:

	Within BCN	Commuting with other cities	Total	Total (%)
BCN citizens	4.775.800	662.760	5.438.560	77,40%
SIMMB citizens	228.109	1.360.797	1.588.906	22,60%
Total journeys	5.003.909	2.023.557	7.027.466	100,00%

Case study: Barcelona

- Average distance of journeys:

	Total private vehicles	Average time	Average distance
BCN citizens	1.262.596	18,4 min	5,6 km
SIMMB citizens	368.867	44,3 min	16,5 km

- Average time per journey:

Average time	Journeys (%)
< de 5 min	14,30%
6 a 15 min	30,40%
16 a 30 min	30,70%
> de 30	24,60%

Methods

Problem definition

- Systematic literature review (WoS and Scopus)
- Review of best practices
- Review of official reports
- Data gathering from Open Data portals (i.e. BCN city council)
- 31 interviews with relevant agents: public administration, logistics operators, citizens.

Empirical framework

- Data series
- Comparison of policy scenarios
- Monte-Carlo simulation

Methods

Scenarios

- S1 – Daily fee
- S2 – Number of entrances/exits
- S3 – Time slots
- S4 – Total distance
- S5 – Total time
- S6 - Number of perimeters crossed

Aim

- Perform a comparative of all scenarios

Empirics

Scenario 1

$$Coll_{day} = \sum_{n=1}^{\infty} n(D_S \cdot (\rho_{daily\ cost} + C_{p0}))$$

Scenario 2

$$Coll_{Accesses} = \sum_{m=1}^{\infty} m(D_S \cdot (\rho_{daily\ cost} \cdot \beta_{Va}) + C_{p0}))$$

Scenario 3

$$Coll_{Stripe} = \sum_{f=1}^{\infty} f(\sum_{n=1}^{\infty} n(D_s \cdot \left(\rho_{fixed\ cost}\right) + \gamma_{Fh} + C_{p0}))$$

Scenario 4

$$Coll_{Distance} = \sum_{n=1}^{\infty} n(D_S \cdot (\rho_{fixed\ cost}) + (\sigma_{dk} * dist.trav.) + C_{p0})$$

Scenario 5

$$Coll_{Time} = \sum_{n=1}^{\infty} n(D_S \cdot (\rho_{fixed\ cost}) + (\tau_t * time) + C_{p0})$$

Scenario 6

$$Coll_{Cordons} = \sum_{n=1}^{\infty} n(D_S \cdot \left(\rho_{fixed\ cost}\right) + \Sigma \subset_n + C_{p0})$$

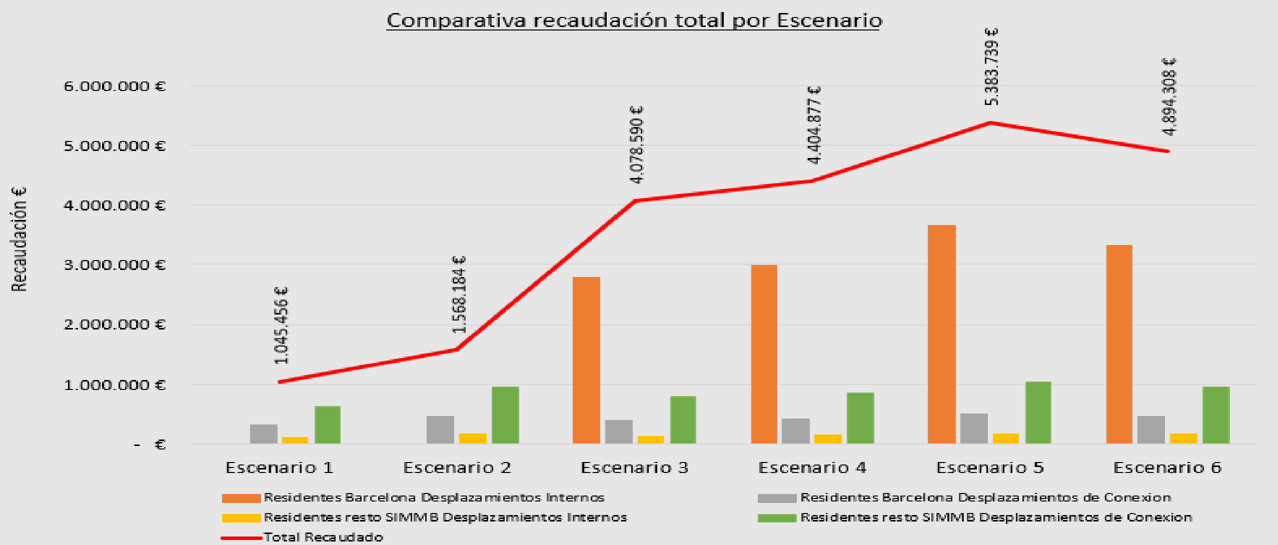
Results

Parameters

	Fee
Scenario 1	2,00 €
Scenario 2	3,00 €
Scenario 3	2,50 €
Scenario 4	2,70 €
Scenario 5	3,30 €
Scenario 6	3,00 €

Journeys			
BCN citizens		SIMMB citizens	
Within BCN	Commuters	Within BCN	Commuters
1.108.708	153.861	52.956	315.911

Results



Results

Public acceptance

- Interviewees working in **public administrations** were **100% in favour** of such measures
- **Logistics operators** were **67% against** such measures.
- Regular **citizens** were **divided**: 46% in favour versus 54% against.

Discussion & conclusions

- International experiences have proved these **policies useful for inducing changes** in the **short term**, altering current routes and fostering modal shift.
- Local public opinion polls show contradictory results.
- Results obtained from our simulation show that the key elements are:
  - Pricing system: implementation and/or technology
  - Pricing system: addressees
  - Fee charged, recharges and discounts
  - Alternative options

The ideal would be to find the optimal solution that:

- Reduces the number of trips
- Alters traffic distribution
- Increases public transport usage
- Revenue obtained from such systems should be reverted to the transport system

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Thank you!

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