Fairness, Pricing, and Modal Shift: Behavioral Perspectives on Urban Toll Acceptability

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Motivation

Achieving a **modal shift** from cars to low-carbon transport requires significant infrastructure investment, expanded network capacity, and improved public transport (PT) service quality.

On the *demand* side, **price-based tools** can reduce car use by raising costs and encouraging commuters to adopt soft modes.

Robust causal evidence on **congestion pricing** is limited, leaving its effectiveness and acceptability debated [7, 8].

Among price-based tools, urban tolls can improve equity in PT access and reduce car use [2, 4], with evidence from London, Stockholm, and Singapore showing **lower congestion** and **higher bus ridership** after implementation [1, 9, 10].

In France, such schemes remain rare, partly due to **low public acceptability**.

Research Question

Our study aims to ***investigate how urban tolls impact commuters' behaviors (modal shifts), and the role of fairness and redistribution in toll acceptability***.

Method

Behavioral perspective: accounting for cognitive biases that weaken responses to price signals, affecting both modal shift and policy acceptability.

- *Psychological inertia* and *loss aversion* can make tolls seem **punitive** or **unfair** when financial burdens appear uneven [3, 6, 11].
- Equity, privacy, uncertainty, and overall perceptions are key predictors of acceptability [5].

We focus on **equity**: road pricing is often seen to disproportionately burden lower-income travelers with limited modal alternatives (Green, 1995; Jones, 1998).

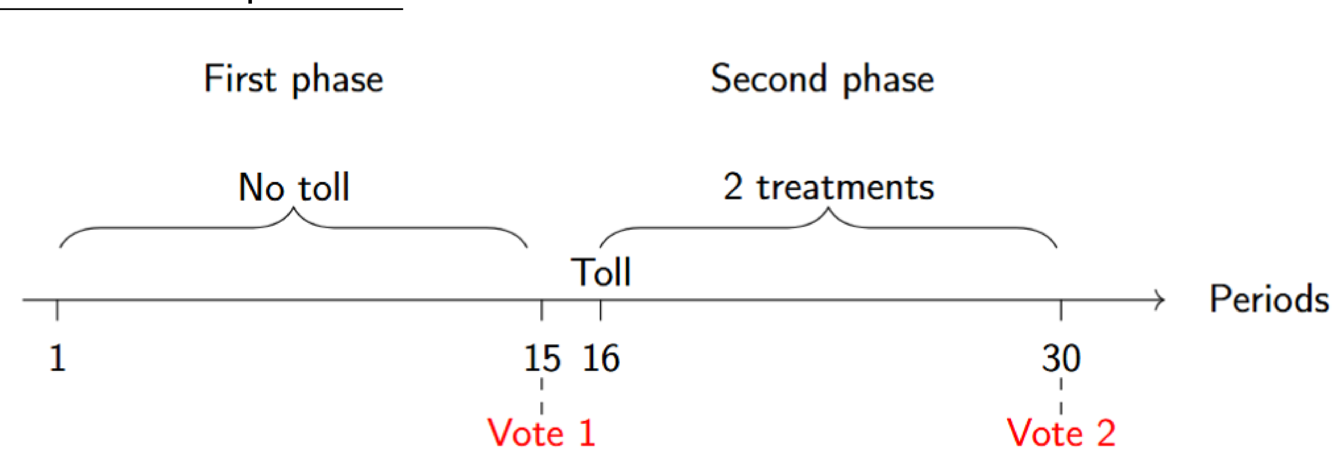
→ **Modal discrete-choice experiment** embedding unequal PT access.

Design

Goal of the task & Experiment's overall Structure

- Reach the same arrival point over 30 periods (by 9:00 a.m.), choosing a car or public transportation option, and a departure time. In each period r, commuter i chooses a pure strategy $\mathbf{a}_i \in \{a^{\text{car},d_1}, a^{\text{car},d_2}, a^{\text{PT},d_3}\}$ with $d_1, d_2 \in \{8{:}20, 8{:}40\}$ and $d_3 = 8{:}30$.
- In each group of 10 participants, 6 are randomly assigned to point 1 (Peri-urban) and 4 to point 2 (Suburban).
- Each player i in group g receives an exogenous endowment $E_{ir} = 11$ at the beginning of period r, to pay for the trip.
- If the number of participants choosing the same mode and time exceeds a threshold δ, earnings are reduced.
- Between rounds: feedback on prior choice, payoff earned, whether congestion occurred.

Timeline of the experiment:



The Network in the First Phase (Periods 1^{st} to 15^{th}):

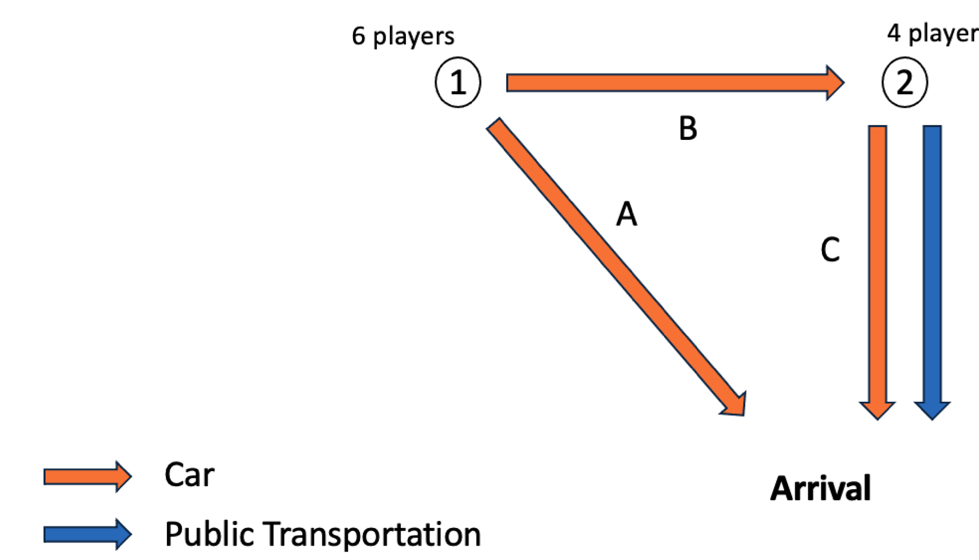


Figure 1. Network in the first phase

Payoffs & Transportation Costs:

The payoff $\pi(a_i|a_{-i})$ received by player i in each period r is:

$$\pi(a_i \,|\, \mathbf{a}_{-i}) = E_{ir} + G(a_i \,|\, \mathbf{a}_{-i}) - C^{\text{use}}(a_i) - C^{\text{time}}(a_i; u_c)\,.$$

Component	Gains G			Usage C^{use}			Time C^{time}			
	On time	Early	Late	Car	PT	Park	$\text{Car}_{c=0}$	$\text{PT}_{c=0}$	$\text{Car}_{c=1}$	$\text{PT}_{c=1}$
Arrival-time gains $G(\cdot)$	12	10	7	—	—	—	—	—	—	—
Usage cost $C^{\text{use}}(\cdot)$	—	—	—	4	4	4	—	—	—	—
Time cost $C^{\text{time}}(\cdot; u_c)$	—	—	—	—	—	—	4	6	9	10
Endowment E_{ir}	11									

Notes: All values are per period (in €). $u_c \in \{0,1\}$ indicates congestion (0 = no congestion; 1 = congestion). *Park* refers to participants starting from point ① who wish to use PT in Phase 1.

The Network in the Second Phase & The Two Treatments (Periods 16^{th} to 30^{th}):

A toll is introduced for car users, funding the addition of a PT line on route A. Travelers from ① can choose their mode and now reach the destination directly by PT.

1. **Fair** Treatment: suburban users pay more to support peri-urban PT — explicit redistribution, lower suburban congestion, and better peri-urban service quality.

	Toll cost t	PT threshold δ
Peri-urban	2	≥ 4
Suburban	4	≥ 3

2. **Equal** Treatment: both groups pay the same toll; PT quality remains higher for peri-urban users.

	Toll cost t	PT threshold δ
Peri-urban	4	≥ 5
Suburban	4	≥ 3

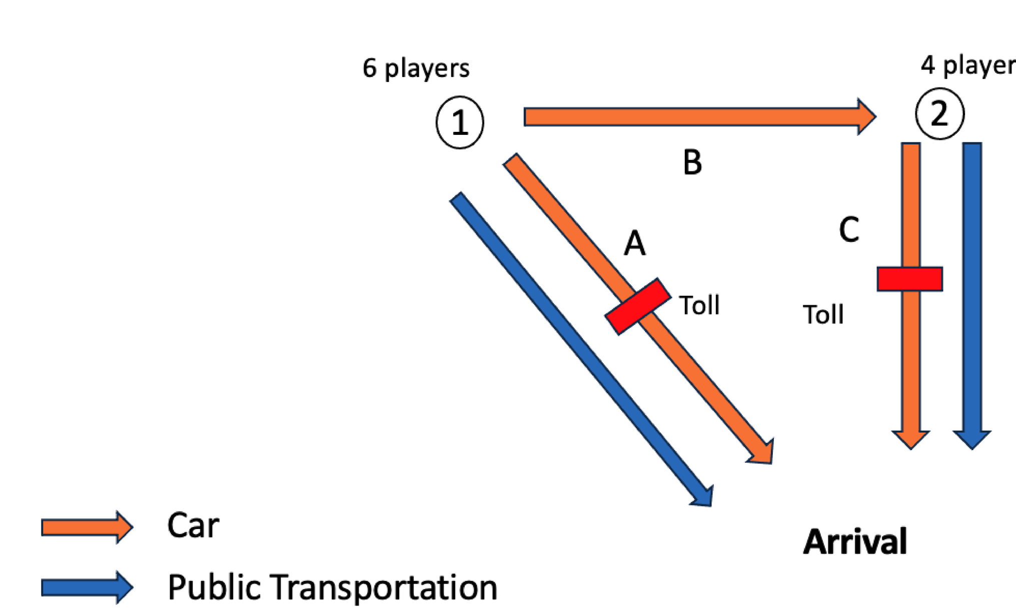


Figure 2. Network in the second phase, with the added PT line

Measuring Acceptability (At the 15^{th} and 30^{th} period):

Are you in favor of introducing a toll to finance the construction of the public transport line on route A?

→ Incentivized vote (following Janusch, 2015)

Nash Coordination Hypothesis

	Peri-urban			Suburban		
# commuters	Car, 8:20	Car, 8:40	PT, 8:30	Car, 8:20	Car, 8:40	PT, 8:30
Phase 1 — No toll	5	1	0	1	1	2
Phase 2 — Equal Treatment	1	1	4	1	1	2
Phase 2 — Fair Treatment	2	1	3	1	1	2

Notes: The entries represent the optimal computed count of commuters per choice and phase. The counts are Pareto optimal in the sense that commuters have no incentive to deviate from their choice. They were computed using an algorithm.

Preliminary Results

The preliminary results are based on collected data of 400 participants, at the LEEP laboratory (Paris 1 Panthéon Sorbonne/PSE).

1. Participants' choices follow the Nash equilibrium predictions

   → Choices converge toward our predictions across periods. This suggests learning (or improved rationality), indicating that participants' understanding and coordination improved over time.

2. Reduction in car use after the introduction of the toll

   → Regarding modal shift, we find that the introduction of both toll and PT leads to an increase (decrease) in the average PT (car) usage. The reduction is found to be significant within treatments ($p < 0.001$).

   → We find that coordination helps to reduce congestion after the toll and PT implementation. This means that the theoretical predictions of the effectiveness of the toll are confirmed (at least, in a descriptive manner).

3. Higher peri-urban support after toll introduction

   → **Peri-urban:** acceptability increases between the two votes in both treatments; in the *Equal* treatment it reaches **56.7% Yes** (vs. 50.8% in *Fair*).

   → **Suburban:** Around **30% Yes** in the *Equal* treatment with no meaningful change; a small, non-significant decline between votes in the *Fair* treatment (**40% Yes**).

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