Trading Trips

Using Tradable Permits to Manage Urban Mobility

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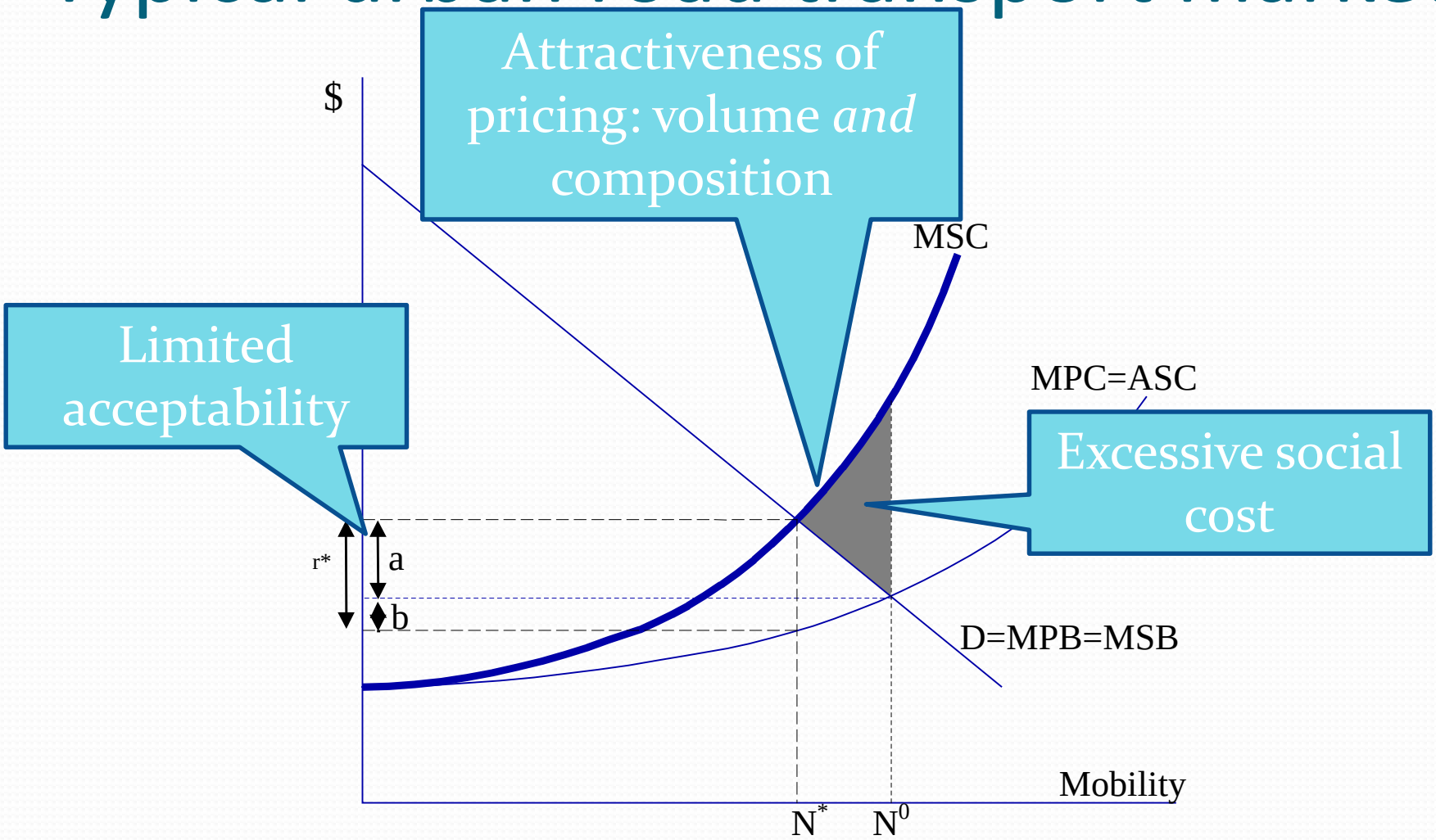
Policy challenges in urban road transport…

- … often external cost, notably
- Congestion
  - Time losses
  - Unreliability
- Emissions
  - Local
  - Global
- Accidents
  - Damage
  - Pain, suffering and fatalities

Typical urban road transport market



Search for more acceptable price instruments

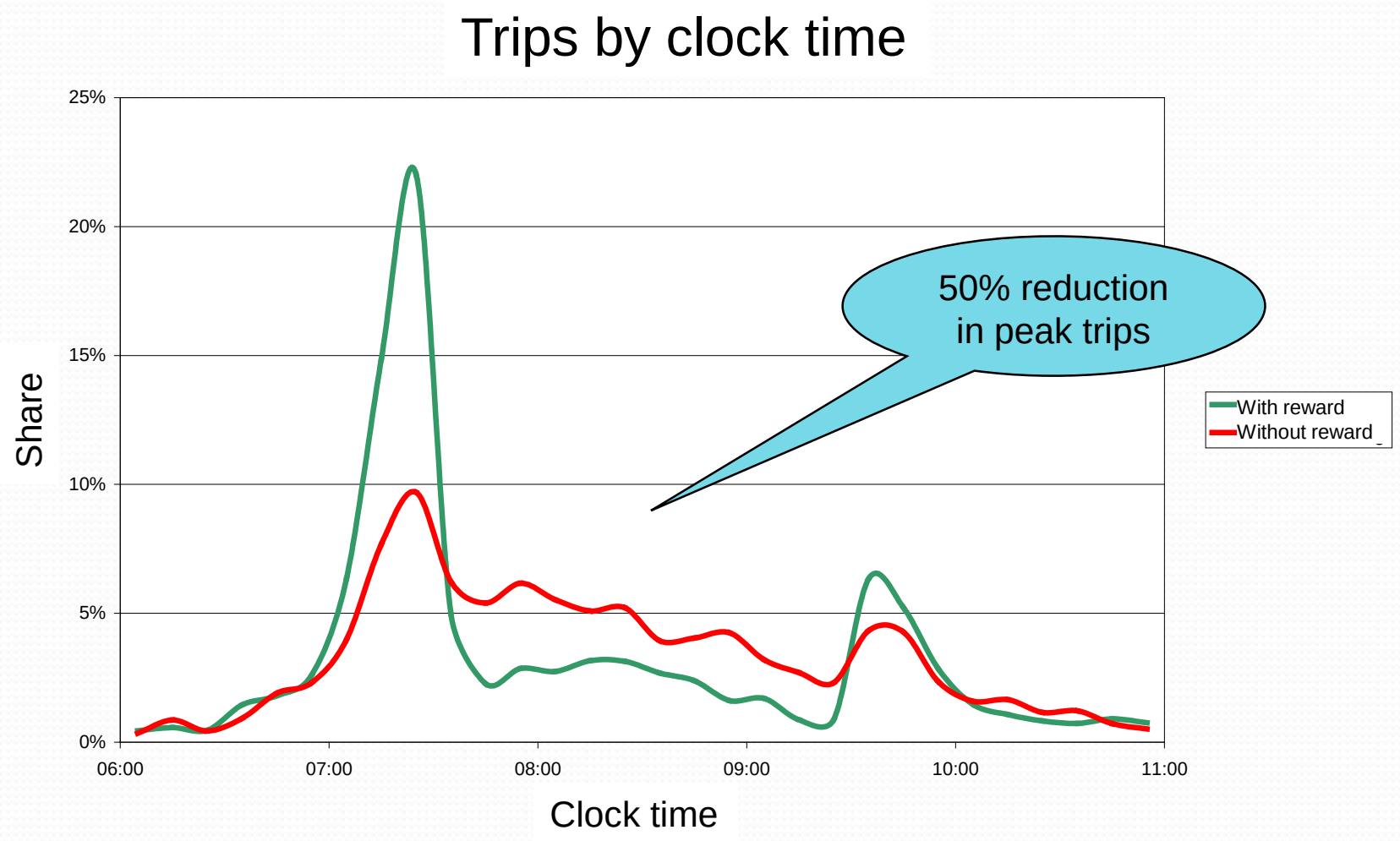
- Pricing: efficient, effective, but low acceptability
- Rewarding (as in “Spitsmijden”: “Peak Avoidance”)
  - Popular, effective
  - But (1): Financially unsustainable (rewards!)
  - But (2): Less efficient (induced or latent demand problem)
- Hybrid solutions?
  - **Budget neutral: tradable permits**

“Spitsmijden” / “Peak Avoidance”

- Series of experiments
  - Road
  - Public transport
- “User paid” instead of “user pays”:
  - Rewards for avoiding peak travel
- Typical characteristics of experiments
  - Automated (GPS) detection of vehicles or individuals
  - Participants invited on the basis of observed peak behaviour
  - Financial incentive of around € 3,- to avoid peak travel

Effectiviness: SpitsMijden I

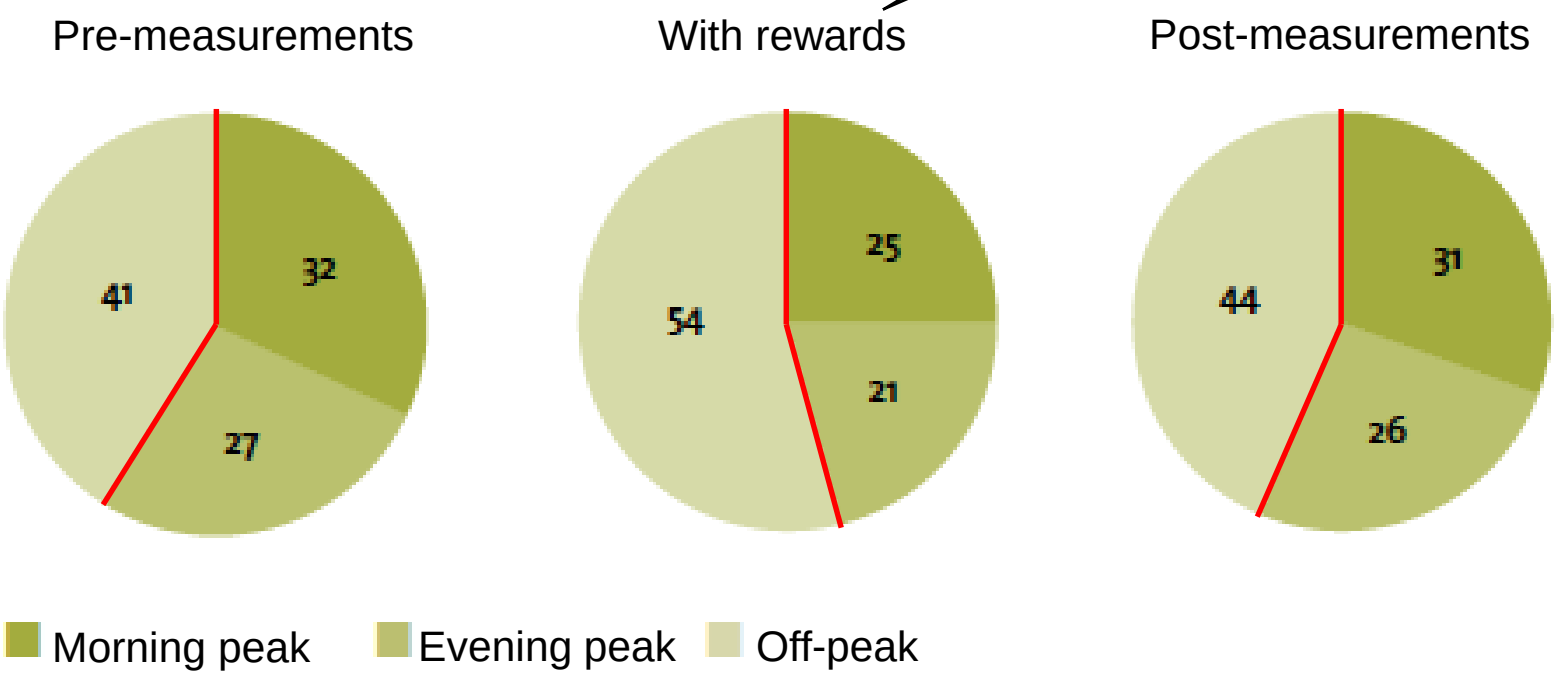
(Zoetermeer, 2006, 340 participants)



SpitsMijden in the Train

(Abonnements, 2012-2013, 467 participants)

22% reduction in peak trips



Pay as you Drive

(Insurees, 2008, 228 participants, max 30 Eur/month for speeding)

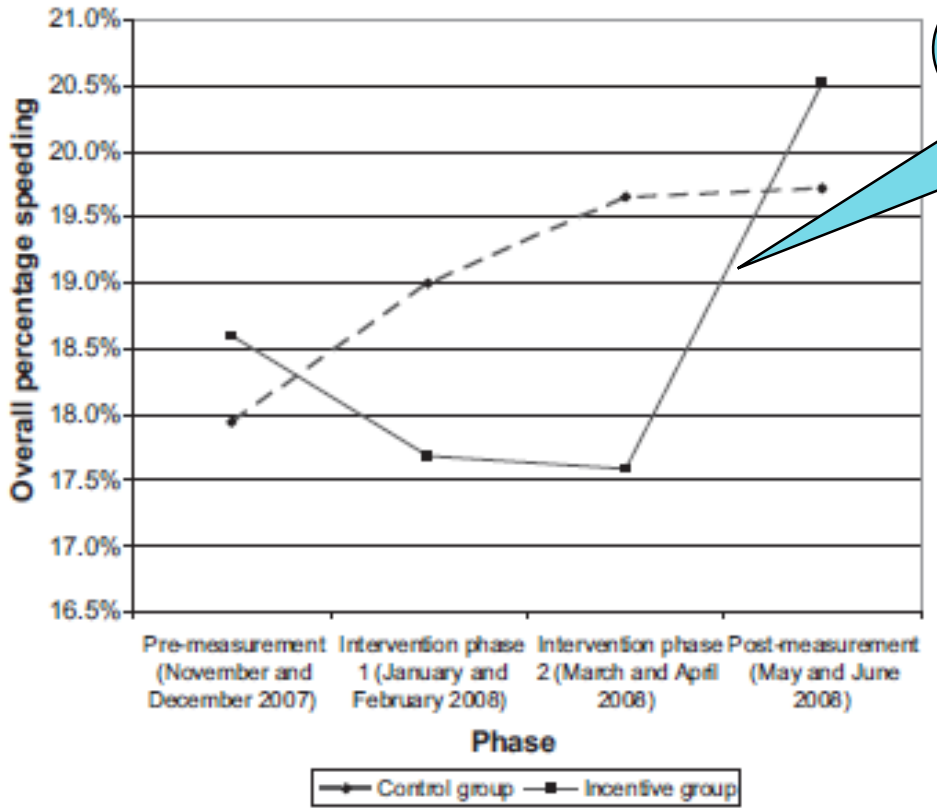
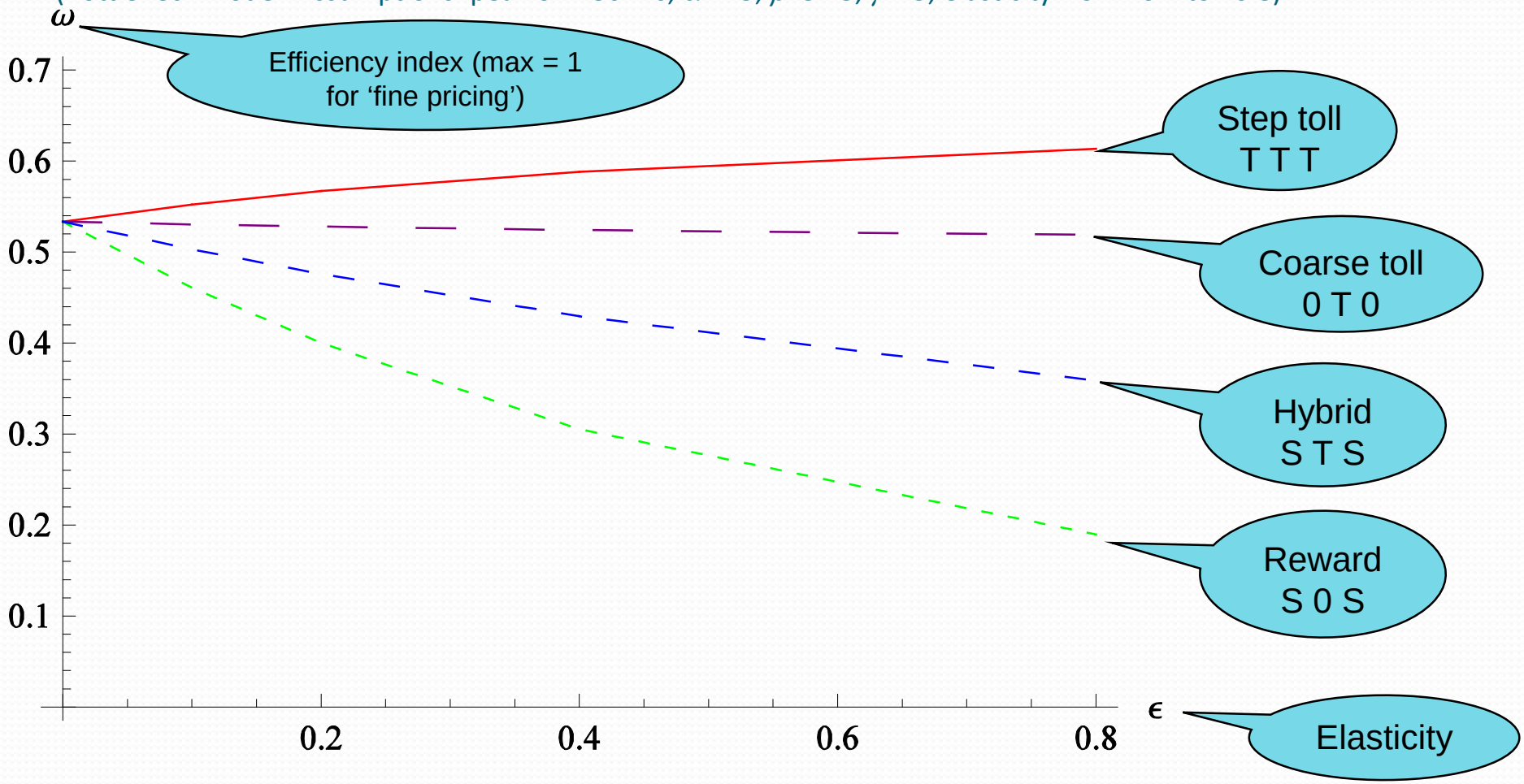


Fig. 1. Overall percentage speeding for incentive and control groups.

14% reduction in km's with speeding

Second-best aspects: 4 coarse schemes

(Bottleneck model. Assumptions: peak of 2:30 hrs; α=7.5, β=3.75, γ=15; elasticity from –0.1 to –0.8)



Relative efficiency budget-neutrality

- Previous slide: budget neutral incentives avoid part of the latent-demand problem with rewarding
- But there are quite a few examples of second-best road pricing where, in fact, budget neutrality is preferred over strictly positive tolls

Partial network pricing…

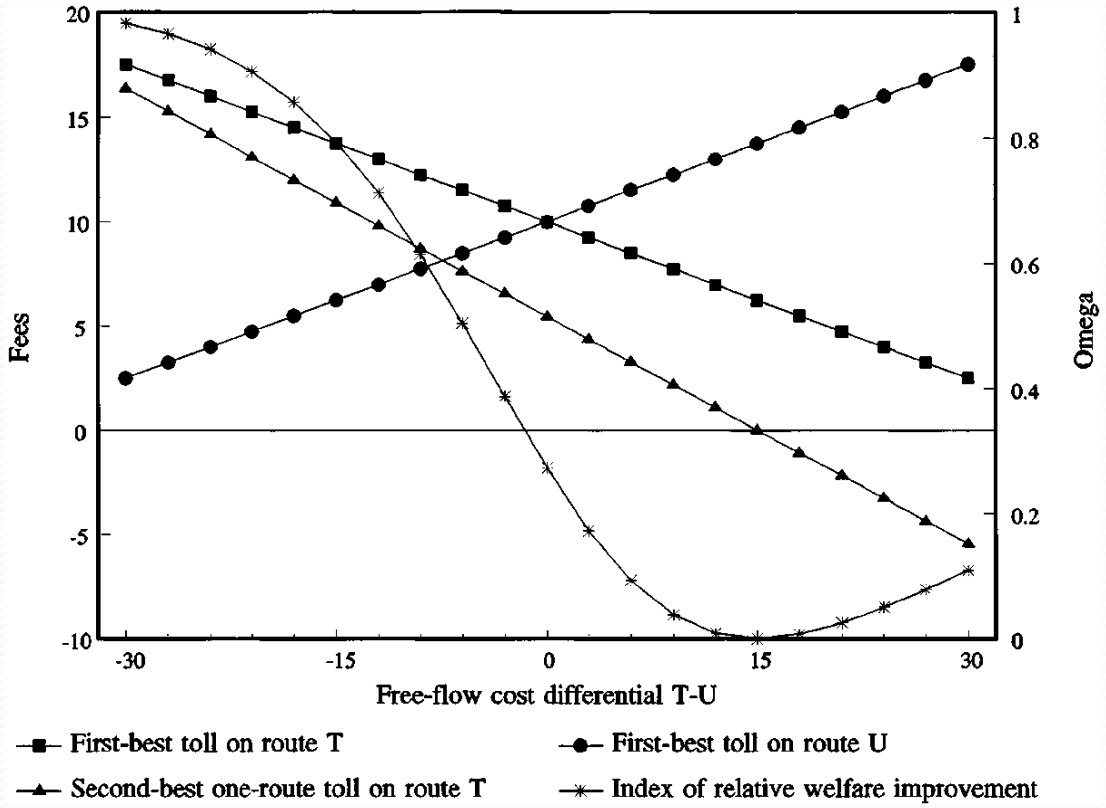
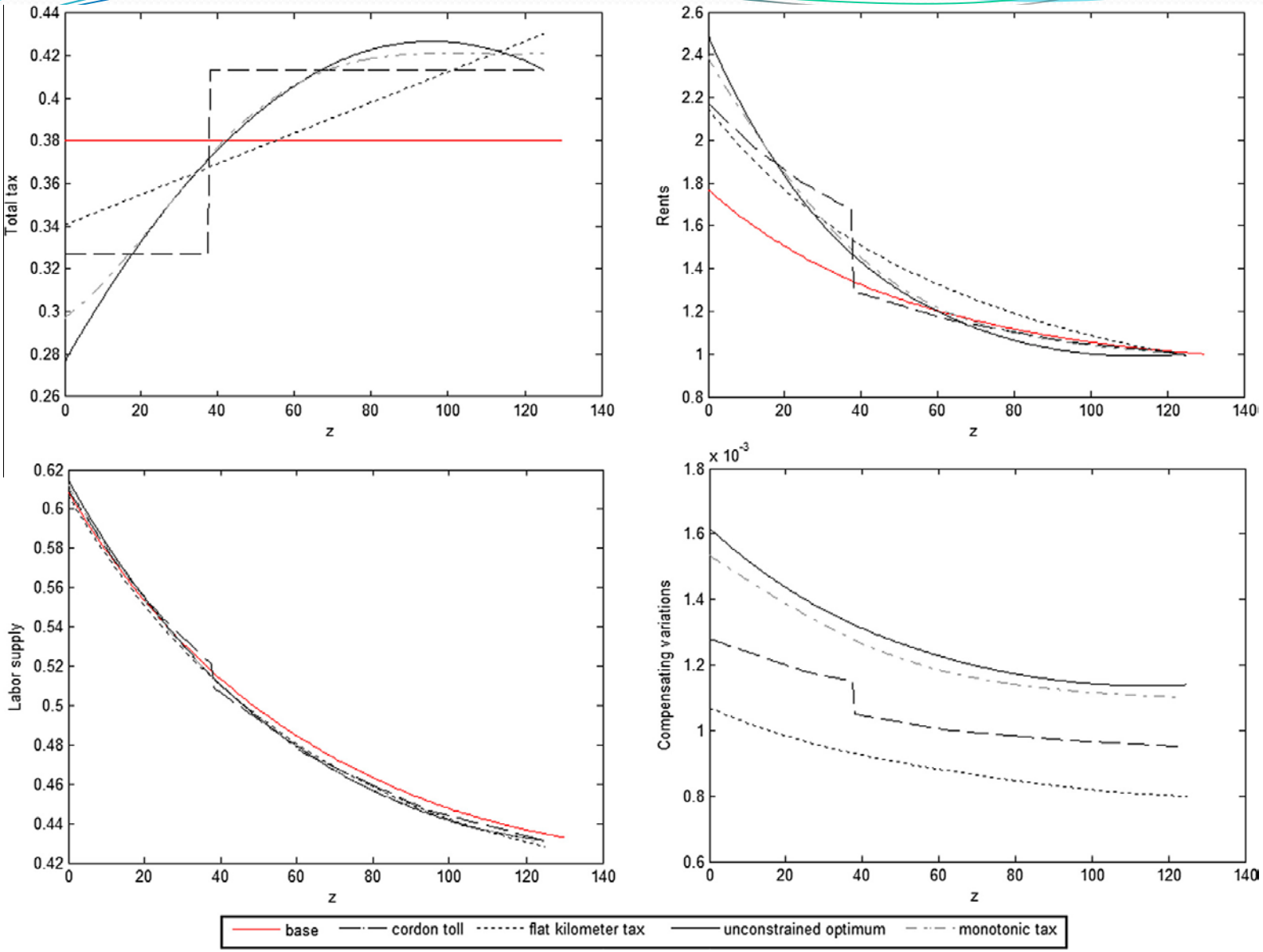


FIG. 2. Varying free-flow costs: optimal fees and index of relative welfare improvement.

Dynamic partial network pricing…

- Two parallel bottlenecks, one with dynamic toll (Braid, 1996)
  - Dynamic toll pattern eliminates queuing
    - … and reduces marginal social cost at priced bottleneck
  - Second-best dynamic toll starts and ends at negative values
    - … to attract users from the unpriced queued bottleneck (with higher marginal cost)


Total tax
z
Rents
z
Labor supply
z
x 10^-3
Compensating variations
z
base
cordon toll
flat kilometer tax
unconstrained optimum
monotonic tax

Prospects for tradeable permits…

- Acceptability: likely to be higher than for pricing
- Efficiency
  - Likely to be higher than for rewarding (latent demand)
  - May approximate or even exceed that of strictly positive tolls under specific circumstance
    - When second-best tolls are negative
    - Often considered infeasible (for example circuitous routes…)
- Attention in literature (economics, engineering)
  - Verhoef *et al.* (1997); Yang & Wang (2011); Xiao *et al.* (2013); Akamatsu & Wada (2017); De Palma *et al.* (2018)
- But… will it work?

Will it work?

- Various aspects
  - Users
    - Willing to trade?
    - Understand the system as intended?
    - Avoid (undesired) speculation?
    - Avoid fraud?
    - Minimize transaction costs?
    - Aggregate behaviour results in stable price and equilibrium?
  - Technical aspects
    - Virtual market and online interface?
    - Monitoring of behaviour?

Design – an example

- Imagine a Spitsmijden experimental setting
  - Aggregate target of *Q* trips per period of 5 working days
    - Less than initial behaviour…
  - A total of *Q* tradable credits *(trip-coins)* is distributed over participants
    - Exact distribution can be chosen
    - One trip-coin is used up for each peak trip
      - Peak trip without trip-coin: penalty (> expected trip-coin price)
    - Trip-coins can be bought and sold
  - Design choice
    - Traveller-to-traveller
    - Bank

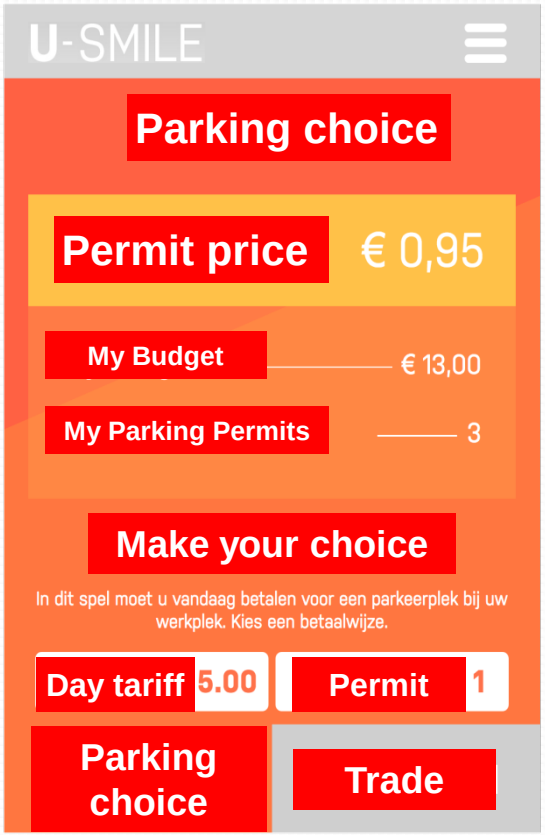
Design – an example

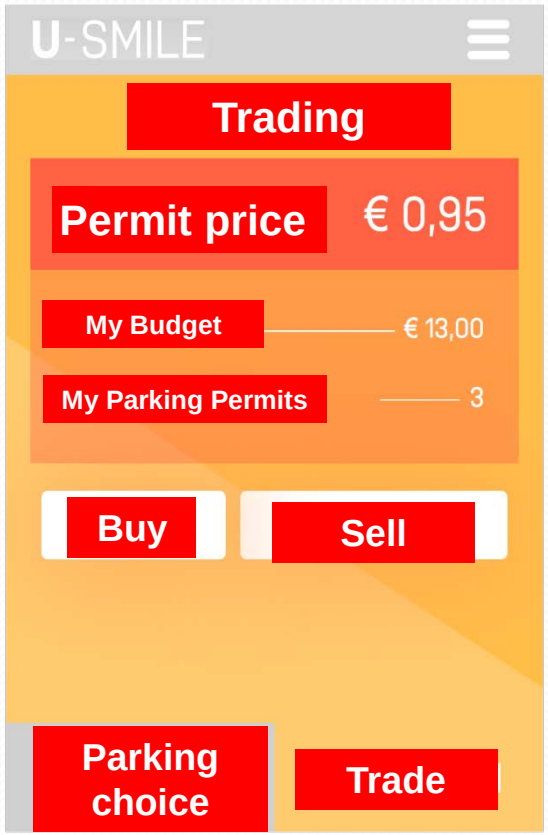
- Behavioural challenges
  - Avoid undesired speculation
    - Never more trip-coins in possession than remaining choices
    - Small transaction fee to avoid manipulation of trip-coin price
  - Avoid cheating
    - Automated purchase of trip-coin when needed for a choice made, with a mark-up
  - Manage transaction costs
    - Trading with bank
- Market challenge
  - Price moves in response to surplus or deficit of trip-coins "in the market"
    - Cumulative past use in the period plus coins in possession

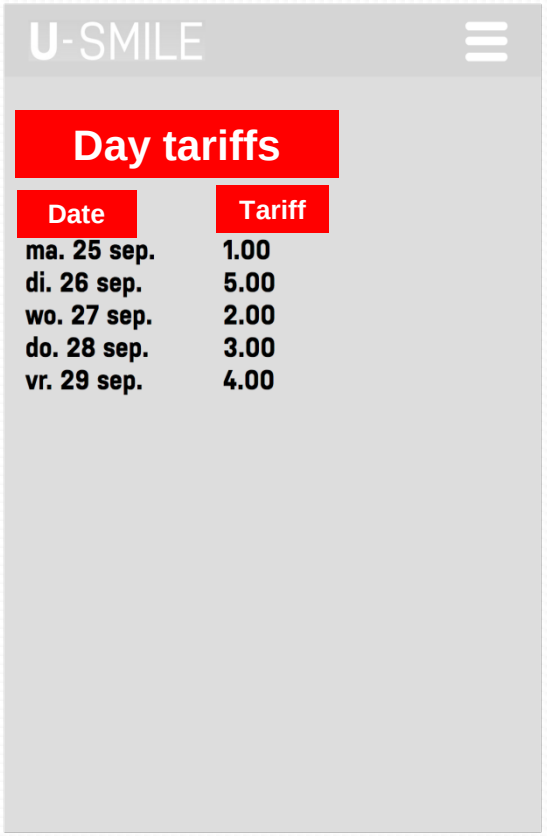
Lab-in-the-field (U-Smile)

- Set-up replicates a permit scheme that is as close as possible to the above case
  - Unit of trade: a commuting trip attribute, for a “weekfull of mobility choices”
  - Virtual / serious gaming environment
    - No interference with actual mobility behaviour
    - Pay-off in true money, depending on performance in the game
    - Complete control of pay-offs / preferences
  - Parking experiment: parking charge vs parking permit
    - Desirability of use of permit varies between days through variation of parking charge
  - Permit-price dynamics require experiment to last for a week
    - Hence: Lab-in-the-field

Lab-in-the-field – the looks



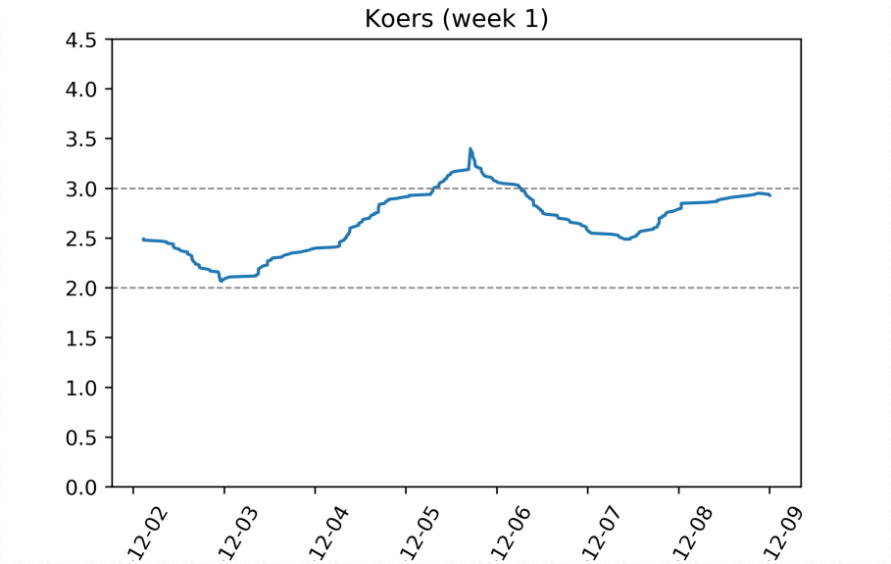


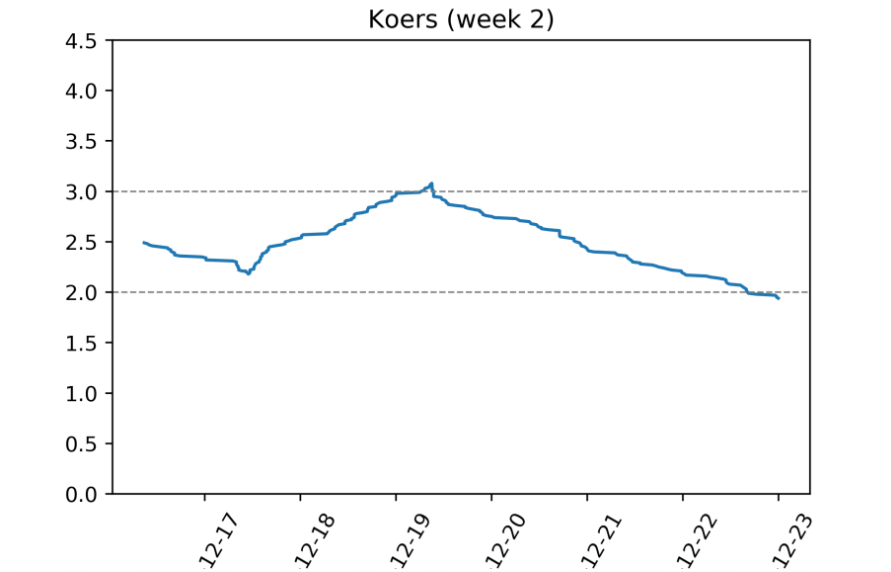


Expected equilibrium

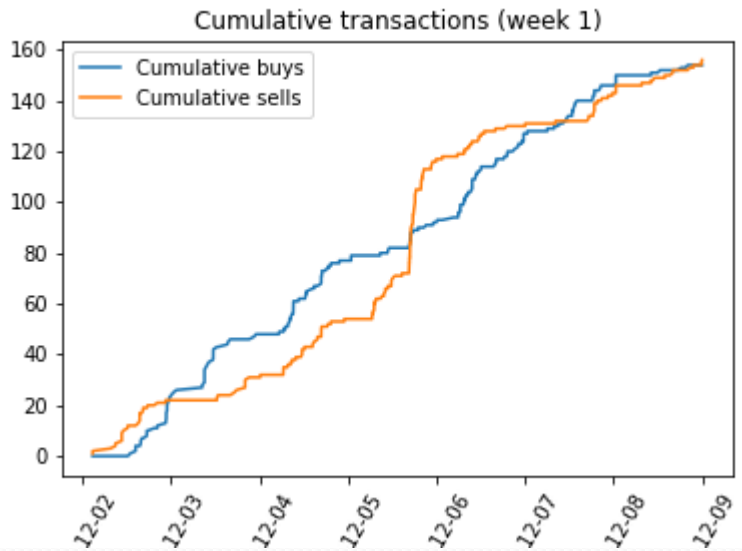
- Participants received on average 3 permits
  - 2 in the one week, 4 in the other, to rationalize trading
- Participants had full information and could in principle compute the expected equilibrium, which looks like:
  - All individuals:
    - Use a permit on days with parking tariffs of €5, €4 and €3
    - Pay the tariff on days with €2 and €1
  - Equilibrium permit price could be anything between €2 and €3
    - But selling is attractive when it's closer to €3, and buying when it's closer to €2
- Initial money budgets were €10.50 and €15.50 so a rational player would have a terminal budget of €10 if permit price does not change

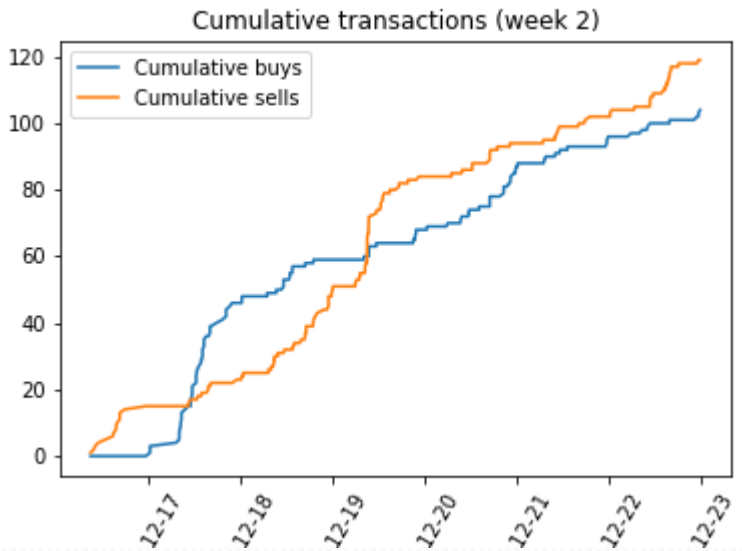
Permit price dynamics





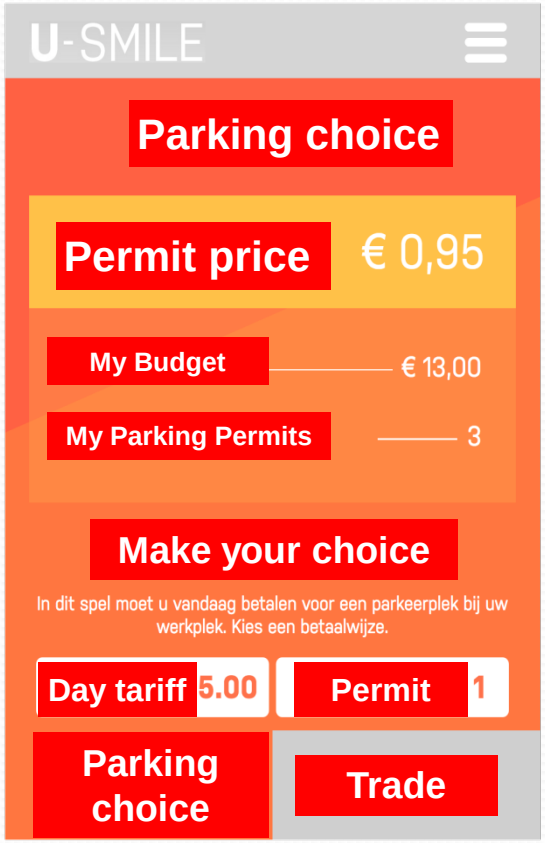
Market dynamics



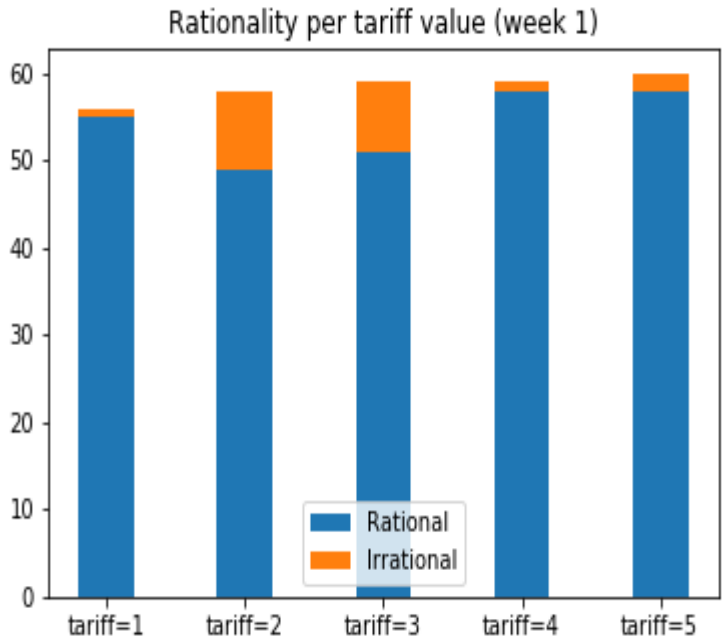


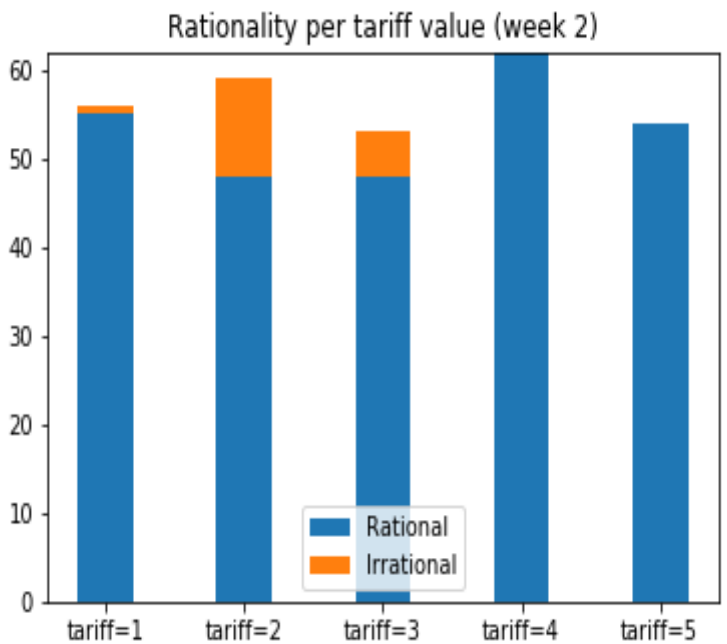
Rationality

- Do we observe *instantaneous* rationality?
  - Indication of understanding/serious participation
- Dynamic rationality?
  - Still to be answered



Instantaneous rationality (1)





Overall rationality

- Participants achieved reasonable pay-offs:

	Week 1	Week 2
Average	€ 7.38	€ 8.40
Average every-day-participants	€10.15	€10.31
Maximum	€12.34	€13.67
Participants earning	73	60

Bank deficit

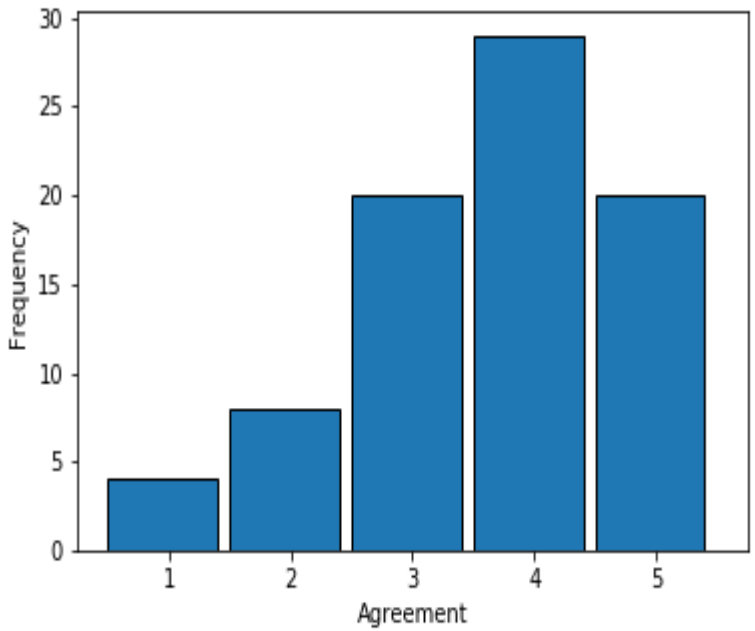
- Single permit price causes a bank deficit

	Week 1	Week 2
Av. price of bought permits:	€2.60	€2.44
Av. price of sold permits:	€2.85	€2.61
Total number of trades:	310	223
Buys	154	104
Sells	156	119
Bank deficit:		
With imbalance buy vs sell:	€41	€55
Without imbalance buy vs sell:	€36	€18
Reward scheme costs:	€297.5	€260

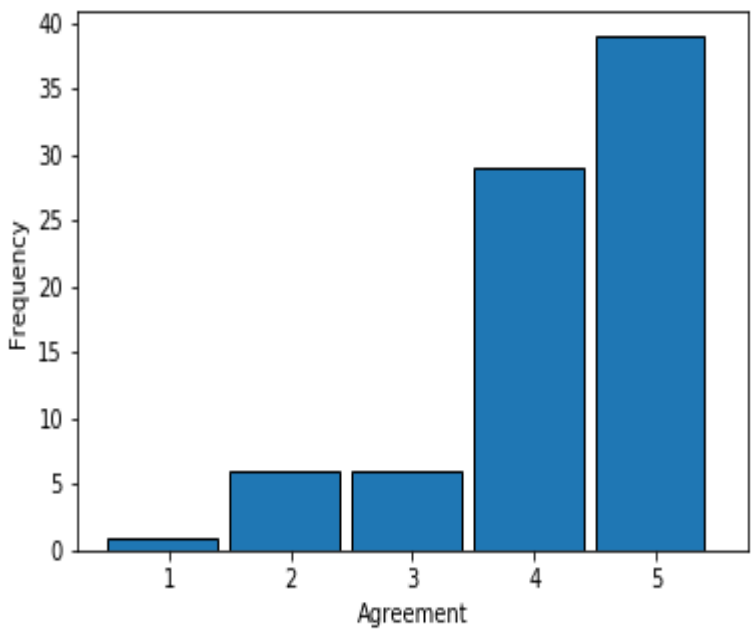
(A €2.5 reward on days that no permit is used and paid parking is chosen)

Responses

It was clear to me what the game was all about



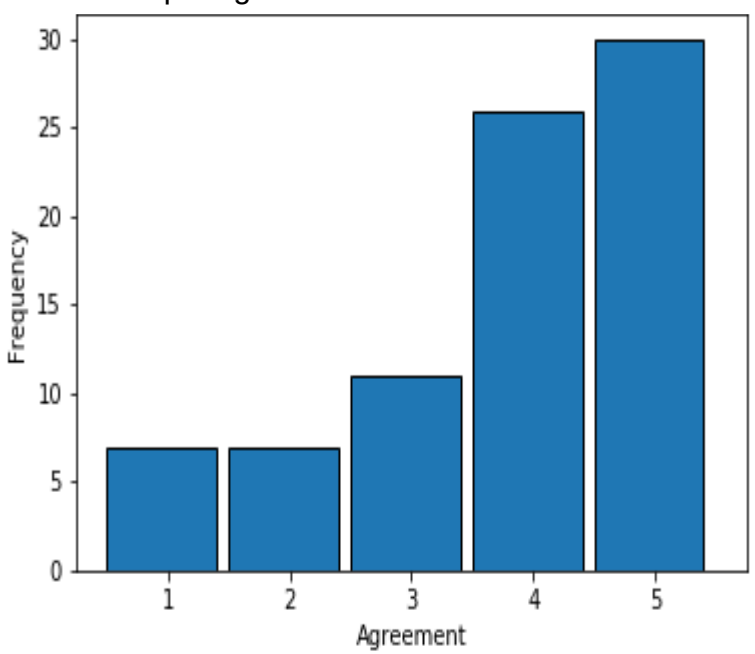
It was clear to me that I could earn real money with this game



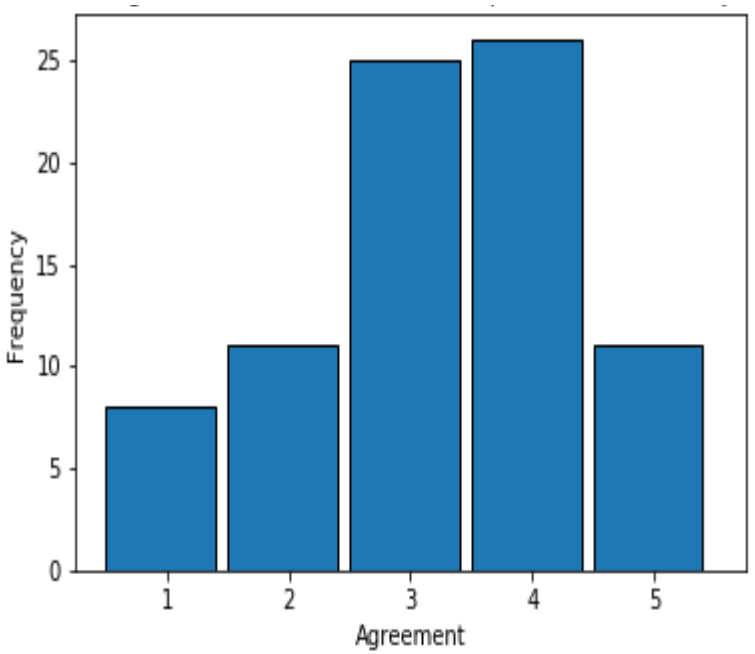
Scale: 1 Totally Disagree - 5 Totally Agree

Responses (2)

Participating took me little time or effort



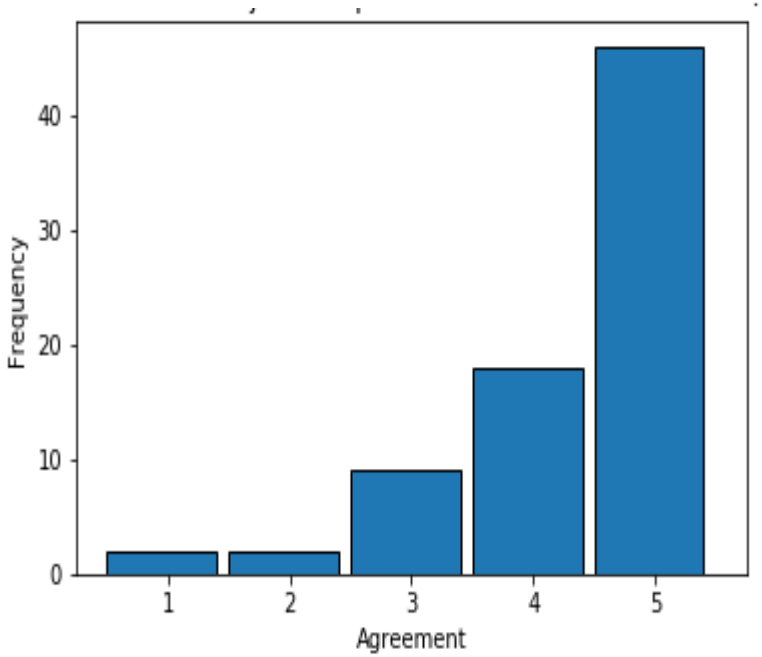
Tradeable parking permits could in reality sometimes be a good alternative for paid parking



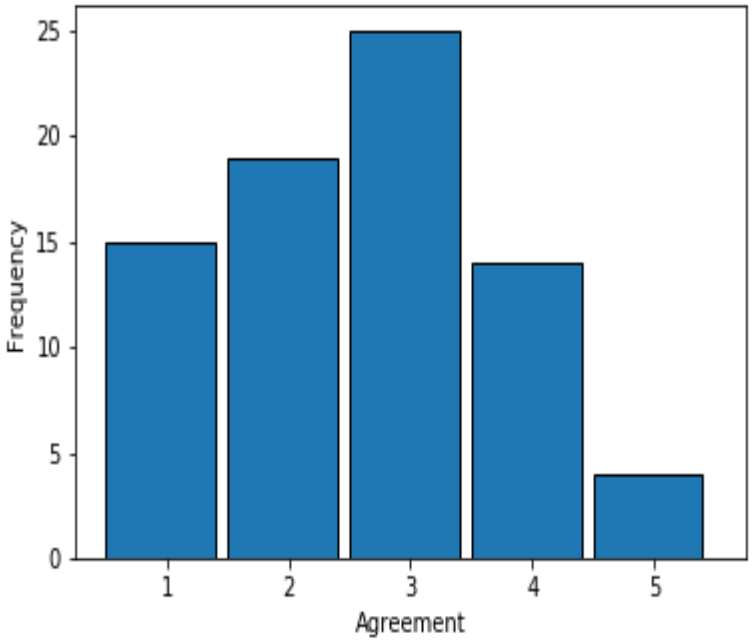
Scale: 1 Totally Disagree - 5 Totally Agree

Responses (3)

It was clear to me that I could trade parking permits



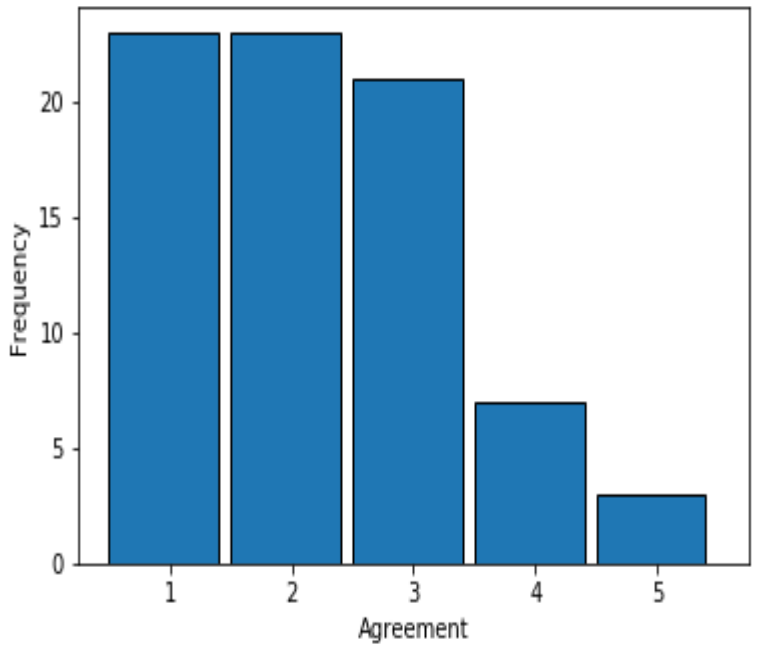
The price of parking permits varied more strongly during the game than what I had expected in advance



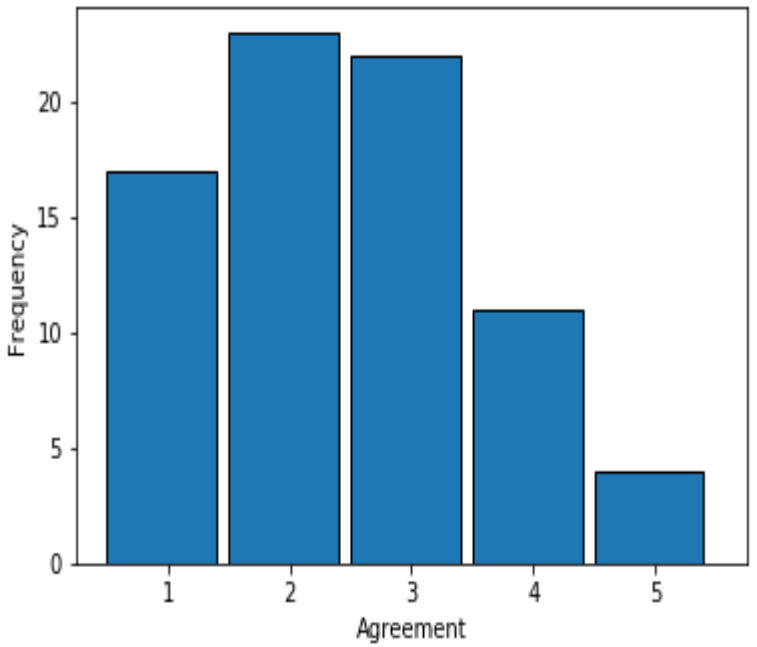
Scale: 1 Totally Disagree - 5 Totally Agree

Responses (4)

I found it difficult to determine the best parking choice



I found it difficult to determine whether it was best for me to buy, sell, or not trade a parking permit



Scale: 1 Totally Disagree - 5 Totally Agree

Lessons learned

- Most participants understand tradable mobility permits
  - Both their tradability as well as how to use them
  - From revealed performance and from questionnaire
- Instantaneous rationality
  - Large majority of choices indeed rational
  - Participants also indicate that making the choice was easy
- Participants find it somewhat more difficult to determine best trading behaviour (according to the survey)

Much wider applicability of principle

- Residential parking permits
  - Currently: scarcity -> waiting list
  - Tradability?
- Potential scheme
  - Suppose: 100 household, 25 parking places
  - Each year, every household gets 1 right
  - 4 rights are needed for 1 permit
    - Permit can even keep its current price!
  - Balances “rewards” (for sellers) and “charges” (parkers)
  - Efficient, effective, fair?

… much much wider… (VNR, 1997)

- User oriented
  - Tradeable vehicle-kilometers
  - Tradeable fuel consumption
  - Tradeable parking permits
- Supply-side oriented
  - Tradeable (firm-external) average environmental quality
  - Tradeable environmentally weighted car sales
  - Tradeable clean vehicle targets (taxis, vans…)

In conclusion

- Tradable permits as a promising application?
  - Budget neutral
    - More efficient and financially sustainable than rewarding
    - More acceptable than pricing
    - In some second-best cases in fact preferable to non-negative tolls
  - First lab-in-the-field experience seems promising
    - User behaviour, rationality and acceptance
    - Market stability and equilibrium

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