Investigating the willingness-to-wait with real-time crowding information in urban public transport

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Introduction

- **Overcrowding (passenger congestion)** – notorious and recurrent issue in public transport networks
- Despite *'hard'* investment programmes – capacity expansion becomes eventually outstripped by the ever increasing demand pressure…
- … instead – growing emphasis on *'soft'* travel demand management strategies

- **ITS-fed data** could be provided to passengers:
  - ➔ to help them **make more informed choices**
  - ➔ and thus improve journey experience

*„**I predict that when Crossrail opens** in 2018 **it will be immediately full**. The people who predicted that it will take all the traffic out of Oxford Street or that we'll be able to sit down on the Central Line in the rush hour will be wrong. It will just be full up with people."*

- *Sir Peter Hendy (2013)*

Former Commissioner of Transport for London

Real-time crowding information - RTCI

public transport crowding

ITS

RTCI

- real-time crowding information

- ITS data, gathered in real-time, could be simultaneously handled to provide information (or even prediction) on passenger flows
  - **increasingly feasible – APC, AFC, smart-card data, CFD…**

- **RTCI** – a fairly novel research topic:
  - ➔ **impact on travel behaviour…?**
  - ➔ proper system architecture / design…?
  - ➔ consequences for PT network effectiveness…?

RTCI and travel behaviour

How could crowding information affect passengers’ travel choices?

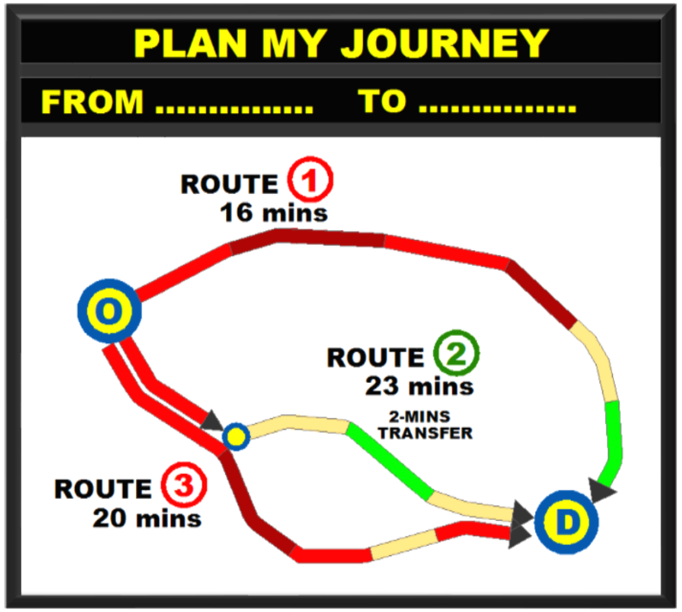
spatial shifts

AND/OR

temporal shifts

willingness to reroute *towards a less-crowded PT line*

➔ trade-off vs. in-vehicle time



willingness to wait *for a less-crowded departure of this PT line*

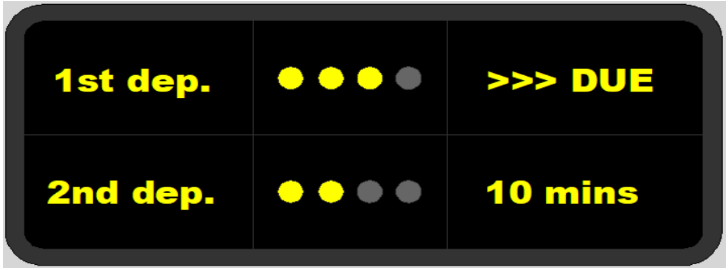
➔ trade-off vs. waiting time

- ?

Methodology

- Focus-group discussions
- Passenger surveys at **bus/tram stops** in the city of Krakow (Poland)
  - ~ 380 respondents, ca. 2,280 SP observations

Q9. Which of these departures would you be willing to choose?



Objectives:

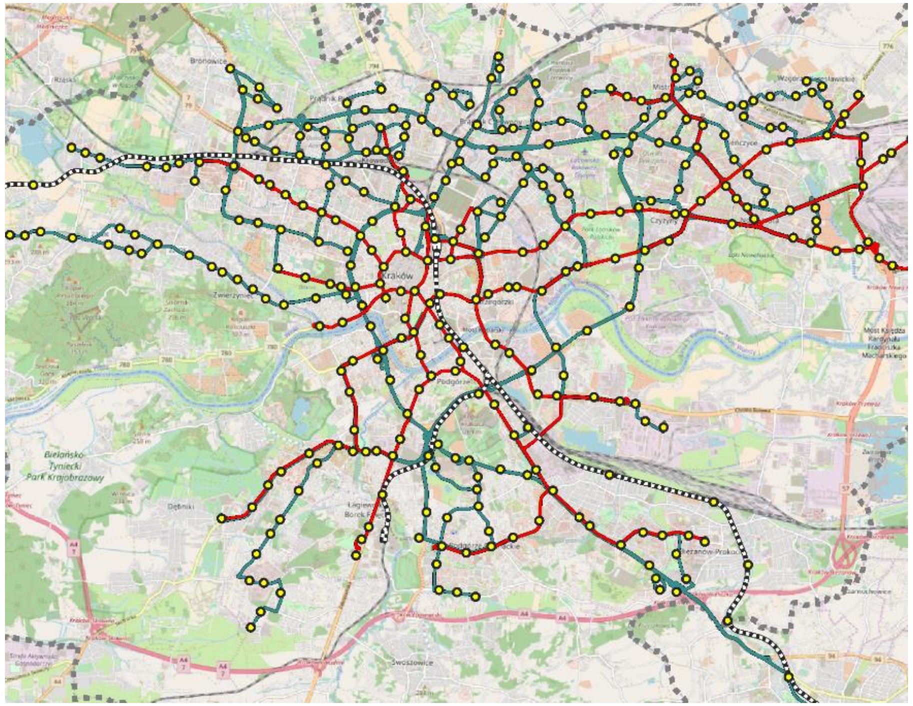
- attitudes/preferences towards the (future) crowding information systems
  - sample RTCI interpretation
- **SP choice survey**
  - **propensity to wait for a less-crowded vehicle**
  - vs. trip- and population-related characteristics

➔ discrete choice model estimation

attributes:

- crowding level (1st vs. 2nd trip)
- waiting time for 2nd trip (5 – 10 minutes)
- choice context
  - journey time / service frequency
  - time criticality / trip purpose
- prior experience of PT crowding
- sociodemographic data
  - age, gender

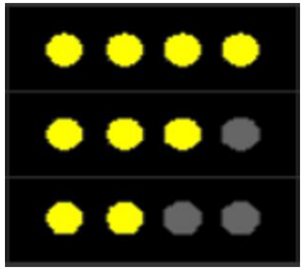
Case study – Krakow



Urban public transport (PT) system in Krakow (Poland):

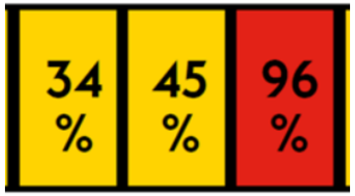
- population: 750k (metro area: ~ 1.4m)
- core PT network: 155 **[bus]** and 23 **[tram]** lines, ca. 500k daily trips
- PT vehicles: typically, increased standing space vs. reduced seating area

Focus groups: how to represent RTCI?



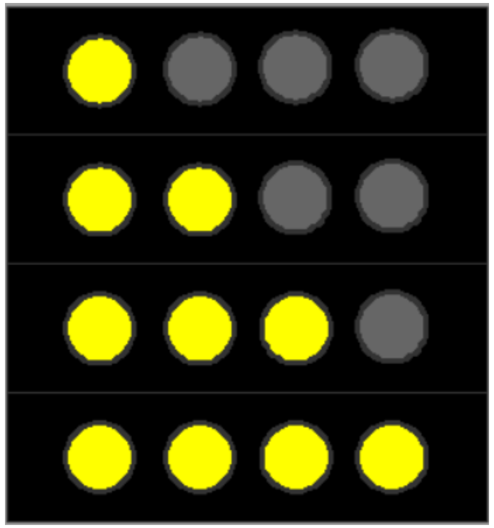
- **descriptive, rating scale**
  - **the most positive solution** – clear and understandable message
  - simple yet sufficient enough to make a decision
  - gives a general idea how ‘bad / good’ the on-board comfort is
  - adequate for short, urban PT trips

- **numerical scale (seats available)**
  - also popular, especially for long-distance trips and rail commuters
  - certain credibility concerns (e.g. sudden *fluctuations* in no. of seats)



- **percentage scale**
  - **in contrast – rather unfavourable reception so far**
  - ambiguous in interpretation – *what does it exactly mean?*
  - [%] values might be perceived in terms of „gambling” risk
  - increased complexity for decision-making process

Focus groups: what kind of information from RTCI?



expectations	*decision attitudes*
• over 50% of seats available • expect a double seat just for myself	would choose this trip ‘at ease’
• last few seats (< 10%) available • might not get a seat	would board and wouldn’t ‘mind’ seeking a comfortable standing place
• no seats available, but can stand comfortably • **overcrowding threshold**	would take this trip, but expect some discomfort
• severely overcrowded, no grip, hard to stand • need to be lucky to ‘squeeze’ inside • might not board	unless in a hurry – should consider different travel options

travel advice expected from the RTCI:

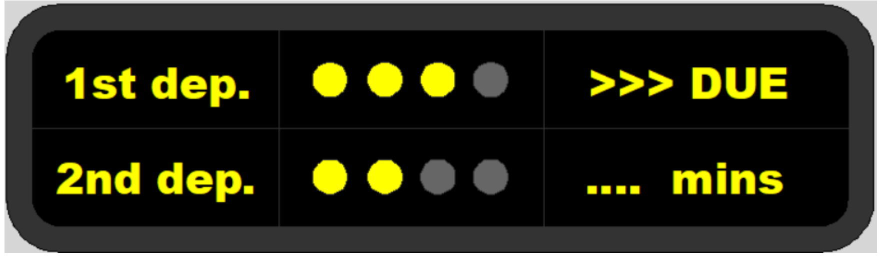
- principally related to higher (over)crowding conditions:
  - for **time-critical** trips: denial-of-boarding risk
  - **non-time-critical** trips: ‘comfortable standing’ conditions and/or seats available
- **accuracy** – **key concern** among respondents
  - would this information still be valid downstream?

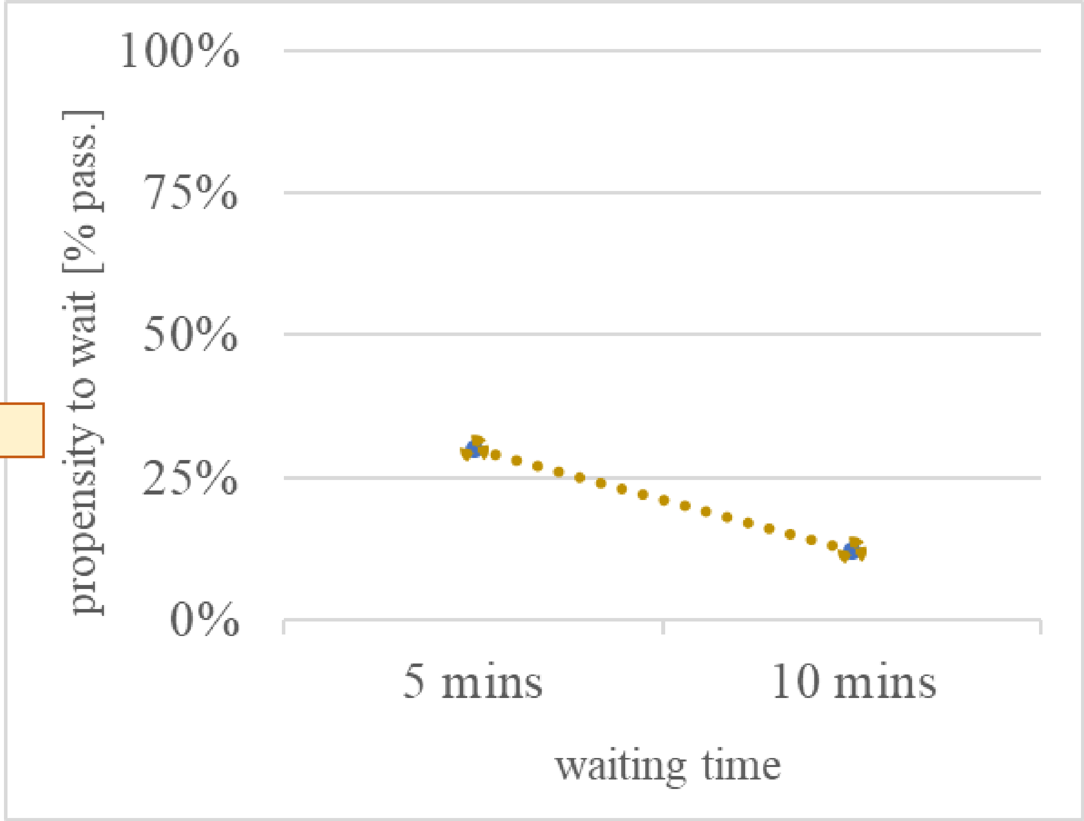
SP survey results

General results – stated willingness-to-wait
with crowding information on 1st and 2nd departure…:

1st dep: no seats, but can stand comfortably
2nd dep: seats available

case
no. 1



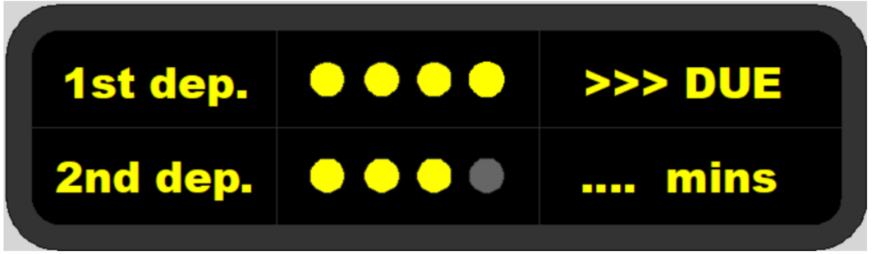


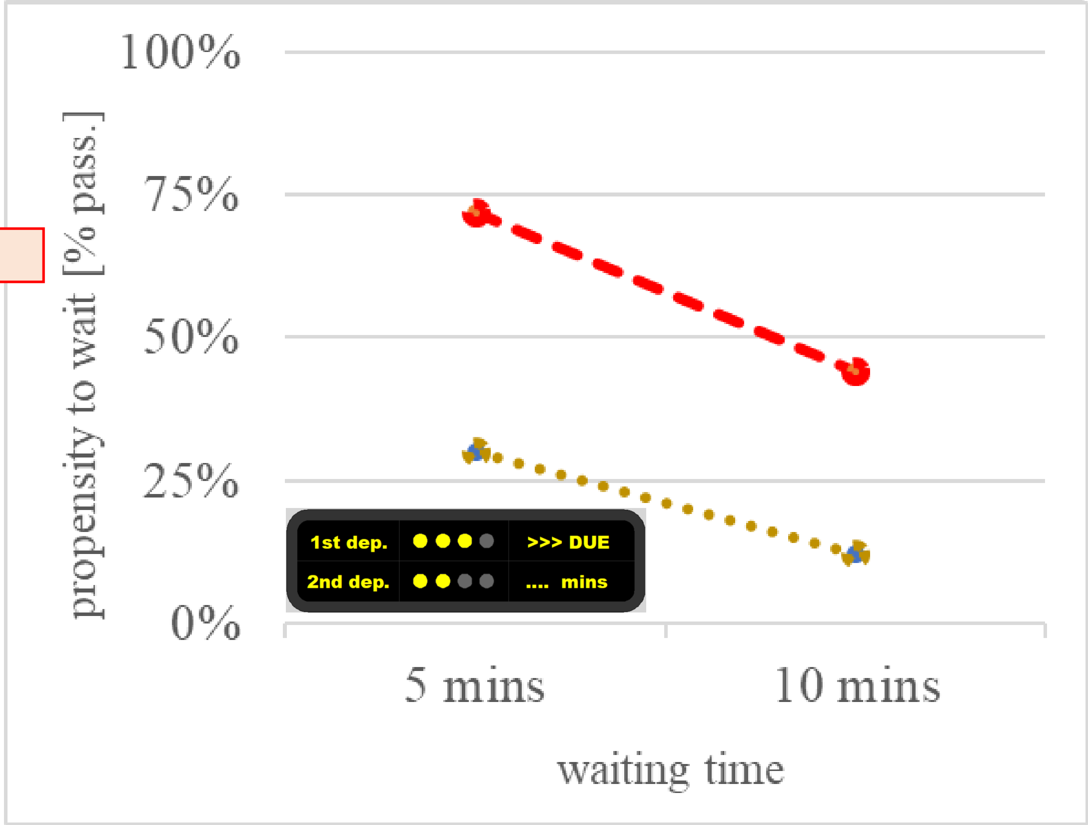
SP survey results

General results – stated willingness-to-wait with crowding information on 1st and 2nd departure…:

1st dep: overcrowded, could barely board
2nd dep: can stand comfortably

case no. 2



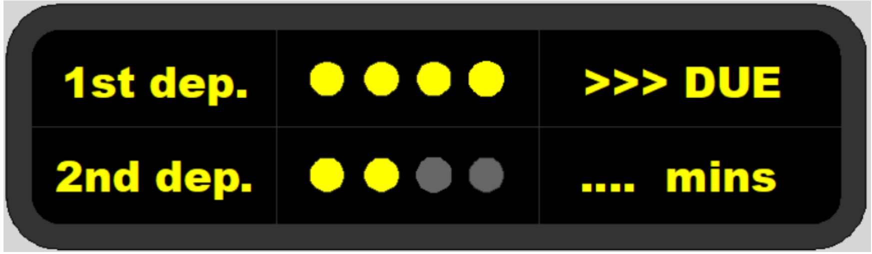


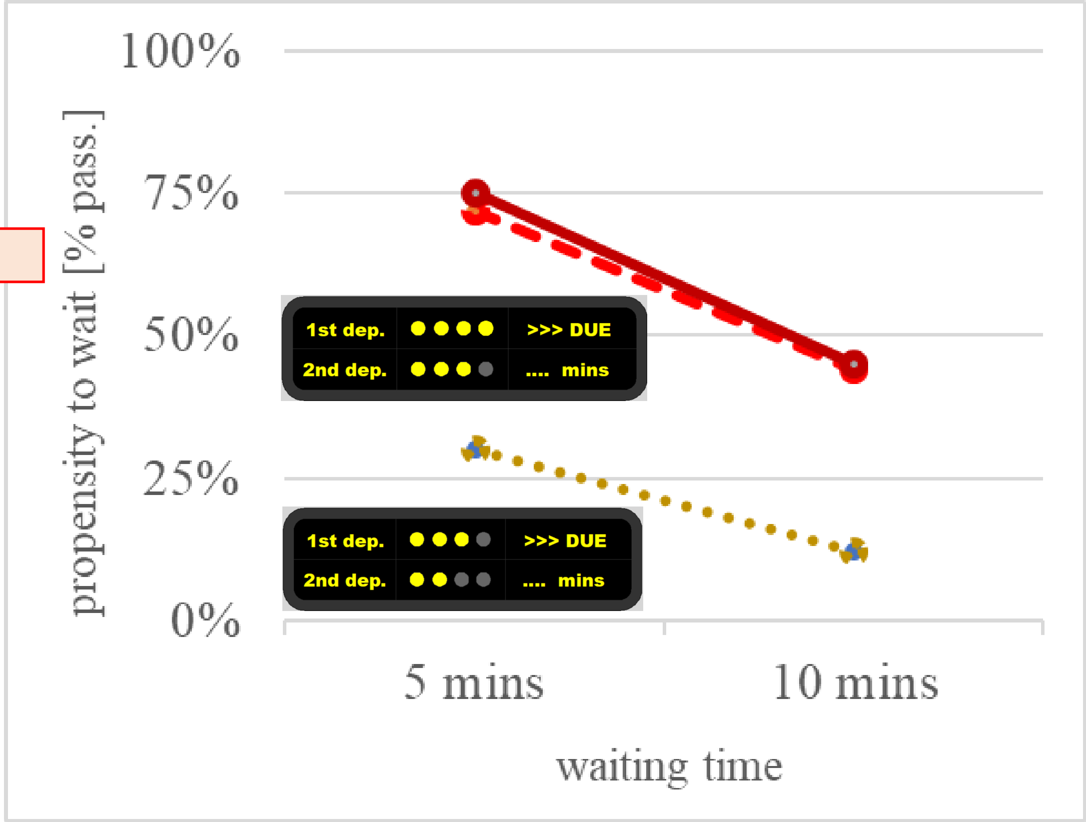
SP survey results

General results – stated willingness-to-wait
with crowding information on 1st and 2nd departure…:

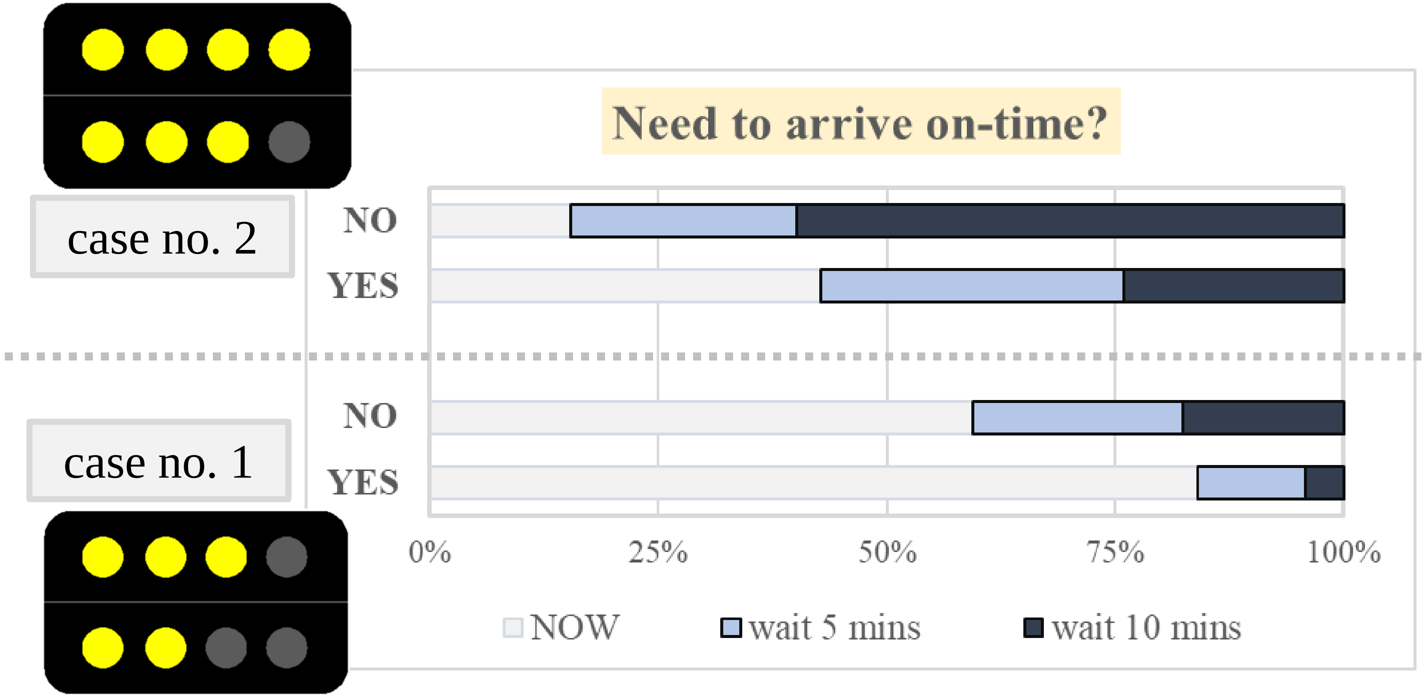
1st dep: overcrowded, could barely board
2nd dep: seats available

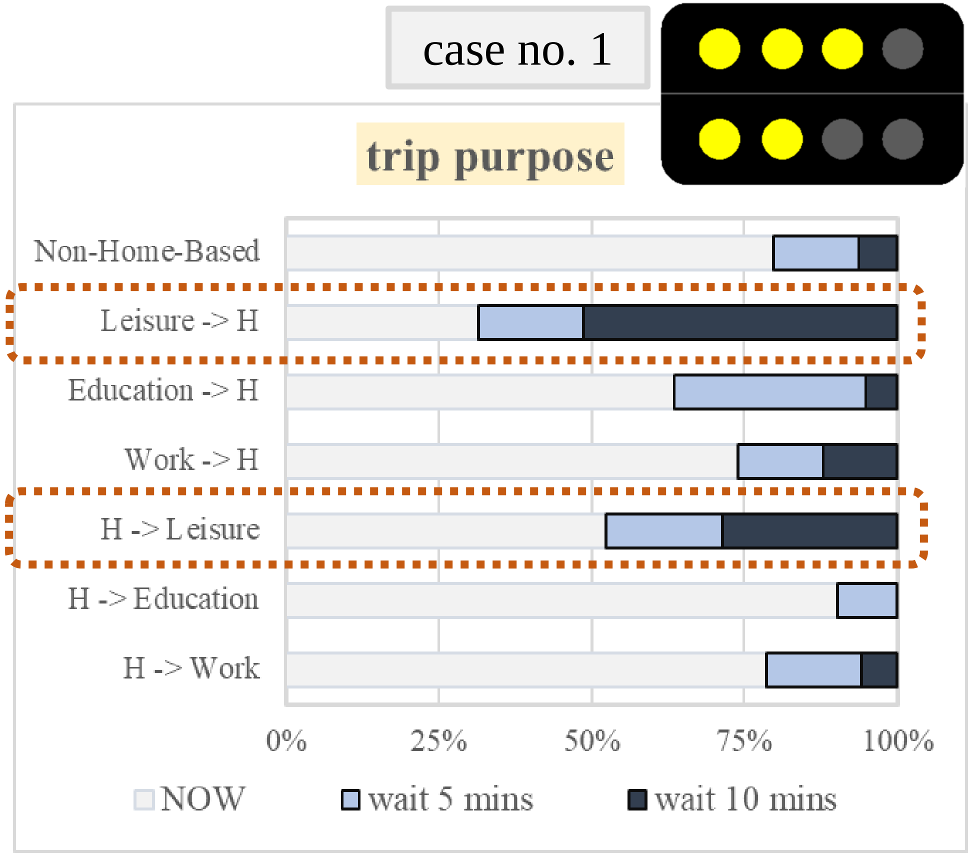
case
no. 3





SP survey results



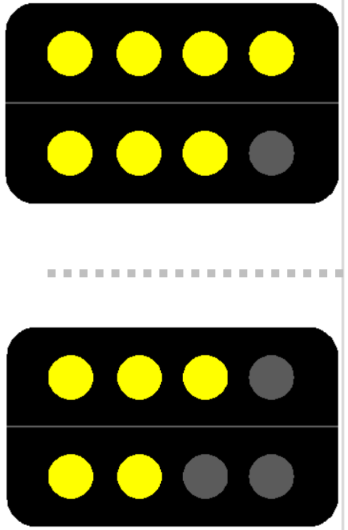


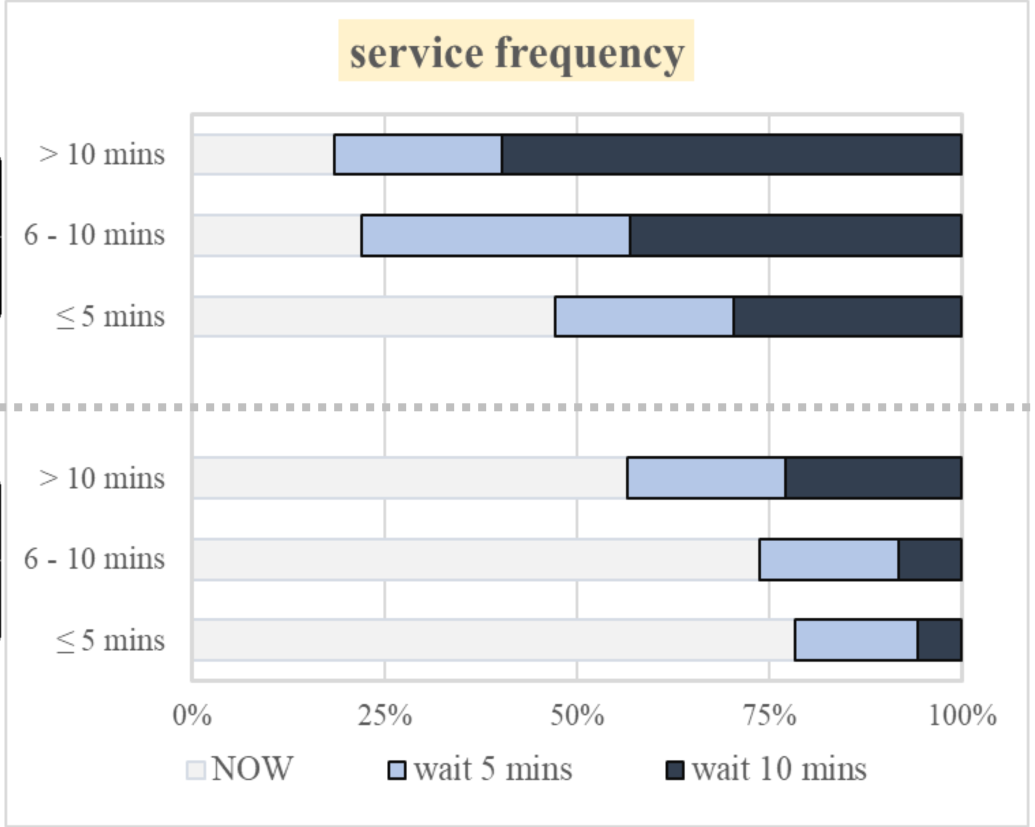
Relevance of trip purpose and time-criticality – higher (stated) willingness-to-wait for:

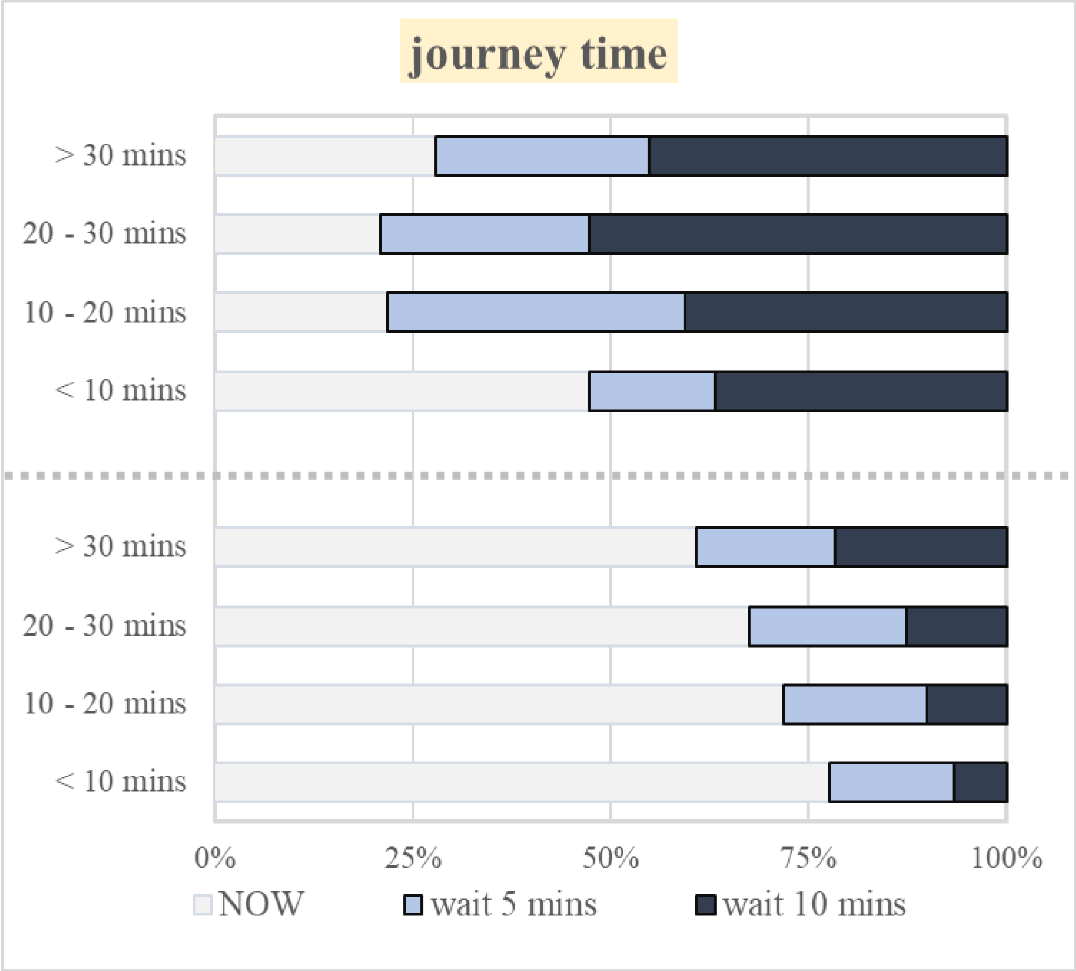
- non-time-critical trips (‘*I don’t need to arrive on-time*’)
- **non-obligatory trips**
- home-return trips

SP survey results

Trip duration – relatively minor impact:





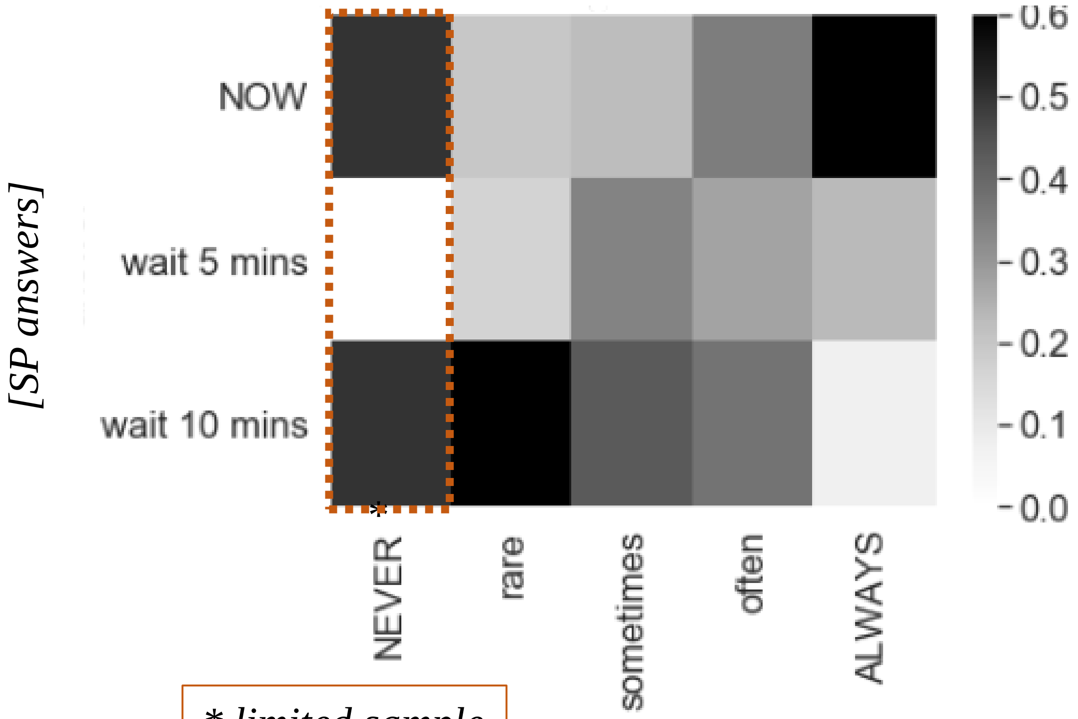


** majority of sampled trips no longer than 30 minutes*

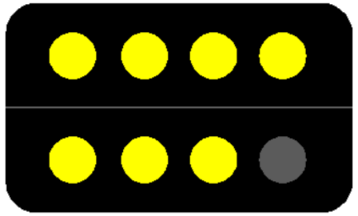
SP survey results

The more frequent the experience of PT overcrowding, the lower the passengers' propensity to avoid it:

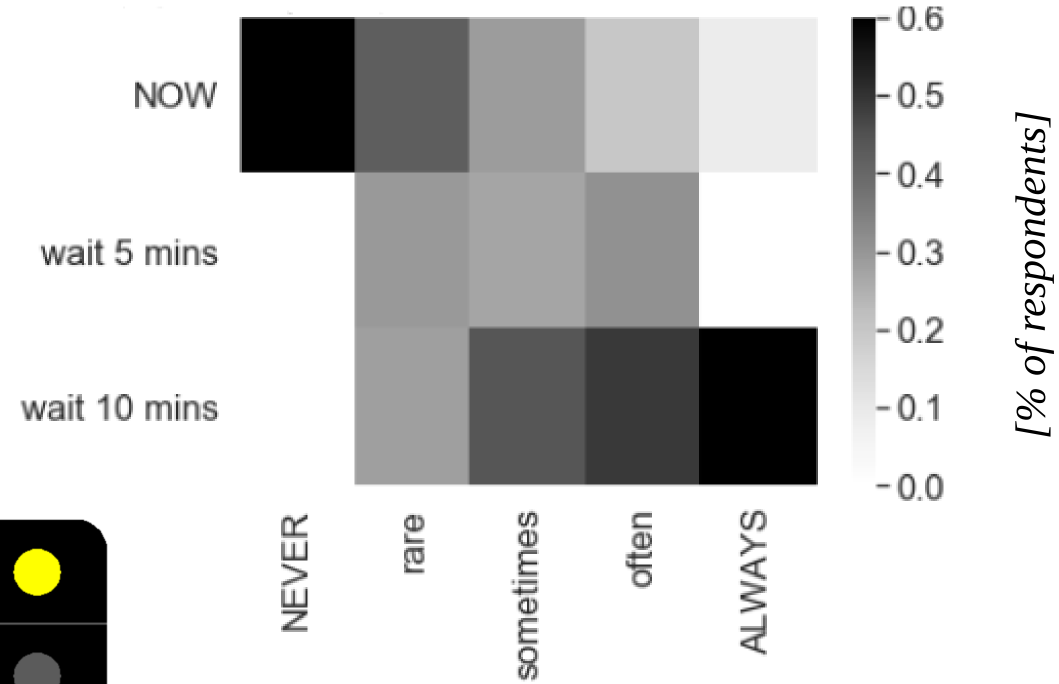
How often do you **experience overcrowding** in your urban PT trips?



** limited sample*



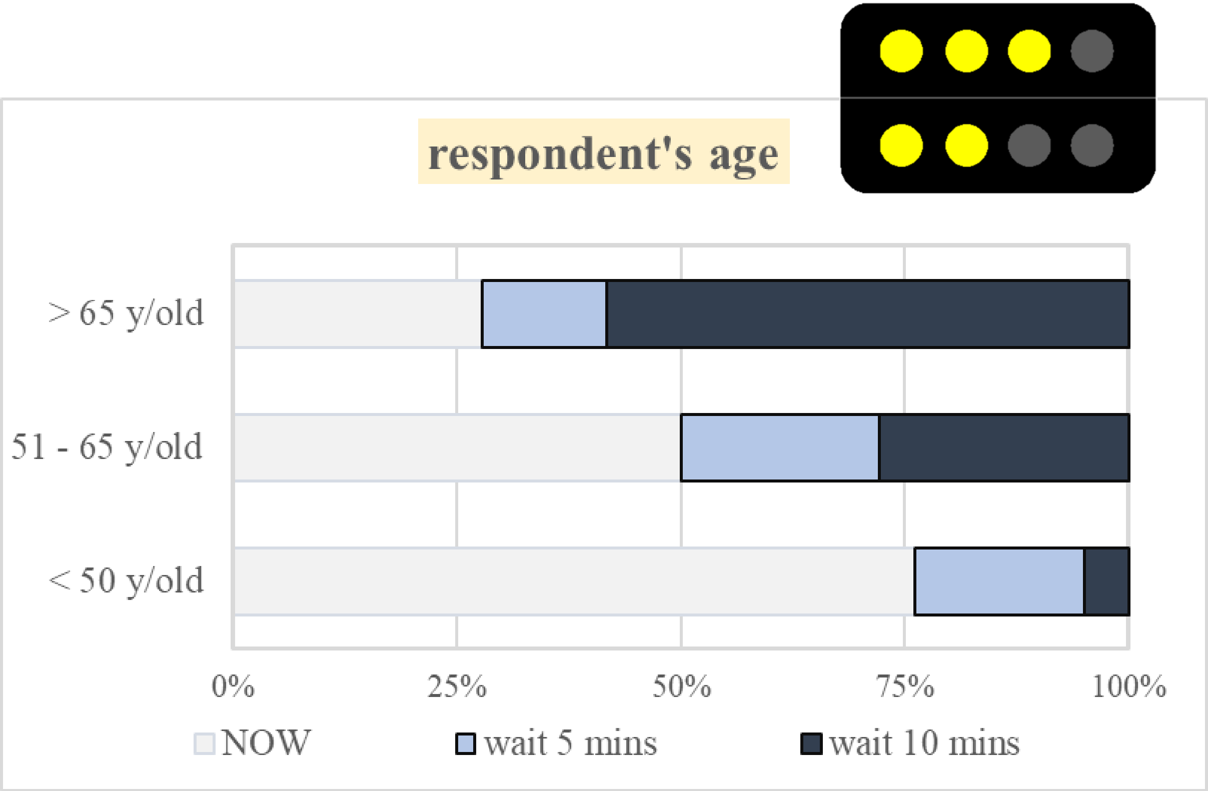
How often are you able to **get a seat** during your urban PT trips?

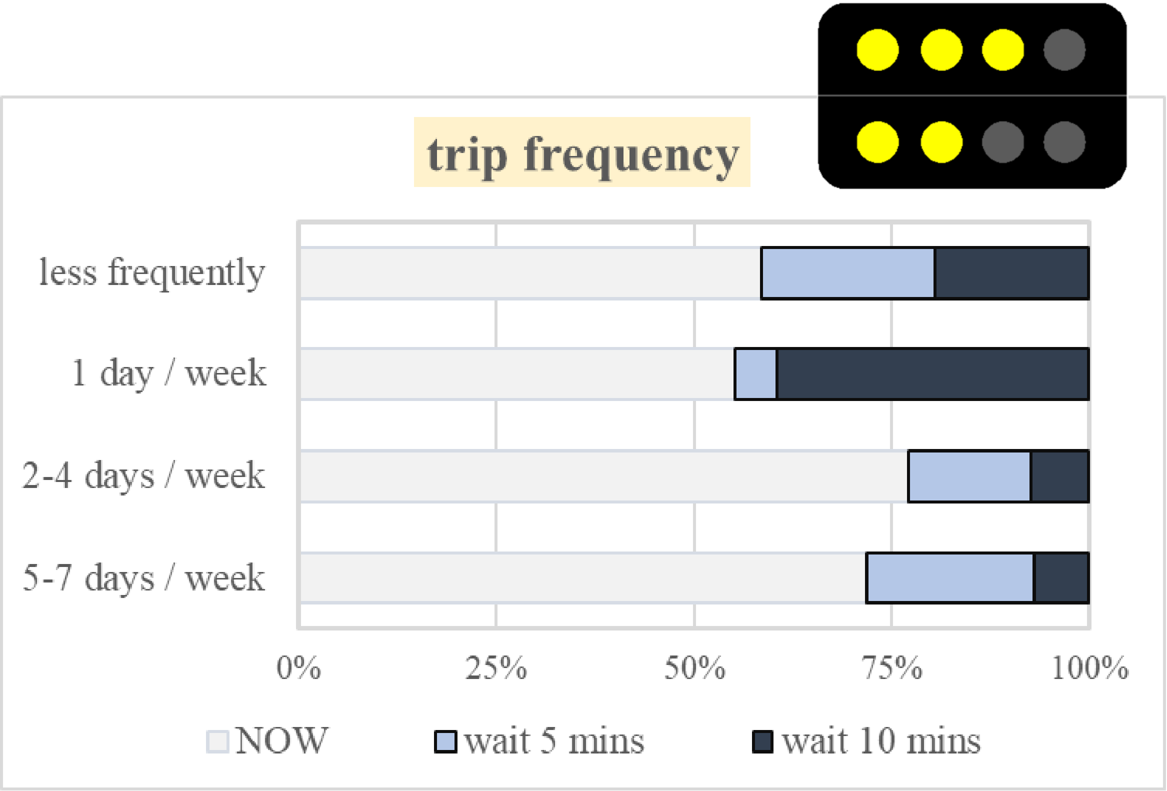


SP survey results

Sociodemographic characteristics:

- limited propensity to wait to reduce crowding among PT commuters and those under the age of 50





Choice modelling

Discrete choice model estimation based on SP results:

- BIOGEME package *(Bierlaire, 2009)*
- MNL (multinomial logit) model

- objective – choice probability between 2 alternatives:

$$P_i = \frac{e^{U_i}}{e^{U_i} + e^{U_j}}$$

depart [NOW] *utility* U_0	OR	**[WAIT] and depart later** *utility* U_1

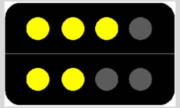
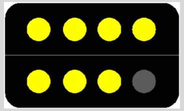
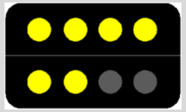
Waiting utility U_1 calculated as a function of:

- temporal utilities
  - in-vehicle time
  - waiting time
- Boolean attributes
  - **RTCI of 1st vs. 2nd departure**
  - other trip- and population-related characteristics

Choice modelling (a) – general model

depart [NOW]: $U_0 = 0$

[WAIT]: $U_1 = \sum \beta_k \cdot \delta_k + \beta^{IVT} \cdot t^{IVT} + \beta_1^{WT} \cdot t_1^{WT}$

		all trips		value	std err	t-test	p-value
boolean	**crowding level (RTCI) of 1st vs. 2nd departure** ***(case-specific)***	β_a^{CR} *case 1.*		0.439	0.234	1.87	0.0613
		β_b^{CR} *case 2.*		2.62	0.245	10.7	0
		β_c^{CR} *case 3.*		2.69	0.246	10.9	0
time	**in-vehicle time**	β^{IVT}		0.0237	0.00441	5.37	8.00E-08
	wait time	β_1^{WT}		-0.29	0.0215	-13.5	0
boolean	**time-criticality**	β^{TCRIT}		**-1.41**	0.109	-13	0
	commuter (2+ trips / week)	β^{PTC}		-0.144	0.141	-1.02	0.306
	age 65+	β^{65}		**1.92**	0.23	8.35	0
	age 50 -65	$\beta^{50\text{-}65}$		0.72	0.242	2.97	0.00295

n = 2,280 Rho-square: 0.277

Choice modelling (b) – time-criticality distinguished

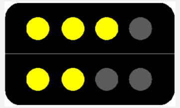
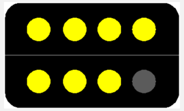
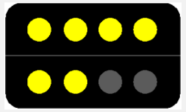
depart [NOW]: $U_0 = 0$

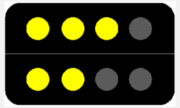
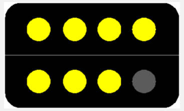
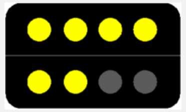
[WAIT]: $U_1 = \boxed{\beta_a^{CR} \cdot \delta_a + \beta_b^{CR} \cdot \delta_b + \beta_c^{CR} \cdot \delta_c} + \boxed{\beta_1^{WT} \cdot t_1^{WT}}$

RTCI of 1st vs. 2nd departure + *waiting time*

boolean

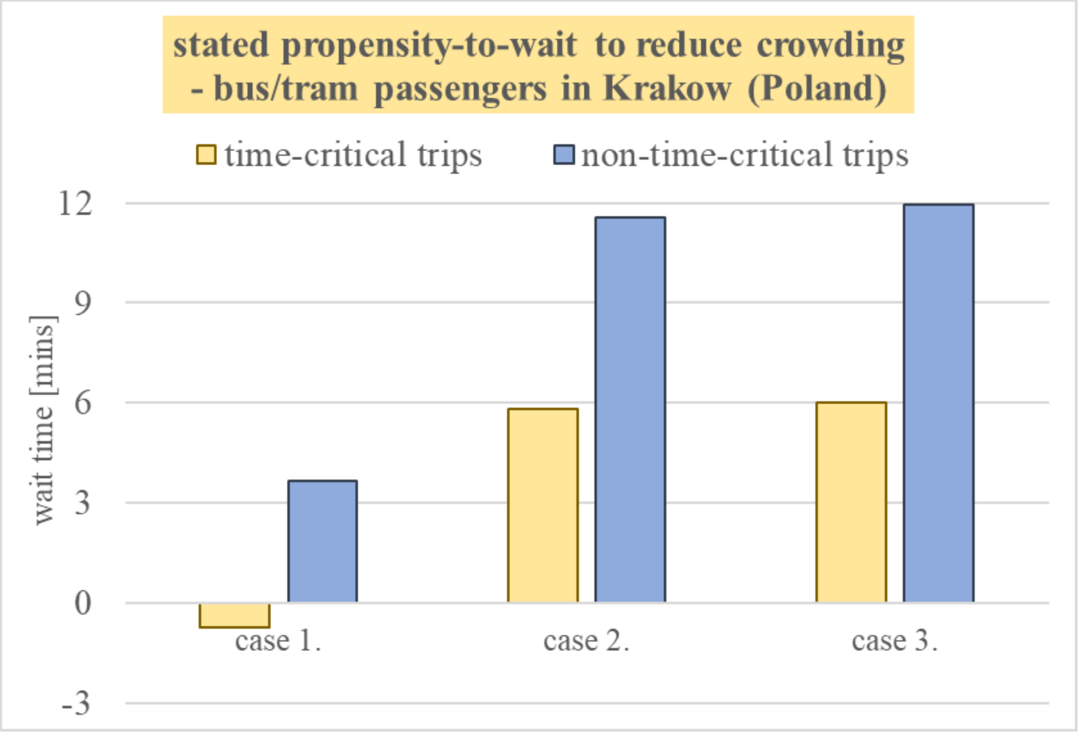
time

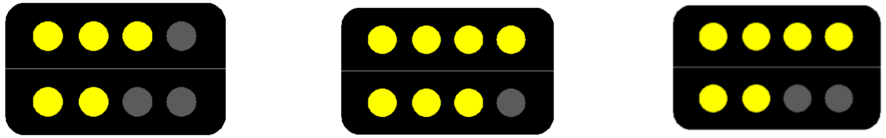
time-critical trips		value	std err	t-test	p-value
β_a^{CR} ***case 1.***		-0.218	0.267	-0.819	0.413
β_b^{CR} ***case 2.***		1.7	0.252	6.78	1.23E-11
β_c^{CR} ***case 3.***		1.76	0.253	6.97	3.24E-12
β^{WT}		-0.292	0.0314	-9.31	0
n = 1,026			Rho-square:		0.264

non-time-critical trips		value	std err	t-test	p-value
β_a^{CR} ***case 1.***		0.926	0.217	4.26	2.07E-05
β_b^{CR} ***case 2.***		2.93	0.251	11.7	0
β_c^{CR} ***case 3.***		3.02	0.253	11.9	0
β^{WT}		-0.253	0.0273	-9.25	0
n = 1,254			Rho-square:		0.201

Estimation results - willingness-to-wait

MNL estimation results:





value of time multipliers *journey time = 20 [mins]*	**time -critical**	**non-time-critical**
case 1.	0.96	1.18
case 2.	1.29	1.58
case 3.	1.30	1.60

SP findings among UK **rail passengers**

- *(Preston et al., 2017)*:

- acceptable wait ca. 15 – 22 [mins]
- VoT multipliers ~ 1.25 – 1.75 (JRT = 30 [mins])

Conclusions

- preference towards crowding information (RTCI) in urban PT:
  - simplified, descriptive representation
- SP results – RTCI could induce willingness-to-wait:
  - **principal choice 'trigger' – avoid excessive (over)crowding in the 1st vehicle**
  - relevance of: trip purpose, propensity to arrive on-time, user characteristics…
  - on average, acceptable wait of 6 – 12 [mins] for a less-crowded vehicle
- applicability and future considerations:
  - RTCI implementation as demand management tool (e.g. mitigating the *bunching* effects)
  - simulation models – passengers' choices and network performance
  - *stated* vs. *revealed* choices with RTCI?
  - **RTCI credibility** – key to its effectiveness

Thank you very much for your attention!

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