Aversion to In-vehicle Crowding before, during and after the COVID-19 Pandemic

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Findings

Based on four consecutive stated choice surveys, we estimate changes in public transport user's valuation (marginal costs) of in-vehicle crowding due to the COVID-19 pandemic in two Norwegian cities. Compared to the pre-COVID level (November 2018), we find significantly higher costs during COVID (November 2021). Post-COVID costs (May 2022) are significantly reduced but remain above the pre-COVID level.

1. Questions

There is a hypothesis that preference for crowding in public transport vehicles (in-vehicle crowding) changed during the COVID-19 pandemic due to an increased risk of getting a viral infection and increased discomfort of sitting or standing close to other persons. For transport planning, a relevant question is if the valuation/marginal costs of crowding in the post-COVID period differs from the pre-COVID period. If costs persist at a higher level, this might indicate long-term changes in preferences that transport planners should account for when designing future public transport supply.

Our research question is therefore: To what degree has public transport user's aversion to crowding – measured by crowding multipliers on the value of travel time saving (Wardman and Whelan 2011) – changed during and after the COVID-19 pandemic compared to pre-COVID level?

Our empirical evidence are from two Norwegian cities, and adds to a growing literature on COVID-related crowding costs (Cho and Park 2021; Aghabayk, Esmailpour, and Shiwakoti 2021; Basnak, Giesen, and Muñoz 2022; Shelat, Cats, and van Cranenburgh 2022). To our knowledge, this is the first paper that presents comparable results from all three periods, i.e. before, during and after the pandemic.

2. Methods

We estimate crowding multipliers on the value of travel time savings based on binary stated choice data, using mixed logit models. Available information that enters our statistical model is dummy variables for the round of data collection D_a with $a = \{1, 2, 3, 4\}$, travel time T_i in minutes for alternative $i = \{1, 2\}$, and dummy variables indicating the crowding situation $C_{i,s,k}$ where

Figure 1. Illustration of crowding levels (here in the case of train and metro)

$s = \{sitting, standing\}$ indicates if one sits or stands over the whole trip and $k = \{ \begin{matrix} 1, \ldots, 10 \ for \ s = sitting \\ 5, \ldots, 10 \ for \ s = standing \end{matrix} \}$ indicates the crowding level as illustrated Figure 1.

Figure 2 shows an example of a choice task. The three attributes travel time, sitting place and crowding level were established based on reported reference values and combined by means of an orthogonal design (Flügel et al. 2020). A variant of the choice experiment, assigned to 50% of the sample, omitted the verbal description of sitting place and instead showed seat position in the illustration of the crowding level.

In our model, the utility function of alternative i for respondent n in choice task t is given as

$$U_{n,t,i,a} = \mu_a * \left(\alpha_i + \sum_a \sum_s \sum_k (\beta_{a,s,k} * D_a * C_{n,t,i,s,k} * T_{n,t,i,a,s,k}) \right) + \varepsilon_{n,t}$$

with

- $\varepsilon_{n,t}$ being i.i.d. Gumbel distributed error terms

- μ_a being scale parameters for the different data collections a. For normalization, we apply $\mu_1 \equiv 1$

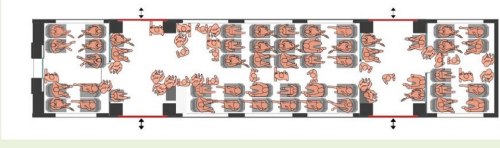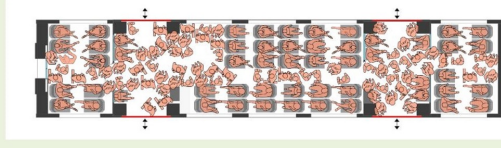- α_i being constant terms. For normalization, we apply $\alpha_1 \equiv 0$

Alternative A	Alternative B
13 minutes	10 minutes
No, you have to stand the whole trip	Yes, you can sit the whole trip

Travel time

Seat

Crowding level

Figure 2. Example of a task in the choice experiment (translated from Norwegian)

- $\beta_{a,s,k}$ being parameters capturing the marginal utility of travel time in different crowding situations. The marginal utility of travel in uncrowded situations, i.e. $\beta_{a,sitting,1}$, is assumed normally distributed over respondents n to account for unobserved taste heterogeneity. For normalization, we set the mean values of $\beta_{a,\,sitting,1}$ to minus 1.

With the applied normalization, the absolute values of $\beta_{a,s,k}$ represent the crowding multipliers in different situations (defined by s and k) given the round of data collection a.

Our data collection was done in four rounds (R1 – R4) using different recruitment techniques. Recruitment was concentrated in the area of the Norwegian capital Oslo (the largest urban area in Norway) and Trondheim (the fourth largest urban area in Norway). Table 1 gives an overview over the samples. Note that all respondents in round 4 also participated in round 2 and/ or round 3 (mainly round 3).

3. Findings

The last four lines of Table 1 paint a picture of the COVID situation in Norway at the different points in time. Based on this context, we expected crowding multipliers to be greater during the pandemic (April 2021 and November 2021) compared to 2018 values, and 2022 values to be close to 2018 values.

This was largely confirmed as shown in Figure 3.[1] Looking at the two left-most panels we see that estimated crowding multipliers were significantly higher during the pandemic (November 2021) compared to pre-COVID (November 2018). Our assessment about significance is based on the robust standard errors (and T-values) of the estimated beta-parameters. They are shown in the form of 95% confidence intervals in the Figure 3. The figure also shows that the post-

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1 Note that the April 2021 results are somewhat indecisive (likely due to the low number of observations) and therefore not shown here.

Table 1. Comparison of samples

Comparison of samples	R1	R2	R3	R4
Period	Nov. 2018	April 2021	Nov. 2021	May 2022
Main recruitment	Intercept method on board and at stations using tablets, with the option to answer later on own device	Commercial E-mail register from a postal service, invitations by email	Mobile register from commercial provider, SMS invitations	Recruited from respondents that left their contact info (mobile number or email address) in R3 (and R2).
Nr. of completed questionnaires	680	475	9701	2912
Female share	54.4%	55.2%	51.0%	51.7%
Age distribution (under 30, 30-60, over 60 years)	35.6%, 54.6%, 9.4%	21.1%, 66.5%, 12.4%	6.8%, 54.1%, 39.1%	2.6%, 49.7%, 47.7%
Mode shares (train, metro, tram, bus)	22.8%, 25.0%, 19.6%, 32.6%	21.9%, 25.5%, 10.7%, 41.9%	23.8%, 29.0%, 9.6%, 37.5%	22.3%, 29.1%, 10.2%, 38.4%
Share using mask in PT	N.A.	96.6%	33.9%	19.1%
Share agreeing that they are worried about infection in PT	N.A.	33.7%	33.6%	17.2%
Share being vaccinated	N.A.	25.5%	98.3%	98.6%
Context of the COVID pandemic in Norway	Pre-COVID	Mild lock-down in Oslo; several national measures; initial vaccination campaign	No lockdown but some local measures reintroduced after increases in infection and rumors of omicron variant	Post-COVID: all measures were removed already in February 2022

COVID (May 2022) values are significantly lower compared to November 2021. The post-COVID values remain somewhat above the pre-COVID levels, however, here the confidence intervals are largely overlapping.

The absolute values of the pre-COVID crowding multipliers seem to compare well against other studies (Wardman and Whelan 2011; Kroes et al. 2014; Hörcher, Graham, and Anderson 2017; Tirachini et al. 2017). While our COVID-related values are rather high, some high values (of up to 5.1) are also found in Basnak, Giesen, and Muñoz (2022).

For context, Table 2 gives the share of respondents agreeing to the statement that they may feel discomfort when standing close to other persons.

We see that the shares increased substantially from round 1 (pre-COVID) to round 2 (April 2021), but has since been on a decline. Still, the 71.7% in round 4 (post-COVID) is substantially above the pre-COVID share, both compared to the 2018-sample and compared to retrospective questions within the 2022-sample ("before COVID"). This indicates that there might be long-term shifts in preferences.

Some caveats should be taken regarding the different samples, e.g. in respect to the age distributions. However, note that the shares in Table 2 for the 2018 sample are rather consistent with the "before COVID" shares from the
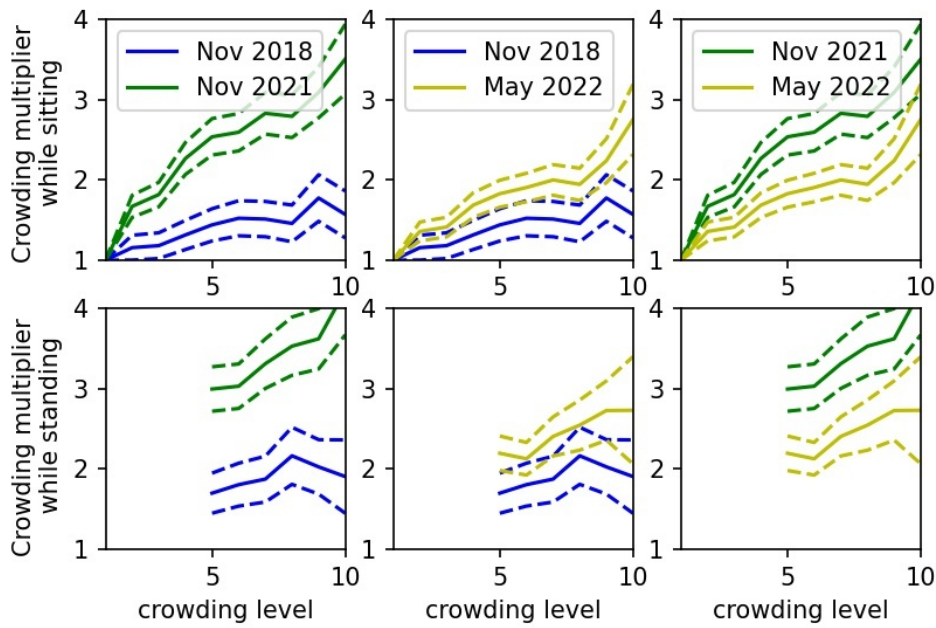
Figure 3. Estimated crowding multipliers while sitting (upper panel) and standing (lower panel); comparison of selected pairs of data collections. 95% confidence intervals given in dashed lines.

Table 2. Share of respondents agreeing that they may feel discomfort standing close to other persons

Subsample	Round 1	Round 2		Round 3		Round 4	
	November 2018	"before COVID"	"today" (April 2021)	"before COVID"	"today" (Nov. 2021)	"before COVID"	"today" (May 2022)
All	57.8 %	61.3 %	91.2 %	58.3%	87.4 %	56.5%	71.7 %
Male	49.4 %	55.5 %	85.6 %	54.3 %	82.3 %	51.8 %	65.6 %
Female	64.9 %	65.6 %	95.4 %	62.0 %	92.2 %	60.2 %	77.0 %
Under 30 years	56.2 %	70.0 %	93.0 %	63.5 %	85.0 %	56.6 %	69.7 %
30-60 years	60.2 %	59.2 %	91.1 %	58.2 %	87.1 %	59.4 %	72.8 %
Over 60 years	50.0 %	57.6 %	88.1 %	57.6 %	88.2 %	53.4 %	70.8 %

later samples. This is encouraging with respect to concerns regarding representativity and comparability of the samples. It also seems like the perception of discomfort is less related to age compared to gender.

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Acknowledgement

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