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The influence of waiting time on the value of headway time on a ferry service in Norway

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ABSTRACT

The value of headway time is travellers willingness to pay for a reduction in the length of the time intervals between departures on public transport services. As such, it is an important number when departure frequencies on such services are determined. Because waiting, according to the literature, gives rise to the emotions of anger and uncertainty it can be assumed that waiting time influences travellers willingness to pay for reduced headway. As such, it is the aim of this study to investigate the relationship between respondents waiting time at ferry terminals and their willingness to pay for reduced headway. The main finding is that the value of headway increases concavely with waiting time. That is, a marginal change in waiting time influences the valuation of headway positively. However, the effect is diminishing. This result implies that, all else equal, the welfare effect of reducing the length of the time interval between departures is greater on services with a long average waiting time than on those where the average waiting time is short.

1. Introduction

More than 50 billion journeys are made annually by public transport in the European Union (UITP, 2015). The service level offered by public transport providers is therefore of great importance to the welfare of Europeans. One of the most important service elements in passenger transport is total travel time (e.g. Hensher, Stopher, & Bullock, 2003), which for public transport is strongly influenced by the length of the time interval between departures (i.e., headway time).

The welfare effect from reduced headway time is reflected in travellers' willingness to pay for improvements, i.e., the value of headway time. Accurate time value estimates for the different segments of travel are essential (Ho, Mulley, Shiftan, & Hensher, 2016), not least because the value of travel time savings typically represent 60% of the user benefit in the economic appraisal of transport investments (Hensher, 2001).

The value of travel time savings is often estimated using stated choice data (Abrantes & Wardman, 2011; Tseng & Verhoef, 2008). These data are derived from studies where respondents are asked to choose between alternatives in hypothetical choice situations. The application of stated choice data is based on the underlying assumption that the respondent, in each choice situation, chooses the alternative with the highest utility to him or her. However, several studies indicate that respondents' choices in stated choice experiments are also influenced by more than the characteristics of the alternatives.

First, with respect to data gathering method, Abrantes and Wardman (2009) find that telephone and internet surveys yield time values which respectively are 33% and 42% higher than those obtained using traditional surveys. The authors suggest that the higher values derived from internet surveys are the result of respondents rushing through the survey, while the higher values from telephone surveys are due to the fact that attribute levels are not presented side by side but sequentially. Hence, both the speed with which the survey is conducted (internet) and the sequential presentation of attribute levels (telephone) make respondents emphasise travel time more strongly than cost, leading to higher time value estimates (Abrantes & Wardman, 2009).

Second, with respect to the complexity of the survey instrument used, Hensher (2004) concludes that average willingness to pay for total travel time savings is higher when survey designs with more items to process for the respondents are used. The focus on choice task complexity is related to respondent's cognitive capability and commitment to effort, both of which are challenged as survey complexity increases.

Finally, in a third study, Hanssen (2012) suggests that interview

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location matters in value of travel time studies. More specifically, he finds that the mean value of headway time savings is significantly higher among respondents interviewed onboard ferries than among those interviewed at home. The author suggests that this is due to a rosy retrospection effect, i.e. that respondents interviewed at home remember time spent waiting at ferry terminals more positively than the actual experience. Hence, they emphasise short headway time less when they participate in stated choice experiments.

These examples indicate that psychological factors influence economic decision-making in stated choice experiments, thus supporting the suggestion by Jain and Lyons (2008) that travel time is not easily reducible to an economic value. Following this line of reasoning, and taking into consideration that it is well known from the literature that waiting gives rise to the emotions of anger and uncertainty (see e.g. Friman, 2010), this study investigates the relationship between waiting time and respondent's willingness to pay for reduced headway time. More specifically, we expect to find that in stated choice experiments, travellers who have waited a long time emphasise headway time relatively more strongly than price, compared to travellers who waited a short time, thus leading to a positive association between waiting time and value of headway time.

The remainder of this article is organised as follows. In Section 2, we present the methodological approach of the study, the model specification and the value of travel time. The design of the choice experiment is presented in Section 3. In Section 4, the estimation results are presented, and the time value estimates are derived. Finally, in Section 5 we provide some concluding remarks.

2. Model specification and the value of travel time

2.1. Methodological approach

To investigate the relationship between waiting time and the value of headway time we use a mixed logit model, which is a generalization of the multinomial logit model, to accommodate preference heterogeneity across individuals (Revelt & Train, 1998). In the mixed logit model (Sarrias & Daziano, 2017) the random utility of person i for alternative j and for choice occasion t is given by:

$$\begin{aligned} U_{ijt} &= X_{ijt}^T\beta_i + \varepsilon_{ijt}, \\ i &= 1,\ldots,N, \\ j &= 1,\ldots,J, \\ t &= 1,\ldots,T_i, \end{aligned} \tag{1}$$

where X_{ijt} is a $K \times 1$ vector of observed alternative attributes; ε_{ijt} is the error term which is independently and identically distributed (IID) extreme value type 1; the parameter β_i is a $K \times 1$ vector which is unobserved for each i and is assumed to vary in the population following the continuous density $f(\beta_i|\theta)$ where θ are the parameters of this distribution. Also, observed heterogeneity (deterministic taste variations) can be accommodated in the random parameters β_i by including individual-specific covariates (Greene, 2012).

If we include individual-specific covariates and assume that the vector β_i of random parameters are multivariate normally distributed, β_i may be written as in (Sarrias & Daziano, 2017):

$$\beta_i = \beta + \Pi z_i + L\eta_i \tag{2}$$

where β is the $K \times 1$ vector of the means of the random parameters; z_i is a $M \times 1$ vector of characteristics of individual i that influence the means of the random parameters β_i; Π is a $K \times M$ matrix of additional parameters which adjust the influence of individual-specific covariates on the means of β_i; the $K \times 1$ vector $\eta_i \sim \mathrm{N}_K(0,I)$; and the $K \times K$ matrix L is the lower-triangular Cholesky factor of $\sum$ such that $LL^T = Var(\beta_i) = \sum$.

By using equations (1) and (2), the random utility U_{ijt} may be written as:

$$U_{ijt} = V_{ijt} + x_{ijt}^T L\eta_i + \varepsilon_{ijt} = x_{ijt}^T\beta + x_{ijt}^T \Pi z_i + x_{ijt}^T L\eta_i + \varepsilon_{ijt} \tag{3}$$

where V_{ijt} constitute the deterministic part, and the last two terms constitute the unobserved random part. The $K \times 1$ vector β contains the means of the random parameters for the alternative attributes while the $M \times K$ matrix Π contains the fixed parameters for the interaction terms between the alternative attributes and the individual specific variables. Due to the term $x_{ijt}^T L\eta_i$, the utility may be correlated over alternatives. However, for the multinomial logit model, η_i is identically to zero due to the fact that all parameters are fixed in the multinomial logit model. Thus, the term ε_{ijt}, which is IID extreme value type 1, constitutes the random part of U_{ijt} in the multinomial logit model, such that there are no correlation in utility over the alternatives in the multinomial logit model.

The dependent variable in the mixed logit model above is the choice made by the decision maker, and the decision maker i will only choose alternative j on choice occasion t if $U_{ijt} > U_{ikt}, \forall k \neq j$.

Let $y_{ijt} = 1$ if individual i chooses alternative j on occasion t, and 0 otherwise. The unconditional probabilities of the sequence of choices by individual i in the choice occasions $1, \ldots, T_i$ for this model is in Sarrias and Daziano (2017) given by:

$$P_i(\theta) = \int \left\{ \prod_{t=1}^{T_i} \prod_{j=1}^{J} \left[\frac{\exp\left(x_{ijt}^T\beta_i\right)}{\sum_{j=1}^{J}\exp\left(x_{ijt}^T\beta_i\right)} \right]^{y_{ijt}} \right\} f(\beta_i|\theta)d\beta_i = \int S_i(\beta_i) f(\beta_i|\theta)d\beta_i \tag{4}$$

The log-likelihood of this model is $LL(\theta) = \sum_{i=1}^{N} \ln P_i(\theta)$. However, the integral in (4) is not solvable analytically such that we approximate $P_i(\theta)$ by simulation $SP_i(\theta) = \frac{1}{R}\sum_{r=1}^{R} S_i(\beta_i^{r|\theta})$ and maximise the simulated log-likelihood function $\mathrm{SLL}(\theta) = \sum_{i=1}^{N} \ln SP_i(\theta)$, see Revelt and Train (1998). Here R is the number of draws of β_i from the distribution $f(\beta_i|\theta)$, and $\beta_i^{r|\theta}$ is the r-th draw of β_i.

The estimated coefficients indicate the marginal utility associated with each attribute. Moreover, the ratio of two coefficients will yield a measure of willingness to pay for reduced travel time, if the nominator is a measure of travel time and the denominator is in monetary terms. That is, the amount of money individuals are willing to forfeit to have their travel time reduced by one unit.

2.2. Model specification

In accordance with Equation (3), we use the mixed logit model with the following deterministic part to analyse the influence of waiting time on the value of headway time:

$$V_{ijt} = [P\ H\ O]\begin{bmatrix}\beta_P\\ \beta_H\\ \beta_O\end{bmatrix} + [P\ H\ O]\begin{bmatrix}\beta_{WP}\\ \beta_{WH}\\ \beta_{WO}\end{bmatrix}[W] = \beta_P P + \beta_H H + \beta_O O + \beta_{WP} W \cdot P + \beta_{WH} W \cdot H + \beta_{WO} W \cdot O \tag{5}$$

where the letter P represents the price, in Norwegian kroner (NOK), paid to travel with the ferry, H is the time between departures and O is the onboard time, i.e., the time it takes the ferry to cross the strait. These factors are the attributes of the alternatives, as expressed in the stated choice experiment (see Fig. 1). Further, β_P, β_H and β_O are the means of the random parameters for P, H and O, while β_{WP}, β_{WH} and β_{WO} are the fixed parameters for the interaction terms between the individual specific variable W, i.e. the number of minutes the respondent had to wait at the ferry terminal prior to boarding the ferry, and the attributes P, H and O of the alternatives. Finally, we assume that the random parameters for the attributes P, H and O of the alternatives are multivariate normally distributed, such that the random part of the mixed logit model may be written as in Equation (3):

Which of the following two alternatives do you prefer based on ticket price, time between departures and travel time across the strait:

Alternative A		Alternative B
153 NOK	Ticket price (car and driver)	210 NOK
68 min	Time between departures	56 min
54 min	Travel time across the strait	45 min
☐	← I prefer →	☐

Fig. 1. An example of a choice situation from the study.

$$x_{ijt}^{T} L\eta_i + \varepsilon_{ijt} \tag{6}$$

where the 3×1 vector $\eta_i \sim N_3(0, I)$, the 3×3 matrix L is the lower-triangular Cholesky factor of Σ such that $LL^T = \mathrm{Var}(\beta_i) = \Sigma$, and ε_{ijt} is IID extreme value type 1.

Because both time and money costs are part of the generalised cost notion (Button, 2010), shorter travel times and less expensive alternatives are expected to be preferred over longer more expensive ones. Hence, we expect to find that: $\beta_P, \beta_H, \beta_O < 0$. In other words, higher prices, longer headway time and longer on-board time reduce travellers' utility.

Three interaction variables are included in Equation (5). The first is between the length of time the decision maker waited at the terminal before boarding the ferry (W) and price (P), the second is between waiting time and time between departures (H), and the third is between waiting time and onboard time (O). As such, the interaction variables allow the preferences of the decision makers to vary with the time they waited at the terminal prior to boarding the ferry.

2.3. The value of travel time

Marginal willingness to pay is a measure of the benefits from changes in an attribute. That is, the amount individuals are willing to pay to receive a one-unit improvement in an attribute. In transportation, the concept is frequently applied with respect to "the monetary rate at which a given travel-time saving or loss in a particular context can be compensated for by a corresponding loss or saving of money" (Gunn, 2008, pp. 503). This value of travel time (*VOT*) is considered the most important number in transport economics (Fosgerau, 2006), and is the marginal rate of substitution between travel time and cost for constant utility. In other words, *VOT* shows the rate at which an increase in travel time can be compensated by the reduced travel cost while holding the utility of the traveller constant.

For the purpose of this study, we address the value of headway time (VOT_{HW}). In other words, it is relevant to address the amount of money travellers are willing to pay to have the time between the departures reduced by one unit, and how this value is affected by the number of minutes the respondent waited at the terminal before boarding the ferry on which he or she answered the stated choice experiment. This waiting time adjusted value of headway time (VOT_{HW}) is given by Equation (7), and is calculated in Section 4.2 using estimation results of Equation (5).

$$VOT_{HW} = \frac{\beta_H + (\beta_{WH} \cdot W)}{\beta_P + (\beta_{WP} \cdot W)} \tag{7}$$

3. Design of the choice experiment

The ferry industry is an important part of the Norwegian transport infrastructure (Jørgensen & Solvoll, 2018), generating an annual welfare for travellers of approximately 6 billion NOK (Jørgensen, Mathisen, & Larsen, 2011). This study applies data from a stated choice experiment conducted on the February 5, 2010 on the ferry service Bognes-Lødingen, located in Northern-Norway, to analyse the influence of waiting time on the value of travel time. The ferry service had an average daily traffic of 569 passenger car equivalents (The Norwegian Directorate Of Roads, 2011),[2] making it the most trafficked ferry service in Nordland county in 2010. The sailing time between the two ferry terminals was approximately 1 h and the headway varied from 150 min early in the morning to 60 min around noon. The interviewers arrived at Bognes ferry terminal at 6:00 am and finished at 9:00 pm, and the survey was distributed to the drivers of all 195 passenger cars on departures between 06:40 and 20:45. There were 151 drivers who completed the questionnaire. Hence, the response rate was 77%.

3.1. Survey instrument

The survey instrument used in this study is a tailor-made questionnaire. In addition to questions related to demographic characteristics, trip purpose and waiting time at the terminal, eight choice situations were included in each respondent's questionnaire. In each choice situation, the respondent was asked to choose between two alternatives described by onboard time (i.e. the time it takes the ferry to cross the strait), headway time (i.e. the length of the time interval between departures) and ticket price. One of the choice situations is presented in Fig. 1.

The attribute levels, i.e., the values of the attributes, used in stated choice experiments should be sufficiently broad to allow a diverse set of alternatives, while at the same time appear realistic (Hess & Rose, 2009) and feasible to the respondents (Hensher, Rose, & Greene, 2005). The base attribute levels for Alternative A were therefore set equal to the actual values for the ferry service where the data were collected. As such, 170 NOK was the base value for the ticket price, 90 min for headway time and 60 min for travel time across the strait, i.e., on-board time. The base values used for Alternative B were 210 NOK for the ticket price, 75 min for headway time, and 50 min for travel time across the strait. The variations of each attribute are presented in Table 1.

Based on the attribute levels, SPSS was used for an orthogonal fractional factorial design with 32 choice sets. By introducing a blocking variable with four levels, each respondent only had to make eight choices. Moreover, because each attribute level occurs eight times for each attribute, the experimental design of the study is balanced.

3.2. Sample characteristics

As is evident from the sample characteristics in Table 2, the typical respondent was male and had an average income near 400.000 NOK. Considering that more men than women have a driving licence and access to a car (Denstadli, Engebretsen, Hjorthol, & Vågane, 2006) and

Table 1
Profile of the attribute ranges in the SC design.

Attributes	Level 1	Level 2	Level 3	Level 4
Ticket price	Base value – 25%	Base value – 10%	Base value	Base value + 10%
Headway time	Base value – 25%	Base value – 10%	Base value	Base value + 10%
On-board time	Base value – 25%	Base value – 10%	Base value	Base value + 10%

[2] Passenger car equivalents (PCE) is a production measure in the Norwegian ferry sector. For example, a passenger car (<6 m) counts for 1.025 PCE while a vehicle longer than 19 m counts for 10.682 PCE.

Table 2
Characteristics of the sample.

Characteristics	No. of respondents	Average waiting time
Gender		
Male	116	24.3 [19.8–28.9]
Female	35	27.3 [17.1–37.5]
Personal gross income (NOK/year)		
0–100,000	7	33.0 [13.3–52.7]
100,000–300,000	36	29.1 [18.2–39.9]
300,000–500,000	65	23.0 [17.7–28.2]
500,000–700,000	28	19.2 [14.4–24.1]
700,000 +	10	44.1 [9.22–79.0]
Purpose of trip		
Travel to/from job or school	19	32.6 [18.0–47.3]
Business trip	31	27.5 [15.9–39.1]
Leisure trip	79	21.4 [16.4–26.3]
Other	22	28.1 [17.1–39.1]

Note: Average waiting time: 95% confidence intervals are in brackets. All respondents did not answer every demographic question.

that average annual income among Norwegians in 2008 was 345.000 NOK, our sample broadly resembles the characteristics of Norwegian car drivers. However, approximately 80% of car trips in Norway are leisure trips (Denstadli et al., 2006), whereas only half of the respondents were on a leisure trip when they answered the survey. This difference is likely due to the data being gathered in February when relatively few tourists travel by car in Northern Norway.

Income and trip purpose are strongly associated with travel time valuation (Gunn, 2008). We therefore report average waiting time for respondents with different incomes and trip purposes in Table 2. The table shows that average waiting time differs by income and trip purpose. High-income travellers and those travelling to/from job or school waited the longest at the ferry terminal before driving on-board the ferry. However, the 95% confidence intervals reported in brackets are overlapping between income groups and trip purpose groups. We therefore cannot, on a reasonable statistical level, reject the hypothesis that average waiting time is equal across the five income groups and the four trip purpose groups. It is, however, important to note that this does not mean that the groups cannot have different average waiting time.

4. Estimation results and interpretation

4.1. Parameter values

The coefficient estimates reported in Table 3 were derived from a simulated maximum likelihood (SML) procedure in the statistical software program R. Hence, the parameters that were most likely to have occurred for the sample were estimated (Hensher et al., 2005). At this point it is also worth mentioning that the respondents were presented only unlabelled alternatives. It is therefore not feasible to treat parameter estimates as alternatives specific (Hensher & Goodwin, 2004).

The *Final model* is (as shown in the fourth column of Table 3) composed of the three base attributes and two interaction terms. Consequently, one interaction term (β_{WO}) is removed from the *Full model* prior to estimating the *Final model*. The removal of this insignificant term is in accordance with recommendations by Hensher et al. (2005).

The estimation results of the *Final model* in Table 3 show that the mean of the random coefficients of price, onboard time, and headway time are negative and statistically significant ($p<0.01$). Also, the estimated standard deviations of these random coefficients are highly significant, indicating that these parameters do indeed vary in the population of travellers. The log-likelihood of the corresponding multinomial logit model i.e. with all parameters fixed, is −614.53. A log-likelihood ratio-test confirms that the increase in log-likelihood to −537.11 is highly significant, such that the explanatory power of the mixed logit model is indeed considerably greater than with the multinomial logit model. However, as these random parameters are normally

Table 3
Estimation results for three mixed logit models with choice as a dependent variable.[b]

Variable code	Simple-no-interaction (SNI)	Full model	Final model
P: Mean coefficient	−0.06577** (−8.92)	−0.05342** (−6.60)	−0.05572** (−7.00)
P: Standard deviation of coefficient	0.04228** (5.43)	0.04295** (5.42)	0.04228** (5.45)
O: Mean coefficient	−0.10908** (−6.38)	−0.09817** (−4.70)	−0.11164** (−6.41)
O: Standard deviation of coefficient	0.10757** (5.50)	0.10869** (5.60)	0.10952** (5.63)
H: Mean coefficient	−0.09082** (−8.50)	−0.07266** (−5.70)	−0.07408** (−5.85)
H: Standard deviation of coefficient	0.05770** (4.74)	0.05728** (4.66)	0.05732** (4.69)
β_{WP}: Coefficent		−0.00055** (−2.46)	−0.00043* (−2.27)
β_{WO}: Coefficient		−0.00062 (−1.08)	
β_{WH}: Coefficient		−0.00080* (−2.21)	−0.00072* (−2.06)
No. observations	1 180	1 180	1 180
Log-likelihood	−540.91	−536.51	−537.11
LL ratio-test[a]			
Chi-square statistic		8.79	7.60
P-value		0.032	0.022

**Coefficients are statistically significant at the 1% level. * Coefficients are statistically significant at the 5% level.
[b] *t*-statistics are reported in parentheses.
[a] Log likelihood ratios are calculated using "*SNI*" as the base model.

distributed, the probability that the random coefficients of price, onboard time and headway time are positive, are 0.094, 0.143 and 0.096, respectively. This result implies in accordance with our hypothesis, that an increasing price, a longer time between departures and a longer travel time to cross the strait reduce travellers' utility for most of the travellers in this population.

To determine whether the *Final model* is statistically significant, the analyst must compare the log-likelihood (LL) function of the choice model at convergence to the LL function of another "base model" (Hensher et al., 2005). For this study, a model consisting only of variables *P*, *O* and *H*, i.e. the SNI model, function as base model. The LL for this base model is −540.91, and we can reject the assumption that the *Final model* does not improve the LL over the base model. Hence, we conclude that the LL of the *Final model* is statistically closer to zero than that of the model consisting only of variables *P*, *O* and *H*.

Table 4 shows the estimated covariances among the random coefficients of price, onboard time and headway time of the *Final model*.

Table 4
Covariances and correlation among the random coefficients.

Estimated Covariance matrix	Price	Onboard time	Headway time
Price	0.00179**		
Onboard time	0.00103	0.01200**	
Headway time	−0.00035	0.00098	0.00329*
T-statistics for Estimated Covariances	**Price**	**Onboard time**	**Headway time**
Price	2.73		
Onboard time	1.09	2.81	
Headway time	−0.69	0.63	2.34
Correlation Matrix	**Price**	**Onboard time**	**Headway time**
Price	1.00		
Onboard time	0.22	1.00	
Headway time	−0.14	0.16	1.00

The covariances between any pair of these random coefficients are not statistically significant at any reasonable significance level, which indicate that these random coefficients are approximately independent. As a result, there are minor correlation over alternatives in this model. Moreover, the correlation between the explanatory variables and the residuals are less than or equal 0.01. This result suggests that the statistical properties of the final model are generally sufficient, thus indicating that the estimation results are credible.

The two interaction variables included in the *Final model* evaluate the extent to which waiting time at the terminal influences the degree to which a marginal increase in ticket price and time between departures affect travellers' utility. Both interaction coefficients (β_{WP}, β_{WH}) are negative and statistically significant ($p < 0.05$). However, it is worth noting that β_{WH} is 67% greater than β_{WP}, indicating, as such, that headway is emphasised more strongly than price, when taking into consideration how long the respondent has waited at the terminal.

4.2. The influence of waiting time on the value of headway time

Plugging coefficient estimates from Table 3 into Equation (7) renders the following function describing the relationship between waiting time at the terminal and willingness to pay for a 1 min reduction in time between the departures, i.e., the waiting-time-adjusted value of headway time:

$$VOT_{HW} = \frac{(-0.07408) + (-0.00072 \cdot W)}{(-0.05572) + (-0.00043 \cdot W)} \tag{8}$$

where W is waiting time in minutes. By using the first- and second order derivatives of Equation (8), we find that the value of headway time increases concavely with waiting time (W). That is, a marginal change in waiting time influences the valuation of headway time positively. However, the effect is diminishing.

The relationship between waiting time and willingness to pay for reduced headway time is shown in Fig. 2 using index values, i.e., the function in Equation (8) is plotted but the vertical axis is rescaled such that the value 100 corresponds to the respondents' constant willingness to pay for reduced headway time (VOT_H) in the base model in Table 3: $VOT_H = \frac{\beta_H}{\beta_P} = \frac{-0.09082}{-0.06577} \cdot 60 = 82,85$ NOK/hour. The solid line illustrates neatly how the marginal effect of waiting time on the value of headway time (VOT_{HW}) is diminishing, while the dotted horizontal line represents the respondents' constant willingness to pay for reduced headway time (VOT_H) in the base model in Table 3 (82.85 NOK/hour). The two lines intersect at approximately 24 min. Consequently, VOT_{HW} is less (greater) than VOT_H among travellers who have waited a short (long) time.

The figure also confirms the concave relationship between waiting time and the value of headway time. For example, when waiting time increases from 5 to 20 min, the index-value increases by 2.27, whereas it increases by a value of only 0.88 when W increases from 90 to 105 min. Consequently, the increase in VOT_{HW} from a 15 min increase in waiting time is 158% higher in the first situation than in the second.

Finally, it is worth mentioning that our finding, i.e. that there is a positive relationship between the number of minutes a respondent had been waiting and their reported willingness to pay for reduced headway, is supported by it being broadly in accordance with what one would reasonably assume when considering that previous research have found that waiting can lead to anger and uncertainty (Jain & Lyons, 2008).

5. Concluding remarks

This paper investigates the relationship between waiting time and respondent's willingness to pay for reduced headway. Using empirical data from Norwegian ferry travellers, we find that respondents willingness to pay for reduced headway increases concavely with the number of minutes they waited at the ferry terminal meaning that the marginal effect on willingness to pay for reduced headway of increasing

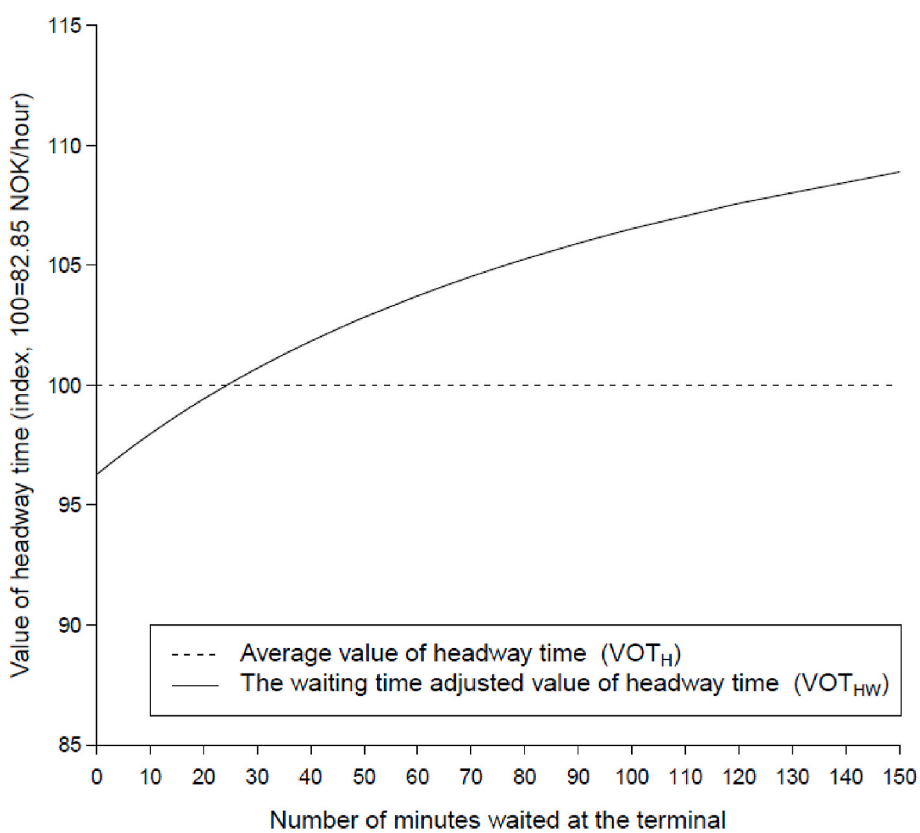

Fig. 2. The relationship between waiting time and willingness to pay for reduced headway time.

waiting time diminishes. This finding suggests that travellers who wait long on the ferry terminal emphasise headway more strongly than price, compared to travellers who wait a short period of time.

At least two factors can be used to explain our finding. The first relate to the fact that waiting gives rise to the emotions of anger and uncertainty. The second relate to the reasonable assumption that those who wait long at the terminal travel less frequently by ferry. Such users will typically not know the timetable as good as frequent users. They will, as such, often arrive randomly at the terminal giving them longer waiting time. Moreover, those who not often travel by ferry will not be as used to waiting as more frequent travellers, making them more irritated, angry and impatient.

The positive association between waiting time and stated willingness to pay for reduced headway implies that, all else equal, the welfare effect of reducing the length of the time interval between departures is greater on services with long waiting time than on those with short waiting time. Because waiting time tends to be longest in rural areas, due to relatively low departure frequencies, reducing the headway om public transport services in such areas would become more attractive in cost-benefit analyses if a waiting time adjusted value of headway time were applied.

It should be noted that our study, in accordance with all empirical studies, has weaknesses. First, the waiting time at the ferry terminal is self-reported. Studies suggest that respondents have a tendency to overestimate the number of minutes they wait (Fan, Guthrie, & Levinson, 2016). It is therefore a risk that the respondents in our survey overestimated the number of minutes they had to wait at the terminal prior to boarding the ferry. Second, the data analysed was collected from travellers solely by ferry. Consequently, data from travellers using other modes of transport may yield different results. Third, the data were collected on a ferry service with no amenities at the terminal. This might have influenced how poor the waiting time experience was, and, as such, it might have affected how the waiting time influenced the respondent's willingness to pay for reduced headway. Fourth, this study is unable to establish at a reasonable statistical level that waiting time at the terminal influences the degree to which a marginal increase in onboard time affect travellers' utility. This could be due to our sample size. Future studies addressing this topic are therefore recommended using larger dataset than the one used here. A larger dataset would also make it possible to make group-specific estimations of our model based on trip purpose and income. Summing up, future research on this topic should 1) use observed, instead of self-reported, waiting time, 2) address the influence of waiting time on the value of headway time on other transport modes than ferries and 3) on services where there are better amenities at the terminals than what was provided at the service where this study was conducted, and 4) apply a larger sample than the one used here. Finally, recent studies cast doubt over whether individuals have stable preferences when they give multiple responses in, for example, stated choice surveys (Belton & Sugden, 2018). Although we restricted the number of choice situations given to each respondent in our survey to reduce the risk of fatigue, within-subject dependence cannot be ruled out.

Despite the above limitations, this paper nevertheless provides an attempt to identify the relationship between waiting time and respondents willingness to pay for reduced headway time.

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