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VALUING TRAVEL TIME CHANGES: A CASE OF SHORT-TERM OR LONG-TERM CHOICES?

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ABSTRACT

The valuation of travel time is of crucial importance in many transport decisions. Most studies make use of data framed around short-term decisions such as route choice. However, people may have a greater ability to trade time and money in a longer term setting, such as when considering changes in residential or employment locations. We study the value of travel time in both the short and long-term, finding differences in the valuations. Given the importance of these valuations for policy making, our results call for more research into how time-cost trade-offs should be represented with stated preference.

Keywords*:* value of time; commuting; WTA; WTP; short and long-term choices; framing effects.

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1. INTRODUCTION

Why and how is time valued?

The valuation of travel time (VTT) is a core input into the appraisal of many transport policy and infrastructure schemes that often have substantial economic, societal and environmental implications. As such, it is not surprising that a substantial share of the research in a travel behaviour context has looked at the specification and estimation of VTT. This comes in the form of numerous smaller scale studies (e.g. Devarasetty et al. 2012, Börjesson et al. 2012, Asensio and Matas 2008, Lam and Small 2001) as well as large national level projects (e.g. Hess et al. 2015, Significance et al. 2013, Fosgerau et al. 2007, Mackie et al. 2003).

The VTT can be estimated from either revealed preference data where estimates are derived from the actual choices made by travellers (see for example Isacsson and Swardh 2009, Van Ommeren and Fosgerau 2009, Tse and Chan 2003, Lam and Small 2001), or from stated preference (SP) experiments where travellers are typically required to make choices between hypothetical travel alternatives that vary in both time and cost (see for example Hensher et al. 2015, Small 2012, Axhausen et al. 2008, Tseng and Verhoef 2007). While each method has positives and negatives[1], many jurisdictions now use stated preference methods (see Abrantes and Wardman 2011 and Wardman 1998 for a review) or a combination of the two (e.g. Axhausen et al. 2015). The data from these surveys is then typically analysed using advanced discrete choice models.

Much of the literature in the SP context has focussed on the experimental design of the hypothetical choice scenarios (in terms of number of alternatives, attributes and statistical design properties) and the econometric specification of the models used in the subsequent analysis. Overwhelmingly however, the context of the choices has focussed on presenting respondents with changes between different options for a given journey (i.e. a single trip), either route choice or mode choice. This is the case in national studies in the United Kingdom (ARUP et al. 2015, Mackie et al. 2003), the Netherlands (Kouwenhoven et al. 2014), Sweden (Börjesson and Eliasson 2014) and Denmark (Fosgerau et al., 2007). While these national studies in Europe use simple settings with two alternatives and two attributes (travel time and travel cost), more local or regional studies, for example in Australia, rely on more complex presentations with often three alternatives and five or six attributes (e.g. Legaspi and Douglas 2015, Hensher and Greene 2011). However, the focus on changes to a single journey remains, something we identify as a short-term decision.

Is this approach appropriate?

The question we ask in this paper goes beyond the much debated issue of how many alternatives and attributes should be included in surveys, and looks instead at the specific context, namely whether the focus on short-term decisions is appropriate? While there are situations in which a short-term choice of route and or mode of transport may involve opposing changes in time and cost (hence leading to a value of time based trade-off), this is not the case for many others, where e.g. the shortest driving route is also the cheapest. Estimating the VTT from such choices thus firstly

[1] Stated preference require respondents to make hypothetical choices which may not be the same as the corresponding real choices, while the reliability of revealed preference can be affected by factors such as unknown choice alternatives, multi-collinearity and difficulties in isolating the effects of key attributes.

requires a certain leap of faith by the respondent in terms of realism of the scenarios presented. Secondly, the estimates will likely relate to a very short-term decision (a traveller may choose the expensive route for a one-off journey, but not in general) while policy work will require estimates of a more general and stable VTT measure. In a travel context, this could for example relate to people making changes to their residential or employment location, i.e. a less reversible choice.

The residential location choice literature acknowledges that travel time, commuting and employment changes are significant determinants of choice (see Schirmer et al. 2014 for a comprehensive overview of the extant literature). Dissonance between where a person lives and where a person would like to live can significantly affect commuting behaviour (Schwanen and Mokhtarian, 2005) indicating that the long-term choice of where to live (or desire of where one would like to live) can influence the shorter term choice of how to commute on a day to day basis; or that the short-term values are potentially predicated by longer-term desires. In one interesting study of commuting and location choice, Rouwendal and Meijer (2014) find that households dislike commuting but preferences for some housing attributes are strong enough to make substantially longer commutes acceptable. In other words, there is evidence that the short-term value of time may be overstated compared to the longer term choice of where to live. The latter is however arguably the most realistic way in which many people can significantly vary the length and expense of their commute.

One paper in the transport literature that seeks to examine differences in long and short run values of time is by Peer et al. (2015). This paper examines departure time choices as a function of schedule delays, finding that significant differences exist in the valuation of time and of schedule delays between the long-run and the short-run model. Specifically, the authors find that travel time is valued higher in the long-run model, as changes in travel time are more permanent and can therefore be exploited better through the rescheduling of routines. Schedule delays are valued higher in the short-run model, since scheduling restrictions are typically more binding in the short-run. This analysis provides evidence for our argument that time may be thought of differently in a longer-term context as it is in the long-term when truly large changes to travel times can be made.

Contribution of this paper

In this paper, we examine differences in the valuation of time between short and long-term choices, using data from SP surveys that reflect the state of practice for the aforementioned national value of time studies. This paper represents one of the first in the transport literature to make this formal comparison, with a view to providing new evidence in the debate on how this important value for transport policy is constructed.

Specifically, we compare and contrast the values estimated in the analysis of short-term commuting changes versus long-term workplace and salary choices. Both represent a time-money trade-off, but with a different context. We do this by using data from a stated preference survey conducted in Sweden where car and public transport users first faced a set of choices where they had to make cost and travel time trade-offs for their commute, before facing an additional set of choices where they considered increases in travel time in return for a higher salary. Trading workplace location clearly represents a long-term choice; it is a decision that is not made easily and cannot be changed quickly. This presents us with the unique opportunity of contrasting valuations in a short-term and a long-term context, for the same respondent. We also gain insights into how valuations differ depending on whether people are presented with scenarios involving an increase in time in return for a reduction in travel cost, or a reduction in time in return for an increase in cost, adding evidence to the literature in this context.

The remainder of this paper is structured as follows; the next section outlines the survey used to collect the data for analysis, this is followed by a discussion of the methods used to examine the short-term and long-term commute choices made by respondents and Section 4 outlines the results of the modelling before presenting final discussions and conclusions.

2. SURVEY DESCRIPTION

The data used in this paper comes from a survey conducted in the Stockholm region of Sweden during April and May of 2005 (cf. Swardh and Algers 2009). The sample consisted of dyadic households, wherein each member of the household provided information about their travel behaviour, in particular commuting, and then provided answers to a number of different stated choice scenarios, where a reference alternative was contrasted with an alternative pivoted around that current experience and an indifference opt out . For a previous application using this data, see Hess et al. 2014.

For the present paper, we use data from three different sets (or games) of stated choice scenarios. The first of the three games we use was given only to public transport users who were presented with four different choice tasks, each involving a choice between their current commute conditions via public transport (data about a respondent's current travel time via public transport was collected, with costs imputed as the 600 Swedish Kroner (KR) cost for a monthly bus pass at this time) and a different trip that varied in time, cost and frequency of service (with changes pivoted around the current commute). Respondents could also indicate that they were indifferent between the two travel alternatives. An example of this choice task is shown in Figure 1, where the respondent was asked "what is the public transport journey that you would choose if you had the following options to travel to work?"

With respect to the design of this experiment, there were two styles of games, differing in the definition of the alternative trip, i.e. option 2. The first asked respondents to consider slower commutes for reduced cost, corresponding to a willingness to accept (WTA) scenario. The second style asked respondents to consider faster commutes for higher cost, corresponding to a willingness to pay (WTP) scenario. The levels used for the alternative trip were changes to the current commute. For frequency, the value for the alternative trip was half or double that for the current commute, while for travel time and cost, the values depended on whether the survey used the WTA or WTP style. For WTA tasks, the travel time for alternative 2 was 10 or 15 minutes slower, while cost was lower by 300KR or 450KR. For WTP tasks, the travel time for alternative 2 was faster by 5 or 10 minutes, but cost was higher by 750KR or 800KR. For either style of experiment, we have three attributes each with two levels, leading to eight possible choice sets (2^3) to cover all possible combinations of levels. These are blocked into two sets of four choice tasks, and a respondent receives one set of either the WTA or the WTP questions. Note that the frequency of service attribute was translated into headway for the analysis.

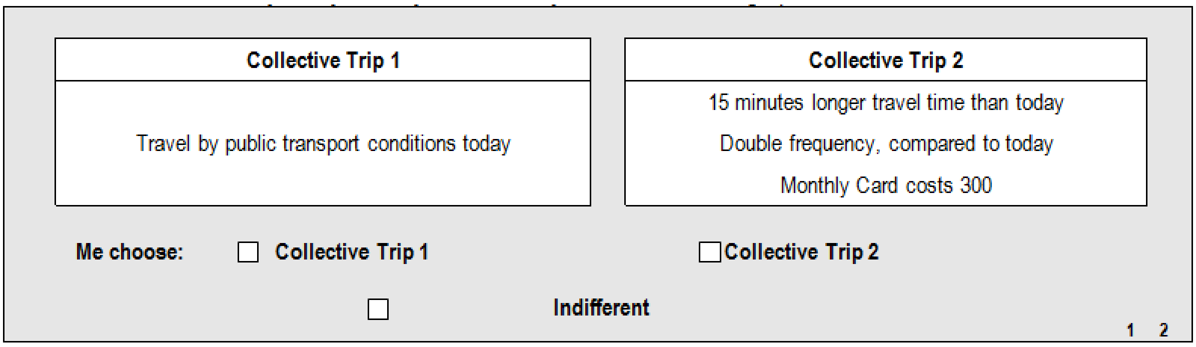

FIGURE 1 Example of public transport short-term choice task

The second game was similar to the first but was given only to car users. These choice tasks were framed as a choice between their current route (on which data was collected) and one that was longer but cheaper (WTA) or one that was faster but more expensive (WTP). The attribute levels within the WTA experiments were: travel time (10 or 15 minutes slower); number of speed cameras (0 or 2); and costs (200KR or 400KR less per month). The same attributes were used in the WTP tasks, with different levels for time and cost, namely 5 or 10 minutes faster for time, and 120KR or 280KR more per month for cost. The resulting eight possible combinations for both the WTA and WTP tasks were again blocked into two sets of four choice tasks and again respondents received one set of either the WTA or the WTP choice sets. An example of this choice task is shown in Figure 2, where respondents were asked “which route would you choose if you had the following options for travel to work?”

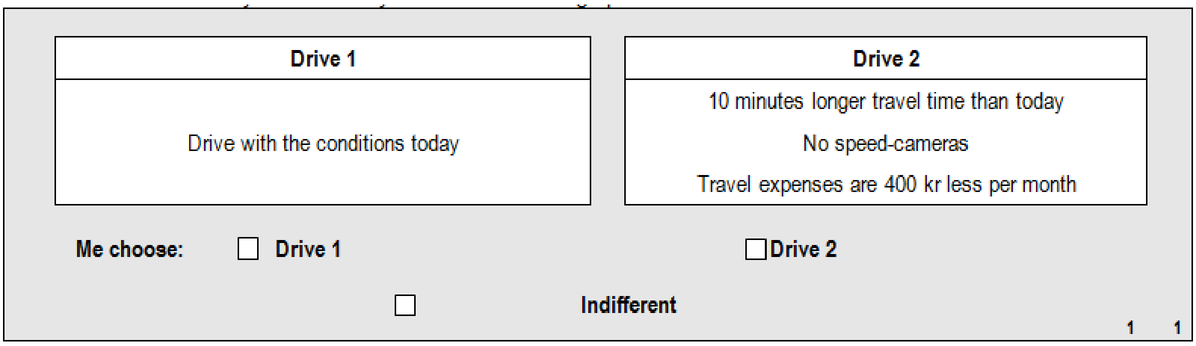

FIGURE 2 Example of car short-term choice task

The third game used in this paper was presented to all respondents after they completed either the public transport or car driver tasks, and involves a choice that represents a longer term context, namely job location. Unlike the other choice scenarios, this experiment was only presented in a WTA context where the current workplace was contrasted with a new workplace that was either 10 or 25 minutes further away for a salary that was higher than a respondent’s current salary by either 500KR or 1000KR. Similar to the previous two scenarios, an indifferent opt-out was also presented as a third alternative. A total of four choice tasks are required to cover all possible combinations of attribute levels (2^2) and all four were given to each respondent. An example of this choice task is shown in Figure 3 and respondents were asked "which option would you prefer if you had the following options in the choice of workplace location?"

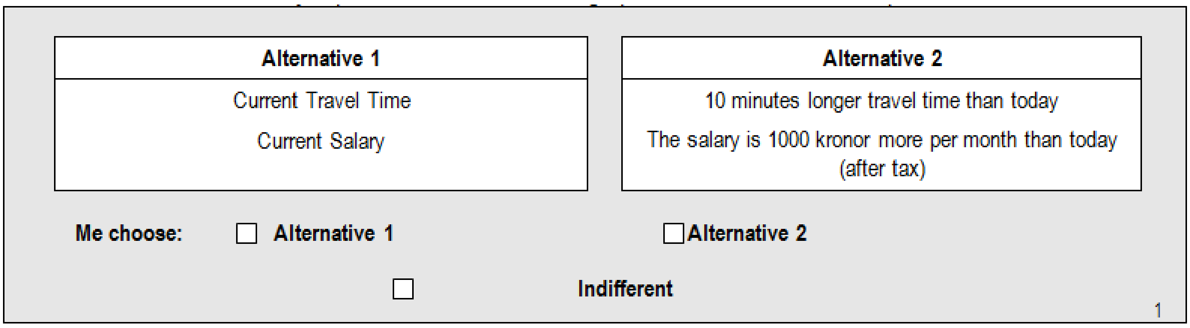

FIGURE 3 Example of long-term choice task

3. DATA DESCRIPTION

Data was collected via a postal questionnaire sent to randomly selected household in the Stockholm region of Sweden. A total of 6000 surveys were mailed out and no compensation was paid to respondents for completing the survey. The final sample included 1,285 respondents who use only public transport and 1,241 respondents who use only car. Overall, the total sample is split evenly across gender, has an average age of 41.6 years and average income of 30,175KR. Socio-demographics from Stockholm at this time are also included in the table and examples of where else this data has been published elsewhere include Swardh and Algers 2016, Hess et al. 2014, Swardh and Algers 2009, Transek 2006). For the purposes of clarity we describe each of the different commuting samples, which are outlined in Section 2, in more detail in Table 1. Car commuters have longer commutes, are older, more likely to be male, earn higher incomes and are less likely to have a university education.

TABLE 1 Characteristics of Public Transport and Car Commuters

		PT Commuters	Car Commuters	Stockholm Population
Age	*Average*	40.8	42.4	39.1
	(Std. Dev)	(7.9)	(7.5)	---
Gender	*Female*	57.4%	36.7%	49.6%
	Male	42.6%	63.3%	50.4%
Income/Mth (pre-tax)	*Average*	28,091KR	32,260KR	24,113KR
	(Std. Dev)	11,932KR	13,780KR	---
Education - No University		35%	48.1%	35.9%
Education - University		65%	51.9%	64.1%
Commute - Less than 20min		10.3%	36%	---
Commute - 20 to 40 min		42.3%	46.3%	---
Commute - More than 40 min		47.4%	17.7%	---

As described earlier, different groups of respondents saw different types of choice tasks. For public transport, 643 respondents completed willingness to accept style choice experiments where they traded increased travel times for public transport in exchange for short-term monetary gains, 642 respondents completed willingness to pay style experiments where they traded reduced times for increases in short-term costs. For car commuters, 619 respondents completed willingness to accept experiments (increased commute times) and 622 completed willingness to pay tasks (reduced travel times). Again for the purposes of clarity, the characteristics of each of these sub-samples are displayed in Table 2.

TABLE 2 Characteristics of Sub-Samples for Short-term Games

		PT – "WTA"	PT – "WTP"	Car – "WTA"	Car – "WTP"
Age	*Average*	40.5	41.1	42.8	41.9
	(Std. Dev)	(8.1)	(7.5)	(7.2)	(7.8)
Gender	*Female*	66.6%	48.2%	29.8%	43.6%
	Male	33.4%	51.8%	70.2%	56.4%
Income/Mth (pre-tax)	*Average*	27,632KR	28,551KR	33,786KR	30,741KR
	(Std. Dev)	(11,896KR)	(11,952KR)	(14,374KR)	(12,988KR)
Education - No University		35%	34.9%	49.2%	47%
Education – University		65%	65.1%	50.8%	53%
Commute - Less than 20min		11%	9.7%	32.5%	39.4%
Commute - 20 to 40 min		43.4%	41.1%	47.5%	45.2%
Commute - More than 40 min		45.6%	49.2%	20%	15.4%

Outside of gender, differences between the samples are marginal. In the estimation of the value of time models, we tested for gender effects but these were not significant, meaning that any differences uncovered later in the calculated values of time are more likely a result of the way in which respondents perceive the experiments. Table 3 provides an overview of how often each alternative has been chosen in each of the different sub-samples.

3. METHODOLOGY

To allow us to conduct reliable statistical tests for the difference in valuations across games, we use a joint model across the two games (long-term and short-term), where for the short-term game, we analyse data from respondents who complete willingness-to-pay (WTP) scenarios and respondents who obtain willingness-to-accept (WTA) scenarios. The utility functions incorporate interactions with current income and travel time, using an approach consistent with other national value of time studies (c.f. Mackie et al. 2003).

As discussed previously, the long-term game is always framed as WTA, and it thus makes sense to use WTA as the base in our model, with multipliers applied to it.

Using car respondents as our example (where for public transport respondents, we would simply replace speed cameras by headway), we define the deterministic utility of alternative *j* in task *t* for respondent *n* in the short-term game as:

$$V_{jnt,s} = \mu_{n,s}\left(\left(\frac{inc_n}{30}\right)^{\lambda_{inc}} \cdot tc_{jnt,s} + \beta_{spcam,n,s} \cdot spcam_{jnt,s} + \beta_{tt,n,s} \cdot \left(\frac{tt_n}{35}\right)^{\lambda_{tt}} \cdot tt_{jnt,s}\right) \quad [1]$$

In equation [1], $tc_{jnt,s}$ is travel cost, $tt_{jnt,s}$ is travel time, and $spcam_{jnt,s}$ is the number of speed cameras, each time referring to alternative *j* in task *t* for respondent *n* in the short-term game *s*. The attributes inc_n and tt_n refer to the income (in 1000SEK units) and reference trip travel time for respondent *n*, respectively. The estimate of λ_{inc} gives the income elasticity on the cost sensitivity and λ_{tt} the elasticity of the time sensitivity in relation to current travel time. The two denominators simply ensure that the base valuations are for a respondent earning SEK30,000 per year, with a reference commute trip of 35 minutes, which are approximately the sample averages.

Our main focus is now on the three remaining components in Equation [1], namely $\mu_{n,s}$, which is an estimated scale parameter (inversely proportional to noise), $\beta_{spcam,n,s}$ which is the directly estimated monetary valuation of reductions in the number of speed cameras, and $\beta_{tt,n,s}$, which is the directly estimated monetary valuation of changes in travel time. We allow for differences across individual respondents in these parameter estimates depending on whether they were presented with a WTP or a WTA game, i.e. whether the non status quo option was faster but more expensive (WTP) or cheaper but slower (WTA) than the status quo.

Specifically, we write:

$$\mu_{n,s} = \mu_{s,wta}\left(wta_{n,s} + \kappa_{wtp,\mu,s} wtp_{n,s}\right) \quad [2]$$

where $wta_{n,s}$ is 1 if respondent *n* is presented with WTA scenarios in the short-term game, and 0 otherwise, where the opposite applies to $wtp_{n,s}$. This means that $\mu_{s,wta}$ is the estimated scale parameter for WTA respondents in the short-term game, and $\kappa_{wtp,\mu,s}$ is a multiplier on that scale parameter for WTP respondents. The estimate of $\kappa_{wtp,\mu,s}$ can then be used to test the hypothesis of differences in the scale parameter between WTA and WTP respondents.

A corresponding approach is used for $\beta_{spcam,n,s}$ and $\beta_{tt,n,s}$, with:

$$\beta_{spcam,n,s} = \beta_{spcam,s,wta}\left(wta_{n,s} + \kappa_{wtp,\beta_{spcam},s} wtp_{n,s}\right) \quad [3]$$

and

$$\beta_{tt,n,s} = \beta_{tt,s,wta}\left(wta_{n,s} + \kappa_{wtp,\beta_{tt},s} wtp_{n,s}\right) \quad [4]$$

where $\beta_{spcam,s,wta}$ and $\beta_{tt,s,wta}$ are the estimated monetary valuations for changes in speed cameras and travel time in the WTA games, while $\kappa_{wtp,\beta_{spcam},s}$ and $\kappa_{wtp,\beta_{tt},s}$ are estimated multipliers on these valuations for the WTP games.

Given the inclusion of an indifference alternative, the use of a standard multinomial random utility model such as MNL is not appropriate as indifference is not a strict rejection of all alternatives as implied by utility theory (see Hess et al. 2014). Rather than relying on a random regret minimisation (RRM) approach, which is well suited to dealing with indifference but unable to produce willingness to pay measures, we turn to an ordered logit specification.

In a simple binary choice process, alternative *1* would be chosen if its utility is higher than that of alternative *2*, and vice versa. This is equivalent to saying that alternative *1* is chosen if the difference in utilities (between alternative *1* and *2*) is positive, while alternative *2* is chosen if the difference is negative. Acknowledging the inability of the analyst to fully capture the choice process under observation, we have that the probability of choosing alternative *1* increases as the difference between the two deterministic components of utility increases. Indifference can be accommodated in this framework by saying that if the difference in utilities between the two alternatives is *small*, then the respondent will select the indifference option. What constitutes a *"small"* difference is estimated from the data.

We now discuss how to accommodate this in an ordered logit framework. We define $dV_{nt,s} = V_{1nt,s} - V_{2nt,s}$ to be the difference in utility between the two alternatives in choice task *t* for respondent *n* in the short-term game. Alternative *1* is likely to be chosen when that difference is positive and large, while alternative *2* is likely to be chosen when that difference is negative and large. In between, indifference would be more likely to be chosen. In model estimation, we estimate two additional threshold parameters, namely $\tau_{1,s}$ and $\tau_{2,s}$. Within an ordered logit framework, the probability of choosing alternative *1* would be given by $1 - \frac{e^{\tau_{2,s} - dV_{nt,s}}}{1+e^{\tau_{2,s} - dV_{nt,s}}}$, which is a logit probability of the difference in utility between alternatives 1 and 2 exceeding the upper threshold, $\tau_{2,s}$. The probability of choosing alternative *2* would be given by $\frac{e^{\tau_{1,s} - dV_{nt,s}}}{1+e^{\tau_{1,s} - dV_{nt,s}}}$, which is a logit probability of the difference in utility between alternatives 1 and 2 being smaller than the lower threshold, $\tau_{1,s}$. Finally, the probability of choosing the indifference option is given by $\frac{e^{\tau_{2,s} - dV_{nt,s}}}{1+e^{\tau_{2,s} - dV_{nt,s}}} - \frac{e^{\tau_{1,s} - dV_{nt,s}}}{1+e^{\tau_{1,s} - dV_{nt,s}}}$, which is a logit probability of the difference in utilities being between the lower and upper threshold. The two threshold parameters ($\tau_{1,s}$ and $\tau_{2,s}$) take on a role similar to alternative specific constants in a multinomial logit model and help capture both an underlying preference for the status quo alternative, as well as an indifference threshold. A larger value for the threshold parameters shifts the preferences away from the status quo (alternative 1), while a smaller gap between the two reduces the likelihood of indifference outcomes.

In particular, with $\delta_{jnt,s}$ being *1* if alternative *j* is chosen by respondent *n* in choice task *t* in the short-term game, and with the indifference option being coded as alternative *3*, the likelihood of the observed choices across 4 tasks for respondent *n* is given by:

$$L_{n,s} = \prod_{t=1}^{4} \left(\delta_{1nt,s} \left(1 - \frac{e^{\tau_{2,s} - dV_{nt,s}}}{1+e^{\tau_{2,s} - dV_{nt,s}}} \right) + \delta_{2nt,s} \left(\frac{e^{\tau_{1,s} - dV_{nt,s}}}{1+e^{\tau_{1,s} - dV_{nt,s}}} \right) + \delta_{3nt,s} \left(\frac{e^{\tau_{2,s} - dV_{nt,s}}}{1+e^{\tau_{2,s} - dV_{nt,s}}} - \frac{e^{\tau_{1,s} - dV_{nt,s}}}{1+e^{\tau_{1,s} - dV_{nt,s}}} \right) \right) \quad [5]$$

In the short-term game, we also allow for differences in thresholds depending on whether respondents receive WTP or WTA games, such that we write:

$$\tau_{1,s} = wta_{n,s} \cdot \tau_{wta,1,s} + wtp_{n,s} \cdot \tau_{wtp,1,s} \quad [6]$$

$$\tau_{2,s} = wta_{n,s} \cdot \tau_{wta,2,s} + wtp_{n,s} \cdot \tau_{wtp,2,s} \quad [7]$$

The use of format specific thresholds allows for a greater/smaller preference for the status quo in the WTA/WTP games.

In the long-term game *l*, we write the deterministic component of utility as:

$$V_{jnt,l} = \mu_{n,l}\left(\left(\frac{inc_n}{30}\right)^{\lambda_{inc}} \cdot sal_{jnt,l} + \beta_{tt,n,l} \cdot \left(\frac{tt_n}{35}\right)^{\lambda_{tt}} \cdot tt_{jnt,l}\right) \quad [8]$$

where $sal_{jnt,l}$ now refers to the presented salary.

An important difference arises between the short-term and long-term games in that the money component is now a ‘good’ (salary) rather than a ‘bad’ (travel cost). With this in mind, we write:

$$\mu_{n,l} = -\kappa_{\mu,l} \cdot \mu_{s,wta} \quad [9]$$

where an estimate of 1 for $\kappa_{\mu,l}$ would imply that the scale is the same in the long-term game as in the short-term WTA game. With $\mu_{n,l}$ now having an expectation of a positive value, we also need to be cautious of the sign of $\beta_{tt,n,l}$, which refers to the monetary valuation of changes in travel time.

Specifically, we write:

$$\beta_{tt,n,l} = -\kappa_{\beta_{tt},l}\beta_{tt,s,wta} \quad [10]$$

where an estimate of 1 for $\kappa_{\beta_{tt},l}$ would imply that the monetary valuation of changes in travel time is equivalent in the long-term game and the short-term WTA game.

We then finally write a corresponding likelihood to Equation [5] for the long-term game as:

$$L_{n,l} = \prod_{t=1}^{4}\left(\delta_{1nt,l}\left(1-\frac{e^{\tau_{2,l}-dV_{nt,l}}}{1+e^{\tau_{2,l}-dV_{nt,l}}}\right)+\delta_{2nt,l}\left(\frac{e^{\tau_{1,l}-dV_{nt,l}}}{1+e^{\tau_{1,l}-dV_{nt,l}}}\right)+\delta_{3nt,l}\left(\frac{e^{\tau_{2,l}-dV_{nt,l}}}{1+e^{\tau_{2,l}-dV_{nt,l}}}-\frac{e^{\tau_{1,l}-dV_{nt,l}}}{1+e^{\tau_{1,l}-dV_{nt,l}}}\right)\right) \quad [11]$$

with estimated thresholds $\tau_{1,l}$ and $\tau_{2,l}$ and choice indicator $\delta_{jnt,l}$ being 1 if alternative *j* is chosen in choice task *t* in the long-term game for respondent *n*.

The final log-likelihood for our model is then given by:

$$LL = \sum_n \log\left(L_{n,s}L_{n,l}\right) \quad [12]$$

In the above specification, we allow for differences in behaviour between the long-term and short-term games, as well as between respondents receiving WTA scenarios in the short-term game and those receiving WTP scenarios. We further allow for an impact of income on cost sensitivities and current travel time on travel time sensitivity. We do not allow for further random heterogeneity as the aim of our study is to offer a simple statistical test of differences between the individual games. Furthermore, while the data used in this study has been used for the estimation of Mixed Logit structures in the past, our work revealed difficulties in doing so as the level of information in the data arguably does not support the reliable estimation of distributed preferences, noting that for example the long-term games focussed on only four different combinations of attributes that were identical across respondents.

The framework above allows us to offer a simple test of a number of different hypotheses:

H1) *Differences in scale between short-term WTP and WTA scenarios:*

- Null hypothesis of no difference can be rejected if $\kappa_{wtp,\mu,s}$ is statistically different from **1**

H2) *Differences in scale between short-term and long-term WTA scenarios:*

- Null hypothesis of no difference can be rejected if $\kappa_{\mu,l}$ is statistically different from **1**

H3) *Difference in monetary valuations between short-term WTP and WTA scenarios:*

- Null hypothesis of no difference can be rejected if $\kappa_{wtp,\beta_{tt},s}$ is statistically different from **1** for travel time, with a similar rationale for $\kappa_{wtp,\beta_{spcam},s}$ and $\kappa_{wtp,\beta_{headway},s}$

H4) *Differences in monetary valuations between short-term and long-term WTA scenarios:*

- Null hypothesis of no difference can be rejected if $\kappa_{\beta_{tt},l}$ is statistically different from **1**

A comparison between the upper threshold parameters across WTA/WTP and short-term/long-term can also give some indications of differences in baseline preferences for the status quo, but this is not a formal statistical test, as the overall scale of utility also has an impact on the values of the thresholds.

4. RESULTS

For reference, the choice frequencies are displayed in Table 3. As can be seen in the table the status quo alternative was preferred in the majority of choice tasks with the indifference option being selected infrequently. It is therefore not surprising there are negative thresholds estimated in both the public transport and car commuter sub-samples, as this reflects the over-arching preference for the status-quo in each of the choice tasks.

TABLE 3 Choice Percentages

		PT-WTA	PT-WTP	Car-WTA	Car-WTP
Short-term Games	Status Quo	71%	74%	73%	65%
	Alternative	24%	19%	21%	27%
	Indifferent	5%	7%	6%	8%
Long-term Games	Status Quo	65%	72%	69%	71%
	Alternative	29%	24%	24%	22%
	Indifferent	5%	5%	7%	7%

TABLE 4 Results from the Value of Time Experiments

Car Commuters	
Observations	4964
Log-likelihood (base)	-10,907.02
Log-likelihood (model)	-6,840.35
Adjusted ρ^2	0.37
AIC	13,712.55
BIC	13,816.71

	Parameter	Robust t-ratio (vs 0)	Robust t-ratio (vs 1)
$\kappa_{wtp,\beta_{tt},s}$	1.068	---	0.32
$\beta_{tt,wta,s}$	0.029	7.77	---
$K_{wtp,\mu,s}$	0.894	---	-0.84
$\mu_{wta,s}$	-4.587	-11.71	---
$\kappa_{wtp,\beta_{spcam},s}$	0.684	---	-0.62
$\beta_{spcam,wta,s}$	0.022	2.44	---
$\kappa_{\beta_{tt},l}$	1.990	---	3.46
$\kappa_{\mu,l}$	0.567	---	-7.48
$\tau_{1,wta,s}$	-1.084	-5.08	---
$\tau_{2,wta,s}$	-0.728	-3.39	---
$\tau_{1,wtp,s}$	-1.084	-8.10	---
$\tau_{2,wtp,s}$	-0.714	-5.33	---
$\tau_{1,l}$	-0.990	-9.35	---
$\tau_{2,l}$	-0.506	-4.84	---
λ_{inc}	-0.386	-9.12	---
λ_{tt}	0.048	1.20	---

Willingness to Pay Calculations		
$WTA_{tt,s}$ (KR/hr)	41.02	$= (\beta_{tt,wta,s} * 1{,}000 * 60)/43$
$WTP_{tt,s}$ (KR/hr)	43.80	$= \kappa_{wtp,\beta_{tc},s} * \mathrm{WTA}_{tt,s}$
$WTA_{tt,l}$ (KR/hr)	81.63	$= \kappa_{\beta_{tt},l} * \mathrm{WTA}_{tt,s}$
$WTA_{spcam,s}$	22.30	$= \beta_{spcam,wta,s} * 1000$
$WTP_{spcam,s}$	15.25	$= \kappa_{wtp,\beta_{spcam},s} * \mathrm{WTA}_{spcam,s}$

Public Transport Commuters	
Observations	5140
Log-likelihood (base)	-11,293.73
Log-likelihood (model)	-6,621.48
Adjusted ρ^2	0.41
AIC	13,270.96
BIC	13,362.59

	Parameter	Robust t-ratio (vs 0)	Robust t-ratio (vs 1)
$\kappa_{wtp,\beta_{tt},s}$	0.309	---	-6.08
$\beta_{tt,wta,s}$	0.044	5.94	---
$\kappa_{wtp,\mu,s}$	1.524	---	0.96
$\mu_{wta,s}$	-2.796	-6.83	---
$\kappa_{wtp,\beta_{headway},s}$	0.713	---	-1.03
$\beta_{headway,wta,s}$	0.030	4.60	---
$\kappa_{\beta_{tt},l}$	1.462	---	1.77
$\kappa_{\mu,l}$	0.969	---	-0.20
$\tau_{1,wta,s}$	-0.276	-1.52	---
$\tau_{2,wta,s}$	0.021	0.11	---
$\tau_{1,wtp,s}$	-1.062	-4.58	---
$\tau_{2,wtp,s}$	-0.624	-2.75	---
$\tau_{1,l}$	-0.611	-6.05	---
$\tau_{2,l}$	-0.264	-2.60	---
λ_{inc}	-0.370	-11.05	---
λ_{tt}	0.004	0.10	---

Willingness to Pay Calculations		
$WTA_{tt,s}$ (KR/hr)	61.95	$= (\beta_{tt,wta,s} * 1{,}000 * 60)/43$
$WTP_{tt,s}$ (KR/hr)	19.16	$= \kappa_{wtp,\beta_{tc},s} * \mathrm{WTA}_{tt,s}$
$WTA_{tt,l}$ (KR/hr)	90.56	$= \kappa_{\beta_{tt},l} * \mathrm{WTA}_{tt,s}$
$WTA_{headway,s}$	29.50	$= \beta_{headway,wta,s} * 1000$
$WTP_{headway,s}$	21.05	$= \kappa_{wtp,\beta_{headway},s} * WTA_{headway,s}$

With respect to the sample of car commuters, the baseline preference for the status-quo alternative in both the WTA and WTP games ($\tau_{2,wta,s} \approx \tau_{2,wtp,s}$) and the range over which respondents are indifferent ($\tau_{2,wta,s} - \tau_{1,wta,s} \approx \tau_{2,wtp,s} - \tau_{1,wtp,s}$) are very similar. With respect to the public transport sample however, comparison of the first threshold parameter reveals that the status quo is more preferred in the WTP task than in the WTA task ($\tau_{2,wta,s} > \tau_{2,wtp,s}$) and that the indifference alternative is also more likely to be selected in the WTP task than in the WTA games ($\tau_{2,wta,s} - \tau_{1,wta,s} < \tau_{2,wtp,s} - \tau_{1,wtp,s}$).

Additionally we estimated income and time elasticities within both the car and public transport commuter choice games. In both samples the income elasticity (λ_{inc}) is negative and significant indicating that respondents with higher incomes are less sensitive to changes in cost than those on lower incomes. With respect to the travel time elasticity (λ_{tt}), the parameter is insignificant for both the car and public transport commuter samples.

We will now address each of the hypotheses which are outlined in the methodology section, which test how monetary valuations might differ across different choice contexts. Note that in calculating the WTA and WTP values, the per-month figure is divided by 43 (the average number of trips per month) to get a single per trip estimate, as journey time was given per trip.

H1) Differences in scale between short-term WTP and WTA scenarios

The null hypothesis of no difference in scale between the WTA and WTP tasks cannot be rejected as the multipliers ($\kappa_{wtp,\mu,s}$) in both samples are not significantly different from 1. This indicates that the amount of noise (from the analyst's perspective) in two different styles of choice tasks is similar.

H2) Differences in scale between short-term and long-term WTA scenarios

With respect to differences between choices made in the long-term and short-term games, the null hypothesis of no difference cannot be rejected for the public transport sample as the multiplier term $\kappa_{\mu,l}$ (0.969) is not significantly different to 1. This indicates that the amount of noise does not differ between choices in the short-term and long-term scenarios. However, for the car commuter sample, the scale parameter $\kappa_{\mu,l}$ (0.567) is significantly less than 1; meaning that the choices in the long-term for car commuters are less deterministic from the analyst's perspective than those in the short-term, i.e. more unobserved factors contribute to the choices made. This is not unreasonable when such choices are less easy to reverse and decision makers may thus take into account the impact on other parts of their life, which we do not know about. While the typical interpretation associates the error in the models with analyst uncertainty, there is of course also scope for more "respondent error", as respondents may find it harder to choose when the implications of the choice play out over a longer time frame (i.e. it is easier to say if you would take a shorter or longer route once (short-term), but thinking about scenario which involves taking a shorter or longer route every day is more difficult (long-term)).

H3) Difference in monetary valuations between short-term WTP and WTA scenarios

With respect to car commuters, the null hypothesis of no difference between WTA and WTP values cannot be rejected, as $\kappa_{wtp,\beta_{tt},s}$ and $\kappa_{wtp,\beta_{spcam},s}$ are not significantly different from 1. Unsurprisingly, this results in very similar WTA and WTP values for time (41.02KR and 43.80KR respectively) and changes in speed cameras (22.30KR and 15.25KR respectively). For public transport commuters, $\kappa_{\mathrm{wtp},\beta_{\mathrm{headway}},s}$ is not significantly different from one indicating that there is no difference between WTA and WTP values for changes to headway (29.50KR and 21.05KR respectively). However, the multiplier $\kappa_{\mathrm{wtp},\beta_{\mathrm{tt}},s}$ is significantly larger than 1 meaning that the null hypothesis can be rejected and that values of time differ significantly in this context depending on whether respondents received a WTA style choice task (61.95KR) or a WTP task (19.16KR).

Such an asymmetry between WTP and WTA results is known within the valuation literature and is often the result of an underlying loss aversion inherent in people (see for example Kim et al. 2015, Lanz et al. 2010, Rose and Masiero 2010, Bateman et al. 2009, Hess et al. 2008, Adamowicz et al. 1993, and Hanemann 1991). The fact that our study is consistent with what is found in the wider literature is reassuring.

H4) Differences in monetary valuations between short-term and long-term WTA scenarios

Turning to the final and most interesting hypothesis in the context of this paper, examination of the multipliers $\kappa_{\beta_{tt},l}$ in both the car and public transport commuter samples reveals that both parameters are significantly different from 1, meaning that the null hypothesis of no difference between short-term and long-term WTA values can be rejected. Indeed, in the car commuter sample the WTA value in the long-term (81.63KR) is almost double the value expressed in the short-term (41.02KR) whereas in the public transport sample the long-term WTA (90.56KR) is almost a 50% increase over the short-term value (61.95KR). In both scenarios the values of time expressed in the long-term are higher than the short. This result is logically consistent: in order to "encourage" people to regularly travel further over the long-term you will need to compensate them more than if the "encouragement" was for a single trip or over a shorter time frame. This is reflected in the significant difference we uncovered. We strongly recommend that in light of this difference, the transport community conduct more research to determine the persistence of this difference and to fully explain why it exists.

Overall, the values of time estimated in this paper are comparable to values found in other work using this data (see Swardh and Algers 2016, Swardh and Algers 2009). However, we observe significant and consistent differences between the valuations obtained in games presenting travel time and cost trade-offs as short-term decisions (on a single trip today would you accept a different route that is longer for a cheaper ticket / would you pay more for a trip today that is faster) compared to framing the choice as a trade-off with longer term implications (would you accept a longer commute every day than the one you have currently if you had a new job that paid you more).

5. DISCUSSION AND CONCLUSION

Using a unique dataset where values of time could be estimated within the same sample of respondents via two different styles of choice task contexts, we find that implied values of time are significantly different depending on whether respondents are making short-term choices (such as different routes for a single trip) or face experiments framed more in the long-term (a change in workplace location that necessitated longer travel times for an increased salary). In the context of public transport we also find asymmetry between willingness to pay and willingness to accept values, however this asymmetry is well known within the valuation literature and is often the result of an underlying loss aversion inherent in people (see for example Kim et al. 2015, Lanz et al. 2010, Rose and Masiero 2010, Bateman et al. 2009, De Borger and Fosgerau 2008, Hess et al. 2008, Adamowicz et al. 1993, and Hanemann 1991).

There have also been limited previous attempts to examine how people might value time in short-term versus long-term contexts, but in this paper we find preliminary evidence that the time horizon over which the choice experiment is being framed results in significantly different values of time; for car commuters the long-term value is almost double the short-term value and for public transport commuters it is 50% higher. This is important as it can be argued that in many contexts, changes to travel time (especially commuting time) are likely to be more salient when making a long-term decision such as where to live or where to work; it may well be the only way in which a person can make a truly significant change to the amount of time spent commuting.

Given that this paper represents one of the few formal attempts to contrast the value of time as a function of short-term versus long-term decisions, there is much research that needs to be conducted in this area. Indeed, it must be noted that the framing of the two experiments may also lead to differences, but by the nature of asking people to consider a choice over different time frames it would be difficult to frame an experiment for a short-term choice in the same way as you would frame an experiment for a long-term choice. For example, this study frames experiments in the short-term as changes to cost and in the long-term refers to changes in salary, which are typically allocated to different mental accounts (Thaler 1999). Future research should explore if there is a way that the short and long-term choices can be represented within a common framing.

Short-term behaviours have been shown to be influenced by longer term choices (Schwanen and Mokhtarian 2005, Rouwendel and Meijer 2001). If this argument is true, and if e.g. the role of the commute is more likely to be front of mind when moving house or changing place of employment, then we strongly argue that more research is needed to determine the best way to frame and present travel time experiments. This is particularly true given that the experiments used in this paper largely mimic those used in many national studies, and that other authors have also emphasised the important implications of differing values of time for the evaluation of infrastructure investment and pricing reforms in the transport sector (De Borger and Fosgerau 2008).

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REFERENCES

Abrantes, P.A.L. and M.R. Wardman (2011). "Meta-analysis of UK values of travel time: An update." *Transportation Research Part A*, 45, 1-17.

Adamowicz W.L., V. Bhardwaj and B. MacNab (1993). "Experiments on the difference between willingness to pay and willingness to accept." *Land Economics*, 69, 416-427.

ARUP, ITS Leeds and Accent (2015). *Provision of market research for value of time savings and reliability*. Phase 2 report to the Department for Transport, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470231/vtts-phase-2-report-issue-august-2015.pdf, accessed 05/05/16.

Asensio, J. and A. Matas (2008). "Commuters' valuation of travel time variability." *Transportation Research Part E*, 44(6), 1074-1085.

Axhausen, K.W, S. Hess, A. Konig, G. Abay, J.J. Bates and M. Bierlaire (2008). "Income and distance elasticities of values of travel time savings: New Swiss results." *Transport Policy*, 15 (3), 173-185.

Axhausen, K.W., I. Ehreke, A. Glemser, S. Hess, C. Joedden, K. Nagel, A. Sauer and C. Weis (2015) Ermittlung von Bewertungsansätzen für Reisezeiten und Zuverlässigkeit auf Basis der Schätzung eines Modells für modale Verlagerungen im nicht-gewerblichen und gewerblichen Personenverkehr für die Bundesverkehrswegeplanung: FE-Projekt 96.996/2011 Zeitkosten Personenverkehr*, Final report to the Federal Ministry of Transport and Digital Infrastructure* (BMVI), Berlin.

Bateman I.J., B.H. Day, A.P. Jones and S. Jude (2009). "Reducing gain–loss asymmetry: a virtual reality choice experiment valuing land use change." *Journal of Environmental and Economic Management*, 58, 106-118.

Börjesson, M. and J. Eliasson (2014). "Experiences from the Swedish Value of Time study." *Transportation Research Part A*, 59, 144-158.

Börjesson, M., M. Fosgerau and S. Algers (2012). "On the income elasticity of the value of travel time." *Transportation Research Part A*, 46(2), 368–377.

Cordoba, J.E and G.P. Jaramillo (2012). "Inclusion of the Latent Personality Variable in Multinomial Logit Models Using the 16pf Psychometric Test." *Procedia-Social and Behavioral Sciences*, 54 (4), 169-178.

De Borger, B. and M. Fosgerau (2008). "The trade-off between money and travel time: A test of the theory of reference-dependent preferences." *Journal of Urban Economics*, 64(1), 101-115.

Devarasetty, P.C., M. Burris and W.D. Shaw (2012). "The value of travel time and reliability-evidence from a stated preference survey and actual usage." *Transportation Research Part A*, 46(8), 1227-1240.

Fosgerau, M., K. Hjorth and S.V. Lyk-Jensen (2007). *The Danish Value of Time Study: Results for Experiment 1*. Report for the Ministry of Transport, Danish Transport Research Institute.

Halton, J. (1960). "On the efficiency of certain quasi-random sequences of points in evaluating multi-dimensional integrals." *Numerische Mathematik*, 2, 84-90.

Hanemann, W.M. (1991). "Willingness to pay and willingness to accept: How much can they difer?" *American Economic Review*, 81(3), 635-647.

Hensher D.A. and W. Greene (2011). "Valuation of Travel Time Savings in WTP and Preference Space in the Presence of Taste and Scale Heterogeneity." *Journal of Transport Economics and Policy*, 45(3), 505-525.

Hensher D.A., Z. Li and C. Ho (2015). "The Role of Source Preference and Subjective Probability in Valuing Expected Travel Time Savings." *Travel Behaviour and Society*, 2(1), 42-54.

Hess, S., M.J. Beck and C.C.G. Chorus (2014). "Contrasts between utility maximisation and regret minimisation in the presence of opt out alternatives." *Transportation Research Part A*, 66, 1-12.

Hess, S., A. Daly, T. Dekker, M. Ojeda-Cabral and R. Batley (2015). "Specification and estimation of behavioural models for the 2015 UK value of time study." *Transportation Research Board Conference*, January 2016, Washington DC.

Hess, S., J.M. Rose and D.A. Hensher (2008). "Asymmetric preference for willingness to pay estimates in discrete choice models." *Transportation Research Part E*, 44(5), 847-863.

Isacsson, G. and J.E. Swardh (2009). "The value of commuting time in an empirical on-the-job search model - Swedish evidence based on linked employee-establishment data." *Working Paper*, Swedish National Road and Transport Research Institute (VTI), 2009.

Kim, Y., C.L. Kling and J. Zhao (2015). "Understanding Behavioral Explanations of the WTP-WTA Divergence Through a Neoclassical Lens: Implications for Environmental Policy." *Annual Review of Resource Economics*, 7, 169-187.

Kluger, A.V. (1998). "Commute variability and strain." *Journal of Organizational Behaviour*, 19, 147-165.

Kouwenhoven, M., G.C. de Jong, P. Koster, V.A.C. van den Berg, E.T. Verhoef, J.J Bates, P.M.J. Warffemius (2014). "New values of time and reliability in passenger transport in The Netherlands." *Research in Transportation Economics*, 47, 37-49.

Lam, T.C and K.A. Small (2001). "The value of time and reliability: measurement from a value pricing experiment." *Transportation Research Part E*, 37(2), 231-251.

Lanz, B. A. Provins, I.J. Bateman, R. Scarpa, K. Willis and E. Ozdemiroglu (2010). "Investigating willingness to pay and willingness to accept asymmetry in choice experiments." In Hess and Daly (Eds), *Choice Modelling: State-of-the-art and the state-of-practice*, Emerald, United Kingdom.

Legaspi, J. and N. Douglas (2015). "Value of Travel Time Revisited: NSW Experiment." *Proceedings of the Australasian Transport Research Forum 2015*, September 2015, Sydney.

Mackie, P., M. Wardman, A.S. Fowkes, G. Whelan, J. Nellthorp and J.J. Bates J.J. (2003). *Values of Travel Time Savings in the UK*. Report to Department for Transport. Institute for Transport Studies, University of Leeds & John Bates Services, Leeds and Abingdon.

Peer, S., E.T. Verhoef, J.Knockaert, P. Koster and Y.Y. Tseng (2015). "Long-Run Versus Short-Run Perspectives On Consumer Scheduling: Evidence From A Revealed-Preference Experiment Among Peak-Hour Road Commuters." *International Economic Review*, 56(1), 303-323.

Rose, J.M. and L. Masiero (2010). "A Comparison of the Impacts of Aspects of Prospect Theory on WTP/WTA Estimated in Preference and WTP/WTA Space." *European Journal of Transport and Infrastructure Research*, 10(4), 330-346.

Rouwendal, J. and E. Meijer (2001). "Preferences for housing, jobs and commuting: a mixed logit analysis." *Journal of Regional Science*, 41(3). 475-505.

Schirmer, P.M., M.A.B. van Eggermond and K.W. Axhausen (2014). "The role of location in residential location choice models: a review of literature." *Journal of Transport and Land Use*, 7(2), 3-21.

Schwanen, T. and P.L. Mokhtarian (2005). "What affects commute mode choice: neighborhood physical structure or preferences toward neighborhoods?" *Journal of Transport Geography*, 13, 83-99.

Significance, VU and J.J Bates (2013). *Values of time and reliability in passenger and freight transport in the Netherlands*. Report for the Ministry of Infrastructure and the Environment.

Small, K.A. (2012). "Valuation of travel time." *Economics of Transportation*, 1(1), 2-14.

Swardh, J. and S. Algers (2009). "Willingness to accept commuting time for yourself and for your spouse: Empirical evidence from Swedish stated preference data." *Working Papers 2009(5)*, Swedish National Road & Transport Research Institute (VTI).

Swardh, J.E. and S. Algers (2016). "Willingness to accept commuting time within the household: stated preference evidence." *Transportation*, 43(2), 219-241.

Thaler, R.H. (1999). "Mental Accounting Matters." *Journal of Behavioral Decision Making*, 12, 183-206.

Transek (2006). *Jämställdhet vid val av transportmedel*. Final report 2006:22, Transek AB, Solna.

Tse, C. Y. and A. W. Chan (2003). "Estimating the commuting cost and commuting time property price gradients." *Regional Science and Urban Economics*, 33(6), 745-767.

Tseng, Y.Y and E.T. Verhoef (2007). "Value of time by time of day: A stated-preference study." *Transportation Research Part B*, 42(7-8), 607-618.

Van Ommeren, J. and M. Fosgerau (2009). "Workers' marginal costs of commuting." *Journal of Urban Economics*, 65(1), 38-47.

Wardman, M. (1998). "The value of travel time: A Review of British evidence." *Journal of Transportation Economics and Policy*, 32(3), 285-316.