Comparing values of travel time obtained from residential, workplace and short-term decisions

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Abstract

The value of travel time (VTT) is an important element cost-benefit analysis of transportation projects, by encapsulating the willingness to pay of the population for improvements in the transport system. Those values are typically obtained from mobility behaviour data, in form of revealed or stated preference survey data. Although short-term decisions are typically used for this purpose, a growing number of authors is arguing that long-term decisions might provide more meaningful values for the evaluation of transportation projects, as those decisions have a longer-lasting effect on the experienced travel times. This paper uses data, which contains both, short- and long-term experiments, to investigate the impact of different time horizons on the valuation of time. In particular, two different long-term experiments (residential and workplace choice) in the dataset allow to evaluate not only the impact of the time horizon, but also the type of long-term decision. Using a joint model including all relevant choice situations, this paper investigates the difference in the valuation of time coming from different kind of choice experiments. The results show that the chosen time horizon does have a significant effect on the valuation of travel time and cost. Another finding is that the type of long-term decision and the structure of the choice experiment itself also influence the valuation. The resulting VTTs with a sharp decline by about a half for commute trips show an opposite effect to previous work. Thus this paper demonstrates the need for refinement of the definition of such a VTT.

Keywords

Long-term vs. short-term value of time, residential location choice, workplace choice, *German VOT Study*, survey design

Highlights

- Changes in people's decisions due to innovations and improvements in transportation systems can have short-term or long-term effects.
- Residential location and workplace influence many other behavioural choices of travellers as they define the marginal cost of further travel and the distances involved.
- Investigation of the impact of different time horizons and the type of long term decision on the valuation of time.
- Different time horizons lead to substantially different time valuations and scale differences.
- Type of long term decision and the structure of the choice experiment itself also influence the valuation.

1 Introduction

Microeconomic models of time allocation have been used to derive the valuations of technologically constrained time use since the work of Becker (1965), Beesley (1965) and DeSerpa (1971). As a result the value of time has been a subject of analysis for the past five decades. The current state of practice draws largely upon past British (Wardman, 1998; Mackie *et al.*, 2003; Department for Transport, 2015; Wardman *et al.*, 2016), Dutch (Significance *et al.*, 2012), and Scandinavian studies (Börjesson and Eliasson, 2014; Ramjerdi *et al.*, 2010; Fosgerau *et al.*, 2007). Time valuation moved from revealed preference (RP) data to a growing reliance on personalized stated preference (SP) experiments, where travellers are typically required to make choices between hypothetical situations. The values of time are estimated using suitably formulated discrete choice models of travel behaviour, especially of route and mode choices.
Those decisions can be called "short-term", in the sense that they only have an effect on the decision-maker's utility for a short time frame. For instance, the choice of a sub-optimal route might lead to being late at work on a particular day, but the decision maker has the possibility to make a different decision the next day in order to be on time. On the other side, the decision-maker is able to change a decision once to adapt to particular circumstances (an accident, bad weather), without long-lasting consequences. Most value of time studies consider such short-term decisions framing their experiments around a situation where respondents are presented with variations to travel time and cost of different modes or routes (see e.g. Wardman *et al.*, 2016, for an overview of value of time studies in Europe). However, there exist other types of decision that have much longer lasting effects. Consider for instance the choice of a residential location. This choice will have long-lasting consequences on the travel patterns of the decision maker, by changing their choice set for future short-term decisions, over periods of time that are typically several years or even decades long. Transportation projects have the same kind of long-lasting consequences, by durably modifying the choice set of travelers. Thus, when estimating willingness-to-pay for policy appraisal, new questions arise: is the focus on short-term decisions most appropriate? Should one consider the willingness-to-pay in the new choice context offered to travelers, or the willingness-to-pay of travelers when they make decisions with a similar time frame?
Beck *et al.* (2017) put this differently, by arguing that travelers anyway have very little possibility to influence their commute in the short-term, but can in the long-term, for instance by changing their residence. From this argument, long-term choices could be more informative regarding the willingness to pay for commute time savings. Beck *et al.* (2017) refers to a recent stream of empirical studies that tries to understand and explain everyday travel behaviour as a routine activity changing due to key events such as residential relocation or workplace decisions. In this context a long-term decision can be defined as a more permanent decision which have an effect on every day travel. Here, the authors compare long and short travel time valuations, using the Swedish stated preference data. In this survey, respondents first faced a set of choices where

they had to make cost and travel time trade-offs for their commute with public transport or car; then, the respondents had an additional set of choices, where they considered increases in travel time, in return for a higher salary (Swärdh and Algers, 2016). The authors found no differences in scale between the short-term and long-term trade-off scenarios, but discovered a significantly higher travel time valuation in the long run. Those results suggest that the time horizon over which the choice experiment is being framed results in significantly different values of time.

Müggenburg *et al.* (2015) review the theoretical framework and the most important studies investigating mobility behaviour in a long-term choice context. Schirmer *et al.* (2014) give a comprehensive overview of residential location choice literature and show that travel time, commuting and employment changes are significant determinants of choices.

The aim of this paper is to contribute to the investigation of the dependence of travel time valuation on the time horizon of the choices. To this end, a combined revealed and stated stated preference experiment conducted in Germany in 2012 (Axhausen *et al.*, 2015) is used. The respondents were presented a series of choice situations including short-term decisions such as route and mode choice, as well as long-term decisions with residential and workplace location. In particular, the long-term experiments asked the respondent to make trade-offs between transport measures and a set of workplace or residence attributes. A first objective is to verify whether the kind of patterns identified by (Beck *et al.*, 2017) can be found in this new dataset. More importantly, while (Beck *et al.*, 2017) only had access to one kind of long-term decision (workplace change), the German data gives access to choices both in terms of residence and workplace. The second objective here is thus to compare the values obtained from those two types of decisions, to give an indication of whether there is one "long-term willingness to pay", or whether this value also depends on the type of decision. Finally, the substantial number of residence and workplace attributes in the German data allows to investigate the relative importance of travel related variables compared to other attributes of the locations, and how this influences the valuation of time.

The remainder of this paper is structured as follows: Section 2 outlines the survey and is followed by the description of the method used to estimate a joint short- and long-term model (Section 3); Section 4 outlines the results of the modelling before presenting the final discussion and outlook in Section 5.

2 Data description

The data used for this analysis is taken from the *German VOT Study*. The German Federal Ministry of Transport and Digital Infrastructure (BMVI) has recently published the 2030 Federal Transport Investment Plan (Bundesverkehrswegeplan, BVWP), its medium- to long-term investment strategy for the country's transport infrastructure serving longer distance travel (BMVI, 2016). As part of this, it updated the overall methodology of its central evaluation tool, cost-benefit analysis (CBA). Within a sub-project - the *German VOT Study* - values of travel time savings and reliability for personal and business travel were estimated and recommended for the BMVI (Axhausen *et al.*, 2015).

The design of the *German VOT study* builds on the experience of time valuation studies in Switzerland. Swiss studies followed a variant path, when compared to international practice, by employing more complex SP experiments including multiple modes and multiple elements of the generalized costs of travel in a series of overlapping choice contexts (Axhausen, 1995; Axhausen *et al.*, 2004, 2008; Weis *et al.*, 2012; Fröhlich *et al.*, 2013).

Two complementary samples - one for business and one for non-business trips - were collected. This paper focuses on the non-business sample as only those respondents received long-term choice experiments. A detailed description of the survey, collected data and response behaviour can be found in (Dubernet and Axhausen, submitted) and (Dubernet and Axhausen, 2017).

After the pre-test in May 2012 the two-step survey was carried out in six sequential waves from July to October 2012. In the first step RP data on three trips undertaken by the respondents were collected in a computer assisted telephone interview (CATI). The purposes of the RP trips were pre-specified: commuting to work and the trips to most important shopping and leisure (< 50 km) destination. Also information on the last long-distance trip over 50 km was collected, and, if the latter was ground-based, data on the most recent air trip was also collected. The gathered trip information was complemented with the usual socio-demographic information and information about mobility tools. Out of the reported trips a reference trip was chosen randomly.

The SP experiments were constructed around the reference trip. Information about the non-chosen options were added. The non-chosen alternatives and their attributes were based on information from a number of sources. Door-to-door car travel times were computed based on the average travel times reported by Tom-Tom Stats and a NavTeq – network for Germany using the MATSim software package (Horni *et al.*, 2016). The average car travel costs were calculated based on the 2012 ADAC (General German Automobile Club) price-per-kilometer estimate for an average sized car in each car segment (range from mini to caravan) (ADAC, 2012). The travel times, headways, transfers and prices on public transport including air travel were obtained from the relevant websites with an internet bot.

The respondents received the SP experiments within a maximum of two weeks of having participated in the CATI. The participants could choose to respond in a paper-and-pencil form or with a web-based survey. Respondents received three different SP experiments either a mode choice or route choice experiment, one reliability and one long-term experiment. In total they were offered 24 choice situations. Each type of SP experiment contained 8 choice situations.

In the mode choice experiments the respondent had to choose between three modal alternatives. The modes offered depending on the reported reference mode were either walking, cycling, car, local public transport (PT) and the various long distance public transport modes: train, air and the newly deregulated coach option.

In the route choice experiments respondents were offered two route alternatives for either car or public transport. The departure time and reliability experiment was formulated as route-departure time choice with an indication of travel time variability. Three formats of different complexity were tested, but each allowing to estimate the mean-variance model of scheduling (Li *et al.*, 2010). All three formats were retained after the pre-test, as it indicated no clear preference between them in spite of their growing complexity.
In order to allow the process of cross-checking of the results, this approach was further expanded to include long-term choice contexts, which also involve travel as an element (residential and workplace location choice), which also had been trialled in an earlier Swiss study (e.g. Weis *et al.*, 2012).
In the workplace games choices were presented via a labeled choice experiment where respondents were asked to choose between their current workplace and an alternative workplace that varied in commute times, commute costs, salary and other workplace attributes.
All the SP experiments had to be generated in a way to gather as much information as possible with the smallest possible sample size. To this end, an efficient design based on variations of the reported attribute levels was computed using the software *Ngene* (Rose *et al.*, 2009).The attributes and their variation can be found in Table 1. An example of this choice task is shown in Fig. 1.

Figure 1: Example of workplace choice task (SP 4).

	Current	New
Car commute time	0:13 h	0:09 h
Car commute cost	58 € / month	34 € / month
PT commute time	0:43 h	0:36 h
PT commute cost	54 € / month	32 € / month
Salary (before tax)	1600 € / month	1440 € / month
Staff managed	4 employees	23 employees
Budget managed	1,0 Mio. € / year	0,7 Mio. € / year
Change industry	No	No
Change company	No	Yes
Choice:	☐	☐

The residential location games were similar to the workplace ones but with residential attributes. In addition to the travel cost and time for commute trips the alternatives also show the time and cost for car and public transport to the nearest shopping location. The residential attributes regard the appearance and location of the dwelling. All attributes and their variation can be found in Table 1. An example of this choice task is shown in Fig. 2.

Table 1: Survey Design and Attribute Levels Long-term Experiments

Attribute (Current altenative (RP))	*Unit*	*Attribute levels (New alternative (SP))*	*Alternative Current*	*Alternative New*
		Workplace choice (SP 4)		
Car commute time	(min)	–30%, –10%, +20%	x	x
Car commute cost	(€/month)	–20%, +10%, +30%	x	x
PT commute time	(min)	–30%, –10%, +20%	x	x
PT commute cost	(€/month)	–20%, +10%, +30%	x	x
Salary before tax	(€/month)	–10%, +/–0%, +10%	x	x
Staff managed	(number)	–50%, +20%, +100%	x	x
Budget managed	(million €/year)	–50%, +20%, +100%	x	x
Change of industry needed	(yes/no)	no, yes	no	x
Change of company needed	(yes/no)	no, yes	no	x
		Residential location choice (SP 5)		
Type	(house/apartment)	house, apartment	x	x
Size	(m^2)	–20%, +10%, +30%	x	x
Standard	(new/renovated/old)	new, renovated, old	x	x
Exterior	(none/garden/balcony)	none, garden, balcony	x	x
Rent/mortgage	(€/month)	–20%, +10%, +30%	x	x
Area	(urban/suburban/rural)	urban, suburban, rural	x	x
Car travel time:				
- Commute	(min)	–30%, –10%, +20%	x	x
- Shopping	(min)	–30%, –10%, +20%	x	x
Car travel costs:				
- Commute	(€/month)	–20%, +10%, +30%	x	x
- Shopping	(€/month)	–20%, +10%, +30%	x	x
PT travel time:				
- Commute	(min)	–30%, –10%, +20%	x	x
- Shopping	(min)	–30%, –10%, +20%	x	x
PT travel costs:				
- Commute	(€/month)	–20%, +10%, +30%	x	x
- Shopping	(€/month)	–20%, +10%, +30%	x	x

Finally at the end of each block all respondents had the opportunity to mark if one or more of the attributes had no impact on their decision in the different choice situations as well as attitudinal questions.

Figure 2: Example of residential location choice task (SP 5).

	Current	New
Type of dwelling	House	Apartment
Size	132 m²	120 m²
Standard	Old	Renovated
Exterior space	Garden	None
Rent / mortgage	600 € / month	540 € / month
Area	rural	rural
Car travel time:		
Commute	0:12 h	0:08 h
Shopping	0:15 h	0:13 h
Car travel costs:		
Commute	56 € / month	43 € / month
Shopping	21 € / month	19 € / month
PT travel time:		
Commute	0:36 h	0:32 h
Shopping	0:15 h	0:18 h
PT travel costs:		
Commute	59 € / month	54 € / month
Shopping	19 € / month	24 € / month
Choice:	☐	☐

The non-business sample contains 50,561 choices of 2,404 respondents (Dubernet and Axhausen, submitted). In order to compare short- and long-term games some adjustments to the full sample had to be made. First a sub-sample of only commute and shopping short-term trips was taken as the long-term games by design only included these two trip purposes. Thus, the choice tasks with a coach or air plane alternative were removed from the data set as these two function as a long distance mode for either leisure or business trips. Second the long-term games only include the modes public transport and car. The short-term experiments also included air plane reliability experiments which were also removed. In the end the retained sample contains 29,968 choice tasks of 2,279 respondents. 13,009 of the tasks are short-term games, 7,621 residential location games and 9,338 workplace games.

3 Methodology

To test the influence of the type of choice experiment on the value of time, a joint model combining multinomial logit models for all relevant experiments was estimated. Using a joint modeling approach allows one to have the same coefficient part of the utility for different experiments. This allows one to make use of as much information as possible, and also provides an intuitive framework to test differences in valuation depending on the kind of experiments.

The following sections describe the utility functions for all experiments. Parameters that have the same name in various experiments are shared, taking the same value in all utilities they appear in.

In the questionnaires, two time horizons were used to specify travel times and costs, namely per trip or per month. In particular, in the long-term experiments, the two time horizons were used simultaneously, with travel times expressed per trip but travel costs per month. In the model, all times and costs are expressed as averages per month, using the averages of 2.05 shopping tours and 4.73 work tours per week from the revealed preferences part of the survey, and an average of 4.28 weeks per month. Shopping and work tours are assumed to consists of two identical trips in opposite directions.

In order to be able to compare the models for long and short-term, some variables of the short-term experiments had to be ignored. In particular, only the door-to-door travel time is used, even though more detailed descriptions are available from the short-term experiments.

All utilities include individual income interaction terms for time and cost sensitivity. For a given decision maker i, it is expressed as follows, with *type* taking the values *cost* and *time*:

$$\psi_{i,type} = \left(\delta_{i,inc} \cdot \frac{\text{inc}_i}{\overline{\text{inc}}} + (1 - \delta_{i,inc}) \cdot \text{inc}_{miss}\right)^{\lambda_{type}} \tag{1}$$

where

- $\delta_{i,inc}$ takes value 1 if respondent i reported his income, 0 otherwise
- inc_i is the reported income of respondent i, and $\overline{\text{inc}}$ the average income over all respondents
- inc_{miss} is a parameter representing the average income of all respondents that did not report their income, and is estimated together with the other parameters of the model
- λ_{type} is a parameter controlling the degree of non-linearity of the income effect

3.1 Mode Choice

The utilities for mode m in {car, walk, bike} and purpose p in {work,shop} is as follows:

$$U_{i,m,p} = \mu_{mc} \cdot (\alpha_m + \psi_{i,time} \cdot \beta_{tt,m,p} \cdot \text{tt}_m + \psi_{i,cost} \cdot \beta_{cost} \cdot c_m) \tag{2}$$

where

- μ_{mc} is the scale for the mode choice experiment
- α_m is the alternative specific constant for mode m
- $\beta_{tt,m,p}$ is the travel time coefficient for mode m and purpose p
- tt_m is the door-to-door travel time with mode m
- β_{cost} is the cost coefficient
- c_m is the total travel cost for mode m (always 0 for walk and bike)

Public transport uses the same formulation, with the addition of the term $\beta_{trans} \cdot n_{trans}$, that accounts for the number of transfers.

3.2 Car Route Choice

The utility for route r for purpose p is as follows:

$$U_{i,r,p} = \mu_{rc,car} \cdot (\psi_{i,time} \cdot \beta_{tt,car,p} \cdot \mathrm{tt}_r + \psi_{i,cost} \cdot \beta_{cost} \cdot c_r) \tag{3}$$

where

- $\mu_{rc,car}$ is the scale for the car route choice experiment
- tt_m is the door-to-door travel time with route r
- c_r is the total travel cost for mode r (always 0 for walk and bike)

3.3 Public Transport Route Choice

The utility in the public transport route choice is identical to the one of the car route choice, with the addition of the number of transfer as in the mode choice experiment.

3.4 Car and Public Transport Reliability

The utilities for the reliability experiments are identical to the ones in the normal route choice experiments ignoring reliability indicators (see Ehreke *et al.*, 2015, for detailed results on the value of reliability).

3.5 Workplace Choice

The travel costs and times in the long-term experiments are expressed on a per-mode, per-purpose basis. To be able to include the other monthly monetary value (rent or salary), one needs to aggregate those costs. This is done by integrating the probability of choosing car or public transport for a given purpose, as coming from the mode choice model, ignoring the number of transfers:

$$P_{i,m,p} = \frac{e^{U_{i,m,p}}}{e^{U_{i,car,p}} + e^{U_{i,pt,p}}} \tag{4}$$

The utility of a workplace alternative a in {current,new} is as follows:

$$U_{i,a} = \mu_{wp} \cdot \left(\begin{array}{l} \alpha_a + \\ \psi_{i,time} \cdot \left(\begin{array}{l} P_{i,car,work} \cdot \kappa_{tt,car,work} \cdot \beta_{tt,car,work} \cdot \mathrm{tt}_{car} + \\ P_{i,pt,work} \cdot \kappa_{tt,pt,work} \cdot \beta_{tt,pt,work} \cdot \mathrm{tt}_{pt} \end{array} \right) + \\ \psi_{i,cost} \cdot \beta_{cost} \cdot (P_{i,car,work} \cdot c_{car} + P_{i,pt,work} \cdot c_{pt} - \mathrm{salary}_a) + \\ \beta_{industry} \cdot \delta_{industry} + \\ \beta_{company} \cdot \delta_{company} \end{array} \right) \tag{5}$$

where

- μ_{wp} is the scale for the workplace choice experiment
- α_a is the alternative specific constant for alternative a
- $\kappa_{tt,m,p}$ is a parameter indicating the difference between the long-term experiment and the short-term experiments in terms of travel time valuations. If this term is not statistically different from 1, the two kind of experiments yield equivalent values of time
- $\beta_{industry}$ is the value of changing industry
- $\beta_{company}$ is the value of changing company

3.6 Residential Choice

The utility of a residential alternative a in {current,new} is as follows:

$$U_{i,a} = \mu_{res} \cdot \left(\begin{array}{l} \alpha_a + \\ \psi_{i,time} \cdot \left(\begin{array}{l} P_{i,car,work} \cdot \kappa_{car,res} \cdot \kappa_{tt,car,work} \cdot \beta_{tt,car,work} \cdot \mathrm{tt}_{car,work} + \\ P_{i,pt,work} \cdot \kappa_{car,res} \cdot \kappa_{tt,pt,work} \cdot \beta_{tt,pt,work} \cdot \mathrm{tt}_{pt,work} + \\ P_{i,car,shop} \cdot \kappa_{tt,car,shop} \cdot \beta_{tt,car,shop} \cdot \mathrm{tt}_{car,shop} + \\ P_{i,pt,shop} \cdot \kappa_{tt,pt,shop} \cdot \beta_{tt,pt,shop} \cdot \mathrm{tt}_{pt,shop} \end{array} \right) + \\ \psi_{i,cost} \cdot \beta_{cost} \cdot \left(\begin{array}{l} P_{i,car,work} \cdot c_{car,work} + P_{i,pt,work} \cdot c_{pt,work} + \\ P_{i,car,shop} \cdot c_{car,shop} + P_{i,pt,shop} \cdot c_{pt,shop} + \\ \mathrm{rent}_a \end{array} \right) + \\ \beta_{size} \cdot \mathrm{surface} + \\ \beta_{house} \cdot \delta_{house} + \beta_{newbuild} \cdot \delta_{newbuild} + \\ \beta_{renovated} \cdot \delta_{renovated} + \beta_{garden} \cdot \delta_{garden} + \beta_{balcony} \cdot \delta_{balcony} \end{array} \right) \tag{6}$$

where

- μ_{res} is the scale for the residential choice experiment

- α_a is the alternative specific constant for alternative a
- $\kappa_{m,res}$ is a parameter indicating the difference between the workplace and residential experiments in terms of the valuation of travel time to work. If this term is not statistically different from 1, the two kind of experiments yield equivalent values of time.
- rent_a is the rent or mortgage, depending on the situation
- β_{size} is the marginal utility of one additional m^2 of floor surface
- β_{house} is the value of living in a one-family house (compared to multiple-family house)
- $\beta_{newbuild}$ and $\beta_{renovated}$ are the value of living in a new or renovated building (compared to old)
- β_{garden} and $\beta_{balcony}$ are the value of living in a dwelling with garden or balcony (compared to no outside area)

4 Results

Table 2 shows the basic statistics of the estimation. The ρ^2 lies within the expected range.

Table 2: Estimation Statistics

Statistic	Value
Number of decision makers	2,279
Number of observations	29,968
Estimated parameters	38
Null log-likelihood	-23,004.73
Final log-likelihood	-15,876.85
ρ^2	0.31
Adjusted ρ^2	0.31
Akaike Information Criterion	31,829.71
Bayesian Information Criterion	32,145.41

Table 3 shows the estimates and indicates which parameters are significantly different from zero or one. The significance levels take the intra-personal correlation of error terms into account. All the signs are as expected. Individual income has an effect on the valuation of time (λ_{time} different from zero and non-linear indicated by being different from one). But income does not seem to have an effect on travel cost (λ_{cost} not being different from zero even if non-linearity seems to be indicated by being different from one).

Most short-term experiments share the same scale as the estimated μ are not significantly different from one. For the workplace experiment the scale is significantly different from zero and one and below one indicating more random choices than in the short-term experiments. The scale for residential location choice is not significantly different from zero. Combined with a large negative constant for the new residential alternative it indicates respondents are just not willing to change residence whatever the alternative is. An explanation can be the high share of home owners (52%) in the sample which needs further investigation. Comparing the valuation of time in long- and short-term experiments the $\kappa_{tt,pt,work}$ and $\kappa_{tt,car,work}$ show that additional commute travel time is perceived less negatively in the long run. All the other are neither significantly different from zero or one. They are more or less random and cannot be extracted from the data. The reason could be that the other estimated κ are only elements of the residential location choice experiment. Again other attributes seem to be more important to the respondents or they don not want to move.

Table 3: Estimates of the Joint Model

Parameter	Estimate	Rob. t-stat (0)	Sign. (0)	Rob. t-stat (1)	Sign. (1)
α_{walk}	0.6312	2.15	*	-1.26	
α_{bike}	1.0006	3.83	*	0.00	
α_{pt}	-0.6030	-3.65	*	-9.70	*
α_{car}	0.0000				
λ_{time}	0.4601	4.51	*	-5.30	*
λ_{cost}	0.0865	0.73		-7.71	*
inc_{miss}	0.8460	3.87	*	-0.70	
$\beta_{tt,walk,work}$	-0.0912	-6.03	*	-72.16	*
$\beta_{tt,walk,shop}$	-0.2867	-5.55	*	-24.91	*
$\beta_{tt,bike,work}$	-0.1951	-9.62	*	-58.94	*
$\beta_{tt,bike,shop}$	-0.5118	-7.54	*	-22.28	*
$\beta_{tt,pt,work}$	-0.0928	-8.18	*	-96.30	*
$\beta_{tt,pt,shop}$	-0.2977	-7.17	*	-31.25	*
β_{trans}	-0.4821	-11.45	*	-35.20	*
$\beta_{tt,car,work}$	-0.1270	-8.03	*	-71.21	*
$\beta_{tt,car,shop}$	-0.2232	-5.59	*	-30.66	*
β_{cost}	-0.0141	-6.79	*	-487.93	*
$\beta_{industry}$	-0.9502	-5.02	*	-10.31	*

To be continued on the next page

Parameter	Estimate	Rob. t-stat (0)	Sign. (0)	Rob. t-stat (1)	Sign. (1)
$\beta_{company}$	-0.7281	-4.83	*	-11.46	*
$\alpha_{curr,work}$	0.0000				
$\alpha_{new,work}$	-1.5364	-5.61	*	-9.27	*
$\alpha_{curr,res}$	0.0000				
$\alpha_{new,res}$	- 90.1665	-1.02		-1.03	
β_{house}	26.6274	1.10		1.06	
β_{size}	1.3380	1.12		0.28	
$\beta_{newbuild}$	35.6567	1.12		1.09	
$\beta_{renovated}$	10.5870	1.12		1.02	
$\beta_{balcony}$	39.1910	1.12		1.09	
β_{garden}	34.0532	1.12		1.08	
μ_{mc}	1.0000				
$\mu_{rc,pt}$	0.7857	6.03	*	-1.64	
$\mu_{rc,car}$	0.7874	5.82	*	-1.57	
$\mu_{rel,pt}$	0.9121	8.76	*	-0.84	
$\mu_{rel,car}$	0.6197	6.01	*	-3.69	*
μ_{wp}	0.4618	6.44	*	-7.51	*
μ_{res}	0.0182	1.13		-60.82	*
$\kappa_{tt,pt,work}$	0.6281	4.28	*	-2.53	*
$\kappa_{tt,pt,shop}$	71.3752	0.40		0.40	
$\kappa_{tt,car,work}$	0.5306	3.96	*	-3.50	*
$\kappa_{tt,car,shop}$	4.0792	0.44		0.33	
$\kappa_{car,res}$	4.4119	0.75		0.58	
$\kappa_{pt,res}$	2.0132	0.52		0.26	

The values of times derived from the model are summarized in Table 4. As already indicated by the κ estimates the short-term values of time are higher than the ones from the workplace choice experiment. Beck *et al.* (2017) found an opposite result. The two major differences of the data used here compared to theirs is the availability of other factors than salary and travel time, and the inclusion of options with lower salary than the current salary. Given the parameter estimates (changing industry or company being equivalent to about 10 minutes of additional commute time), the additional attributes do not suffice to explain this difference. However, previous analysis of the German data showed significant differences in the valuation of salary gains versus losses (Dubernet and Axhausen, 2016), with respondents unwilling to accept any loss in salary. The inclusion of this type of decision has to lead to lower values of time (salary valued more than other attributes).

The valuation of shopping trips his higher than commute trips in the short-term experiments. Those trips are relatively short so additional travel time is perceived more negative. The long-term residential values are only shown for completeness but cannot be trusted given the parameters.

Table 4: Estimates of the Values of Time (€/h)

Mode	Purpose	Short-term	Long-term work	Long-term residential
Car	Work	8.88	4.72	*(20.81)*
PT	Work	6.49	4.08	*(9.49)*
Car	Shopping	15.61	–	*(281.03)*
PT	Shopping	20.82	–	*(128.24)*

5 Discussion and outlook

This paper used the data of the *German VOT Study* to have a look at the difference of valuation of travel time between short- and long-term choice situations. Previous work (Beck *et al.*, 2017) found higher valuations of travel time for long-term decisions, explained by a higher acceptance of long travel times for non-recurring events but a willingness to minimize travel times in the long run. Our results show an opposite effect, most probably due to the inclusion of salary losses, in addition to salary gains, as well as the different framing, where attributes of the work itself are said to change, instead of a simple relocation. More research on this specific issue is needed, as the implications on the derivation of the value of time are not clear. This points for the need of more surveys specifically tailored to investigating this kind of issues. Future surveys should be careful to include high enough variations in travel times (such that small effects could be identified as well, which might have been a problem with residential choice here), include variations in both directions (instead of only considering increase in wage, as in (Beck *et al.*, 2017)), and be careful to frame the questions so as to avoid confounding the effects of aversion to change with low willingness to pay for travel time savings.

The results presented here confirm a difference in scale of the utility between short and long-term, indicating a different choice process, the long-term choices having a stronger random component.

In comparison with previous work, the German data set contains two kinds of long-term experiments, namely workplace and residential location choice. One of the aim of this paper was to check the implicit assumption that there would be one "short-term" and one "long-term" value of time, clearly identified. In our data, no meaningful value of time could be taken out of the residential location choice, indicating a strong indifference to travel times. This can be

explained by a high share of home owners in the respondents (who thus do not want to move), as well as by a totally different choice process between workplace and residential location choice. Additionally, other factors may influence residential choices which are not considered in this study, such as demographics, region, taxes, shopping convenience, closeness to and choice of schools, privacy or housing afford-ability. Further inter-connected family decisions and household joint decision-making were ruled out by survey design but are most likely taken into consideration by families when choosing a workplace or residence.
The dependence of travel time variation on the time frame of the decision is intriguing, and could modify the understanding of what the "best" value for policy appraisal is. However, the current result show how elusive this value can be, and point for the need of further study. In particular, a theory of travel time valuation that would be able to accommodate for different time horizons endogenously would greatly improve the way we understand how individuals value travel time savings, leading to better informed policy evaluations.
Further the question remains which values of time planers and government should use for evaluating projects. The long-term value of time, as we defined it, is the willingness to pay to decrease the average travel time for a given purpose in the long run. The short-term value of time, as it is used today, is the willingness to pay to decrease the travel time for one particular trip. Thus, it would be sensible to choose a value to be used for appraisal based on the type of project. If a project is made to improve social welfare in the long run, considering potential changes in population distribution (for instance new infrastructure), a value based on long-term decisions might be better suited; but if the aim of a project is to provide better options for the current population (for instance traffic signal timings or change in public transport headways), a value based on short-term decisions should be preferred.

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