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

Ilka Dubernet\textsuperscript{a,b,*}, Thibaut Dubernet\textsuperscript{a}, Kay W. Axhausen\textsuperscript{a}

\textsuperscript{a} Institute for Transport Planning and Systems, ETH Zurich, CH-8093 Zurich, Switzerland
\textsuperscript{b} Economics and Social Sciences, Social Sciences in Landscape Research, Swiss Federal Research Institute WSL, Zürcherstrasse 111, CH-8903 Birmensdorf, Switzerland

\textbf{A R T I C L E  I N F O}

Keywords:
Long-term vs. short-term value of time
Workplace choice
German Value of Time and Reliability Study
Survey design

\textbf{A B S T R A C T}

The value of travel time is an important element in 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 behavior data from revealed or stated preference surveys. 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. Using a joint model including all short term, together with workplace choice situations, the differences in the valuation of time coming from different kinds of experiments are investigated. The results reveal difficulties to isolate the willingness to pay from other aspects of monetary compensation, such as income as a status or career progression symbol. The results confirm that the chosen time horizon has a significant effect on the valuation of travel time and cost. The richer data, compared to previous attempts at such an estimation, does reveal, however, potential pitfalls in the underlying theory, namely that there is a perfect substitution between travel costs and income. In particular, focusing on salary neutral situations instead of situations with salary gains changes the direction of the effect of long term decisions. Recommendations are derived for forthcoming studies.

\textbf{1. Introduction}

Microeconomic models of time allocation have been used to derive the valuations of techno- logically 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 respondents are typically required to make choices between hypothetical situations. The values of time are estimated using suitably formulated discrete choice models of travel behavior, 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 last ing effects. Consider for instance the choice of a workplace. 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 travellers. Thus, when estimating willingness-to-pay for policy appraisal, new questions arise: is the focus on short-term
decisions the most appropriate? Should one consider the willingness-to-pay in the new choice context offered to travellers, or the willingness-to-pay of travellers when they make decisions with a similar time frame?

Beck et al. (2017) put this differently, by arguing that travellers anyway have very little possibility to influence their commute in the short-term, but can in the long-term, for instance by changing their workplace. 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 behavior 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 has an effect on every day travel. Here, the authors compare long and short travel time valuations, using 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 (Swärd 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.

Such an approach is reminiscent of the study of the marginal cost of commuting in labor economics, where decisions about residential and work location are analyzed in the light of the characteristics of the commute, including long-term effects. Most of the studies are based on the study of the trade-offs between wages and attributes of the commute, following Rosen (1986). For instance, van Ommeren and Fosgerau (2009) design a model of commute valuation based on search theory, that they estimate on job mobility revealed preference data for the Netherlands. They find much higher commute valuations than for typical studies focused on the short-term travel time valuation. Gutiérrez-i Puigarna et al. (2016) empirically look at the hypothesis that richer households tend to live further away from the city center, and find the opposite for a Danish dataset. However, their results include the effect of the urban structure as an endogenous effect, which makes this kind of model ill-suited for deriving travel time valuation. On another topic, van Ommeren et al. (1998) used a theoretical model based on search theory to study the job and residential mobility behavior of two-earners households, and found strong effects of household structure on mobility, that increase with the distance between the two workplaces. This stream of research, however, does include all aspects of the commute in the valuation, in particular fixed costs and opportunity costs of car usage. Cost-benefit-analysis requires a valuation of the time component only, which is difficult to obtain from those approaches.

Müggenburg et al. (2015) review the theoretical framework and the most important studies investigating mobility behavior in a long-term choice context. This paper aims at evaluating the effect of the time horizon on the value of travel time using a richer experiment as the one used by Beck et al. (2017), in order to guide the design of long-term experiments for forthcoming value of travel time studies. To this end, a combined revealed and stated preference experiment conducted in Germany in 2012 (Dubernet and Axhausen, 2019; 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 workplace choice situations with salary gains, the German data includes situation with gains, losses as well as salary neutral. As it is well known within the valuation literature for short-term choice scenarios that an underlying loss aversion inherent in people often results in a symmetry between willingness-to-pay and willingness-to-accept values (e.g. Borger and Fosgerau, 2008; Hjorth and Fosgerau, 2011; Ojeda Cabral et al., 2016), the availability of both salary gains and losses allows to test for the importance of that phenomenon in the long term. The second objective here is thus to compare the behavior of the respondents under those three types of situations, to explore further the assumptions underlying the work of Beck et al. (2017).

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 Value of Time and Reliability Study. The German Federal Ministry of Transport and Digital Infrastructure (BMVI) published the 2030 Federal Transport Investment Plan (Bundesverkehrswegeplan, BWWP), its medium- to long-term investment strategy for the countrys 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 Value of Time and Value of Reliability 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 Value of Time and Reliability 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 behavior can be found in (Dubernet and Axhausen, 2019).

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 carvan) (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 (a route choice experiment with additional travel time reliability attributes) 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.

The residential games are not used in this paper, and will thus not be described further here. The interested reader is referred to Dubernet and Axhausen (2019) for a complete description.

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). All three formats were retained after the pre-test, as it indicated no clear preference between them in spite of their growing complexity.

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.

The non-business sample contains 50,561 choices of 2404 respondents (Dubernet and Axhausen, 2019).

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 short-term trips was taken as the long-term workplace games by design only included this trip purpose. 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 workplace 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 15,960 choice tasks of 1279 respondents. 6806 of the tasks are short-term games, and 9154 workplace games.

Table 2 shows descriptive statistics of the attributes presented to the respondents (Dubernet and Axhausen, 2019).

Table 1

Survey design and attribute levels of joint model attributes.

| Attribute | Attribute levels | Alternative |
|-----------|------------------|-------------|
| **Mode choice (SP 1)** | | |
| Overall travel time | −30%, −10%, +20% of current state | x | x | x | x |
| Transfers | −1, +/−0, +1 time | x | x | x |
| **Route choice (SP 2) and Departure Time and reliability (SP 3)** | | |
| Overall travel time | −30%, −10%, +20% of current state | x | x | x |
| Travel cost | −20%, +10%, +30% of current state | x | x | x |
| Transfers | −1, +/−0, +1 time | x | x | x |
| **Workplace choice (SP 4)** | | |
| Current alternative (RP) | New alternative (SP) | Current | New |
| Car commute time (min) | −30%, −10%, +20% of current state | x | x |
| Car commute cost (€/month) | −20%, +10%, +30% of current state | x | x |
| PT commute time (min) | −30%, −10%, +20% of current state | x | x |
| PT commute cost (€/month) | −20%, +10%, +30% of current state | x | x |
| Salary before tax (€/month) | −10%, +/−0%, +10% of current state | x | x |
| Staff managed (number) | −50%, +20%, +100% of current state | x | x |
| Budget managed (Mio. €/year) | | |
| Change of industry needed | no, yes | no | x |
| Change of company needed | no, yes | no | x |
respondents in the single choice experiments. Respondents who reported to have no responsibility for staff or budget were sometimes presented with a budget or staff to manage. This is why the means for this two attributes are higher for the new alternative. The number of cases for a change of industry or company show how often were presented with a new company or industry in the games. In this description choice means the respondent's choice regarding his/her workplace. It can be seen that most of the respondents chose to keep their current workplace (71%).

At the end of each block all respondents had the opportunity to mark the impact of the attributes on their decision in the different choice situations. The respondents were asked to tick the attributes which they thought were rather unimportant to them or did not influence their choice at all. They could also state that they took all variables into consideration when choosing the alternative. So all the variables they did not chose were coded as important or if they stated all attributes were equally important to them all the variables were also coded as important.

Fig. 2 shows the importance of the variables of the workplace experiment. Overall 256 respondents answered to the question of variable importance. The salary is by far the most important attribute to the respondents of SP 4. Car commute travel time and cost is important to respondents in contrast to public transport time and cost which is another indication for the main mode of transport for commute in the data. The least important variable in the workplace games is the budget managed. This is why the means for this attribute are equal in the new alternative and if the respondent is responsible for.

The absolute number of choices of the current or new workplace alternative by the difference in salary is shown in Fig. 3. In 92% of the cases respondents choose their current working situation if the new alternative includes a salary loss. If the new salary is equal to the current salary about one third (29%) of the respondents choose the new workplace. If the new workplace includes a salary gain about half of the respondents (48%) still prefer to stay in their current job situation.

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 modelling 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.

The model focuses on workplace choice as a long-term decision, and thus for the short-term experiments, only commuting situations are considered. In the questionnaires, two time horizons were used to specify travel times and monetary costs, namely per trip or per month. In particular, in the workplace experiment, the two time horizons were used simultaneously, with travel times expressed per trip but monetary travel costs per month. In the model, all times and monetary costs are expressed as averages per month, using the average 4.73 work tours per week from the revealed preferences part of the survey, and an average of 4.28 weeks per month. Work tours are assumed to consist 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. This simplification did not have a substantial impact on the resulting short-term values of time computed elsewhere from the full range of attributes available in the short term experiments Dubernet (2019).
All utilities include an individual income interaction term for monetary cost sensitivity. For a given decision maker \(i\), it is expressed as follows:

\[
\Psi_i = \left( \delta_{i,inc} \cdot \frac{inc_i}{inc} + (1 - \delta_{i,inc}) \cdot \frac{inc_{miss}}{inc} \right) \beta\delta \tag{1}
\]

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 \(inc\) 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
- \(\beta\delta\) is a parameter controlling the degree of non-linearity of the income effect

### 3.1. Mode choice

The utility for route \(m\) in (car, walk, bike) is as follows:

\[
U_{i,m} = \mu_{inc} \cdot (\epsilon_{m} + \delta_{i,m} \cdot t_{m} + \psi_{i} \cdot \beta_{cost} \cdot c_{m}) \tag{2}
\]

where

- \(\mu_{inc}\) is the scale for the mode choice experiment
- \(\epsilon_{m}\) is the alternative specific constant for mode \(m\)
- \(\delta_{i,m}\) is the travel time coefficient for mode \(m\)
- \(t_{m}\) is the door-to-door travel time with route \(m\)
- \(\beta_{cost}\) is the monetary cost coefficient
- \(c_{m}\) is the total travel monetary 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 \(r\) is as follows:

\[
U_{i,r} = \mu_{rc,car} \cdot (\beta_{rc,car} \cdot t_{rc} + \psi_{i} \cdot \beta_{cost} \cdot c_{r}) \tag{3}
\]

where

- \(\mu_{rc,car}\) is the scale for the car route choice experiment
- \(t_{rc}\) is the door-to-door travel time with route \(r\)
- \(c_{r}\) is the total travel monetary 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 workplace experiment are expressed on a per-mode, per-purpose basis. To be able to include the other monthly monetary value (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:

\[
P_{i,m} = \frac{e^{\Psi_{i,m}}}{e^{\Psi_{i,car}} + e^{\Psi_{i,pt}}} \tag{4}
\]

The utility of a workplace alternative \(a\) in (current, new) is as follows:

\[
U_{i,a} = \left( \begin{array}{c}
\psi_{inc} \cdot \beta_{cost} \cdot (P_{i,car} \cdot \epsilon_{car} + P_{i,pt} \cdot \epsilon_{pt} + \kappa_{salary,age} \cdot \delta_{salary,age} + \beta_{salary,age} + \beta_{salary,age} \cdot \delta_{salary,age} + \beta_{salary,age} \cdot \delta_{salary,age} + \beta_{salary,age} \cdot \delta_{salary,age})
\end{array} \right) \tag{5}
\]

where

- \(\psi_{inc}\) is the scale for the workplace choice experiment
- \(\epsilon_{a}\) is the alternative specific constant for alternative \(a\)
- \(\kappa_{a,m}\) is a parameter indicating the difference between the workplace experiment and the short-term experiments in terms of travel time valuations for mode \(m\). If this term is not statistically different from 1, the two kind of experiments yield equivalent values of time
- \(\kappa_{salary,age}\) is a multiplier for \(\beta_{cost}\) for salary, for age class age in \(\{< 24, [24; 45), [45; 63); \geq 63\}\), testing the hypothesis that one euro of salary is exchangeable with one euro of travel cost. That assumption is central to the validity of such a computation. The optimal thresholds for the age were determined by analyzing the cut points identified by a gradient boosting model, as proposed by Hillel et al. (2019). Those thresholds make intuitive sense, corresponding to rather natural thresholds in terms of career development.
- \(\beta_{salary,age}\) is the monthly salary for alternative \(a\)
- \(\beta_{salary}\) is the value of changing property \(x\) (industry, company, budget in Million Euros, staff)
- \(\kappa_{x,company}\), \(\kappa_{x,industry}\), \(\kappa_{x,budget}\) are correcting factors in the case the decision maker does not yet manage \(x\) (budget or staff)
- \(\delta_{x,company}\), \(\delta_{x,industry}\), \(\delta_{x,budget}\) are an indicator variable that is 1 if the decision maker does not yet manage \(x\) (budget or staff), 0 otherwise

### 3.6. Subsets

Behavior was found to differ greatly depending on whether the situation was a salary gain, loss, or was salary neutral. To investigate those differences, the model is estimated on three subsamples: only situations where there was a salary gain, a salary loss, or was salary neutral. This might be due to systematic behavior patterns in workplace choice situations for those persons that decide not to reveal their income. Given the model formulation and estimate values, it means that those persons are less sensitive to income gains when choosing whether to change jobs, probably because they are
cautious and more reluctant to change. In addition, people with either very high or low income are believed to report their income less often than the ones with median income (Sanko et al., 2014).

On the contrary, the estimates of the workplace location choice model vary greatly between samples, revealing very different choice processes depending on whether the situation corresponds to a salary gain or a loss. Independent of the magnitude of the salary change, individuals are more likely to change jobs than keep their current job in the case of a salary gain, and more likely to keep their current job than to change in the case of a salary loss (sign of the constants). The scale \( \mu_{\text{temp}} \), however, varies greatly between the samples: it is much smaller for salary gains than for losses, indicating that changes in the case of gains are less predictable, probably because they depend on the satisfaction with the current job. The scale in the equal salary case is even 0, indicating an indifference to the attributes of the situation. This reinforces the interpretation in terms of satisfaction.

\( \kappa_{\text{no staff}} \) and \( \kappa_{\text{no budget}} \) are significantly different from 1 in all cases, showing how the perception of such attributes varies depending on the current situation. In future experiments, it might be beneficial not to include such attributes and state to the respondents that all such attributes are considered similar to the current job situation.

The most important estimates are the various \( \kappa_{\text{salary}} \) values, which indicate how equivalent are a Euro of salary and a Euro of travel cost. Both samples with salary changes exhibit opposite trends: whereas in the case of salary losses, \( \kappa_{\text{salary}} \) increases with age, it decreases with age in the case of salary gains. Those opposite trends indicate a consistent difference in the relative importance of salary and travel cost: while younger decision makers value income first and foremost, older decision makers tend to focus on minimizing their travel cost. This might be linked to a perceived equivalence of career progression and salary increase: the younger the worker, the more willing he or she is to “move to the next step”, even at the cost of some additional commuting discomfort. In any case, the results indicate that income is not only perceived as money, and that this perception changes with age. This makes the formulation of models of willingness to pay for commuting time changes very difficult to formulate for choice situations with a change in salary: although decision makers very likely trade off salary, travel cost and travel time, separating the “money” and “status” component of income is not straightforward but necessary to get values of time that can be trusted for appraisal.

Given that difference of valuation of income, the situations with salary change cannot be used to compute values of travel time. Table 5 shows the weighted mean of the individual values from the model with equal salary only. In the case without salary changes, the values of time in the long term are smaller than in the short term, a result opposite to the ones presented in Beck et al. (2017). The numbers into parenthesis indicate the confidence intervals at the 95% confidence level, computed by applying the delta method (Daly et al., 2012) at the mean salary.

Table 6 shows the values of time from the sample with salary gains only, fixing the values of the various \( \kappa_{\text{salary}} \) to 1 to ignore the difference of valuation between travel cost and income. This results in a situation that is more similar to the one considered by Beck et al. (2017). The values of time become higher than in the short term, as in Beck et al.

Table 3
Estimation statistics.

| Statistic | Loss | Equal | Gain |
|-----------|------|-------|------|
| # Decision Makers | 1132 | 1280 | 1211 |
| # Observations | 9702 | 10,327 | 9543 |
| \( L \_L0 \) | -7613.288 | -8046.505 | -7563.078 |
| \( L \_\text{Equal} \) | -4957.862 | -6598.57 | -5950.568 |
| # Parameters | 29 | 25 | 29 |
| \( \rho^2 \) | 0.35 | 0.18 | 0.21 |
| \( \rho^2 \) | 0.34 | 0.18 | 0.2 |
| AIC | 9973.72 | 13247.14 | 11959.14 |
| BIC | 10181.95 | 13428.2 | 12166.88 |

Table 4
Model estimates.

| Variable | Est. | Loss Rob. Std. Err. | sign. 0 | sign. 1 | Est. | Equal Rob. Std. Err. | sign. 0 | sign. 1 | Est. | Gain Rob. Std. Err. | sign. 0 | sign. 1 |
|----------|------|---------------------|--------|--------|------|---------------------|--------|--------|------|---------------------|--------|--------|
| \( \alpha_{\text{w}} \) | 0.779 | 0.8258 | * | * | 0.7565 | 0.6784 | * | * | 0.7131 | 0.6134 |
| \( \beta_{\text{b}} \) | 1.624 | 0.398 | * | * | 1.616 | 0.4457 | * | * | 1.623 | 0.4107 |
| \( \gamma_{\text{d}} \) | 0.5685 | 0.3622 | * | * | 0.5619 | 0.3988 | * | * | 0.5702 | 0.3792 |
| \( \delta_{\text{c}} \) | 0.9288 | 0.3622 | * | * | 0.916 | 0.4457 | * | * | 0.923 | 0.4107 |
| \( \alpha_{\text{stf, no staff}} \) | -0.0736 | 0.0299 | * | * | -0.0741 | 0.0269 | * | * | -0.0739 | 0.0253 |
| \( \beta_{\text{stf, no staff}} \) | -0.2104 | 0.0258 | * | * | -0.2129 | 0.028 | * | * | -0.2163 | 0.0255 |
| \( \gamma_{\text{stf, no staff}} \) | -0.3565 | 0.0201 | * | * | -0.3565 | 0.0611 | * | * | -0.3603 | 0.0469 |
| \( \lambda_{\text{stf, no staff}} \) | -0.1108 | 0.1452 | * | * | -0.1151 | 0.1356 | * | * | -0.1206 | 0.022 |
| \( \kappa_{\text{stf, no staff}} \) | -0.5569 | 0.9131 | * | * | -0.5219 | 0.6431 | * | * | -0.4017 | 0.1243 |
| \( \kappa_{\text{no staff}} \) | 3.412 | 0.1029 | * | * | 0.0223 | 0.1029 | * | * | 0.0138 | 0.0118 |
| \( \kappa_{\text{no staff}} \) | 0 | 0 | * | * | 0 | 0 | * | * | 0 | 0 |
Table 5
Values of travel time (Equal Salary Case) e/h.

| Mode   | Short-term e/h | Workplace e/h |
|--------|----------------|---------------|
| Car    | 10.25 (8.12, 12.38) | 3.66 (0.337, 6.98) |
| PT     | 8.35 (6.50, 10.20)   | 4.39 (2.83, 5.94)  |

Table 6
Values of travel time (Salary Gain Case) e/h.

| Mode   | Short-term e/h | Workplace e/h |
|--------|----------------|---------------|
| Car    | 10.49 (8.78, 12.20) | 675.79 (549.64, 801.94) |
| PT     | 8.29 (6.56, 10.00)   | 438.05 (348.80, 527.20) |

(2017), although the magnitude of the difference is much bigger. That difference might come from the fact that in Beck et al. (2017), travel cost was not varied, whereas the results in Table 4 suggest that older decision makers value travel cost more than income, distorting the estimates. In any case, the fact that the ordering between short and long term is the same as in Beck et al. (2017), might indicate that this is an effect of considering income rather than travel cost.

5. Discussion and outlook

In this paper the data of the German Value of Time and Value of Reliability Study was used 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, interpreted as a higher acceptance of long travel times for non-recurring events but a willingness to minimize travel times in the long run. Our results, however, show an opposite effect when only salary neutral situations are considered. Moreover, the equivalence of income and travel cost, implicitly assumed in Beck et al. (2017), was found not to hold, and the relative importance of the two monetary values varies with age. Combining travel cost and salary changes by considering them equivalent lead to values for the value of travel time that cannot be trusted.

Those results lead to the following recommendations for future research:

- Experiments for the value of travel time savings should focus on direct travel costs only as the money component. In particular, changes in income seem to have an additional meaning which makes their use in trade-offs with travel time problematic. This means that experiments should focus on salary-neutral changes in the case of workplaces, or rent-neutral changes in the case of residential choice.
- The attributes of the workplaces should be limited, similar to Beck et al. (2017). The complex situations presented here make the interpretation more difficult, without added value in terms of willingness to pay computation.

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 planners 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.

CRediT authorship contribution statement

Ilka Dubernet: Conceptualization, Methodology, Formal analysis, Visualization, Writing - original draft, Writing - review & editing.
Thibaut Dubernet: Software, Methodology, Formal analysis. Kay W. Axhausen: Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to thank the two anonymous reviewer for their very useful comments which helped the paper greatly to shift to the current focus. This research was funded by the German Federal Ministry of Transport and Digital Infrastructure as part of the project 96.0996/2011 within the framework of “Bundesverkehrswegeplan 2015 and is a collaboration of IVT, ETH Zurich and TNS Infratest with the help of Prof. Stephane Hess and Prof. Kai Nagel. We are grateful for the careful management of the project and substantial advice of Mrs. J. Monse and Mr. H. Hasheider of the BMVI, Berlin.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tbs.2020.02.002.

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