

## HEART 2019 Abstract – Budapest

### Individual-level decomposition of the value of travel time savings into the value of leisure and the value of time assigned to travel

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#### Motivation and objectives

Recent research has shown a trend towards a potentially more insightful way to decomposing the VTTS - typically derived from mode, route and/or destination choice models - into two separate elements. Following Jara-Diaz et al. (2008), the VTTS for mode  $i$  and individual  $n$  is given by

$$VTTS_{i,n} = VOL_n - VTAT_{i,n} \quad (1)$$

(1) the value of leisure (VoL) representing the monetary equivalent of the willingness to reduce travel time in favor of other activities that generate more utility, and (2) the monetary value of the reduction in direct (dis)-utility derived from the time assigned to travel (VTAT). Therefore, the VTAT cannot be derived from travel choices alone, but requires the integration of travel decisions

into a framework of consumers' time allocation, goods consumption and home production. A shift of focus from the VTTS to these two components in cost-benefit analyses would help assessing the options to be valued under a budget constraint (for example, investing in speed or improving the conditions of in-vehicle travel; for a discussion, see e.g. Jara-Diaz and Astroza, 2013).

Mainly due to the expensive data requirements, only few studies exist that have estimated the VoL, and only one has used time use, expenditure and travel data from the same individuals (Hössinger et al., 2018), a prerequisite for the models applied in this paper. The aim is not only to investigate the VTTS, VoL and resulting VTAT for the same respondents, but also to conduct for the first time the decomposition at the individual-level. This allows for testing the following two hypotheses:

(H1) Time use research has established the general view that the VoL and VTTS are positively related (or even identical, as postulated in the pioneering work of Johnson, 1966): People with a high VoL exhibit a higher VTTS, preferring to perform more utility-generating activities (i.e. leisure) instead of travelling.

(H2) The VTAT and VTTS are negatively related, as e.g. a higher (perceived) comfort level, better opportunities for productive time use or enjoyment while travelling reduce the willingness to pay to reduce travel time.

## **Data**

Data were analyzed for a sample of 355 working respondents in Zurich, Switzerland, surveyed between 2015 and 2016, using a detailed seven-day travel, online/tele-activity and expenditure diary to get information about individuals' time use, expenditure allocation and travel behavior over a whole work-leisure cycle (Schmid et al., 2018b). For the travel choice model, 8'692 RP mode choice observations were pooled with 3'902 SP mode and route choice observations, leading to an average of 35.5 choice observations per respondent (see also e.g. Schmid et al., 2018a).

## **Model formulation**

The modeling consists of two parts:

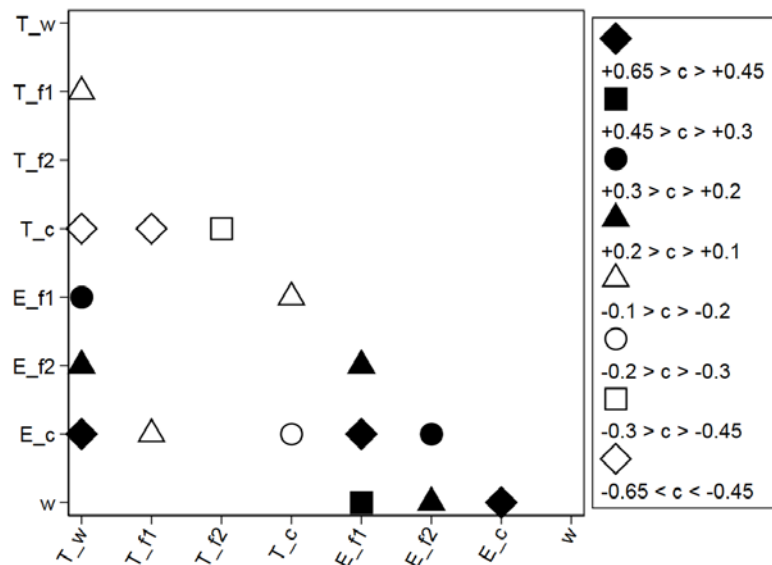
- (1) Respondent's time use and expenditure allocation utility is assumed to have Cobb-Douglas form with weak complementarity (Zellner et al., 1966), which is a function of the time assigned to work ( $T_w$ ), the time assigned to freely chosen activities ( $T_{f1}$  and  $T_{f2}$ ), the expenditures assigned to freely chosen goods ( $E_{f1}$  and  $E_{f2}$ ) and the committed activities ( $T_c$ ) and expenditures ( $E_c$ ).

Importantly, the allocation of activities and expenditures to the different categories is critical because it is – at least to some extent – arbitrary, but influences the results. We mainly follow the classification in Hössinger et al. (2018): Both, freely chosen expenditures

and activities, are divided into two categories: T\_f1 consists of out-of-home leisure activities and T\_f2 consists of online/tele entertainment, while T\_c consists of the residual between T\_f1, T\_f2, T\_w and the time constraint (e.g. sleeping, personal care, etc.). E\_f1 consists of recreational expenses such as holidays, hotels and entertainment and E\_f2 consists of other, more basic but also freely chosen goods such as electronic devices (e.g. smartphone) and clothing. E\_c consists of expenses associated with physical needs such as housing, taxes, food and health, etc.

Figure 1 shows the correlation pattern between all input variables and key measures used to estimate the VoL. For example, T\_w is positively related to committed expenses and negatively related to committed time as assumed by the theory (Jara-Diaz et al., 2008). Another notable aspect is the opposite pattern of time use and expenditure variables: All time use variables are negatively correlated due to the common time constraint, whereas the expenditure variables are all positively correlated with each other and also with T\_w. This follows from the relationships associated with labor income: It increases by T\_w and thus increases the available money for all types of goods.

Figure 1: Correlation pattern of time use model variables.



The analytic solution to the constrained maximization problem as defined in Jara-Diaz et al. (2008) leads to a system of three equations. The baseline utility parameters of the Cobb-Douglas function are estimated using maximum simulated likelihood techniques (Hössinger et al., 2018), accounting for observed (socio-economic characteristics) and unobserved coefficient heterogeneity.

- (2) Respondent's mode and route choice for car, public transportation (PT), carsharing (CS), carpooling (CP), walk or bike is assumed to have a linear-additive indirect utility function in mode-specific attributes such as travel time and cost. The conditional choice probability

is of Mixed Logit type (Train, 2009), and the model is parametrized in the willingness-to-pay (WTP) space accounting for observed (trip purpose, distance, weather, socio-economic characteristics) and unobserved travel cost/scale and VTTS heterogeneity. For each data/experiment type (RP mode choice, SP mode choice, SP route choice car and SP route choice PT), scale parameters control for the differences in error variances.

Travel, activity time and expenditure allocation are choices that may belong to the same superordinate framework of utility maximization (Munizaga et al., 2008). In contrast to Munizaga et al. accounting for bidirectional correlations between time use, expenditure allocation and mode choice using a very complex analytical framework, we use a control-function approach including the residuals of the time use (1) in the mode choice model (2) affecting the constants of the mode choice utilities (e.g. Guevara, 2015). Thus, we intuitively assume that if endogeneity is present, the path passes from the longer-term decisions (1) to the shorter-term ones (2).

Finally, Bayes' rule is applied to calculate the individual-level parameters conditional on observed behavior and fitted distributions in (1) and (2), from which the VoL and VTTS sample distributions are obtained. Importantly, for subsequent analyses, mode-specific VTTS values are only considered for those respondents who have chosen the corresponding mode at least once. Inferring a VTTS for an individual who has *never* used a certain mode during the observation period (and for whom we do not know, if he/she has even considered it) cannot be justified. Although this restriction does, in most cases, not affect results substantially, it still has some noticeable effects on reported VTTS and therefore VTAT distributions (see also Schmid et al., 2018a).

### **Preliminary results**

The estimated median VoL is 25.8 CHF/h (see also Table 1; 1 CHF = 1 US\$), which is about half of the median wage rate (49.5 CHF/h), exhibiting a highly right-skewed distribution (see Figure 2). Given that the VoL equals the wage rate plus the value of time assigned to work (VTAW; see Jara-Diaz et al., 2008), it means that the median respondent only works for the money and dislikes work as an activity (median VTAW = -15.6 CHF/h). The median and mean of the ratio between the VoL and the wage rate of about 0.49 and 0.78, respectively, are in line with previous research, and are close to the reported mean value of 0.88 for Thurgau, Switzerland, in 2003 (see Hössinger et al., 2018, for a summary of previous studies estimating the VoL).

Figure 2: Sample distribution of the value of leisure (VoL).

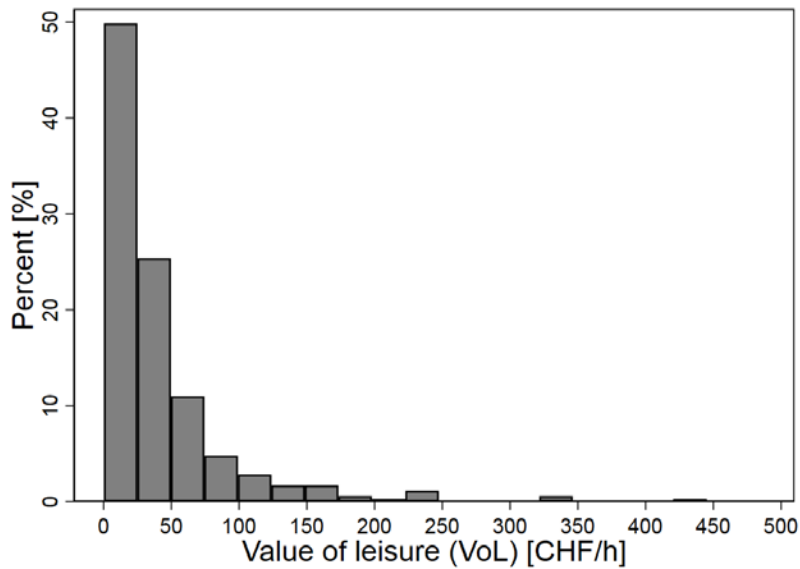


Table 1: Value of leisure (VoL), value of travel time savings (VTTS) and resulting value of time assigned to travel (VTAT; all values are in CHF/h). Values are calculated based on the posterior means of VoL and VTTS distributions. For the VTTS (and the resulting VTAT = VoL - VTTS), only those respondents are included who have chosen the corresponding mode at least once. The second column shows the number of respondents observed in each category.

|           | N (respondents) | Median | Mean | IQR (interquartile range) |
|-----------|-----------------|--------|------|---------------------------|
| VoL       | 355             | 25.8   | 41.6 | 36.1                      |
| VTTS walk | 258             | 18.2   | 19.1 | 8.6                       |
| VTTS bike | 167             | 11.2   | 15.4 | 18.5                      |
| VTTS car  | 255             | 19.6   | 21.1 | 12.1                      |
| VTTS PT   | 334             | 8.7    | 10.1 | 6.7                       |
| VTTS CS   | 222             | 19.5   | 19.8 | 6.1                       |
| VTTS CP   | 122             | 22.8   | 23.5 | 12.5                      |
| VTAT walk | 258             | 7.1    | 21.8 | 33.1                      |
| VTAT bike | 167             | 10.4   | 20.2 | 34.8                      |
| VTAT car  | 255             | 4.4    | 16.9 | 40.5                      |
| VTAT PT   | 334             | 15.4   | 31.1 | 37.4                      |
| VTAT CS   | 222             | 4.5    | 22.7 | 35.2                      |
| VTAT CP   | 122             | 0.1    | 12.2 | 29.7                      |

A likelihood-ratio test indicates that endogeneity in mode choice with respect to time use is present (9 degrees of freedom, increase in log-likelihood by 33 units;  $p < 0.01$ ), but not substantial, and the estimated VTTS are not much affected. Median VTTS for the car travel modes are all about 20 CHF/h (see Table 1), with CP exhibiting the highest value of 22.8 CHF/h. Median VTTS

for walk is 18.2 CHF/h, followed by bike (11.4 CHF/h) and PT (8.7 CHF/h). Interestingly, the VTTS for bike exhibits the largest variation in the sample, which can partly be explained by the heterogeneous physical conditions of the respondents, while the heterogeneity in VTTS for CS is lowest: Renting a car may be seen as an objective-oriented transportation mode for very specific purposes, where people value the travel time more similarly.

The median VTAT are all positive and mainly follow the reversed VTTS ranking (see Table 1), with the highest value for PT (15.4 CHF/h) and the lowest for CP (0.1 CHF/h), followed by car (4.4 CHF/h) and CS (4.5 CHF/h). The low value for CP can be explained by negatively perceived social interaction with the non-acquainted driver (as described in the introduction text of the SP experiments). Also, the huge discrepancy between the car modes and PT is striking, which has been similarly observed for Austria (Schmid et al., 2018a): Travel time is perceived as more pleasant in PT than in a car, where the in-vehicle time can be used more productively to engage in all kinds of activities.

Contrary to the assumptions, our results reject the first hypothesis that the mode-specific VTTS and VoL are positively related: Correlations never exceed +0.13 (in the case of CP;  $p = 0.16$ ) and are all insignificant. This is explained by the fact that the size of income – one main component of the VoL – does not show any substantial effect on the mode-specific VTTS. On the other hand, the VTTS and VTAT are all negatively correlated, ranging from CS and CP (-0.09; both not significant) to PT (-0.12;  $p < 0.05$ ), walk (-0.16;  $p < 0.01$ ), car (-0.30;  $p < 0.001$ ) and bike (-0.32;  $p < 0.001$ ), partly supporting the second hypothesis. One explanation might be that compared to other modes, the travel time preferences towards car and bike exhibit a more pronounced heterogeneity than VoL does (with, for example, bike lovers exhibiting very low VTTS for bike), which – for a given VoL – is enhancing the negative relation between the VTTS and VTAT. This will be part of further investigations; note that data on attitudes towards traditional (car, PT, walk and bike) and emerging transportation modes (CS and CP) were collected for the same respondents (Schmid et al., 2018b).

We therefore conclude that the VTTS is unrelated to the VoL, but that high VoL respondents exhibit a higher VTAT, which directly follows from Equation (1). First, in Zurich, travelling seems to be a pleasant activity, for which especially high VoL respondents assign more time than the technical minimum. Second, while the quality of travel – especially in PT – is very high in Zurich, first class PT compartments and well as luxury travel modes used by high VoL respondents may further accentuate this effect.

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