EJTIR

Issue 17(2), 2017
pp. 248-262
ISSN: 1567-7141
tlo.tbm.tudelft.nl/ejtir

On the consistency between commuting satisfaction and traveling utility: the case of the University of Luxembourg

François Sprumont[1]
MobiLab, University of Luxembourg, Luxembourg.

Paola Astegiano[2]
L-Mob Leuven Mobility Research Center, KU Leuven, Belgium.

Francesco Viti[3]
MobiLab, University of Luxembourg, Luxembourg.

According to random utility theory, there is no clear distinction between the utility inferred from observed choices (decision utility), the experienced outcome of decision makers' (experienced utility) or their retrospective evaluation (remembered utility). While empirical experiments have shown that decision utility and remembered utility do not perfectly coincide, little is known regarding the magnitude of this discrepancy, especially in the transport field. Using a cross-sectional travel survey, the objective of this paper is to quantify the relationship between commuters' stated choice satisfaction (a proxy for remembered utility) and the Logsum function of the utility of all available modes of transport (decision utility). This is of tremendous importance, as implemented transport policy measures, which aim to increase the overall decision makers' utility, may have low impact on their satisfaction level and thus be ineffective. Results indicate that the utility Logsum is associated with respondents' commuting satisfaction. However, context specificities have an important impact on this association.

Keywords: *Commuting mode choice, commuting satisfaction, discrete choice modelling, Utility Logsum.*

1. Introduction

For many decades, Discrete Choice Theory (DCT) (McFadden, 1980) has been successfully applied to travel mode choice modelling (Ben-Akiva & Lerman, 1985). Random Utility Models (RUM), which are currently among the most popular DCT methodologies used in travel mode choice behaviour, are indeed well suited for mode choice understanding and forecasting. Their main advantage is their relative simplicity in relating choice decisions, which can be observed and/or stated through opportunely designed surveys based upon what-if scenarios, to quantifiable variables, such as travel times, delays, public transport fares, etc.

In economy, utility is defined as a measure of preference for a decision maker over a choice set (Varian, 1992). The most popular way to adopt this concept in travel behaviour analysis is to use it within an optimization problem where travellers choose their travelling options such that their overall utility is maximised. In this framework, utility is defined as a combination of different attributes related to a specific decision, e.g. whether using a certain mode of transport for reaching a location where to do an activity. In this decision-making process framework, the

1 A: 6, rue R. Coudenhove-Kalergi, L-1359 Luxembourg T: +352 46 66 44 55 01 E: francois.sprumont@uni.lu
2 A: 300A, Celestijnenlaan, 3001 Heverlee, Belgium T: +32 16 32 27 80 E: paola.astegiano@kuleuven.be
3 A: 6, rue R. Coudenhove-Kalergi, L-1359 Luxembourg T: +352 46 66 44 53 52 E: francesco.viti@uni.lu

definition of utility is of crucial importance. Ben-Akiva and Lerman (1985) defined it as an index of attractiveness, which has a direct relation with attributes related to a specific travelling purpose, the available travelling options and attributes related to the decision maker (e.g. socio-economic characteristics).

Kahneman et al. (1997) highlighted the necessity to distinguish various types of utility and were the first to differentiate concepts such as decision or experienced utility. The concept of utility commonly used in mode choice modelling is referred to as decision utility, while the experienced outcome of a mode choice, instead, is called experienced utility (Ettema et al., 2010). Remembered utility is simply the retrospective evaluation of past decisions. Utility inferred from observed choices (decision utility) is not the same as the experienced or the remembered utility (Kahneman & Sugden, 2005). The discrepancy between ex-ante (decision utility) and ex-post (experienced or remembered utility) utility concepts has been demonstrated using empirical experiments (Kahneman et al., 1997) and is now widely adopted (Ettema et al., 2010; Abou-Zeid, 2009; Abou-Zeid & Ben-Akiva, 2012; Chorus & de Jong, 2011; De Vos et al., 2016). Ettema et al. (2010) and Abou-Zeid (2009) were the first to raise this question in travel behaviour research.

It is well known that travel is a derived demand, not a proper activity that individuals wish to undertake for their own sake (Banister, 2008). The activity at the destination is valuable, not the trip. However, characterizing the way in which traveling is a derived activity is a debated issue (see Mokhtarian & Salomon (2001) and Redmond & Mokhtarian (2001)). According to various authors (St-Louis et al., 2014; Whalen et al., 2013) positive utility and satisfaction feelings have been observed for traveling. Furthermore, this was observed for commuting trips as well as for leisure trips (i.e. where the trip is the activity) or trip to leisure activities. Redmond & Mokhtarian (2001) showed that commuting trips are not unequivocally a source of disutility to be minimized.

To some extent, this is in line with the seminal work of Kahneman et al. (1997) which showed, using empirical experiments, that in addition to being distinct from decision utility, experienced utility is not always directly maximized by decision makers. The peak-end rule for instance (see Kahneman & Thaler (2006) for a recent discussion) postulates that when evaluating an event, individuals are greatly influenced by the event's most intense period and by its ending intensity.

While some authors such as Chorus & de Jong (2011) or Abou-Zeid & Ben-Akiva (2012) discussed the possible solutions to close the gap between experienced and decision utility, few publications have tried to quantify the relation between both concepts. Accordingly, the main objective of this paper is to better understand the relation between commuting utility, quantified by a multinomial logit model, and stated satisfaction. Using economic terms, our objective can be summarized as: analysing the link between decisions utility and remembered utility evaluated for repeated commuting travels. The hypothesis used in this work is that stated travel satisfaction and decision utility are strongly positively correlated. If this holds true, then interventions aiming at achieving system goals while not reducing the overall satisfaction of the users are likely to be effective. Our study contributes to verify this hypothesis and to identify reasons for which decision utility may in some conditions be a good substitute of commuting satisfaction, and in which cases other utility components may be as important, if not more important, as those used in the travelling utility concept.

This work is in line with a previous study of Chorus (2012), where satisfaction and decision utility where also systematically compared, but the analysis is here done at both aggregated and disaggregated levels, using classical cross-sectional travel surveying and the results obtained are also relatively different.

2. Satisfaction determinants overview

Having an intrinsic link with emotions, travelling satisfaction is a difficult concept to quantify, or to characterize with a functional relationship. Mokhtarian & Salomon (2001) indicated that the utility for travelling has 3 main components: the utility for any activity that can be done during the trip, the utility of the activity at destination and, finally, the enjoyment of travelling. The utility regarding the activity at destination is often taken into account and controlled. Intuitively, leisure activities generate more satisfaction than commuting trips. Ory & Mokhtarian (2005) give an interesting example: "Thus, two individuals traveling to the same flight may experience the travel differently due to their difference in trip purpose". Regarding the activity that can be conducted while travelling, a large range of activities can be experienced. Read a book, listen to news, talk show, podcast, music, audiobook, discuss with people, have phone call, work, think, relax are example of ways to make best use of the available travelling time (for an exhaustive list, readers might consult Páez & Whalen (2010) and St-Louis et al. (2014)). The enjoyment of the trip in itself is the third and last dimension. Scenic beauty, nice landscape, speed excitement are examples of feelings than can improve a trip's utility.

St-Louis et al. (2014) interestingly distinguished the determinants for travel satisfaction into 2 classes: external factors and mode-specific attributes and, on the other hand, internal and non-mode specific factors. The first category refers to "objective elements" of a commute such as travel time, travel cost, travel mode, road congestion state. Intuitively, Turcotte (2011) found that satisfaction decreases with travelling time and that the congestion level was an important source of dissatisfaction for the travellers. Each travelling mode has its own characteristics that can influence trip satisfaction. Soft modes (walking and biking) are usually the ones associated with the highest satisfaction levels. The least satisfied travellers are most frequently the ones using the public transport system. Thus, car users have an intermediate satisfaction between soft modes users and public transport users (Páez & Whalen, 2010). As expected, the results of St-Louis et al. (2014) showed how weather conditions have a stronger impact on soft mode users than on public transport users. Drivers are the least impacted commuters by weather conditions such as snow or rain. Interestingly, the authors also mentioned some bias in the satisfaction rating. Indeed, mode-captive people might not rate objectively their travelling mode. Internal and non-mode specific factors refer to commuter personality, behaviour and preference. Of course, socio-demographic characteristics play an important role in the way individuals take decision and experience activities. But other factors such as travellers' values, attitude towards the mode and lifestyle play an important role in travelling experience as well (Ory & Mokhtarian, 2005). Two travellers living in the same building, commuting to the same place with the same travelling mode might evaluate their trips differently.

Very few studies relate satisfaction with attributes linked to the planned activities and the available modes of transport. Abou-Zeid (2009) proposed a commuting satisfaction model that links activity and travel choices using a well-being maximising formulation. She also identified the main factors for both work and non-work trips that influence well-being using a structural equation modelling approach. Ettema et al. (2011; 2013) developed and tested, using an SP survey approach involving hypothetical trips, a measure of satisfaction based on the concept of Subjective Well-Being, which has been introduced as alternative to the more traditional utility concept. However, the Subjective Well-Being concept depends on the choices' outcome and not only on the expected value of the systematic components. A recent study was performed by Chorus (2012), where hypothetical scenarios were designed and presented to a group of respondents to test the correlation between the Logsum (for both utility-maximising and regret-minimising functions) and stated satisfaction measures.

3. Methodology

This paper aims to understand the relation between the utility of commuting with a particular mode of transport, which is inferred from observed choice (decision utility) and stated satisfaction (a proxy for remembered utility). In order to reach this goal, the utility-based Logsum as adopted in Chorus (2012) is computed and then it is compared to stated satisfaction using two well-established approaches, namely multiple regression analysis and one-way Analysis of Variance (ANOVA). The contribution of this paper lies in the validation of this approach on another dataset in which mode choice decisions instead of route choice decisions are used. Furthermore, the findings in our study provide a significantly higher correlation between utility and satisfaction with respect to the findings reported in the existing literature.

Random Utility Theory (Ben-Akiva & Lerman, 1985) is based on the hypothesis that every individual is a rational decision-maker, which aims at maximizing the utility related to his choice. In particular, the generic decision-maker *i*, when making a choice, considers m_i mutually exclusive alternatives that constitute his choice set; he then assigns to each alternative *j* in his consideration set a perceived utility U_j^i and selects the alternative that maximizes this utility; the utility associated to each choice alternative depends on a number of attributes X_j^i of the alternative itself and/or of the decision-maker. The utility function U_j^i can be expressed as the sum of two terms: a systematic utility V_j^i and a stochastic residual ε_j^j. The systematic part represents the mean utility perceived by all decision-makers having the same choice context while the residuals capture the unknown deviation of the utility perceived by user *i* from this mean value and capture the combined effects of the various factors that introduce uncertainty in choice modelling. The deterministic utility is instead usually assumed as a linear-additive function of weights β_k of the attributes X_{kj}^i. Therefore:

$$U_j^i = V_j^i + \varepsilon_j^j \tag{1}$$

where

$$V_j^i = \sum_k \beta_k \; X_{kj}^i \tag{2}$$

Among the different random utility models, the simplest and most popular is perhaps the Multinomial Logit. It is based on the assumption that the random residuals are independently and identically distributed as Gumbel random variables with zero mean and variance equal to $\frac{\pi^2}{6}$. Consequently to this assumption, the probability of choosing alternative *j* from among those available (1,2,…,m) can be expressed as:

$$p[j] = \frac{\exp(V_j)}{\sum_{i=1}^{m} \exp(V_i)} \tag{3}$$

The logarithm of the denominator of equation (3) provides the aggregated utility that the traveller receives from the different alternatives and is commonly referred to as the Logsum:

$$LS_{RUM} = E\left[max_{j=1,\ldots J}\left\{U_j\right\}\right] = \int_{\varepsilon}\left[max_{j=1,\ldots J}\left\{U_j\right\}\cdot f\left(\varepsilon\right)\right]d\varepsilon = \ln[\sum_{j=1,\ldots J} \exp\left(V_j\right)] \tag{4}$$

The Logsum gives the opportunity to have a single scalar measure representing multiple alternatives at once. Mathematically, it allows having an aggregated measure of all potential options that a traveller may have in its evaluation set. Chorus & de Jong (2011) define the Logsum as “the expected maximum utility associated with a traveller’s choice set”. For this reason, it has been regarded in the literature as a suitable metric providing a value to user benefit, and it is commonly used as a measure of accessibility (Geurs, 2006).

A notable property of the Logsum is that it monotonically increases in value if a new alternative is added, even if its utility is very low. On the other hand, only alternatives with a sufficiently comparable utility with respect to the best alternative increase the value significantly. This property is associated to the intuitive sense of appreciation for having a larger set of alternatives where to choose the travelling mode. Hence, in mode choice, this expression is commonly adopted to compare two choice sets made of different travelling alternatives.

4. Case Study

4.1 Luxembourg, the heart of a cross-border region

At the heart of Europe, encompassing a total area of 2586 km², the Grand-Duchy of Luxembourg is a small country facing big mobility challenges. Every day, in addition to the commuting trips of its 563 000 residents, the country welcomes 170 000 cross-border workers, representing 43% of the total working force (STATEC, 2016). These cross-border workers coming from Belgium, France and Germany generate an important pressure on the transport infrastructure of the country. While 76% of the workers living in Luxembourg commute by car, the share is reaching 89% for cross-border workers (Carpentier & Gerber, 2009). Inside Luxembourg, the public transport use is relatively low compared to the high service quality both in terms of frequency and coverage (Klein, 2010). As mentioned by Epstein (2010), high car use may be explained partly by the dense motorway network and the positive image associated with car ownership. As far as commuting mode choice is concerned, the important difference between resident and cross-borders workers is mainly related to home-to-work distances. For the residents, the median commuting distance reaches 12km while it reaches 40km for the cross borders commuters (Carpentier & Gerber, 2009). Of course, such long distances are incompatible with soft modes use and hardly compatible with public transport use. This difference in trips characteristics and mode availability between cross-border workers and residents are, as previously argued, commuting satisfaction determinants (Turcotte, 2011; St-Louis et al., 2014).

4.2 The University of Luxembourg

Founded in 2003, the University of Luxembourg (the only University in the country) is welcoming every-day 6500 students and 1500 staff members. The majority of the University activities are located on three different campuses which are in Luxembourg-City (namely Kirchberg and Limpertsberg campuses) or a few kilometres away from the city centre (Walferdange campus). Since its creation, the university has constantly grown in total population and has now reached a limitation due to the infrastructure size. To solve this issue and to foster land-use polycentric development the national government has imposed the relocation of the University in Belval, a new town located around twenty kilometres southwest of the capital.

This workplace relocation will greatly impact the commuting behaviour of the staff members, which are, in line with the national trends, scattered in and outside of the country, with a significant number of cross-border workers. In our previous study (Sprumont et al., 2014) involving an earlier travel survey data analogous to the one described in this paper, we showed that the most impacted staff members will be the German workers while only a few people will decrease their commuting distances. In general, this workplace relocation will increase the commuting of the University staff members of, on average, 18% (from 28.7 to 33.8km).

Currently, the university is developing measures to increase staff members' satisfaction regarding their home-to-work trip in order to compensate for the loss caused by the government targets and in general by the relocation. A carpooling platform, a shuttle service between campuses and a car-sharing system are running from mid-September 2015. These services have been introduced with the objective of compensating the general loss of accessibility. Hence, assuming that the positive correlation between commuting satisfaction and the utility satisfaction measure expressed by the Logsum is verified in this study, we may then use the predictive properties of the latter model to evaluate the impact of these services.

4.3 The 2014 / 2015 travel survey

Between December 23rd and January 23rd, around 500 respondents replied to the 2014/2015 staff's travel survey. This means that 34% of the staff members (including PhD students) replied to the survey. Appendix A provides an overview of the resulting key figures. Such surveys are a great tool to monitor the commuting behaviour and to assess the implementation of Travel Demand Management (TDM) measures. The survey collected standard information regarding socio-demographic status, transport mode availabilities, and selected commuting mode.

The question regarding the (stated) commuting satisfaction was formulated as follow:

> "Are you globally satisfied by your daily work commute? (If you take into account elements such as the cost, the distance and the stress caused by your home-to-work trips)".

The respondents had the choice between very unsatisfied, unsatisfied, satisfied and very satisfied (coded as Sat1, Sat2, Sat3, Sat4 in the appendix B). This four-point Likert scale question without neutral answer forced the respondent to attribute a positive or negative rate to their commuting trips. As usual when using Likert scales, the extreme response might be underused, showing a desire to not be perceived as a person with extreme feelings.

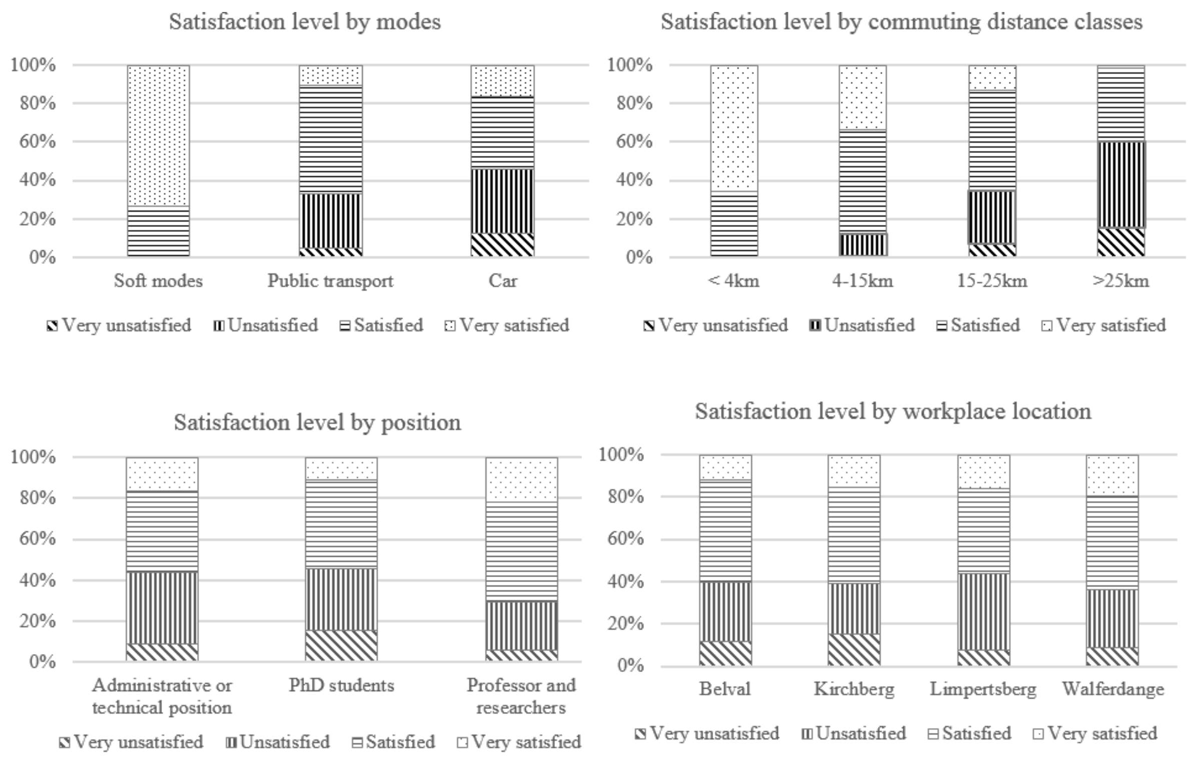

Figure 1. Satisfaction levels

Figure 1 presents satisfaction level's variation according to 4 variables, namely selected modes, commuting distance classes, work position and workplace location. Our data, similarly to the reported scientific literature, shows higher levels of satisfaction for soft mode use. Indeed, 100% of the walkers or cyclists are satisfied or very satisfied. The travel survey respondent exhibits higher satisfaction level for public transport use opposed to car use which is different from what has been observed by Turcotte (2011). Commuting satisfaction levels also seem to be negatively correlated with home-to-work distance. While soft modes and public transport use normally generate higher satisfaction levels, high travelling distances are naturally not compatible with soft mode and hardly compatible with public transport use, except for the routes served by a railway connection. The work position, a good proxy of the income level, also affects the commuting satisfaction. PhD students are the least satisfied of their commuting trip. Further research is needed but using university travel survey information, income level seems to be positively correlated with higher satisfaction levels. Because the various campuses all present different car and public transport accessibilities, different satisfaction levels would have been expected but no big difference is observed.

Important behavioural mode choice determinants such as attitude, subjective norms and perceived behavioural control which, according to Ajzen (1985), influence intention and finally decision's choice were not collected in this survey. Thus, the inclusion of these variables, which have been described as important satisfaction determinants by Ory & Mokhtarian (2005) in the MNL model, is unfeasible for this study.

5. Results

The aim of this paper is to verify whether Random Utility Maximizing Logsum and the stated satisfaction for the commuting mode of transport are positively correlated. In particular, we aim to express the Logsum as a single measure taking into account all mode alternatives available to the respondent.

In order to compute the utilities for each alternative, a Multinomial Logit Model was formulated and calibrated. The systematic part of the utility function for the three modes of transport that have been considered (CAR, PT, SOFT), takes the following form:

$$V_j^i = ASC_j + B\_TIME_j * Ttime_j + B\_COST_j * Cost_j + B\_PHD_j * PHD^i + B\_PROF_j * PROF^i \quad (5)$$

Where i and j are respectively the user and the mode alternative. Ttime and Cost are the travel time and travel cost associated with each alternative. PHD and PROF are two dummy variables that take value 1 if the user is a PhD student or a Professor (or postdoc researcher level) at the University of Luxemburg and zero otherwise. ASC is the so-called Alternative Specific Constant, which appears on all alternatives except one, and represents somewhat a systematic preference for certain modes, which is not captured by the systematic component.

Car cost has been set up to €0.15/km, no travelling cost has been assigned to soft mode use and public transport cost has been computed by dividing the yearly transport pass cost by an approximation of the total annual number of home-to-work trips (420). Estimating public transport travelling cost for each individual is far from easy.

First, based on the postal code, it has been assumed that individuals were commuting from the closest bus stop / train station which might represent an oversimplification in some instances. Second, some train stations recently introduced parking fees, and the collected data is insufficient to correctly identify their costs. Concerning the travelling time, a "Friendly Batch Routing" (Medard de Chardon & Caruso, 2012) application running in combination with the Google Maps API was used to obtain car travelling time and origin-destination distance. No congestion coefficient has been used in this study. Soft modes have been assumed to be characterized with a speed of 11km/h, an intermediate speed between walking and cycling.

In Table 1 the results of the MNL calibration are shown. The model was calibrated with the support of the software package BIOGEME (Bierlaire, 2003). The sign of the resulting parameters are all found consistent. The value of the ρ2 is 0.3 and the efficiency of the model reaches 77%. The value of the ASC_PT and B_PHD should be analysed with caution due to their relatively high p-value.

Table 1. Results of the MNL calibration

Name	Value	Std err	t-test	p-value
ASC_CAR	0.00 Fixed			
ASC_PT	-0.229	0.327	-0.70	0.48
ASC_SOFT	-0.936	0.397	-2.36	0.02
B_COST	-0.132	0.026	-2.51	0.01
B_PHD	0.379	0.400	0.95	0.34
B_PROF	0.384	0.283	1.35	0.18
B_TIME	-0.0513	0.0101	-5.10	0.00

5.1 Multiple regression approach and ANOVA analysis

Given the results of the calibration process (see Table 1), it was possible to compute the utility-based Logsum expressed in eq. (4). Below, Figure 2 provides a first overview of the relation between the utility of the selected mode and the satisfaction level. From a visual inspection, it seems that our primary hypothesis can be confirmed. There appears indeed to be a positive relation between the utility of the selected mode and the satisfaction levels.

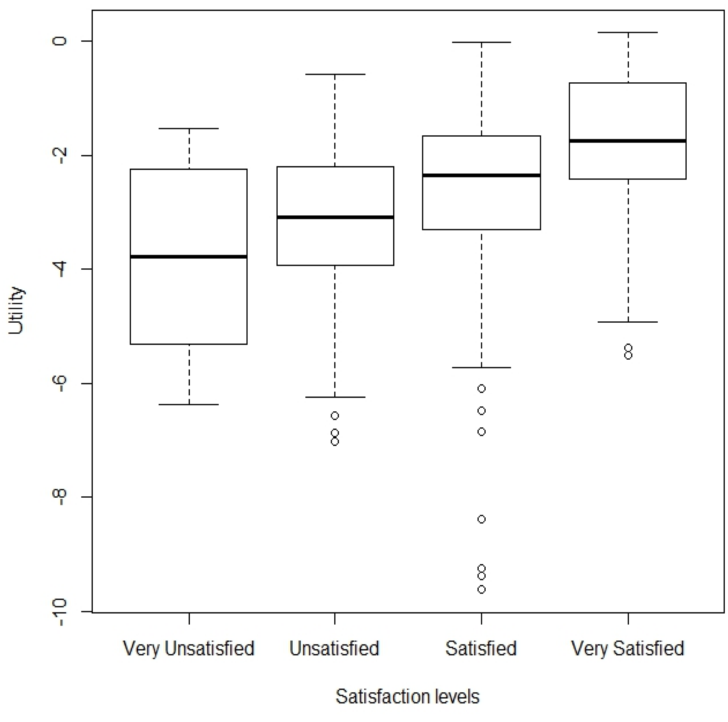

Figure 2. Satisfaction levels and utility of the selected mode

In order to analyse the strength of the association between the utility-based Logsum and the stated satisfaction, the multiple regression (Edwards, 1985) and the one-way ANOVA (Christensen, 2011) approaches have been employed. The multiple linear regression is used to explain the relationship between one continuous dependent variable and two or more independent variables. ANOVA is instead a statistical method typically employed to perform analysis of variance between and within groups.

Employing the multiple regression approach, the analysis of the strength of the association between the Logsum and the stated satisfaction produced a coefficient of determination R^2 equal to 0.24 and a multiple correlation coefficient equal to 0.48 for the full sample. The one-way ANOVA analysis, implemented as a confirmation approach, turned out to provide similar results. The correlation between fitted and observed values of the dependent variables is the same as it was for the multiple regression model. The "proportion of variance explained" measure R^2 for multiple regression has an ANOVA equivalent, η^2 (eta squared), which has in this case a value equal to 0.24.

These results, to some extent, confirm the main hypothesis of the paper. The utility-based Logsum (decision utility) is importantly correlated with the stated satisfaction (a proxy for remembered utility). As expected, the correlation is not perfect but is still significantly higher than the correlation found by Chorus (2012) who used stated choice experiment data and obtained correlations between 0.155 and 0.203.

However, as described in Section 4, our dataset is composed of very different profiles. PhD students have, for instance, lower salaries than professors, and in general have different socio-economic characteristics (e.g. lower car ownership rates, near-free public transport access) and different activity-travel patterns. In addition, the country of residence, as already mentioned, has a huge impact on commuting time and public transport availabilities. Table 2 presents the multiple correlation coefficient for different population categories (in appendix B, a detailed table with the coefficients and their significance tests is included).

To begin with, a high correlation value is observed when the Logsum value is proportional to the satisfaction levels. For instance, someone having several efficient alternatives for commuting and expressing a high satisfaction level would have a high correlation index. A low correlation would indicate that individuals are 1) satisfied by a low workplace accessibility (expressed by the utility-based Logsum) or 2) unsatisfied by a good accessibility. The most striking observation is related to the variation between the residents and the cross-border workers. While commuting satisfaction for Luxembourgish residents is well aligned with their travelling alternatives quality, this does not hold for cross-border workers.

Table 2. Multiple correlation coefficient

		Multiple correlation coefficient
	Total sample	0.48
Employment status	PhD students	0.46
	Professors and researchers	0.51
	Administrative or technical position	0.49
Country of residence	Luxembourg	0.51
	Belgium	0.12
	France	0.31
	Germany	0.1
Socio-demographic characteristics	man	0.49
	woman	0.48
	children(no)	0.45
	children(yes)	0.54
	Age (<=30)	0.53
	Age(>30)	0.47
Commuting mode choice	Car	0.47
	public transports	0.44
	Soft modes	0.19

The interesting fact is that this dissimilarity is consistent for all three cross-border countries. The quality of the commuting alternatives (expressed by the Logsum value) is far lower, mainly for Germany and Belgium, than the ones of Luxembourgish residents but cross-borders are, on average, "happier" with respect to their resident colleagues. One hypothesis that could be made is that, by stating their general satisfaction, cross-borders workers included other non-travelling related elements such as the advantage of living in their own country (where housing is significantly cheaper), while earning higher Luxembourgish salaries. Similar reasoning is probably applicable for soft modes users who have stated higher satisfaction levels than expected compared to their Logsum value (leading to lower correlation index value). In this case, elements such as the pleasure of being outside, self-contentment of doing a physical activity or having a sustainable behaviour, etc. could have influenced their answers. However, due to a low number of soft modes users this result has to be interpreted with caution.

6. Conclusion and policy implications

This paper focused on confirming the relation between Random Utility Maximization Logsum and commuting mode choice satisfaction. While random utility theory assumes a perfect correlation between decision utility and remembered utility, some empirical experiments (e.g. Kahneman et al., 1997) showed that the two concepts were in fact different. The discrepancy between ex-ante and ex-post utility evaluation has already been discussed (Abou-Zeid & Ben Akiva, 2012; Ettema et al., 2010; Chorus and de Jong, 2011). However, with the exception of Chorus (2012), the quantification of this difference has received almost no attention from researchers. The importance of this analysis is to assess whether the utility-based satisfaction measure, which is quantifiable, can be a proxy of the travellers' commuting satisfaction, and hence be used for predicting the impact of changes in accessibility, the introduction of new transport services and in general for assessing different TDM strategies.

The travellers' satisfaction responses were collected using a conventional travel survey. These measurements were then correlated with the Logsum that was computed based on parameter estimates obtained from an MNL model. Compared to Chorus (2012) who used stated preferences data and obtained low correlations (between 0.155 and 0.203), our results show that the multiple correlation coefficient in our dataset is significantly higher (0.48). This seems to be in line with Ettema et al. (2010) who formulate the hypothesis that for repeated choices such as commuting, remembered utility will be, after some time, related to decision utility. The Logsum is indeed a good measurement of the satisfaction level but, in our opinion, it is still not fully capable of reproducing the stated satisfaction.

After observing that, at the aggregated level, Logsum and stated commuting satisfaction levels are positively associated, in-depth analysis has shown strong variations among respondents' categories. While association indices are rather stable among socio-demographic classes, this is not anymore the case for the different country of residence and commuting mode choice. Being a resident or not affects the correlation indexes considerably. The cross-border workers having lower Logsum values indicated average satisfaction levels. It seems that, for them, satisfaction is not only related to the trip in itself but also in other elements such as the benefit of living in their own country and having a Luxembourgish salary.

This is also confirmed by the results of the MNL model. Indeed, results show very similar parameters values for PhD students and Professors. However, the ASCs, which represent effects not directly captured by the systematic component, highlight how the car is the most preferred mode. This could be connected with some residential aspects such as the accessibility to public transport infrastructure or, for example, the inability to cycle for very long distances. The introduction of these types of attributes will be object of future research study.

According to Ettema et al. (2010) the goal of policy makers and practitioners should be that of increasing travellers' satisfaction. As shown in this study, decision utility and people evaluations' of their trips do not fully coincide; as a consequence, using standard cost-benefit analysis might be complex from the point of view of policy makers. In addition to classical variables such as travel time, travel cost, number of interchanges, etc. policy makers could systematically take into account soft variables such as comfort, cleanliness, noise level, etc. Kahneman et al. (1997) mentioned that the peak-end rule was, for instance, introducing bias in the evaluation of experience toward the most intense and the end of the considered event. This is particularly interesting regarding the implementation of sustainable transport policies. For instance, when using public transport important delays, strikes and overcrowded services might affect travellers' appreciation more sharply than a high ticket cost. Reliability and consistency in public transport service should constitute important goals of mobility providers. In addition, because the end of the trip (commuting trip or not) will play an important role in the way public transport users evaluate their experience, efforts have to be made to avoid long waiting times (due to red lights, bus bunching, etc.) close to major workplace areas.

Similarly to what Abou-Zeid and Ben-Akiva (2012) suggested for household travel surveys, systematically collecting satisfaction for the travel alternative within cross-sectional travel surveys is a must. The University of Luxembourg, when implementing travel surveys, is adding a single question regarding the home-to-work trip satisfaction. Considering that decision and remembered utility do not totally coincide and that, as pointed out by Ettema et al. (2010), the goal of policy makers is to increase travellers' satisfaction, it is important to collect information on individual trips' satisfaction.

Possible future research directions include: the development of metrics fully capable to reproduce the stated satisfaction; the estimation of the parameters (in the utility function) through a Nested logit and how they could reflect on the Logsum and consequently in the correlation with satisfaction.

Acknowledgements

This research has been funded by the Luxemburgish FNR ("Fonds National de la Recherche") through an AFR grant for the STABLE project (7951609), and by the EU Marie-Curie funded project InCoMMune (618234). The authors are grateful to Dr. Marco Rinaldi for his valuable comments.

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Appendices

Appendix A. Key Figures

Socio-demographic information					
Male	42%		Professors or researchers	41%	
PhD students	16%		Technical or administrative position	43%	
Average age	39.5		Presence of kids younger than 12 in the household	37%	
Mode choice					
	Total	Belgium	France	Germany	Luxembourg
Car	55%	71%	52%	58%	54%
Public transport	39%	29%	48%	42%	37%
Soft modes	6%	0%	0%	0%	10%
Mode availability					
	Total	Belgium	France	Germany	Luxembourg
Car	76%	86%	90%	73%	73%
Public transport	96%	93%	95%	86%	100%
Soft modes	44%	0%	9%	0%	69%
Travel distances and time					
	Minimum	Maximum	Average	Standard Deviation	
Distance (km)	0.2	167.2	29.3	25.4	
Traveling time (min)	1.0	138.5	46.1	25.1	
Work position					
	Total	Belgium	France	Germany	Luxembourg
Technical or administrative position	43%	64%	69%	37%	36%
PhD students	16%	14%	9%	23%	16%
Professors or researchers	41%	21%	22%	40%	48%
Satisfaction level					
Average Satisfaction level:		2.7 (out of 4)			
Mode of the satisfaction level		Satisfied			
Satisfaction level by mode					
		Car	Public transport	Soft modes	Total
Very unsatisfied		13%	5%	0%	9%
Unsatisfied		33%	28%	0%	29%
Satisfied		38%	56%	27%	44%
Very satisfied		16%	11%	73%	18%

Appendix B. Full ANOVA results

		Estimate	Std. error	t value	Pr.	MultipleR squared	Multiple Correlation coefficient
PHD	Intercept	2.8756	0.4097	-7.019	1.31e-09 ***	0.22	0.46
	Sat2	0.7407	0.5018	1.476	0.1445		
	Sat3	0.8872	0.4769	1.86	0.0672		
	Sat4	2.671	0.6314	4.23	7.15e-05 ***		
PROF	Intercept	2.8556	0.4067	-7.021	4.53e-11 ***	0.26	0.51
	Sat2	0.4358	0.4569	0.954	0.341396		
	Sat3	1.6419	0.4311	3.809	0.000193 ***		
	Sat4	2.5076	0.4605	5.445	1.71e-07 ***		
ADMIN	Intercept	-2.935	0.3111	-9.435	< 2e-16 ***	0.24	0.49
	Sat2	0.4141	0.35	1.183	0.2382		
	Sat3	0.741	0.3445	2.151	0.0328 *		
	Sat4	2.3567	0.3894	6.053	7.95e-09 ***		
LUX	Intercept	2.0475	0.2762	-7.414	1.65e-12 ***	0.26	0.51
	Sat2	0.4704	0.2972	1.583	0.11461		
	Sat3	1.0998	0.2855	3.852	0.000147 ***		
	Sat4	1.7486	0.2929	5.97	7.60e-09 ***		
BE	Intercept	2.2078	0.7796	-2.832	0.00922 **	0.01	0.12
	Sat2	0.4116	0.8269	-0.498	0.62313		
	Sat3	0.3942	0.8619	-0.457	0.65151		
	Sat4	0.7177	1.3503	-0.532	0.59992		
GE	Intercept	3.7664	0.3253	-11.579	<2e-16 ***	0.01	0.1
	Sat2	0.145	0.3984	0.364	0.717		
	Sat3	0.0786	0.3945	0.199	0.843		
	Sat4	0.7677	0.9758	0.787	0.434		
FR	Intercept	-2.486	0.3219	-7.723	2.77e-10 ***	0.01	0.31
	Sat2	0.2201	0.3971	-0.554	0.5817		
	Sat3	0.4311	0.4035	-1.068	0.2902		
	Sat4	1.4282	0.8517	1.677	0.0993 .		
CAR	Intercept	-2.7839	0.2351	-11.843	< 2e-16 ***	0.22	0.47
	Sat2	0.6608	0.2769	2.386	0.0178 *		
	Sat3	1.2785	0.2718	4.704	4.33e-06 ***		
	Sat4	2.2966	0.3132	7.333	3.48e-12 ***		
PT	Intercept	-3.3294	0.4889	-6.811	1.70e-10 ***	0.2	0.44
	Sat2	0.4111	0.528	0.779	0.4373		
	Sat3	1.3148	0.5088	2.584	0.0106 *		
	Sat4	2.6154	0.5875	4.451	1.56e-05 ***		
SOFT	Only Sat3 and Sat4 are present					0.36	0.19
	Intercept	-0.3295	0.2891	-1.14	0.266		
	Sat4	0.3184	0.3382	0.941	0.356		
Male	Intercept	-2.6873	0.3763	-7.141	2.15e-11 ***	0.24	0.49
	Sat2	0.2303	0.4309	0.534	0.5937		
	Sat3	0.9502	0.4061	2.339	0.0204 *		
	Sat4	2.3093	0.4346	5.314	3.11e-07 ***		

Female	Intercept	-3.0126	0.263	-11.455	< 2e-16 ***	0.23	0.48
	Sat2	0.6106	0.3	2.035	0.0429 *		
	Sat3	1.3166	0.2913	4.519	9.60e-06 ***		
	Sat4	2.536	0.3443	7.365	2.59e-12 ***		
With KIDS	Intercept	-2.8762	0.3251	-8.846	1.72e-15 ***	0.29	0.54
	Sat2	0.1672	0.3764	0.444	0.65753		
	Sat3	1.1216	0.3664	3.061	0.00259 **		
	Sat4	2.4261	0.4023	6.03	1.12e-08 ***		
No KIDS	Intercept	-2.911	0.289	-10.071	< 2e-16 ***	0.21	0.45
	Sat2	0.6741	0.3273	2.06	0.040371 *		
	Sat3	1.2165	0.3122	3.897	0.000123 ***		
	Sat4	2.5076	0.3527	7.11	1.02e-11 ***		
Age (<=30)	Intercept	-2.7916	0.4959	-5.63	2.98e-07 ***	0.28	0.53
	Sat2	0.4374	0.5636	0.776	0.4401		
	Sat3	1.007	0.5474	1.84	0.0698 .		
	Sat4	2.5182	0.5945	4.236	6.40e-05 ***		
Age (>30)	Intercept	-2.9186	0.2414	-12.089	< 2e-16 ***	0.22	0.47
	Sat2	0.4818	0.2761	1.745	0.0818 .		
	Sat3	1.2186	0.2641	4.615	5.51e-06 ***		
	Sat4	2.4441	0.299	8.175	5.29e-15 ***		
FULL SAMPLE	Intercept	-2.8958	0.2162	-13.396	< 2e-16 ***	0.24	0.48
	Sat2	0.4745	0.2469	1.922	0.0553 .		
	Sat3	1.1819	0.2368	4.991	8.69e-07 ***		
	Sat4	2.473	0.2653	9.321	< 2e-16 ***		