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INCORPORATING NEEDS-SATISFACTION IN A DISCRETE CHOICE MODEL OF LEISURE ACTIVITIES

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ABSTRACT
In this paper we extend the behavioural scope of discrete choice models for leisure activity-travel choices. More specifically, we investigate to what extent choices for leisure activities and related travels are driven by the satisfaction of needs. In addition to conventional attributes (such as activity costs), our regret based discrete choice model incorporates latent variables representing the anticipated level of individual needs-satisfaction by a particular leisure activity. The latent variables are calibrated with the help of subjective indicators of needs-satisfaction associated with the leisure activities. Results show that needs-satisfaction allows us to decompose a substantial share of the unobserved heterogeneity in leisure activity-travel decisions across respondents. Identifying the structural drivers of anticipated needs-satisfaction also enables a better prediction of leisure activity choice.

Keywords: Leisure activities, Needs-satisfaction, Hybrid choice models, Bayesian modelling

1. INTRODUCTION

Recent work in this journal (e.g. Ettema and Schwanen, 2012; Ettema and Zwartbol, 2013) stresses the importance of increasing our understanding of factors determining leisure related travel. These studies highlight that (joint) leisure trips and related decisions regarding trip destinations are determined by more than personal characteristics and preferences. They argue that leisure activity participation should be analysed within the social network. Individual drivers of leisure trips, including the extent to which they satisfy individual needs (Tinsley and Kass 1978, Melamed et al. 1995, Tinsley and Eldredge 1995), should however not be neglected. Barnett (2013) acknowledges that both our personal characteristics and the (social) environment affect the way in which we spend our spare time. Given the context-sensitivity and complexity of leisure activity participation it comes as no surprise that Dillard and Bates (2011) conclude that limited (theoretical) consensus exists concerning what motivates our leisure decisions.

In this paper, we focus on individual `needs' (e.g. Arentze and Timmermans 2009) and related `satisfaction' (Tonn 1984a,b) as driving factors behind choices for leisure activities. Needs are conceptualised as an inherently dynamic factor developing over time and triggering activity participation. For example, the presence or absence of an individual's need for physical exercise is likely to drive the decision to visit the gym, go for a walk, or relax on the sofa. The notion of `needs' as covered by Arentze and Timmermans (2009) relates to ex ante levels of desire for e.g. physical exercise, socializing, and entertainment which drive decisions.[1] Conducting a leisure activity satisfies particular needs up to a certain degree and depending on the speed at which needs regenerate, activities are repeated or new activities are pursued. Tonn (1984a,b) builds on the same types of desires and stipulates individuals select leisure activities in order to satisfy their physiological, sexual-sensual and group belonging needs given a set of economic and time-geographic constraints.

Inter-temporal changes in needs, as a result of `needs-creation' and `needs-satisfaction', can only be studied by examining a panel of individuals over a longer period in time. Indeed, Arentze and Timmermans (2009) conduct a synthetic micro-simulation study over a period of 63 days. Most leisure related surveys, however, rely on one-off surveys (e.g. Nijland et al. 2010; Ettema and Zwartbol 2013) centred around a recent or hypothetical leisure choice. One-off surveys by definition provide a static representation of the driving needs and the potential of activities to satisfy those needs. In fact, when individuals are presented with multiple similar hypothetical leisure choices within the same survey, as would be the case in a stated choice experiment, the researcher is more likely to measure what we label as `long-term', 'stationary', or average needs and needs-satisfaction. That is, people who in general have a higher need for physical exercise are usually more likely to make active leisure choices in an attempt to satisfy that need, whereas people with high needs for socializing might visit a bar more frequently.[2]

[1] The notions of `needs' and `needs-satisfaction' are conceptually different from the ex post evaluation of satisfaction as studied in the satisfaction-related literature (e.g., Ettema et al. 2012; Pedersen et al. 2011). The former relates to desire, whereas the latter can best be described as evaluating whether a particular leisure activity lived up to the a priori expectations.

[2] Since these hypothetical choices typically do not relate to a leisure activity that will instantly satisfy an individual's present needs, individuals are more likely to decide based upon their long-term (or stationary) needs and preferences. Alternatively, needs-satisfaction can also be interpreted based on the (constant) level of needs existing at the time of the survey. Within a specific socio-economic group some respondents will be above and some will be below their average needs, at the specific moment in time the survey was filled out. These variations are likely to cancel out within the socio-economic group due to asymmetric developments in needs over time across the respondents. Accordingly, the model is able to identify through the structural equation (see

The primary goal of this paper is to show that anticipated needs-satisfaction arising from leisure activity participation forms an important explanatory variable in selecting leisure activities. Specifically, the inclusion of anticipated needs-satisfaction forms a relevant behavioural extension to discrete choice models of leisure activity choice.

We define anticipated needs-satisfaction as a latent construct potentially driving leisure activity participation in addition to standard explanatory variables, such as accessibility and socio-economic characteristics. Tinsley and Kass (1979) already acknowledged that needs are inherently latent constructs. Its latent nature implies that, in contrast to standard explanatory variables, variations in individual needs and anticipated needs-satisfaction across individuals and leisure activities cannot be directly observed. A related goal of this paper is to deal with certain methodological challenges surrounding the inclusion of latent constructs, such as anticipated needs-satisfaction, in a discrete choice model of leisure activity choice. We infer about this latent construct through its impact on observed choices in a stated choice experiment, and through a series of subjective `needs-satisfaction' statements based on Nijland et al. (2010).

To properly represent the latent nature of needs-satisfaction and the correlation it introduces between the observed leisure choices and responses to the subjective needs-satisfaction statements, we develop a structural equation model (SEM). SEMs are common practice in mathematical psychology in relating a series of indicators to psychometric constructs (e.g. Song and Lee 2012). Recently, SEMs have been introduced in the discrete choice modelling literature to allow for the inclusion of latent constructs as explanatory variables of choices and are also known as hybrid choice models or integrated choice and latent variable models (ICLV) (e.g., Walker & Ben-Akiva, 2002; Bolduc et al. 2005). The choice model applied in this paper is that of Random Regret Minimization (Chorus, 2010), which is a regret minimization based counterpart of the conventional Random Utility Maximization model. This choice for the regret based approach was based on empirical performance (model fit and out of sample predictive ability) of the regret and utility based approaches, on our data.

The ICLV model deals with measurement error as a result of the subjective needs-satisfaction statements being imperfect measures of latent anticipated needs-satisfaction. Moreover, it accounts for the possible existence of a spurious relationship between socio-economic characteristics and leisure activity participation. That is, socio-economic characteristics may explain leisure choice both directly and indirectly by explaining variations in latent needs-satisfaction. The ICLV model should thus be preferred over the direct inclusion of the subjective needs-satisfaction as explanatory variables in the choice model.

In the developed model, both the stated activity-travel choices and subjective statements on activity specific needs-satisfaction are treated as a set of dependent variables which are linked by means of the latent needs-satisfaction terms, which in turn have a set of explanatory variables of their own. This set of explanatory variables enables the researcher to identify the driving factors of needs-satisfaction, which might be used to generate more accurate predictions of future decisions. One of the main advantages of the proposed approach is its ability to decompose otherwise unobserved heterogeneity in activity-specific utility into variation of utility that is associated with the anticipated needs-satisfaction, and other factors. We study the role of needs-satisfaction in the context of a stated choice survey on leisure trips selected by elderly people.

Section 2.3) whether some socio-economic group generally has a higher or lower level of anticipated needs-satisfaction than other socio-economic groups.

Overall, this results in a methodological paper enabling researchers to study the driving factors behind needs-satisfaction of leisure trips, including the role of geography-related factors. The structure of the paper is as follows. Section 2 discusses how subjective ratings of need-satisfaction can be incorporated in an integrated choice and latent variable modelling framework based on the random regret framework. Section 3 presents the data collection effort. The empirical analyses (model estimation and validation) are discussed in section 4. Section 5 wraps up with conclusions and a discussion of our findings.

2. A ICLV MODEL ACCOUNTING FOR NEEDS-SATISFACTION

This section describes the proposed hybrid choice, or integrated choice and latent variable model (ICLV) linking subjective statements regarding needs-satisfaction to the responses in a stated choice experiment. The ICLV structure can be decomposed into a regret-based choice model, a measurement model and a structural equation (e.g. Bolduc et al. 2005).

2.1 The choice model

In each scenario of the stated choice survey, individual n is presented with a set of possible leisure activities J. The individual is requested to select his/her most preferred leisure activity and is subsequently presented with a sequence of T similar choices. The presented leisure activities in this paper differ in terms of their accessibility characteristics such as travel time, travel cost and activity costs.

The typical way to analyse these stated choices in a Random Utility Maximisation (RUM) framework (McFadden 1974) is to assume that the individual selects the activity generating the highest level of utility. As an alternative, the Random Regret Minimisation (RRM) model assumes individuals select the activity associated with the lowest level of regret (Chorus 2010).[3] In this study, we hypothesize that the regret attributed to a specific leisure activity not only varies due to differences in accessibility characteristics X, socio-economic characteristics Z, but also due to the extent to which the leisure activity has the ability to satisfy our needs S. The main difference between S and X, Z is that S is not directly observable to the researcher. We can only imperfectly measure anticipated needs-satisfaction through an additional set of subjective statements. The latent nature of S forces us to incorporate the choice model into a structural equation model, of which the measurement model and structural equation are discussed in sections 2.2 and 2.3. For ease of explanation, assume the level of anticipated needs-satisfaction S_{ni} is observed and varies across individuals n and activities i in the remaining of this subsection.

Let R_{nit} in (1) denote the deterministic level of regret individual n derives from activity i in choice task t. Regret arises because a particular leisure activity is outperformed by another leisure activity on a (or more) characteristics. For example, because it is further away or the activity's costs are higher.[4] In (1), M different accessibility characteristics x_{nimt} are included, each associated with regret parameter β_m. Note that the experimental design ensures the

[3] We only present results for the RRM model specification, which was selected as the best fitting model. To our knowledge, this paper presents the second application of the RRM framework in an ICLV setting (see Hess and Stathopoulos, 2012 for another example). Moreover, it also is the first time the RRM model is estimated using Bayesian methods.

[4] In our case, we only look into regret arising due to differences in accessibility characteristics. After empirical testing of various model specifications, it was decides to treat alternative specific constants and anticipated needs-satisfaction in the standard RUM fashion using α_{ni}, S_{ni} and Z_{ni}. This is also known as a Hybrid RUM-RRM model (Chorus et al., 2013). For an interpretation of the β parameters see Chorus (2010).

accessibility characteristics vary across individuals, leisure activities and choice tasks. Attribute level-regret is defined by: $R^{m}_{nit\leftrightarrow njt} = \ln\left(1+\exp\left[\beta_m \cdot \left(x_{njmt} - x_{nimt}\right)\right]\right)$, where the difference in x represent differences in accessibility characteristics. Here we take costs as an example. The non-linearity of the function implies that regret of activity i is close to zero when activity j performs (much) worse than i , i.e. when j is (much) more expensive than i. In the opposite case when i is much more expensive than j, regret increases almost linearly in the costs of i. Such binary comparisons are made between all available leisure activities on all accessibility characteristics. Deterministic regret is in turn conceived to be the sum of all so-called 'binary regrets', i.e. $R_{nit} = \sum_{j\neq i}\sum_{m=1}^{M} \ln\left(1+\exp\left[\beta_m \cdot \left(x_{njmt} - x_{nimt}\right)\right]\right)$.

(1) $$RR_{nit} = R_{nit} + \varepsilon_{nit} = -\left(\alpha_{ni} + \tau_i S_{ni} + \sum_{a=1}^{A}\theta_{ai} z_{na}\right) + \sum_{j\neq i}\sum_{m=1}^{M} \ln\left(1+\exp\left(\beta_m\left(x_{njmt} - x_{nimt}\right)\right)\right) + \varepsilon_{nit}$$

In (1), α_{ni} represents a constant measuring the average regret derived from an activity after controlling for all other factors. This generic level of regret is assumed to vary across individuals and is modelled in the form of a set of normally distributed random parameters with underlying mean μ_i and standard deviation σ_i.[5] The anticipated impact on needs (i.e. degree of needs-satisfaction) of a particular alternative S_{ni} varies across individuals and leisure activities. We assume the impact this has on regret is measured by the parameter τ_i which varies across leisure activities. Since we are working with hypothetical choices for leisure activities we currently do not take into account the inter-temporal dynamics of S_{ni}, but assume we are measuring a long-term (or at least static) impact on needs associated with a leisure activity. The presented model structure can be adapted to situations where real-world data are available on actual choices and stated needs-satisfaction on multiple occasions (see for example Dekker et al., 2013). The socio-economic characteristics z_{na} only vary across individuals, hence the subscripts na, where a refers to a specific socio-economic characteristic. Their impact on regret is measured by the parameter θ_{ai}. Finally, ε_{nit} represents an independently and identically distributed error term covering all non-modelled elements affecting leisure choice. (2) then describes the associated multinomial logit model choice probabilities of the RRM model when assuming that the negative of ε_{nit} is i.i.d. Extreme Value Type I-distributed.

(2) $$P\left(Y_{nt} = i \mid S_{ni}\right) = \frac{\exp\left(-R_{nit}\right)}{\sum_{j=1}^{J}\exp\left(-R_{njt}\right)}$$

The typical discrete choice model would not include S_{ni} as an explanatory variable. Accordingly, the heterogeneity in the level of needs-satisfaction would be accounted for by the alternative specific constant α_{ni} and its associated parameters μ_i and σ_i. Of interest to this paper is the comparison between regret-based choice models (not) including $S_{ni,}$ and the potential to attribute the unobserved heterogeneity in the alternative specific constant to the anticipated impact on needs associated with a particular leisure activity.

[5] An alternative interpretation of this random alternative specific constant is the use of an error components model introducing correlation across the alternatives. Following Walker et al. (2007) we normalize the activity with the smallest standard deviation.

If we find significant τ_i parameters at the expense of changes in μ_i and (or) σ_i, then accounting for needs-satisfaction forms a relevant behavioural extension of the RRM framework. Specifically, τ_i traces the marginal impact of needs-satisfaction on regret and higher (positive) values indicate the importance of (latent) anticipated needs-satisfaction on leisure activity participation. Identification of τ_i, i.e. the impact of anticipated needs-satisfaction, is ensured due to the inclusion of the subjective-statements on anticipated needs-satisfaction and the expected correlation between the observed choices and these statements.

2.2 The measurement model

In the choice model we infer through the τ's about the extent to which (latent) anticipated needs-satisfaction drives the selection of leisure-type of activities. The challenge is to measure the S_{ni}, i.e. the level of anticipated needs-satisfaction across activities and individuals. A first strategy could be to directly ask the respondents about the degree of need-satisfaction associated with leisure activity i. The latter strategy would, however, leave the researcher faced with the question of what drives these differences in anticipated needs-satisfaction apart from variations in socio-economic characteristics across respondents. Accordingly, we take an alternative approach and elicit the extent to which activity i satisfies `need type' k of individual n. Physical activity is an example of such a need type which can be satisfied by leisure activities. Section 3 describes the K alternative need types included in this paper. Their degree of needs-satisfaction is elicited for each activity separately. Responses I_{nik} to these needs-satisfaction indicators questions are provided on an ordinal (Likert) scale with G response categories and constitute the second set of dependent variables in the ICLV model.

It is worth noting that the indicators do not directly measure need-satisfaction. Rather, they indicate instrumentality, i.e. the potential of the activity to satisfy a particular need. Although this does not provide a direct measure of the strength of the underlying need, the estimated parameter τ that maps the anticipated level of needs-satisfaction onto the regret of an activity captures the importance of the need for participating in an activity in the decision.

A statistical model is required linking S_{ni} to I_{nik}. We specify this so-called measurement model using an ordered probit model given the ordered nature of the responses I_{nik} (see Daly et al. 2011) and for computational convenience in our Bayesian estimation procedure. Equation (3) describes a relationship between S_{ni} and I_{nik}^*, where I_{nik}^* represents a mapping of I_{nik} on a continuous scale, such that a respondent will select $I_{nik} = g$ when I_{nik}^* falls between thresholds ψ_{g-1} and ψ_g. The basic assumption that more positive responses to I_{nik}, i.e. a higher level of instrumentality or strength of the underlying need type, are observed when latent anticipated needs-satisfaction S_{ni} increases is represented by the case $\zeta_{ik}>0$.

$$I^*_{nik} = \gamma_{ik} + \zeta_{ik} S_{ni} + \upsilon_{nik} \tag{3}$$

Equation (3) merely accounts for the likely presence of measurement error in I_{nik}. The structural equation introduced in the next subsection accounts for variations in anticipated needs-satisfaction across respondents and leisure activities. The reason we include a single latent needs-satisfaction term per activity rather than a unique latent term for each need type per activity is that we present the respondents with a limited set of distinct activities (being a museum visit, an outdoor concert or a nature walk). The limited variation in activities would hamper identification of the impact of the instrumentality of the alternative need types per activity. As such, the ζ's capture the correlation between the instrumentality of a leisure activity to satisfy a need type and the overall degree of anticipated needs-satisfaction.

2.3 The structural equation

Anticipated needs-satisfaction thus affects leisure activity decisions and can be measured indirectly through a set of indicators. In this subsection we connect the choice model and the measurement model by defining the structural equation which completes the ICLV model. The structural equation defines what drives variations in anticipated needs-satisfaction across individuals and leisure activities S_{ni}. Changes in the structural equation impact both model components since S_{ni} is an explanatory variable in both. Effectively, the researcher learns about the factors driving the anticipated impact on needs of a particular leisure activity indirectly through the observed choices and more directly through the subjective statements (indicators).

A structural equation is established for every activity i (see Equation (4)), where socio-economic characteristics Z^*, not necessarily equal to Z in (1), explain the heterogeneity in anticipated needs-satisfaction for activity I across individuals. All un-modelled heterogeneity is comprised in the normally distributed error term η_{ni}.

(4) $$S_{ni} = \delta_i Z_n + \eta_{ni}$$

2.4 Model structure and a note on estimation

The structure of the ICLV model is summarized by Figure 1. Figure 1 is based on the empirical application as described in Section 3. The oval shapes in Figure 1 cover the observed explanatory variables included in the choice model and the structural equations. The rectangles denote latent anticipated needs-satisfaction S_{ni} for the three activities. The diamond shapes represent the dependent variables, where the indicators are included in the measurement model and the choices in the choice model. The arrows summarize the modelled relationships and illustrate the connecting function of S_{ni}. Note that the terms ‘Museum’, ‘Concert’ and ‘Nature’ refer to the three types of leisure activities that were considered in the Stated Choice experiment (as elaborated in more detail in the next section). Details about the associated likelihood function, required normalizations, and Bayesian estimation framework are available upon request from the corresponding author.

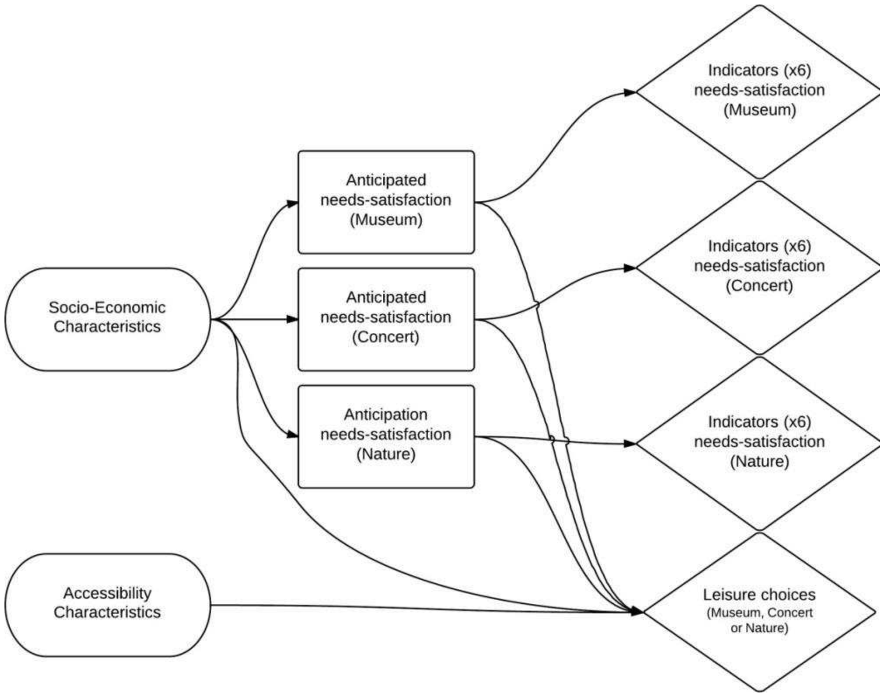

Figure 1: Summary of the model structure

3. DATA-COLLECTION

The data collection effort focused on activity-travel choices made by elderly (a minimum age limit of 60 years was used in the sampling process). A total of 498 people were approached by an internet panel maintained by IntoMart in October 2011 (a 61% response rate resulted in 302 filled out surveys). Care was taken to ensure that the sample was representative of the elderly segment of the Dutch population in terms of gender, age and education level. For all respondents, car was available as a travel mode.

Respondents to the survey were first asked to rate three leisure-activities in terms of the extent to which performing the activity would satisfy a set of potential types of need. The activities were 'Going to a museum', 'Visiting an outdoor-concert', and 'Taking a walk in a nature area'.[6] In an empirical study into motivations underlying leisure activity choice of individuals, Nijland et al. (2010) found that 6 specific need dimensions could explain leisure activity choice considering a wide range of leisure activity types. The 6 dimensions they found include need for physical exercise, need for socializing, need for relaxation, need for being outdoors, need for new experiences, and need for entertainment. Hence, we used these 6 dimensions as potential needs in the experiment. Responses were given on a five-point Likert scale ranging from 'The activity does not satisfy the need at all' to 'The activity completely satisfies the need'. For example, an arbitrarily chosen rating-question read as follows: "Please indicate for the activity 'Going to a museum' to what extent you feel that this activity satisfies a need for relaxation.".

Subsequently, respondents were asked to imagine the hypothetical situation where they were planning a leisure activity on an afternoon. No further contextual information was provided to respondents, in an attempt to arrive at a maximum level of generic applicability of results. This absence of contextual information has the potential disadvantage of compromising the ability of respondents to identify with the hypothetical choice situations – although it should be noted here that our empirical results suggest that has not been the case in our data

[6] For each of the activities, respondents were free to imagine a specific destination according to their own taste.

collection effort (as all empirically identified relations are intuitive). Respondents were asked to choose between the three different activity-types discussed above (Museum, Outdoor concert, Nature walk). These activities differed in terms of the four attributes: total door-to-door travel time (i.e., to and from together) by car (30, 60, 90 minutes), total travel costs (€5; €10; €15), activity costs (€0; €7.5; €15), and the opportunity to eat or drink something at the activity-location (no; yes, but no seats available; yes, with seats available). Importantly, the choice scenarios did not show respondents their own subjective ratings of the extent to which particular activities satisfied particular needs so as to avoid artificially increasing the salience of these need-satisfaction statements.

The Ngene-software package (ChoiceMetrics, 2009) was used to generate a so-called ‘optimal orthogonal in the differences’-design to ensure a statistically efficient data collection. This design resulted in nine choice tasks per respondent and 2,538 choice observations (282 respondents) in total. Figure 2 shows one of these tasks.

	Museum visit	**Concert visit**	**Nature walk**
Total travel time (minutes)	30	60	90
Total travel costs (euros)	€10	€5	€15
Total activity costs (euros)	€7,5	€15	€0
Opportunity to have something to drink or eat	no	Yes, but no seats available	Yes, seats available
YOUR CHOICE	□	□	□

FIGURE 2: Example of a choice task

4. EMPIRICAL ANALYSIS

We first look at anticipated needs-satisfaction ratings in isolation. There appears to be a non-trivial amount of variation across activities in terms of the satisfaction of particular needs, and across different needs in terms of the extent to which they are satisfied by performing different activities. Results are fairly intuitive: for example, the activity ‘Walk in nature’ scores higher than the other activities in terms of satisfying the need to be outdoors and in terms of satisfying the need for physical exercise, while the activity ‘Outdoor concert’ scores higher than the other activities in terms of satisfying the need for entertainment. When considering going to a museum, respondents anticipate that the need for relaxation will be more satisfied than any other of the six mentioned needs.

Fifteen out of eighteen standard deviations are larger than 1, which can be considered an indication of considerable variation across respondents in terms of their subjective ratings of need-satisfactions for given combinations of needs-activity types. This in turn suggests that if there are effects of increased need-satisfaction on the popularity of an activity, these effects can be recovered in the process of model estimation.

4.1. Estimation results

A sample of 225 respondents (80%) is used for estimation, while the remaining 57 respondents (20%) are retained for model validation purposes in Section 4.2 Table 1 presents the results for the Hybrid RUM-RRM choice models (not) accounting for needs-satisfaction. Models 1 and 2 respectively describe the MNL model and introduce unobserved heterogeneity in the alternative specific constant (ASC) across respondents.[7] Socio-economic characteristics are accounted for by interacting the variables Male and Age with the ASCs for concert and nature.

The accessibility characteristics in the MNL models confirm expectations, namely that activities become less attractive when becoming less accessible, i.e. longer travel times and higher travel and activity costs. Responsiveness towards travel costs is, however, not as strong as to activity costs. Although this is likely to be partly due to the fact that the used range for activity costs was larger than that for travel costs (€15 versus €10), the observed difference in cost sensitivity is somewhat unexpected. There appears to be no particular preference for having the opportunity to eat or drink something at the activity location, except when there is also an opportunity to sit down while eating or drinking. The importance of seat availability may be specifically related to the age group targeted by the survey (the elderly). The inclusion of socio-economic characteristics Male and Age in the utility function only reveals that the probability of selecting a walk in nature or visiting an outdoor concert decreases as people become older. This is not surprising as a museum visit is physically less demanding than the other two leisure activities. Despite the age effect, respondents reveal a higher preference, all else being equal, for going to an outdoor concert or, especially, for visiting a nature park.

A closer examination of the deterministic MNL regret levels, based on the parameter estimates, reveals that besides the accessibility characteristics many other factors play a role in choosing a leisure activity. That is, the ASCs determine the regret levels to a large extent. The random ASCs introduced in Model 2 account, amongst other things, for needs-satisfaction by allowing the average level of regret of an activity to vary across individuals and activities. Not surprisingly, substantial heterogeneity is detected with standard deviations exceeding their associated means. Some people prefer museums over walking in nature or going to an outdoor concert, and vice versa. Compared to Model 1, the introduced heterogeneity results in a decisive improvement in model fit (Kass & Raftery, 1995).[8]

[7] Unobserved heterogeneity was also introduced in the sensitivities to the accessibility characteristics, but this did not translate into large improvements in model fit.

[8] Model fit is evaluated using the method of Gelfand and Dey (1994).

	Multinomial Logit (1) HYBRID RUM-RRM		Random Parameters Logit (2b) HYBRID RUM-RRM	
	Post. Mean	Post st. dev	Post. Mean	Post st. dev
Travel Time	-0.006	0.001	-0.008	0.001
Travel Costs	-0.004	0.004	-0.005	0.004
Activity Costs	-0.015	0.003	-0.019	0.003
Food; no seats	0.033	0.061	0.039	0.068
Food and seats	0.406	0.056	0.504	0.064
Male x concert	0.172	0.122	0.171	0.182
Age x concert	-0.020	0.010	-0.019	0.015
Male x nature	0.222	0.114	0.242	0.222
Age x nature	-0.041	0.010	-0.053	0.018
mean_concert	0.156	0.095	0.082	0.141
mean_nature	0.647	0.091	0.685	0.173
stdev_concert	-		0.804	0.110
stdev_nature	-		1.345	0.116
Marginal likelihood	-2125.94		-2012.59	
Average fit LL	-2048.55		-1910.60	
Bayes Factor	-		113.35	
Obs	2025			
n	225			
T	9			

TABLE 1: Estimation results for basic multinomial and random parameter logit models

In the ICLV model (see Model 3 in Table 2), gender and age only affect leisure activity decisions indirectly through latent anticipated needs-satisfaction. Models 3 no longer supports a direct impact on regret through the interactions with the ASCs. The structural equations highlight that males experience a lower degree of needs-satisfaction from every activity. Age negatively affects the degree of needs-satisfaction associated with walking in nature. Again, this confirms the decreasing physical capabilities associated with ageing.

The τ parameters tracing the impact of anticipated latent needs-satisfaction in the choice model, are of the expected sign and reveal regret is decreasing in individual anticipated needs-satisfaction of a specific activity. The inclusion of the three additional parameters in the choice model primarily affects the ASC and its associated unobserved heterogeneity while hardly altering the parameters of the accessibility characteristics relative to Model 2. Needs-satisfaction explains a large share of unobserved heterogeneity for the 'walk in nature' activity. A decrease of 39.2% is observed for the standard deviation associated with the random ASC on walks in nature. Also a 37.8% reduction in the standard deviation associated with the random ASC on outdoor concerts is observed. Mean values are hardly affected. Overall, this decomposition of random heterogeneity confirms Arentze and Timmermans (2009) in that anticipated needs-satisfaction is an important driver of activity choices. The large responsiveness of 'walk in nature' to needs-satisfaction is not surprising given the high levels of average subjective needs-satisfaction reported for this activity.

Integrated Choice and Latent Variable Model

(3)

HYBRID RUM-RRM

Choice Model	Post. Mean	Post st. dev	**Measurement Model (ζ)**	Post. Mean	Post st. dev
Travel Time	-0.008	0.001	Museum		
Travel Costs	-0.005	0.004	Physical	0.796	0.132
Activity Costs	-0.019	0.003	Socializing	0.764	0.123
Food; no seats	0.038	0.068	Relaxation	0.692	0.119
Food and seats	0.509	0.064	Outdoors	0.777	0.149
Male x concert	0.208	0.220	New experiences	0.449	0.100
Age x concert	0.001	0.016	Entertainment	0.422	0.100
Male x nature	0.478	0.306			
Age x nature	0.020	0.030	Outdoor Concert		
mean_concert	0.096	0.151	Physical	0.450	0.110
mean_nature	0.696	0.178	Socializing	0.678	0.119
stdev_concert	0.500	0.104	Relaxation	0.780	0.128
stdev_nature	0.817	0.206	Outdoors	0.667	0.120
tau_museum	0.409	0.122	New experiences	0.697	0.119
tau_concert	0.693	0.121	Entertainment	0.643	0.118
tau_nature	1.063	0.184			
Structural Equation			Walk in nature		
Museum			Physical	0.610	0.134
Male	-0.657	0.201	Socializing	0.331	0.101
Age	0.018	0.016	Relaxation	0.559	0.121
Outdoor concert			Outdoors	0.573	0.138
Male	-0.450	0.204	New experiences	0.378	0.106
Age	-0.020	0.017	Entertainment	0.183	0.097
Walk in nature					
Male	-0.478	0.242			
Age	-0.062	0.024			
Marginal likelihood	-4756.80				
Average fit overall	-4149.16				
Average fit choice	-1913.21				
Obs	2025				
n	225				
T	9				

TABLE 2: Results of the Integrated Choice and Latent Variable Model

Moving to the measurement model, the ζs confirm that variations in overall anticipated needs-satisfaction across respondents also affect their individual (subjective) anticipated satisfaction of particular need types. The ordered probit nature of the measurement model requires us to look into the differences between the ζs for a specific activity rather than their absolute levels. For example, overall anticipated needs-satisfaction for walking in nature is highly correlated with the responses to the need for i) physical exercise, ii) relaxation and iii) being outdoors. Similarly, people with a high overall anticipated needs-satisfaction for outdoor concerts also have a high subjective rating for the need for relaxation and new experiences, but the anticipated satisfaction of the need for physical exercise shows less variability across respondents. Having a high utility for going to a museum shows limited correlation with the need for new experiences and entertainment. The latter can be explained given the high correlations with the utility for museum and the need types of relaxation and socializing. The positive influence of physical activity and the need to be outdoor comes as a surprise in this regard. It may, however, explain why the anticipated needs-satisfaction plays a limited role in the decision to go to a museum as revealed by the low value for the corresponding τ in the choice model. Evaluating the responses to the indicator variables confirms that on average museums have limited instrumentalities in satisfying the need for physical activity or to go outdoors. Moreover, museums provide on average a high satisfaction of the anticipated need for new experiences and entertainment.

The results imply that anticipated needs-satisfaction plays an important role in driving leisure decisions. The extension of the model by eighteen indicators and the estimation of a joint likelihood function precludes a formal comparison of fit relative to Model 2 (Vij and Walker, forthcoming). The conditionality of Equation (6) on augmented needs-satisfaction does however allow for a crude comparison in fit of the choice models. The ICLV model provides a slight reduction in model fit by controlling for needs-satisfaction. The latter is not uncommon in the ICLV literature. ICLV models evaluate the joint likelihood function rather than solely the observed choices. Moreover, decomposing the unobserved heterogeneity does not necessarily lead to a large improvement in model fit. The primary benefit of the ICLV model arises in the decomposition of the unobserved heterogeneity, providing a more natural behavioural representation for the observed activity choice patterns.

4.2. Model validation

In addition to comparing the different models in terms of model fit and parameter estimates (Tables 1 and 2), we also perform a validation exercise. That is, we re-estimate model specifications 2 (the random parameter logit model) and 3 (the ICLV model) on the smaller validation-sample. The draws from their respective Gibbs Samplers (GS) were used to derive choice probabilities and other measures of fit in the validation sample.[9] The conditional densities in the likelihood function of the ICLV model imply that choice probabilities can be predicted without relying on the responses to the needs-satisfaction indicators, another key advantage over methods using such responses as explanatory variables. Predicted choice probabilities can be contrasted directly between models 2 and 3, as well as in between models. An expected benefit of the ICLV model structure is that the explanatory variables in the structural equation for needs-satisfaction still provide additional information that may help in better predicting choices for specific activities. Based on our limited set of explanatory variables, we expect limited differences.

First, we examine the overall fit to the hold-out sample. At each draw of the GS, the overall log-likelihood of the choice model for the hold-out sample is calculated, which is subsequently averaged across the set of maintained draws (see Table 3). As expected, adding latent needs-satisfaction does not add much predictive power to our model. Second, we examine the variation in expected choice probabilities of the chosen activities in the hold-out sample (Table 3). The expected choice probability of the chosen activity is an indication of the ability of an estimated model to assign high choice probabilities to those alternatives that are in fact chosen; as such it constitutes a measure of predictive ability. The random

[9] MLHS draws (Hess et al. 2006) are applied to derive expected choice probabilities (at each draw of the GS).

parameter model provides a relatively more accurate prediction for some choices, while doing a poor job in predicting some other choices. The differences on average are, however, small across specifications and controlling for needs-satisfaction does not improve the model's predictive power to a large extent. These small differences are also confirmed by our third test based on the average hit-rate across model specifications.[10]

		Fit	Mean-prob of chosen alternative				Hitrate
		LL	mean	std	min	max	
Random parameter	Hybrid RUM-RRM	-493.23	0.3852	0.1429	0.0864	0.7286	0.4540
ICLV	Hybrid RUM-RRM	-491.78	0.3836	0.1357	0.1015	0.7021	0.4552
	obs	513					
	n	57					

Table 3: Predictive ability of the different choice models on a hold-out sample

5. CONCLUSIONS AND DISCUSSION

The notion of needs-satisfaction is intrinsically related to the concept of leisure travel activities. If the activity does not satisfy a particular need, individuals are unlikely to undertake it, including its associated journey. The inherently latent nature of needs and anticipated needs-satisfaction has been acknowledged throughout the literature on leisure activity participation (e.g. Tinsley and Kass, 1979). Typically, mathematical psychologists apply structural equation models to link indicators, in the form of subjective needs-satisfaction statements, to latent constructs and thereby identify the driving factors. In this paper, we develop a particular type of structural equation model, also known as a hybrid choice model, which apart from explaining heterogeneity in (latent) anticipated needs-satisfaction also enables researchers to study its impact on leisure activity-travel decisions.

The inclusion of anticipated latent needs-satisfaction in a choice model is a step forward from what, to our knowledge, has been done in the leisure modelling literature so far (e.g. Jun et al. 2012). For example, Chen et al. (2013) only measure the relationship between leisure motivation and leisure satisfaction in a structural equation model without modelling the actual decision. Leversen et al. (2012) ask about activity participation amongst adolescents, but treat it as an exogenous explanatory variable of the latent construct life satisfaction. We are aware of some studies (e.g. King et al. 2006) that use participation intensity as a dependent variable in structural equation modelling, i.e. how often do you undertake activity x per week. This appears to be a method mainly applied in medical sciences with little connection to the type of behavioural models applied in (transport) economics and geography. As such, the behavioural scope of traditional utility-based tourism and leisure activity-travel choice models is extended.

Using a stated choice-dataset involving hypothetical choices between leisure activities made by citizens of The Netherlands aged 60 and older, we contrast regret-minimisation based discrete choice models including and excluding the subjective measurements of need-satisfaction. Empirical results show that approximately 40% of the unobserved heterogeneity in the activity specific utility levels can be attributed to anticipated needs-satisfaction. Hence,

[10] The hitrate is obtained as follows: for each estimated model we identify, for each case in the validation sample, the alternative that is predicted by that model to be the most likely to be chosen (i.e., the one with highest predicted choice probability). If this alternative is in fact observed to be chosen, this is considered a 'hit' (coded as a 1). The average of this hit-variable across cases and draws in the validation sample is the hitrate.

it appears to be an important driver of individual decisions in this context. The close match between our findings and those of Barnett (2013) is remarkable. She finds that after controlling for personal characteristics, to which anticipated needs-satisfaction belongs, about 50-60% of inter-respondent variation in leisure activity participation is left unexplained. This is where the social environment is likely to come in, something currently not included in our model. Although the impact of social relations and group decision making process would require a reformulation of the choice model itself, we see no (theoretical) limitation to linking group decision making process to latent psychometric measures of individual leisure activity drivers such as needs-satisfaction. This, however, goes beyond the scope of this paper. Sharmeen et al. (2014) provide an illustration how structural equation modelling can be used to link dynamics in social networks to dynamics in activity and travel needs.

The benefits of the developed model primarily arise in generating a better understanding of the behavioural processes underlying leisure activity participation. It could be argued that drops in model fit and increases in predictive ability from the proposed decomposition are somewhat limited in our case. This is, however, not uncommon in the ICLV literature given that the unobserved heterogeneity is appropriately taken into account in our base model and we only have a limited set of variables explaining the driving factors of needs-satisfaction. Vij and Walker (forthcoming) proved that a hybrid model can never produce better fit than the corresponding reduced form model. We shouldn't be too much concerned about model fit in the estimation sample. In terms of policy, the key point is that hybrid models provide efficiency gains by using more data per person and thereby provide more robust estimates of the structural drivers of leisure activity participation, both directly and indirectly through an impact on anticipated needs-satisfaction. Understanding these (possibly spurious) relationships is useful for policy analysis as it allows the development of programs targeted at changing anticipated needs-satisfaction of, for example, visiting a museum. The simplicity of our structural equation precludes an extensive exploration of these predictive benefits. Nevertheless, Table 3 illustrates the ICLV model does increase our predictive abilities.

It would be particularly interesting to find out whether other datasets are able to better characterize the driving factors of latent needs-satisfaction, which is clearly limiting the predictive capabilities of the model presented in this paper. Better indicators of these drivers ensure that predicted choice probabilities become more deterministic rather than driven by unobserved heterogeneity. Currently, we only apply a composite needs-satisfaction term for each activity, but it would be of interest how the different need types directly influence decisions. As noted in the paper, this would require the use of a broader set of activities which are less distinct. In such decisions the role of a particular need type would become more apparent.

There are also limitations to our study. We have disregarded the temporal dynamics of `needs' and `satisfaction' as introduced into the transport geography literature by Arentze and Timmermans (2009) and Tonn (1984a,b). One-off stated preference surveys are unable to capture these dynamics since they do not follow a panel of individuals over a longer time, and because hypothetical choices do not satisfy real needs. We do believe that at least the importance of long-term anticipated (or stationary) needs-satisfaction in leisure activity participation can be partially captured in stated preference surveys. Leisure activity participation remains, however, a context-sensitive and complex phenomenon influenced by many different (latent) factors of which only one is included in our model. The selected modelling framework allows for such extensions, but eliciting multiple psychometric measures and social interactions is likely to put a heavy time and cognitive burden on respondents.

When the model is extended along those lines, the framing of the indicators of latent needs-satisfaction becomes more delicate. In our case, we interpreted the indicators as measures of instrumentality, which did not provide a measure of the strength of the underlying need. Although the two are likely to display large degrees of empirical confounding in our long-term perspective, this is not necessarily the case in short-term models allowing for temporal fluctuations in needs and related satisfaction levels.

The methodological framework provided by this paper enables researchers to study various interactions between needs-satisfaction and the accessibility characteristics of leisure activities. As such, it can be established in future research whether individuals are willing to travel further, or pay more, for activities which satisfy their needs to a larger extent. This would provide a close linkage with the work by Ettema and Zwartbol (2013). Additionally, it is important to investigate whether the results we obtained in the context of our data can be replicated in the context of other stated and revealed activity-travel choice data.

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