A Model of Travel Happiness and Mode Switching

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Abstract

In previous research (Abou-Zeid et al., 2008), we postulated that people report different levels of travel happiness under routine and non-routine conditions and supported this hypothesis through an experiment requiring habitual car drivers to switch temporarily to public transportation. This paper develops a modeling framework of travel happiness and behavior and tests the relevance of the two travel happiness measures to decision-making contexts. The framework consists of a standard mode choice model plus the two happiness measures used as indicators of utility. Using maximum likelihood and a simultaneous estimation technique, it is found that for the study sample utility correlates better with the happiness measure collected under routine conditions, but the non-routine happiness measure predicts choices better. The data description, model framework and results, and directions for future work are presented.
1. Introduction

The study of subjective well-being has been of prominent interest among psychologists and economists over the last few decades (Bruni and Porta, 2007; Camerer et al., 2003; Frey and Sutzer, 2002; Kahneman et al., 1999; Kahneman and Krueger, 2006; Van Praag and Ferrer-I-Carbonell, 2004). It has been argued that economic measures are not sufficient on their own as indicators of quality of life (Diener and Seligman, 2004). Many surveys have been conducted to measure life and domain satisfaction resulting in additional measures of the well-being of society (see, for example, DIW Berlin, German Institute for Economic Research, 2009; The ESRC United Kingdom Longitudinal Studies Centre, 2009; European Commission, 2008; National Opinion Research Center at the University of Chicago, 2009; World Values Survey, 2009). In the travel domain, and along the same lines, it can be postulated that travel choices, which are usually modeled using the concept of generalized cost, are more likely to be motivated by a broader goal of maintaining and enhancing travel well-being. Measuring and modeling travel well-being are needed to enhance travel behavior models and to better capture travel benefits.

In previous research (Abou-Zeid and Ben-Akiva, 2007), we measured travel and activity well-being through a cross-sectional survey of a web-based sample of commuters. We established evidence for the existence of relationships between travel well-being and behavior. In subsequent research (Abou-Zeid et al., 2008), we investigated the measurement of travel well-being in a way that accounts for the routine nature of travel. We postulated that when people are in a routine, they don’t engage in a cognitive process of fully evaluating their travel happiness. Only when people evaluate their options and reconsider their decisions will they carefully think of their travel happiness. We tested this hypothesis through an experiment requiring habitual car drivers to switch temporarily to public transportation. After this intervention, participants reported significantly greater levels of happiness with their commute by car compared to what they reported when they were in a routine.

In this paper, we develop and test a framework which models the relationship between travel happiness and mode switching using data collected from this experiment. The happiness measures for different modes are used as indicators of the utilities of these modes in addition to the standard choice indicators. Using this model structure, we are able to determine which of the two travel happiness measures (routine vs. non-routine) is more relevant in decision-making contexts. By using a simultaneous estimation technique, this model extends a previous model we estimated sequentially (mode choice first, then happiness) in Abou-Zeid et al. (2008).

The remainder of this paper is organized as follows. Section 2 summarizes the data collected in the experiment and the main descriptive findings. Section 3 describes the model formulation, and Section 4 presents the estimation results. Section 5 concludes the paper.
2. Data and Descriptive Findings

Thirty self-selected employees of Geneva airport, Ecole Polytechnique Fédérale de Lausanne (EPFL), and Université de Lausanne (UNIL) participated in the experiment. They were habitual car drivers who have not commuted by public transportation for a long time or who used it only occasionally. The experiment consisted of three phases: pre-treatment, treatment, and post-treatment. In the pre-treatment phase, participants responded to questionnaires measuring their satisfaction with the commute by car, perceptions, attitudes, and plans in addition to standard socio-economic and demographic questions. The commute satisfaction question, with a 5-point response scale anchored by “Very dissatisfied” to “Very satisfied”, was phrased as follows:

“Taking all things together, how satisfied are you with your commute by car between your residence and work?”

In the treatment phase which lasted for one week, participants were “required” (as a condition for participation) to commute by public transportation for 2-3 days in that week. As an incentive, they were given free public transportation passes that were valid for 2-4 weeks starting from the beginning of the treatment phase. Throughout the treatment week, and for one week before the treatment and one week after, participants filled out daily travel diaries.

In the post-treatment phase, participants filled out the same questionnaire as in the pre-treatment phase, measuring their satisfaction with the commute by car, perceptions, attitudes, and plans. They also indicated their satisfaction with their commute by public transportation (phrased similarly to the car commute satisfaction question) and evaluated various aspects of their public transportation experience.

After the treatment, none of the participants cancelled their parking permits and switched completely to public transportation. However, 10 out of the 30 participants commuted by public transportation at least once in the week following the treatment (when the free pass was still valid). Of the 25 participants who were contacted a few months later, 5 participants indicated that after the expiration of the pass they commuted by public transportation at a higher rate than that before the intervention.

The distribution of reported satisfaction with the commute by car changed significantly from pre- to post-treatment, with an overall trend of increase in reported car satisfaction. Out of 29 participants, 16 did not change their ratings, 11 gave higher ratings, and 2 gave lower ratings. This finding provides support for the hypothesis that the travel happiness measures collected under routine and non-routine situations are different. We now turn to the question of which of the two measures is a better indicator of utility.
3. Model Formulation

In this section, we formulate a model that allows us to test the relationships between travel happiness and behavior and the relevance of the different happiness measures to utility. Our framework uses the travel happiness measures as indicators of utility in addition to the standard choice indicators.

Mode choice data are obtained from travel diaries recorded in the week following the treatment. Two measures of satisfaction with the commute by car are available: pre-treatment (denoted as $h_{\text{Car}}^{\text{Before}}$) and post-treatment (denoted as $h_{\text{Car}}^{\text{After}}$). Only one post-treatment measure of satisfaction with the commute by public transportation (denoted as $h_{\text{PT}}$) is available.

Intrinsic Utility

The structural model is a specification of the intrinsic utility difference between car and public transportation:

$$\Delta U = \Delta V + \varepsilon = V_{\text{Car}} - V_{\text{PT}} + \varepsilon$$  \hspace{1cm} (1)

where $\varepsilon$ is a standard normal error term ($\varepsilon \sim N(0,1)$) and $V_{\text{Car}}$ and $V_{\text{PT}}$ denote the systematic utilities of car and public transportation, respectively, and are specified as follows:

$$V_{\text{Car}} = \beta_0 + \beta_1 \times \text{Travel time}_{\text{Car}} + \beta_2 \times \text{Distance}_{\text{Car}}/\text{income}$$  \hspace{1cm} (2)

$$V_{\text{PT}} = \beta_1 \times \text{Travel time}_{\text{PT}}$$  \hspace{1cm} (3)

The travel time variable is door-to-door time in hours. Distance (measured in kilometers) is used as a proxy for car commuting fuel costs since parking subscription costs have already been paid by the participants. No cost variable is included in the systematic utility of public transportation since the data come from a post-treatment week when participants still had a valid free public transportation pass. Income is monthly income measured in 100’s of Swiss Francs.

Choice Model

The choice between car and public transportation is assumed to be based on utility maximization, as follows:

$$y = \begin{cases} 
1 (\text{Car}) & \text{if } \Delta U + \mu \eta \geq 0 \\
0 (\text{PT}) & \text{otherwise} 
\end{cases}$$ \hspace{1cm}, \hspace{0.2cm} \mu \geq 0 \hspace{1cm} (4)
where \( y \) is a choice indicator, \( \mu \) is a scale parameter, and \( \eta \) is an i.i.d. Logistic error term with a location of 0 and a scale parameter of 1 (\( \eta \sim \text{Logistic}(0,1) \)).

**Happiness Model**

The travel happiness model is given by the following equations:

\[
\Delta h^\text{After} = h^\text{After} - h^\text{Before} = \alpha_1 + \lambda_1 \Delta U + \nu_1 \\
\Delta h^\text{Before} = h^\text{Before} - h^\text{Before} = \alpha_2 + \lambda_2 \Delta U + \nu_2
\]

(5)

(6)

where \( \Delta h^\text{After} \) denotes the post-treatment difference in happiness ratings between car and public transportation, \( \Delta h^\text{Before} \) denotes the pre-treatment difference, \( \alpha_1 \) and \( \alpha_2 \) are intercept terms, \( \lambda_1 \) and \( \lambda_2 \) are loading factors, and \( \nu_1 \) and \( \nu_2 \) are normally distributed error terms (\( \nu_1 \sim N(0, \sigma_1^2) \) and \( \nu_2 \sim N(0, \sigma_2^2) \)). \( h^\text{After} \), \( h^\text{Before} \), and \( h^\text{PT} \) are measured on a scale of 1 to 5 and are treated as continuous in this model.

Equations (5) and (6) can be written in deviations form as follows:

\[
\Delta h^\text{After} = \Delta h^\text{After} - \Delta h^\text{After} = \lambda_1 (\Delta U - \Delta V) + \nu_1 = \lambda_1 \Delta U^* + \nu_1
\]

\[
\Delta h^\text{Before} = \Delta h^\text{Before} - \Delta h^\text{Before} = \lambda_2 (\Delta U - \Delta V) + \nu_2 = \lambda_2 \Delta U^* + \nu_2
\]

(5’)

(6’)

where \( \Delta h^\text{After} \), \( \Delta h^\text{Before} \), and \( \Delta V \) are the sample averages of \( \Delta h^\text{After} \), \( \Delta h^\text{Before} \), and \( \Delta V \), respectively. It is assumed that all error terms (\( \varepsilon, \eta, \nu_1, \) and \( \nu_2 \)) are uncorrelated with each other. The correlation between \( \Delta h^\text{After} \) and \( \Delta h^\text{Before} \) comes from their dependence on \( \Delta U \) (and thus on \( \varepsilon \)) and is captured by \( \lambda_1 \) and \( \lambda_2 \).

**Likelihood Function**

The maximum likelihood method is used for estimation. The likelihood of a given observation is the probability of observing the choice and the two happiness difference indicators. Conditional on \( \varepsilon \), the probabilities of the choice and each of the happiness difference indicators are independent. The likelihood for observation \( n \) is computed by integrating the product of these conditional probabilities over the density of \( \varepsilon \), as follows:

\[
P_n = \int \epsilon \ A_1(y|\epsilon) f_2(\Delta h^\text{After}|\epsilon) f_3(\Delta h^\text{Before}|\epsilon) f_4(\epsilon) d\epsilon
\]

(7)

where \( A_1(y|\epsilon) \) is the choice probability, \( f_2(\Delta h^\text{After}|\epsilon) \) is the density function of the post-treatment happiness difference in deviations form, and \( f_3(\Delta h^\text{Before}|\epsilon) \) is the density
function of the pre-treatment happiness difference in deviations form – all conditional on $\varepsilon$ which has a density function denoted as $f_4(\varepsilon)$.

$A_t(y|\varepsilon)$ is a logit model given by the following equation:

$$A_t(y|\varepsilon) = \left(1 + e^{\frac{-\Delta U}{\mu}}\right)^y \left(1 + e^{\frac{-\Delta U}{\mu}}\right)^{(1-y)}$$ (8)

$f_2(\Delta h^*_{\text{After}}|\varepsilon)$ and $f_3(\Delta h^*_{\text{Before}}|\varepsilon)$ are normal density functions specified as follows, where $\phi$ denotes a standard normal density function:

$$f_2(\Delta h^*_{\text{After}}|\varepsilon) = \frac{1}{\sigma_{v_1}} \phi\left(\frac{\Delta h^*_{\text{After}} - \lambda_{v_1} \Delta U^*}{\sigma_{v_1}}\right)$$ (9)

$$f_3(\Delta h^*_{\text{Before}}|\varepsilon) = \frac{1}{\sigma_{v_2}} \phi\left(\frac{\Delta h^*_{\text{Before}} - \lambda_{v_2} \Delta U^*}{\sigma_{v_2}}\right)$$ (10)

$f_4(\varepsilon)$ is a standard normal density function:

$$f_4(\varepsilon) = \phi(\varepsilon)$$ (11)

The log-likelihood for the full sample is given by the following equation:

$$L = \sum_{n=1}^{N} \ln P_n$$ (12)

4. Model Estimation

The model specified in Section 3 was programmed in Gauss (Aptech Systems, 1995) and estimated simultaneously using the maximum likelihood approach with multiple imputations for income used in the estimation. Problems encountered in the estimation included the presence of multiple local optima in a region characterized by a relatively high degree of overfitting of the happiness measurement equations (very small standard deviations of the error terms in the happiness equations). Therefore, we have chosen a solution in a smooth region of the likelihood function that results in less overfitting of the happiness equations.

Table 1 shows the parameter estimates and t-statistics. The intrinsic utility coefficients indicate that the car is generally preferred to public transportation for this sample of habitual car commuters. The time and distance coefficients imply a value of time ranging
between 12-18 Swiss Francs/hour\(^1\). The implied constants for the happiness equations are -1.13 for the “happiness after” and -2.10 for the “happiness before”.

To determine which of the two happiness measures (post- or pre-treatment) is a better indicator of utility, we compare the standard deviations \(\sigma_{\epsilon_1}\) and \(\sigma_{\epsilon_2}\) of the error terms in the two happiness equations. The idea is that a lower standard deviation means a better fit for the corresponding happiness equation. For this model, the standard deviation of the error term in the pre-treatment happiness equation is significantly smaller than that in the post-treatment happiness equation. This signifies that for this sample of commuters, the pre-treatment happiness measure is better correlated with the utility than the post-treatment happiness measure, contrary to what we expected.

Table 1. Estimation results for a combined model of mode switching and post- and pre-treatment travel happiness.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intrinsic Utility</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASC Car</td>
<td>2.12</td>
<td>1.54</td>
</tr>
<tr>
<td>Time (hours)</td>
<td>-3.40</td>
<td>-5.42</td>
</tr>
<tr>
<td>Distance/income (km/100 Swiss Francs)</td>
<td>-3.38</td>
<td>-4.68</td>
</tr>
<tr>
<td><strong>Choice Model</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\mu)</td>
<td>2.15</td>
<td>2.06</td>
</tr>
<tr>
<td><strong>Happiness After</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\lambda_1)</td>
<td>0.892</td>
<td>9.08</td>
</tr>
<tr>
<td>(\sigma_{\epsilon_1})</td>
<td>0.908</td>
<td>11.93</td>
</tr>
<tr>
<td><strong>Happiness Before</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\lambda_2)</td>
<td>1.13</td>
<td>11.26</td>
</tr>
<tr>
<td>(\sigma_{\epsilon_2})</td>
<td>0.233</td>
<td>1.17</td>
</tr>
<tr>
<td><strong>Log-likelihood</strong></td>
<td>-378.3</td>
<td></td>
</tr>
</tbody>
</table>

Another criterion for determining which of the two happiness measures is more relevant for decision-making is to evaluate which of the two predicts choices better. We estimated two additional models: one consisting of the choice model and the post-treatment happiness model (equations 1-4 and 5’) and the other consisting of the choice model and the pre-treatment happiness model (equations 1-4 and 6’). For each of these models, we computed the choice log-likelihood at the estimated parameter values. Table 2 shows the parameter estimates of the happiness model, the total log-likelihood, and the choice log-likelihood for the combined (choice + two happiness equations) and each of the separate models (choice + one happiness equation at a time).

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\(^1\) This assumes a gas mileage range of 20-30 miles/gallon (8.5-12.7 km/liter), a gas price of $6.36/gallon (1.9 Swiss Francs/liter), and a monthly income of 8000 Francs.
Table 2. Estimation results for three models of mode switching and travel happiness.

<table>
<thead>
<tr>
<th></th>
<th>Choice + happiness after + happiness before</th>
<th>Choice + happiness after</th>
<th>Choice + happiness before</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Happiness After</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda_1$</td>
<td>0.892</td>
<td>0.837</td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\epsilon_1}$</td>
<td>0.908</td>
<td>0.939</td>
<td></td>
</tr>
<tr>
<td><strong>Happiness Before</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda_2$</td>
<td>1.13</td>
<td>1.13</td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\epsilon_2}$</td>
<td>0.233</td>
<td>0.249</td>
<td></td>
</tr>
<tr>
<td><strong>Total log-likelihood</strong></td>
<td>-378.3</td>
<td>-240.2</td>
<td>-229.3</td>
</tr>
<tr>
<td><strong>Choice log-likelihood</strong></td>
<td>-57.7</td>
<td>-57.3</td>
<td>-57.7</td>
</tr>
</tbody>
</table>

The results indicate that even though the “choice + happiness before” model has a better total log-likelihood than the “choice + happiness after” model (as also shown by the better overfitting of the pre-treatment happiness measure discussed before), the “choice + happiness after” model predicts the choices slightly better which is consistent with our study hypothesis.

5. Conclusion

In this paper, we presented a model framework relating travel happiness to utility and mode switching. The main postulate was that people don’t fully think of their travel happiness unless they reconsider their decisions, and so happiness measures collected under routine and non-routine situations are expected to be different. Data collected from an experiment in Switzerland requiring habitual car drivers to commute temporarily by public transportation showed that the pre-treatment and post-treatment happiness measures were significantly different. The objective of this paper was to test which of the two happiness measures was better correlated with utility and hence more relevant in decision-making contexts. The model presented in this paper is an extension of the model shown in Abou-Zeid et al. (2008) where a sequential estimation technique was used. In this paper, all model parameters are estimated simultaneously.

The model consists of a structural equation specifying the intrinsic utility difference between car and public transportation as a function of time, cost (distance used as proxy), and income. Three measures are used as indicators of the intrinsic utility difference: post-treatment mode choice (car vs. public transportation), post-treatment happiness difference, and pre-treatment happiness difference.

The model was estimated in Gauss using maximum likelihood. It was found that for this sample of commuters the utility correlated better with the pre-treatment measure of travel happiness, contrary to what was hypothesized. However, when the model was estimated
separately for each of the happiness measures (i.e. choice + one happiness measure at a time), the post-treatment happiness measure resulted in slightly better choice log-likelihood than the pre-treatment measure despite the better overall fit of the pre-treatment model. Thus, the results provide preliminary evidence that the post-treatment happiness measure predicts choices better than the pre-treatment measure, but the difference is small and this finding needs to be validated with larger samples and in different settings. Work is currently underway by the authors to replicate these findings with a similar experiment conducted at the Massachusetts Institute of Technology.

The model presented in this paper assumed that utility does not change over time. Future work will model time-varying utility and test various behavioral mechanisms that might be driving the change in reported travel happiness, such as hedonic adaptation (Brickman and Campbell, 1971; Brickman et al., 1978) or scale norming (Frederick and Loewenstein, 1999; Groot, 2000).
References


