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## Mode choice in Switzerland (Optima)

### MNL with Generic Attributes

*Files to use with BIOGEME:*

*Model file: MNL\_generic\_optima.mod*

*Data file: optimaTOT3\_valid.dat*

The choice set consists of the following three alternatives:

1. public transports (PT),
2. private modes (CAR), and
3. soft mode (MD).

In this first model, we assume travel time and cost are factors influencing the choice between PT and CAR. We also assume that the coefficients of travel time and cost variables are generic, i.e. they do not vary between PT and CAR. We define the deterministic part of the utility for the mode choice by including the alternative specific constants (ASCs) and two attributes for PT and CAR, namely cost (MarginalCost and CoutAutoCHF) and time (DureeTP1 and DureeAuto), with their respective generic coefficients  $\beta_{\text{COST}}$  and  $\beta_{\text{TIME}}$ :

$$\begin{aligned} V_{\text{PT}} &= \text{ASC}_{\text{PT}} + \beta_{\text{TIME}} \cdot \text{DureeTP1} + \beta_{\text{COST}} \cdot \text{MarginalCost} \\ V_{\text{CAR}} &= \text{ASC}_{\text{CAR}} + \beta_{\text{TIME}} \cdot \text{DureeAuto} + \beta_{\text{COST}} \cdot \text{CoutAutoCHF} \\ V_{\text{MD}} &= \text{ASC}_{\text{MD}} + \beta_{\text{DIST}} \cdot \text{distance\_km} \end{aligned}$$

The estimation results are reported in Table 1. The results indicate that all the rest being equal, the private modes (CAR) is the most preferred option. There is no such preference for the soft modes (MD):  $\text{ASC}_{\text{MD}}$  is negative but the t-test of  $\text{ASC}_{\text{MD}}$  shows that alternative specific constant for soft mode (MD) is not significantly different from zero. The signs of the time coefficient  $\beta_{\text{TIME}}$ , the cost coefficient  $\beta_{\text{COST}}$  and the distance coefficient  $\beta_{\text{DIST}}$  are negative, as expected, meaning that the utility of an alternative decreases with increase in travel time, cost and distance.

### MNL with Alternative-Specific Coefficients

*Files to use with BIOGEME:*

*Model file: MNL\_specific\_optima.mod*

*Data file: optimaTOT3\_valid.dat*

<b>Generic MNL estimation</b>				
Parameter number	Parameter name	Parameter estimate	Robust standard error	Robust <i>t statistic</i>
1	$ASC_{CAR}$	0.304	0.102	2.98
2	$ASC_{MD}$	-0.0403	0.296	-0.14
3	$\beta_{COST}$	-0.0752	0.0138	-5.43
4	$\beta_{DIST}$	-0.198	0.0492	-4.02
5	$\beta_{TIME}$	-0.00484	0.00144	-3.36
<b>Summary statistics</b>				
Number of observations = 1906				
$\mathcal{L}(0) = -2093.955$				
$\mathcal{L}(\hat{\beta}) = -1310.070$				
$\bar{\rho}^2 = 0.372$				

Table 1: Estimation results for the MNL model with generic attributes

In this second specification we relax the hypothesis of generic coefficients. To illustrate this idea, two different time coefficients are introduced, one for PT and the other for CAR. We present a model (unrestricted) with alternative-specific travel time coefficients and we compare it with the (restricted) model with generic coefficients presented in the previous section. We carry out a statistical test (likelihood ratio test) to assess if one specification is significantly better than the other. The deterministic utilities for this model with alternative-specific travel times are:

$$\begin{aligned}
 V_{PT} &= ASC_{PT} + \beta_{TIME\_PT} \cdot DureeTP1 + \beta_{COST} \cdot MarginalCost \\
 V_{CAR} &= ASC_{CAR} + \beta_{TIME\_CAR} \cdot DureeAuto + \beta_{COST} \cdot CoutAutoCHF \\
 V_{MD} &= ASC_{MD} + \beta_{DIST} \cdot distance\_km
 \end{aligned}$$

Note that instead of only  $\beta_{TIME}$ , we have now  $\beta_{TIME\_PT}$  and  $\beta_{TIME\_CAR}$ .

The results for the unrestricted model are reported in Table 2. In this case, both time coefficients for CAR and PT are estimated. Both their signs are negative, as expected, and the larger absolute value for  $\beta_{TIME\_CAR}$  indicates that people are more sensitive to time in case of private modes. The interpretation for other parameters remains the same.

**Generic vs Specific Test** The likelihood ratio test can be used to test the generic vs. the alternative-specific model specifications. The likelihood ratio test

<b>Alternative specific MNL estimation</b>				
Parameter number	Parameter name	Parameter estimate	Robust standard error	Robust <i>t statistic</i>
1	$ASC_{CAR}$	0.563	0.106	5.31
2	$ASC_{MD}$	0.0801	0.303	0.26
3	$\beta_{COST}$	-0.0677	0.0128	-5.27
4	$\beta_{DIST}$	-0.232	0.0525	-4.43
5	$\beta_{TIME\_CAR}$	-0.0325	0.00679	-4.78
6	$\beta_{TIME\_PT}$	-0.0130	0.00306	-4.25
<b>Summary statistics</b>				
Number of observations = 1906				
$\mathcal{L}(0) = -2093.955$				
$\mathcal{L}(\hat{\beta}) = -1245.963$				
$\bar{\rho}^2 = 0.402$				

Table 2: Estimation results for the MNL model with specific attributes

statistic for the null hypothesis of generic attributes is

$$-2(L(\beta_R) - L(\beta_U)),$$

Under the null hypothesis:

$$H_0 : \beta_{TIME\_CAR} = \beta_{TIME\_PT}$$

We can reject null hypothesis (generic travel time coefficient) if :

$$-2(L(\beta_R) - L(\beta_U)) > \chi_{((1-\alpha),df)}$$

where  $\mathbf{R}$  and  $\mathbf{U}$  denote the restricted (generic) and unrestricted (alternative-specific) models, respectively. It is  $\chi^2$  distributed with the number of degrees of freedom equal to the number of restrictions ( $K_U - K_R$ ), with  $K_U$  and  $K_R$  the numbers of estimated coefficients in the unrestricted and restricted models, respectively. In this case,  $-2(-1310.070 + 1245.963) = 128.214$ . Since  $\chi_{0.95,1}^2 = 3.841$  at 95% level of confidence, we can conclude that the null hypothesis of a generic time coefficient can be rejected.

## Inclusion of Socio-Economic Characteristics

*Files to use with BIOGEME:*

*Model file:* `MNL_socioecon_optima.mod`

*Data file:* `optimaTOT3_valid.dat`

The previous two models only include variables that are attribute of the alternatives. It is reasonable to assume that people make choices not only in relation to the attributes that characterize the alternatives but also depending on some personal characteristics or socioeconomic indicators. The availability of individual-specific information gives us the opportunity to model partly the heterogeneity present in the population. We introduce a socio-economic characteristic, namely the region where the respondent inhabits, in the utility of the CAR alternative. If the respondent lives in French speaking region, the dummy variable **FrenchRegion** is 1, 0 if German speaking region. It should be noticed that the socio-economic variables do not vary among the alternatives and are individual specific. We modify the previous model by adding language of respondents into the utilities.

$$\begin{aligned}V_{PT} &= ASC_{PT} + \beta_{TIME\_PT} \cdot DureeTP1 + \beta_{COST} \cdot MarginalCost \\V_{CAR} &= ASC_{CAR} + \beta_{TIME\_CAR} \cdot DureeAuto + \beta_{COST} \cdot CoutAutoCHF \\&\quad + \beta_{LANGUAGE\_CAR} \cdot FrenchRegion \\V_{MD} &= ASC_{MD} + \beta_{DIST} \cdot distance\_km\end{aligned}$$

Since the variable of the language does not vary between the alternatives and only differences in utilities matter, we need to normalize one alternative to zero (PT). Here we fixed a second one to zero, since it was not significant (MD). We interpret the estimated coefficients for the remaining alternatives with respect to the reference alternative (PT), which arbitrarily is alternative PT. It is similar to what we did when specifying alternative specific constants.

We assumed that the language of the respondent affects differently each alternative.

The estimation results of this model are reported in Table 3.

The coefficient of the **FrenchRegion** is statistically significant different from zero and indicates that people in French speaking region have higher preference towards using private modes. The interpretation of the other coefficients rest the same as the previous model specifications.

<b>Socio-Economic MNL estimation</b>				
Parameter number	Parameter name	Parameter estimate	Robust standard error	Robust <i>t statistic</i>
1	ASC_CAR	0.350	0.109	3.22
2	ASC_MD	0.134	0.304	0.44
3	BETA_COST	-0.0633	0.0121	-5.24
4	BETA_DIST	-0.231	0.0522	-4.41
5	BETA_LANGUAGE_CAR	1.08	0.140	7.72
6	BETA_TIME_CAR	-0.0309	0.00656	-4.72
7	BETA_TIME_PT	-0.0126	0.00300	-4.22
<b>Summary statistics</b>				
Number of observations = 1906				
$\mathcal{L}(0) = -2093.955$				
$\mathcal{L}(\hat{\beta}) = -1214.994$				
$\bar{\rho}^2 = 0.416$				

Table 3: Estimation results for the MNL model with socioeconomic variables