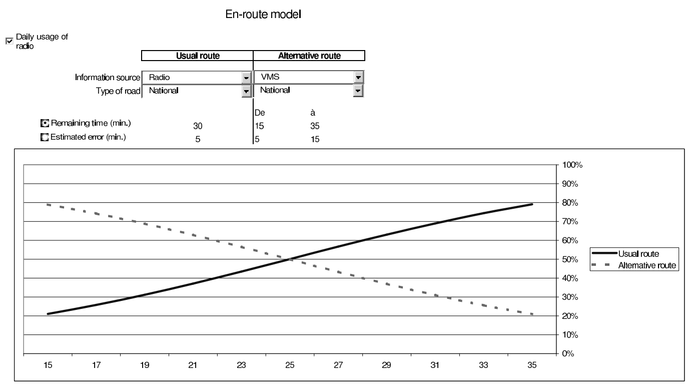

Development of Swiss models for transportation demand prediction in response to real-time traffic information

Michel Bierlaire, EPFL
Michaël Thémans, EPFL

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Development of Swiss models for transportation demand prediction in response to real-time traffic information

Michel Bierlaire and Michaël Thémans
Institute of Mathematics, EPFL, Lausanne
Email: michel.bierlaire@epfl.ch, michael.themans@epfl.ch

Abstract

Discrete choice models have been intensively used to analyze and predict the behavior of people in a transportation network. Nowadays the emergence of the telematic technology increases the possibilities for the management of transportation systems. In order to exploit at best this technology, specific demand models have to be designed to explicitly capture the impact of Intelligent Transportation Systems (ITS) on travelers. More precisely, we need to understand how people will react in response to traffic information. In this context, we present behavioral models designed to capture the response of drivers to real-time traffic information provided by the transportation system. These models will be helpful to predict travel decisions and consequently the transportation demand with regard to different strategies of traffic management. During the last two years we have conducted a national survey in Switzerland in order to collect both Revealed Preferences (RP) and Stated Preferences (SP) about choice decisions in terms of route and mode. The RP data contains socio-economic characteristics of the individuals in our samples, their actual usage of ITS as well as their actual route and mode choice behavior. The SP data provide us with stated route and mode choices when drivers are faced with different hypothetical choice situations involving real-time information about the state of the network. This specific type of data has been used to calibrate GEV models using the BIOGEME software. First we present a Mixed Multinomial Logit model with panel data to analyse the drivers' decisions when traffic information are provided during their trip by the mean of Radio Data System (RDS) or variable message signs (VMS). This model is referred to en-route choice model. Second we present Nested Logit models capturing the behavior of drivers when they are aware of traffic conditions before their trip. These last models allow to predict pre-trip route choice decisions with regard to route and mode when traffic information is available. The calibrated models are subsequently included in a simulator which predicts travelers behavior in specific scenarii (described by adjustable parameters) allowing the sensitivity analysis of the demand with regard to the variations of various parameters. In this paper, we discuss the results of the estimation process, give some words about the Value of Time (VoT) in this context and present some scenarii developed with our simulator.

Keywords: Intelligent Transportation Systems, Behavioral models, Advanced Traffic Information Systems, Users response
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1 Introduction

Intelligent Transportation Systems (ITS) are aiming at the improvement of transportation systems through advanced information and control technologies. Namely, Dynamic Traffic Management Systems (DTMS) combine those technologies with the appropriate decision-aid tools.

Demand models play a central role in such systems. Indeed, the impact of ITS on travelers' behavior must be captured, understood and explicitly predicted. In this context, representing transportation demand through (possibly dynamic) origin-destination matrices is not sufficient. A disaggregate representation is necessary, where individuals are considered with their characteristics (trip purpose, available ITS equipement, etc.) and with their decisions in terms of route and mode choice.

Most recent methodologies for the evaluation and management of ITS are based on behavioral models, predicting the response of users to the ITS environment. Among them, we can cite the software systems developed at the Massachusetts Institute of Technology: MITSIM Laboratory (Ben-Akiva et al., 1997) for the evaluation of DTMS and DynaMIT (Ben-Akiva et al., 2001) for real-time traffic information and prediction. Other tools, like VISSIM or AIMSUM in Europe, and DYNASMART and TRANSIM in the US are also based on a disagreggate representation of the demand.

The use of such tools allows for an operational approach of telematics, which optimizes the impact of existing infrastructures, such as Variable Message Signs (VMS), RDS, etc. Disaggregate demand models also help to analyze the impact of longer term strategies such as road-pricing, congestion-pricing, diversion strategies, etc.

In this paper, we present behavioral models capturing the response of Swiss travelers to traffic information, designed to be used in such DTMS. It is the result of a research project conducted between 2002 and 2004. The research team was composed of two engineering consulting firms (Robert-Grandpierre et Rapp, SA, Lausanne, and Büro Widmer, Frauenfeld), IVT (Institute for Transport Planning and Systems), ETHZ, and the Operations Research Group ROSO, EPFL.

The data collection process is described in Section 2. The model for en-route behavior is presented in Section 3 while the models for pre-trip behavior are presented in Section 4. Before concluding in Section 6, we illustrate examples of how these models can be used in a simulator in Section 5.

2 Data collection

Data collection has been conducted in two waves, starting in Spring 2003. The first questionnaire contained questions about the current traveling behavior of the respondents, their current use of advanced information systems, and about various socio-economic characteristics. We refer to this first questionnaire as the "revealed preferences" (RP) questionnaire. It was also asked if they would be willing to participate in the second wave of the survey, involving stated preferences (SP) questions. For each wave, a pre-test has been conducted first, in order to test the quality of the questions.

Three focussed groups have been contacted:

- commuters in the French speaking part of Switzerland,
- commuters in the German speaking part of Switzerland,
- owners of a second home in Ticino.

The latter group has been chosen because it involves long distance non-work related trips, which is of special interest in Switzerland.

The number of RP questionnaires sent, received and useful are reported in Tables 1 and 2. A questionnaire was not considered useful if the description of the actual trips was not detailed enough, or if the reported trips were shorter than 7 km.

Stated preferences questions have been generated based on the longest reported trip (which we call the reference trip) of each respondent. For each of them, 7 hypothetical pre-trip choice situations (route and mode choice) have been prepared, and 7 hypothetical en-route choice situations (route choice only). In the pre-trip case, we assume that traffic information is available two hours before the trip starts. Three alternatives are proposed: base alternative, alternative recommended by the information system,

	Pre-test	Main survey	Total
Sent questionnaires	100	726	826
Received questionnaires:	38	194	232
• without reminder	31 (82%)	149 (77%)	180 (78%)
• with reminder	7 (18%)	45 (23%)	52 (22%)
Useful questionnaires	37	186	223
Return rate	**37%**	**26%**	**27%**

Table 1: RP questionnaires: French speaking part

	Pre-test	Main survey	Total
Sent questionnaires	100	823	923
Received questionnaires:	42	300	342
• without reminder	31 (74%)	141 (47%)	172 (50%)
• with reminder	11 (26%)	159 (53%)	170 (50%)
Useful questionnaires	41	278	319
Return rate	**41%**	**34%**	**35%**

Table 2: RP questionnaires: German speaking part + Ticino

or public transportation. The attributes of the base alternative are those of the actual longest trip described in the RP questionnaire, in order to maximize the credibility of the choice context. The attributes of the two other alternatives are based on a SP design generated by IVT. The attributes for the two first alternatives are

- departure time,
- estimated travel time, out of congestion
- estimated travel time, within congestion
- estimated total travel time (the sum of the two previous)
- error on the predicted times,
- expected arrival time,
- cost (operational costs including fuel, oil and maintenance).

The attributes of the public transportation alternative are

- Departure time from the closest public transportation stop.
- Estimated travel time to the final stop (closest to the destination)
- Arrival time at the final stop (the sum of the two previous)
- Fare (accounting for yearly passes and specific discounts)

In the en-route case, we assume that traffic information is available during the trip. We also suppose that the radio is turned on in the car and that there are VMS along the route. Two alternatives are proposed: base alternative and alternative recommended by the information system. Their attributes are

- Estimated travel time to the destination
- Error on the predicted time
- Type of road to the destination: National roads, other roads, or both,
- Source of information: Radio or Variable Message Signs (VMS)

The number of SP questionnaires sent, received and useful are reported in Tables 3 and 4.

	Pre-test	**Main survey**	**Total**
Send questionnaires	14	89	103
Received questionnaires	11	60	71
• without reminder	11 (100%)	43 (72%)	52 (78%)
• with reminder	-	17 (28%)	19 (22%)
Useful questionnaires	9	56	65
Return rate	**79%**	**67%**	**69%**

Table 3: SP questionnaires: French speaking part

3 En-route model

A mixed logit model (see Train, 2003) with panel data has been estimated using the software package Biogeme (Bierlaire, 2003). The model specification is reported in Table 5.

	Pre-test	Main survey	Total
Send questionnaires	24	153	177
Received questionnaires	13	124	137
• without reminder	5 (38%)	62 (50%)	67 (49%)
• with reminder	8 (62%)	62 (50%)	70 (51%)
Useful questionnaires	12	117	129
Return rate	**50%**	**76%**	**73%**

Table 4: SP questionnaires: German speaking part + Ticino

	Current route	Alternative route
β_{current}	1	0
σ_{panel}	1	0
β_{time}	remaining time	remaining time
$\beta_{\text{error\_radio\_high}}$	error * radio * daily_usage	error * radio * daily_usage
$\beta_{\text{error\_radio\_low}}$	error * radio * lower_usage	error * radio * lower_usage
$\beta_{\text{error\_vms}}$	error * VMS	error * VMS
$\beta_{\text{non-national}}$	non-national	non-national

Table 5: En-route model specification

where “radio” is 1 if information is received by the radio, 0 otherwise; “VMS” is 1 if information is received by VMS, 0 otherwise; “non-national” is 1 if the trip to the destination is using of non-national roads, 0 otherwise; “daily_usage” is 1 if the traveler frequently uses the radio to get traffic information, 0 otherwise; “lower_usage” is 1 if the traveler does not frequently use the radio to get traffic information, 0 otherwise.

A total of 1358 observations have been used (7 questions per respondent, 194 respondents). The estimated parameters are reported below.

Name	Value	Std error	$t-$test
β_{current}	0.552	0.110	5.015
β_{time}	-0.133	0.012	-10.87
$\beta_{\text{error\_radio\_high}}$	-0.055	0.016	-3.405
$\beta_{\text{error\_radio\_low}}$	-0.076	0.023	-3.352
$\beta_{\text{error\_vms}}$	-0.078	0.016	-4.938
$\beta_{\text{non-national}}$	-0.270	0.101	-2.679
σ_{panel}	-0.716	0.156	-4.576

- Number of estimated parameters: 7
- Initial log-likelihood: -940.601
- Final log-likelihood: -701.949
- Rho-square: 0.253723

All parameters are significant. We briefly discuss each of them.

$\beta_{\textbf{current}}$ is the Alternative Specific Constant associated with the first alternative. It is positive as expected. Indeed, if everything else is equal, there is an intrinsic preference toward the current route. This captures a type of inertia to change.

$\beta_{\textbf{time}}$ is negative, as expected.

$\beta_{\textbf{error\_radio\_high}}$, $\beta_{\textbf{error\_radio\_low}}$, $\beta_{\textbf{error\_vms}}$ are all negative, capturing the impact of uncertainty on travelers' choice, as people will not favor alternatives for which imprecise information is available. Comparing the three values, it appears that a same level of error will be more penalized for a VMS than for the radio. Also, travelers who currently listen and use traffic information from the radio have a tendency to penalize less the errors made by this media. This could be explained by the fact that travelers have a better experience of radio than VMS.

$\beta_{\textbf{non-national}}$ is negative, capturing the fact that travelers are reluctant to leave the main road network. However, its absolute value is less than β_{current}, showing that, everything else being equal, travelers prefer their current route on non-national roads, rather than an alternative itinerary using national roads.

$\sigma_{\textbf{panel}}$ is significant, showing that it was important to include intra-personal effects in the model. Its sign is irrelevant.

Note that we have tried to estimate separate models for each subsample, but they did not appear to be significantly different.

4 Pre-trip models

We have estimated a joint nested logit model, combining a model for the Ticino sample (second home owners) and the rest of the sample (we did not discover any significant difference between the French and Germand speaking parts). A total of 1302 observations have been used (7 questions per respondent, 186 respondent). A total of 34 parameters have been estimated: 2 nest parameters, one scale parameter, 11 parameters specific to the Ticino model, 16 specific parameters to the other model, and 4 parameters common to both models: β_{cost}, β_{error}, $\beta_{\text{radio\_usage}}$ and $\beta_{\text{profession}}$.

- Initial log-likelihood: -1399.63
- Final log-likelihood: -767.245
- Rho-square: 0.451824

Although jointly estimated, we present the results separately.

The specification of the Ticino model is reported in the following table.

	Nest A		Nest B
	Route 1	Route 2	Public transportation
$\beta_{\text{ASC1-Ticino}}$	1	0	0
$\beta_{\text{ASC2-Ticino}}$	0	1	0
β_{cost}	cost	cost	-
β_{error}	error	error	-
$\beta_{\text{time\_jam1-Ticino}}$	time in jam	-	-
$\beta_{\text{time\_jam2-Ticino}}$	-	time in jam	-
$\beta_{\text{radio\_usage}}$	daily_usage	-	-
$\beta_{\text{aware-Ticino}}$	-	aware	-
$\beta_{\text{impact-Ticino}}$	-	impact	-
$\beta_{\text{half\_fare-Ticino}}$	-	-	half-fare ticket
$\beta_{\text{people\_nbr-Ticino}}$	-	-	people
$\beta_{\text{car\_nbr-Ticino}}$	-	-	cars
$\beta_{\text{profession}}$	-	-	manager
$\beta_{\text{income-Ticino}}$	-	-	income(>8000CHF)
$\beta_{\text{public\_transportation-Ticino}}$	-	-	usage_percentage

where “daily_usage” is 1 if the traveler frequently uses traffic information, 0 otherwise; “aware” is 1 if the traveler was informed by radio about the traffic state during the reference trip, 0 otherwise; “impact” is 1 if the traveler has actually used traffic information during the reference trip, 0 otherwise; “half-fare ticket” is 1 if the traveler owns such a ticket, 0 otherwise; “people” is the number of persons within the traveler’s household; “cars” is the number of cars in the household; “manager” is 1 if the traveler is working as a manager or working at home, 0 otherwise; “income($>$8’000 CHF)” is 1 if the monthly household income is above 8’000 CHF, 0 otherwise; “usage_percentage” is the percentage of public transportation trips among all trips to the second home.

The results of the estimation are reported below.

Name	Value	Std error	t-test
β_{cost}	-0.145	0.034	-4.214
β_{error}	-0.021	0.009	-2.209
$\beta_{\text{radio\_usage}}$	0.401	0.125	3.218
$\beta_{\text{profession}}$	-2.297	0.409	-5.613
$\beta_{\text{ASC1-Ticino}}$	12.11	3.225	3.754
$\beta_{\text{ASC2-Ticino}}$	12.67	3.293	3.847
$\beta_{\text{half\_fare-Ticino}}$	2.386	0.862	2.768
$\beta_{\text{income-Ticino}}$	3.186	1.314	2.425
$\beta_{\text{aware-Ticino}}$	-0.354	0.182	*-1.942*
$\beta_{\text{impact-Ticino}}$	0.505	0.196	2.579
$\beta_{\text{people\_nbr-Ticino}}$	-1.210	0.391	-3.094
$\beta_{\text{car\_nbr-Ticino}}$	-1.173	0.446	-2.634
$\beta_{\text{public\_transportation-Ticino}}$	0.190	0.053	3.579
$\beta_{\text{time\_jam1\_Ticino}}$	-0.048	0.014	-3.322
$\beta_{\text{time\_jam2\_Ticino}}$	-0.073	0.025	-2.967
$\mu_{\text{Nest A-Ticino}}$	4.057	0.971	3.147^*
λ_{scale}	0.580	0.151	-2.787^*

Superscript * means that the t-test is against 1

All parameters are significant to the 95% level of confidence, except $\beta_{\text{aware-Ticino}}$. However, the t-test is close to the 1.96 threshold. Therefore, we have decided to keep the parameter in the model.

$\beta_{\textbf{cost}}$ is negative, as expected for a travel cost coefficient.

$\beta_{\textbf{error}}$ is negative, as expected. Same conclusion as in the en-route model.

$\beta_{\textbf{radio\_usage}}$ is positive. It seems to show that the inertia is larger for frequent users of the traffic information at the radio. It is not clear if it is a feature of the model, or if the frequent usage of the radio indeed encourages inertia, because of bad experiences. This requires more investigation.

$\beta_{\textbf{profession}}$ is negative, illustrating the aversion of managers and home-working persons to use public transportation.

$\beta_{\textbf{ASC1-Ticino}}$ **and** $\beta_{\textbf{ASC2-Ticino}}$ are the Alternative Specific Constants. There are positive, illustrating the attractiveness of the car versus public transportation.

$\beta_{\textbf{half\_fare-Ticino}}$ is positive, showing a propension to use public transportation by the owners of a half-fare ticket.

$\beta_{\textbf{income-Ticino}}$ is positive, showing an attractivity of public transportation for households with a high income. It may be due to the relatively high cost of long distance trips by public transportation in Switzerland, which only high incomes can afford when traveling with the whole family.

$\beta_{\textbf{aware-Ticino}}$ is negative, capturing an inertia, a preference toward the current alternative for more informed people. This is consistent with the comments about $\beta_{\textbf{radio\_usage}}$ (note that $\beta_{\text{aware-Ticino}}$ is in the utility function of the alternative route).

$\beta_{\textbf{impact-Ticino}}$ is positive, showing that people who have used traffic information to modify their decision during the reference trip have a propension to change. It seems to support the assumption about the bad experience proposed in the analysis of the sign of $\beta_{\textbf{radio\_usage}}$.

$\beta_{\textbf{people\_nbr-Ticino}}$ is negative. Indeed, the marginal cost of one more person in the family is much more important for public transportation than for private transportation.

$\beta_{\textbf{car\_nbr-Ticino}}$ is negative. Indeed, the more cars in the household, the less likely the use of public transportation.

$\beta_{\textbf{public\_transportation-Ticino}}$ is positive, showing an atttractivity for the public transportation by the most frequent users of public transportation.

$\beta_{\textbf{time\_jam1\_Ticino}}$ **and** $\beta_{\textbf{time\_jam2\_Ticino}}$ are both negative. The sensitivity to the predicted time in jam for the alternative route is more important. Note also that the free flow travel time did not appear significant in the model. It is due to the very low variability of this attribute for the Ticino sample.

The specification of the commuters model is reported in the following table.

	Nest A		Nest B
	Route 1	Route 2	Public transp.
β_{ASC1}	1	0	0
β_{ASC2}	0	1	0
β_{cost}	cost	cost	-
β_{error}	error	error	-
$\beta_{\text{time\_jam-short}}$	time in jam * d(0-50)	time in jam * d(0-50)	-
$\beta_{\text{time\_jam-medium}}$	time in jam * d(50-100)	time in jam * d(50-100)	-
$\beta_{\text{time\_free-short}}$	fr. flow time * d(0-50)	fr. flow time * d(0-50)	-
$\beta_{\text{time\_free-medium}}$	fr. flow time * d(50-100)	fr. flow time * d(50-100)	-
$\beta_{\text{radio\_usage}}$	daily_usage	-	-
$\beta_{\text{internet\_usage}}$	daily_usage	-	-
β_{aware}	-	aware	-
β_{early}	-	-	early arrival
β_{fare}	-	-	fare
$\beta_{\text{timetable}}$	-	-	timetable
$\beta_{\text{profession}}$	-	-	manager
β_{age}	-	-	age(0-40)
β_{mode}	-	-	car_as_mode
$\beta_{\text{availability}}$	-	-	car_availability
β_{type}	-	-	car_type
β_{kms}	-	-	kilometers

where “d(0-50)” is 1 if the trip length is between 0 and 50km, 0 otherwise; “d(50-100)” is 1 if the trip length is between 50 and 100km, 0 otherwise; “daily_usage” is 1 if the traveler frequently uses traffic information, 0 otherwise; “aware” is 1 if the traveler was informed by radio about the traffic state during the reference trip, 0 otherwise; “manager” is 1 if the traveler is working as a manager or working at home, 0 otherwise; “early_arrival” is the number of minutes between the arrival by public transportation and the scheduled arrival time; "fare" is the public transportation fare; "timetable" is the scheduled travel time from the timetable; "age(0-40)" is 1 if the traveler is younger than 40, 0 otherwise; "car_as_mode" is 1 if the car was the chosen mode for the reference trip, 0 otherwise; "car_availability" is 1 if a car is available to the traveler, 0 otherwise; "car_type" is 1 if a company car has been used during the reference trip, 0 otherwise; "kilometers" is the number of kilometers traveled by car per year.

The results of the estimation are reported below.

Name	Value	Std error	t-test
β_{cost}	-0.145	0.034	-4.214
β_{error}	-0.021	0.009	-2.209
$\beta_{\text{radio\_usage}}$	0.401	0.125	3.218
$\beta_{\text{profession}}$	-2.297	0.409	-5.613
β_{ASC1}	-3.054	1.144	-2.670
β_{ASC2}	-2.780	1.141	-2.436
β_{mode}	-1.390	0.297	-4.683
$\beta_{\text{availability}}$	-3.659	1.081	-3.386
β_{type}	-3.016	1.093	-2.760
$\beta_{\text{internet\_usage}}$	-0.239	0.125	*-1.910*
β_{aware}	0.708	0.156	4.523
β_{age}	-1.197	0.341	-3.513
β_{kms}	-0.041	0.012	-3.420
β_{early}	-0.033	0.011	-3.166
β_{fare}	-0.037	0.022	*-1.674*
$\beta_{\text{timetable}}$	-0.066	0.009	-7.019
$\beta_{\text{time\_jam\_medium}}$	-0.088	0.019	-4.543
$\beta_{\text{time\_jam\_short}}$	-0.084	0.015	-5.582
$\beta_{\text{time\_free\_medium}}$	-0.066	0.011	-5.752
$\beta_{\text{time\_free\_short}}$	-0.122	0.015	-8.081
$\mu_{\text{Nest A}}$	1.951	0.311	3.051^{*}
λ_{scale}	0.580	0.151	-2.787^{*}

Superscript * means that the t-test is against 1

All parameters are significant to the 95% level of confidence, except $\beta_{\text{internet\_usage}}$ and β_{fare}. However, the t-test is close to the 1.96 threshold value, and we have decided to keep them in the model.

$\beta_{\textbf{cost}}$ see above.

$\beta_{\textbf{error}}$ see above.

$\beta_{\textbf{radio\_usage}}$ see above.

$\beta_{\textbf{profession}}$ see above.

$\beta_{\textbf{ASC1}}$ **and** $\beta_{\textbf{ASC2}}$ are the Alternative Specific Constants for the two first alternatives. They are negative, which is difficult to interpret. Indeed, the cost and time parameters are alternative specific. For instance, if we compare alternatives with a cost of 10 CHF, a travel time of 50 minutes (both for car and public transportation), the probability of choosing the public transportation is significantly smaller than the probability to choose the car, as expected.

$\beta_{\textbf{mode}}$ is negative, meaning that people reporting to use their car have a preference toward the car, so it affects negatively the public transportation alternative.

$\beta_{\textbf{availability}}$ is negative, meaning that people who have a car available have a tendency to use it, so it affects negatively the public transportation alternative.

$\beta_{\textbf{type}}$ is negative, for the same reason as described above.

$\beta_{\textbf{internet\_usage}}$ is negative, showing that people who use Internet to access the information have a propension to switch route. It is interesting to note that the parameter $\beta_{\text{radio\_usage}}$ is positive in comparison.

$\beta_{\textbf{aware}}$ is positive, showing that people who are aware of alternative routes, have a propension to switch. Note that, in comparison to the Ticino model, the commuter model deals with situations where the number of feasible routes is usually higher.

$\beta_{\textbf{age}}$ is negative, showing that people younger than 40 have a preference for the car.

$\beta_{\textbf{kms}}$ is negative, showing that the more the car is used per year, the less appealing public transportations are.

$\beta_{\textbf{early}}$ is negative, capturing the inconvenience of mismatch between the actual arrival time and desired arrival time when using public transportation.

$\beta_{\textbf{fare}}$ is negative, as expected for a cost coefficient. Note that it is less negative than the cost coefficient for the car alternatives.

$\beta_{\textbf{timetable}}$ is negative, as expected for a travel time coefficient.

$\beta_{\textbf{time\_jam\_medium}}$, $\beta_{\textbf{time\_jam\_short}}$, $\beta_{\textbf{time\_free\_medium}}$, $\beta_{\textbf{time\_free\_short}}$ are all negative, as expected. As discussed below, although they have the correct sign, we are somehow suspicious about the parameters estimates for the short trips. Indeed, there are plenty of context-specific constraints associated with short trips that are not accounted for in this model. The fact that travel time in free-flow conditions is more penalized than travel time in jam is counter-intuitive. In the "medium" case (trips between 50 and 100km), travel time in traffic jam is more penalized than travel time in free-flow conditions.

It is interesting to analyze the Value of Travel Time Savings (VOTTS), as provided by the commuter model. As we use a linear specification, this quantity is simply given by the ratio between the travel time coefficient and the travel cost coefficient.

VOTTS (CHF/min)	Free flow	in Jam
Short distance ($\leq$ 50km)	*50.7*	34.8
Medium distance ($>$ 50km)	27.3	36.5

The values for the medium distances are comparable with the results provided by Koenig et al. (2004): 35.9 CHF, assuming an income of 10'000 CHF/month and a business trip of 75km. However, for the short distance, our values are significatively higher. Koenig et al. (2004) obtain 24.22 CHF, assuming an income of 10'000 CHF/month and a business trip of 25km. Clearly, in our model, we have a low granularity of distances and travel times for short distance trips. The approach by Koenig et al. (2004) is more appropriate to estimate VOTTS for short trips. Anyway, the value 50.7 CHF, reported in italic above, does not seem valid to us. We believe the time and cost parameters capture other effects associated with short trips, that should be explicitly analyzed.

5 Simulation

We have implemented a simulator for the models. We illustrate here some examples based on the en-route model.

In Figure 1, the x-axis represents various values between 15 and 35 minutes for the remaining time on the alternative route. The error on the information is 5 minutes for both alternatives. The value of the other attributes are reported above the chart. Among other things, it is interesting to note that the 50% probability is reached when the alternative route is 25 minutes, compared to the 30 minutes on the usual route. Also, if both routes are said to be 30 minutes, the probability to switch route is only about 34%, illustrating the inertia to change.

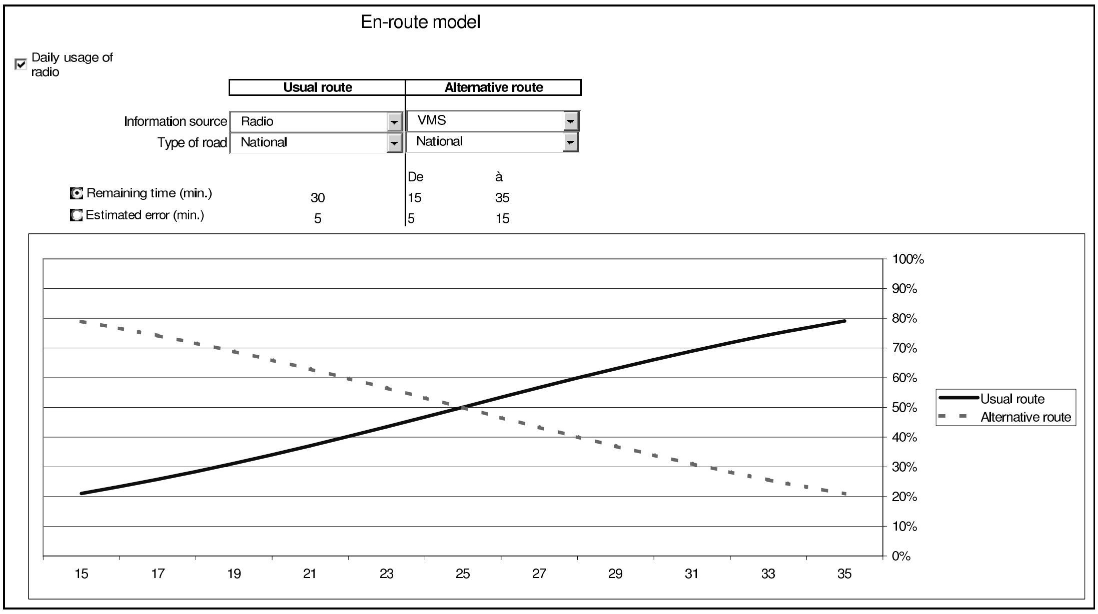

Figure 1: First scenario

In Figure 2, the x-axis represents various values between 5 and 15 minutes for the error on the information about the alternative route, given that the error on the information about the usual route is 10 minutes. The travel time on the usual route is predicted to be 35 minutes, while it is predicted to be 30 minutes on the alternative route. The 50% is reached for a value of about 8.5. If both errors are 10 minutes, the probability to switch is about 47%.

Figure 3 is the same scenario as Figure 2, except that the information about the usual route is obtained from a VMS instead of the radio. We note that the 50% value shifts from about 8.5 to about 11.5, illustrating that travelers have less confidence in VMS, everything else being equal.

6 Conclusions

We have estimated a model capturing the response to en-route information, and two models capturing the response to pre-trip information, based on data collected in Switzerland during 2003.

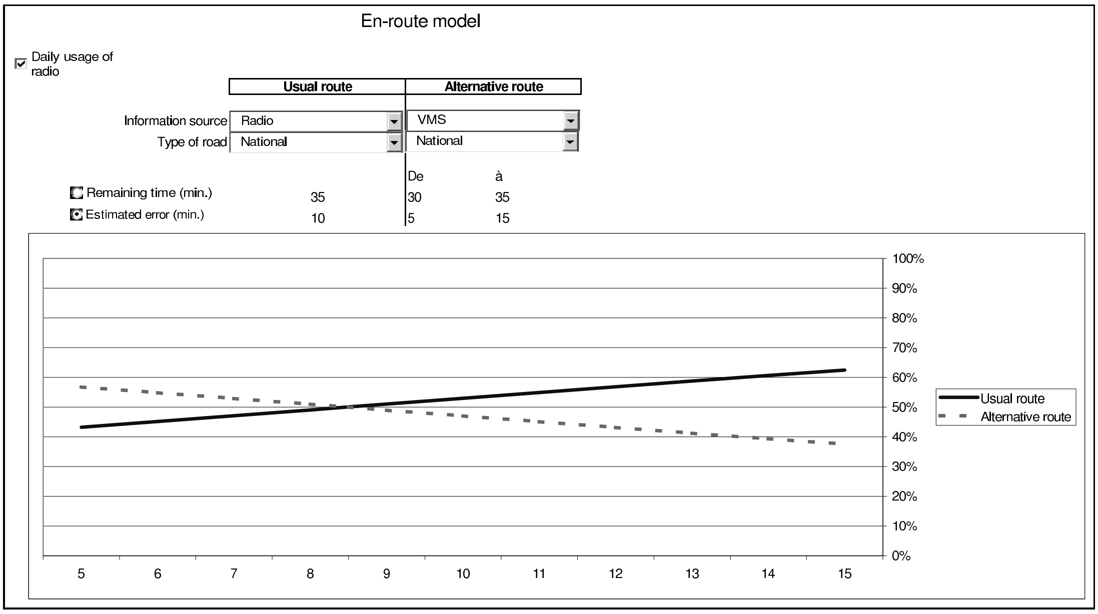

Figure 2: Second scenario

The en-route model enables to measure the level of inertia to en-route switching and the preference toward national roads, among other things. It has been illustrated using some examples of the simulator.

In the pre-trip models, the heterogeneity of the sample has been emphasized. Indeed, the socio-economic characteristics play a significant role in these models. First, a model for the owners of a second home in Ticino has been estimated. It allows to capture and predict the important role of traffic information, and of public transportation in this specific context, and may help to design appropriate focussed policies for long distance, non-work related, trips. Second, a model for commuters has been estimated. While the model seems valid for medium distance trips, we have significant suspicions of its validity for short distance trips. More investigation is necessary to better understand the constraints and the choice context of such trips. The attributes included in our SP experiments are probably not sufficient to explain them.

The models that have been estimated are advanced random utility models. The en-route model is a mixed binary logit model with panel data. The pre-trip models are heterogeneous nested logit models. They have all been estimated using the Biogeme software package.

We conclude by mentioning some potentially interesting streams of investigations:

- The diversity of behaviors emphasized in this study suggests the development

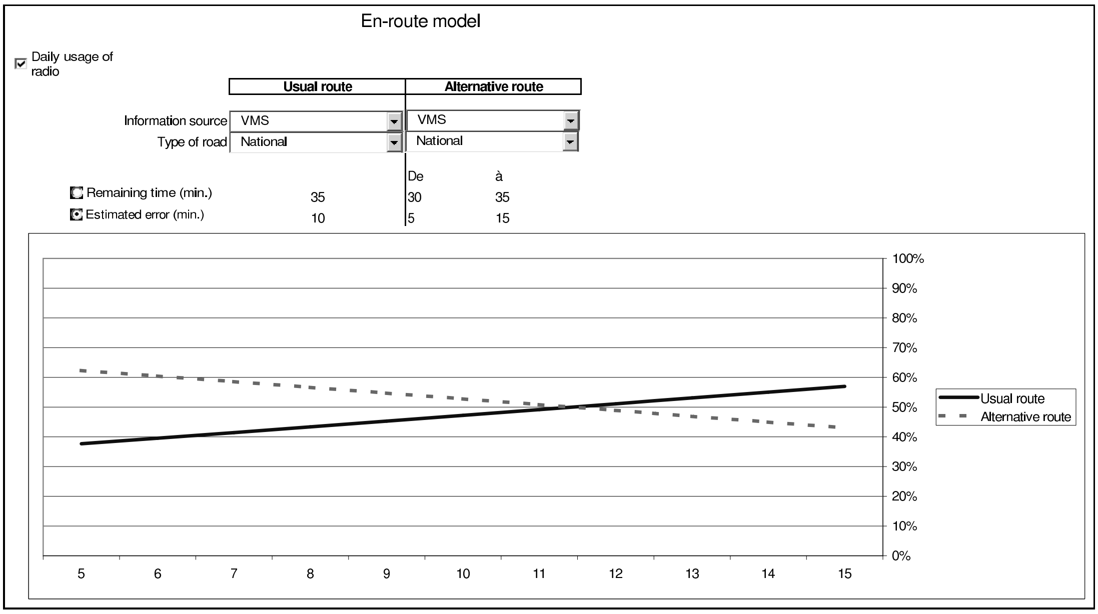

Figure 3: Third scenario

of regular surveys to better understand this phenomenon. The cost of collecting such data being important, organizing regular surveys would also bring very valuable information at a low marginal cost. Moreover, it would allow to analyze the behavioral dynamics, in order to understand how travelers change their behavior as they experience the use of ITS.

- The abnormally high VOTTS for short distance trips should be investigated. For instance, mixed GEV models could be considered, along the lines discusses by Hess et al. (to appear).

- It appears from the models that the level of error in an information system significantly influences its perception. However, this concept has been kept at an abstract level in our surveys, and would deserve a deeper analysis.

- Our sample is biased toward private car users. A more systematic analysis of mode choice would require more public transportation users in the sample.

The use of demand models is more and more critical in the ITS context. The models estimated in this paper allows to better understand and predict the response of travelers to traffic information.

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