THE ROLE OF FLEXIBILITY ON TRAFFIC INFORMATION ACQUISITION

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ABSTRACT

This paper attempts to gain fundamental understanding on the factors that influence real time information acquisition prior or/and during travellers'' primary tour and also investigate the role of flexibility in this decision process. In a sense, one can argue that those who are more prone to use ATIS have less flexibility, while those that show a higher inertia, or in other words would need a significant utility advantage in order to use ATIS, are more flexible.

A case study was developed for the Athens Metropolitan Area, Greece in 2008 and 2009, where 462 observations through telephone interviews, e-mail and traditional mail were collected. Travel information sources available in Attica encompass both conventional forms of information, such as radio and TV traffic reports, and advanced traveller information systems, such as variable message signs (VMS) and in-car navigation systems.

Analysis of the revealed preferences results indicates that the majority of the sample is aware of the traffic information systems available in the Athens metropolitan area, while approximately 65% have acquired deliberately traffic information prior or/and during their primary tour. Moreover, the majority of the respondents stated that doesn't have flexibility in their daily activities schedule and have to be at their workplaces a specific time.

An integrated choice and latent variable model that explicitly captures the flexibility of travelers for acquiring traffic information has been developed. The integrated model consists of two parts: a discrete choice model and a latent variable model.

Keywords: Flexibility, Travel Information Acquisition, Discrete and Latent variable choice models.

INTRODUCTION

Travel information can be acquired from various sources, assisting individuals to plan and execute their daily trips. Additionally, traffic information sources, along with traffic management and other novel concepts can significantly contribute to the optimization of urban transport and thus lead to a cleaner and more efficient transport environment.

The approach developed in this paper is based on a survey that took place in Athens Metropolitan Area, Greece and included both revealed and stated preference data. Individuals were asked about the travel information consulted in the tour which they consider to be the most important tour of the day, as well as regarding their beliefs towards ATIS. It should be noted that travel information sources available in Attica encompass both conventional forms of information, such as radio and TV traffic reports, and advanced traveler information systems, such as variable message signs (VMS) and in-car navigation systems.

The remainder of this paper is organized as follows. Section two presents the findings from the literature review. Section three presents the data collection and descriptive statistics. Section four presents the modelling framework and estimation results and section five presents the conclusions.

FINDINGS FROM THE LITERATURE

The importance of traffic information provision has been acknowledged from transportation authorities worldwide, while travel information is being disseminated from both conventional (e.g radio, tv, etc.) and advanced (e.g.GPS, VMS, Web, etc.) travel information systems. So far, a significant amount of literature on ATIS has been focused on the effect of travellers' socio-economic characteristics (such as gender, profession, education and income) on ATIS usage, (Chorus et al, 2006b; Petrella and Lappin, 2004; Peirce and Lappin, 2004; Emmerink et al., 1996).

Other factors that have proven to significantly affect traffic information acquisition are travel related characteristics, such as trip purpose (Emmerink et al., 1996; Hato et al, 1999; Petrella and Lappin, 2004; Peirce and Lappin, 2004; Zhang and Levinson, 2006) and traffic conditions (Hato et al., 1999; Yim and Khattak, 2002; Targa et al., 2003; Petrella and Lappin, 2004; Peirce and Lappin, 2004; Pecheux και Vandergriff , 2005; Zhang and Levinson, 2006) and information and communication technologies (ICT), such as ownership of mobile communication technologies (Polydoropoulou and Ben-Akiva, 1998; Lappin, 2000; Yim and Khattak, 2002). According to de Palma and Marchal (2008), minimizing travel time uncertainty seems to be one of the most important stimulants for ATIS usage, since the utility loss due to uncertainty has the same order of magnitude with the total travel cost.

More recent developments have emphasized the importance of socio-psychological factors in the decision making process. Past travel experiences, as well as attitudes and perceptions were found to significantly affect travelers' behavior. Recent studies (e.g. Farag and Lyons, 2008; Choocharukul, 2008) showed that social and psychological factors affecting decisions and choices (habit, attitudes, anticipated emotions, and perceived behavioral control), play an important role both in ATIS usage and switching behavior, necessitating further research in this field.

The literature review presented above, provides a comprehensive summary of the factors that influence traffic information systems usage.

DATA COLLECTION AND DESCRIPTIVE STATISTICS

The objective of this study was to examine the level of awareness, usage and the impact of information acquisition on travellers' daily activity schedule, as well as to identify and quantify the role of intention on the actual travellers'' decisions. The survey was conducted in the Athens metropolitan area, through telephone interviews, e-mail and traditional mail. The survey included four (4) sections to gather data on travellers' daily activity pattern (focusing on the tour that they consider to be the most important tour of the day (primary tour)), responses and attitudes towards travel information, basic demographic information and stated preferences towards the usage of next generation ATIS and individuals response to the information acquired by them.

A total of 462 individuals participated in the survey, out of which 415 observations were used for the estimation of the traffic information acquisition model. The average age of the sample is 45 years and more than fifty percent are female. Almost one third of the respondents search regularly through internet for information regarding services and products (28%) and 56.4% use car as their primary mode.

The majority of the sample is aware of the traffic information systems available in the Athens metropolitan area. More than two thirds of the respondents' primary tour purpose is work, while the average tour duration is 37 minutes. Almost 76% of the respondents make only one tour per day, while approximately 28% have acquired deliberately in the past traffic information through web sites. Regarding the occupational status of the sample, 21% are freelancers, 5.3% housewife and 5.5% are pensioners. Moreover, 52% of the respondents have an average monthly income above 1.500€.

Table 1: Traffic information acquisition

	Time of Traffic Information Acquisition			
	Prior to the First/Second Half of the Primary Tour	During the First/Second Half of the Primary Tour	Prior to and During the First/Second Half of the Primary Tour	No Usage
Traffic Information Acquisition	8.67%	22.65%	4.58%	35.9%

The respondents also replied to six questions that can be used to infer their lack of flexibility. Table 2 presents the statements that reflect travellers'' flexibility. In a sense, one can argue that those who are more prone to acquire traffic information have less flexibility. A seven-point scaling ranking from Strongly Disagree to Strongly Agree was used to indicate the level of agreement of these statements. As it can be seen the majority of the respondents doesn't have flexibility in their daily activities schedule and have to be at their workplaces a specific time.

Table 2: Indicators of lack of flexibility

Statements	Mean	Std. Deviation
I have to be at my office specific time	5.53	1.49
I have to pick up/drop off my children from school	3.58	1.99
I don't have flexibility on my schedule	4.28	1.74
My daily schedule is heavy	4.91	1.61

MODELING FRAMEWORK AND ESTIMATION RESULTS

This section presents the modelling framework developed representing traveller's behaviour concerning the acquisition of traffic information.

Behavioural Choice Model

Figure 2 presents the modelling framework of traffic information acquisition. In this figure ellipses represent variables that are not directly observable and therefore called latent variables. Rectangles represent observable variables, either explanatory or indicators of the latent variables. The alternatives are:

1. Usage prior to the primary tour
2. Usage while en route
3. Usage both prior and during the primary tour
4. No Usage

The attributes that influence travelers' decision-making patterns can be broadly categorized into three groups. The first group consists of socio-economic characteristics, such as gender and age. The second group includes variables, which express individuals' technology characteristics, such as access to the Internet, high-speed connections, and cellular phone ownership, while the third group includes travel related characteristics, such as travel time, tour purpose and number of tours per day.

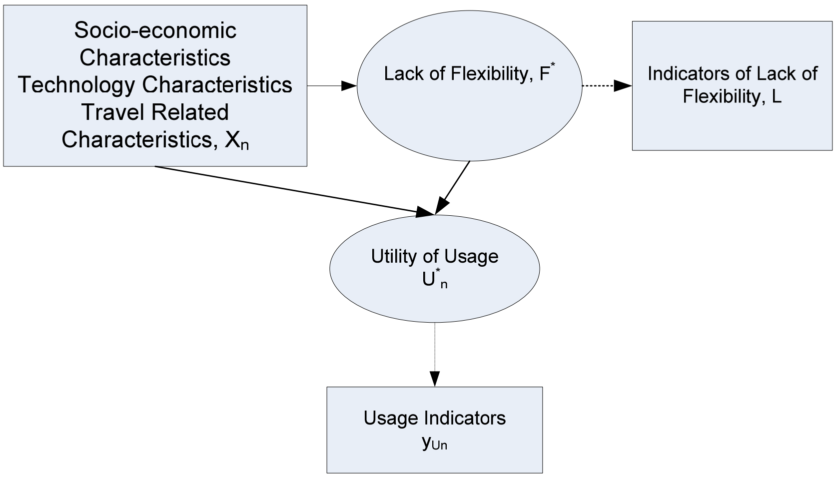

Figure 2: Modelling Framework

The selected model specification is a standard linear-in-the-parameters specification, used in the vast majority of such models. The actual choice of variables is limited by data availability and postulated based on a priori expectations. The model specification has been refined based on statistical tests on estimation results of alternative considered models. The integrated model consists of two parts: a discrete choice model and latent variable model.

The notation for the usage model is:

X_n Explanatory variables (observed), such as characteristics of individuals
F^* Latent (Unobserved) Variable, attitude towards lack of flexibility
y Choice indicators,
L Indicator of Latent Variables
α, β, λ Vectors of Unknown parameters
$\omega, \varepsilon, \upsilon, k$ Random disturbance terms
Σ, σ Covariance of random disturbance terms
φ Standard normal probability density function
Φ Standard normal cumulative distribution function

The usage model with latent attribute comprises structural and measurement equations. A more detailed description of these classes of models can be found in Walker (2001).

Structural equations

For the latent variable model of Lack of Flexibility, we need the distribution of the latent variable given the observed variables, $f_1(F_n^* / X_n; \lambda, \Sigma_\omega)$

$$F_n^* = X_n \lambda + \omega_n, \quad \omega_n \sim N(0, \Sigma_\omega \quad diagonal)$$

For the choice model, we need the distribution of the utilities, $f_2(U_n / X_n, F_n^*; \beta, \Sigma_\varepsilon)$.

$$U_{in} = X_{in}\beta_1 + F_n^*\beta_2 \quad + \varepsilon_{in} \quad and \quad \varepsilon_{in} \sim N(0,1)$$

Note that the latent variables of lack of flexibility are specified only in the utility of no usage.

Measurement equations

For the latent variable model of Lack of Flexibility, we need the distribution of the indicators conditional on the values of the latent variable,
$f_3(L_n / X_n, F_n^*; \alpha, \Sigma_u)$

$$L_{rn} = F_n^*\alpha_r + \upsilon_{rn}, \quad r = 1,2,3,4 \quad and \quad u_{rn} \sim N(0, \Sigma_u \quad diagonal)$$

This measurement equation (one equation for each indicator, i.e., each survey question) relates the indicator variables I (left hand side) with the latent variables and individual characteristics (right-hand-side).

No constants are included in the measurement equations since L_{rn} is in deviation form.

For the Choice Model we express the choice as a function of the utilities.

$$y_{in} = \begin{Bmatrix} 1, if \quad U_{in} \geq U_{jn}, \; for \quad j = 1,2,3,4 \\ 0, otherwise \end{Bmatrix}$$

The covariance's of the error terms in the latent variable structural and measurement model are constrained to be equal to zero (denoted by the Σ diagonal notation).

Likelihood Function

Maximum likelihood techniques can be used to estimate the unknown parameters. The likelihood function for the integrated model presented above can be written as:

$$f_4(y_n, L_n \setminus X_n; \alpha, \beta, \lambda, \Sigma_\varepsilon, \Sigma_\upsilon, \Sigma_\omega, \Sigma_k) = \int_{F^*} P(y_n \setminus X_n, F^*; \beta, \Sigma_\varepsilon) f_3(L_n / X_n, F_n^*; \alpha, \Sigma_u) f_1(F_n^* / X_n; \lambda, \Sigma_\omega)$$

The first term of the integrand corresponds to the choice model, the second term to the measurement equation from the latent variable model and the fourth term to the structural equation of the latent variable model. The joint probability of the y_n, L_n, and F_n^* is integrated over the vector of latent construct F_n^* because the latent variable is only known to its distribution.

Model Estimation

The Table below presents the estimation results corresponding to the above model framework. The model estimation/calibration was made with ICVL (Denis Bolduc). The presented model was selected on the basis of statistical goodness-of-fit (likelihood ratio tests, estimated coefficient significance t-tests, the rho-square (ρ^2), as well as parsimony.

The (negative) sign of the values of the estimated alternative specific constants show that, ceteris paribus, there is inertia towards no use.

The negative value of the estimated coefficient associated with the daily number of tours (specific to no use) indicates that travellers' are more likely to acquire traffic information as the number of tours increases. Moreover, as indicated by the negative coefficient associated with the no use alternative, if individuals use public transport modes for their primary tour, are less likely to acquire traffic information, than those who use private modes. Individuals', who search internet for information regarding products and services, are more likely to acquire traffic information either during their primary tour, or both prior and en route of their primary tour, while those that have internet access through their mobile phone are more likely to acquire traffic information. Freelancers are less likely to acquire traffic information, probably because they can easily modify their schedule, compared to employees.

Moreover, the presence of the lack of flexibility latent variable is also significant. Specifically, as the coefficients signs indicates, the greater the lack of flexibility, the higher the likelihood of traffic information acquisition.

The structural equation of the lack of flexibility latent variable model suggests that pensioners, individuals with high monthly incomes, as well as car owners are more flexible, in contrast to students that are less flexible. The coefficients of the four indicators of the lack of flexibility measurement equations were found significant as expected.

Table 3: Model estimation results

	MNL		**MNL with latent variable**	
CHOICE MODEL				
Explanatory Variables	**Est. Coef.**	**t-stat**	**Est. Coef.**	**t-stat**
Alternative specific constant (specific to prior)	-2.90	-7.45	-2.390	-2.75
Alternative specific constant (specific to en route)	-2.81	-6.89	-2.404	-2.71
Alternative specific constant (specific to both prior and en route)	-4.24	-8.50	-3.815	-4.05
Daily number of tours (specific to no use))	-0.391	-1.91	-0.526	-1.98
Occupation: Freelancer (specific to prior)	-1.24	-2.01	-1.276	-1.94

	MNL		**MNL with latent variable**	
CHOICE MODEL				
Explanatory Variables	**Est. Coef.**	**t-stat**	**Est. Coef.**	**t-stat**
Occupation: Freelancer (specific to both prior and en route)	-1.81	-1.74	-1.829	-1.56
Search internet for information regarding products and services (specific to en route)	0.886	3.35	0.973	3.19
Search internet for information regarding products and services (specific to both prior and en route)	1.03	2.10	1.098	2.01
Primary Transport Mode: Public Transport (specific to no use)	0.622	2.55	0.869	2.62
Average Tour Duration (specific to no use)	- 0.0164	-3.40	-0.021	-3.22
Deliberate Past Usage of Web Traffic Info Site	-0.567	-2.34	-0.776	-2.41
Cell Phone Ownership with Internet Access	0.518	2.01	0.62	1.97
Deliberate Past Usage of VMS	0.465	1.96	0.584	2.06
F_n^* **Lack of Flexibility** (specific to no use)			-0,391	-2.38
Summary Statistics				
Number of Observations	415		415	
Initial Log Likelihood	-575.312		-575.312	
Final Log Likelihood	-372.226		-369.451	
Rho-square	0.353		0,357	
Latent Variable Model – Lack of Flexibility				
Structural Model for the Lack of Flexibility F_n^*				
Income above 1.500 €			-0,267	-2.26
Occupation: Pensioner			-0,428	-1.48
Occupation: Student			0,587	1.57
Car Ownership			-2.595	-9.45
ρ^2			0.424	
Measurement Model				
λ_1 I have to be at my office specific time			1.994	37.97
λ_2 I have to pick up/drop off my children from school			1.318	29.27
λ_3 I don't have flexibility on my schedule			1.569	36.24
λ_4 My daily schedule is heavy			1.796	37.41
σ_1 I have to be at my office specific time			1.257	17.64
σ_2 I have to pick up/drop off my children from school			1.763	20.15

	MNL		MNL with latent variable	
CHOICE MODEL				
Explanatory Variables	**Est. Coef.**	**t-stat**	**Est. Coef.**	**t-stat**
σ_3 I don't have flexibility on my schedule			1.375	23.01
σ_4 My daily schedule is heavy			1.209	23.30

CONCLUSIONS

In the presented research, the factors that influence traffic information acquisition has been investigated. A joint choice and latent variable model that explicitly captures the role of lack of flexibility in the decision to acquire traffic information has been developed.

The model developed revealed that traffic information acquisition is mainly affected by the following factors: (a) individuals lack of flexibility while scheduling their daily activities; (b) travel related characteristics, such as the average duration of the primary tour, the transport mode and the daily number of tours; (c) personal characteristics, such as occupation ;and (d) familiarity with information and communication technologies (ICT), such as mobile internet access, internet search.

However it should be noted that the estimated model should be seen in the context of the available data. Further research should focus: (a) on the dynamic representation of travellers’’ behaviour towards traffic information acquisition, where the appropriate data will be collected at several time periods from the same individuals and (b) at extending the presented modelling framework with additional variables and structures that would capture the underlying processes more accurately and would provide better fit.

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