Integrated Choice and Latent Variable Models for evaluating Flexible Transport Mode choice

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ABSTRACT

Flexible Transport Modes and Services are primarily demand oriented initiatives that presuppose the self motivation of each individual in order to be preferred in a constant way. Given that fact, the examination of the potential success of such interventions should take into account not only quantitative data but also qualitative / behavioural parameters that participate in the mode choice procedure. This examination should follow specific guidelines in order to have common accepted evaluation procedures.

In this paper, an Integrated Framework for the ex ante evaluation of a Flexible Transport Mode Schemes, is presented.

The proposed framework is implemented in a real life problem: the introduction of Flexible Transport Mode scheme for commuting trips. Following the theories and concepts of the Framework, ICLV (Integrated Choice and Latent Variables) models were developed, in order to estimate the importance of a set of variables into mode choice process, for four alternative to the car modes The models that were developed though the usage of Structural Equation Modeling techniques are hybrid binary choice models and the discrepancy function that was used was the Bayesian estimation.

The analysis showed that latent variables can significantly contribute in the process of interpreting the mode choice decision.

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1. Introduction

Nowadays, traffic congestion, the unreliable transportation networks as well as the modern way of life in urban areas, make individuals' mode choice decision a complex, multiparametric procedure.

The first mathematical models that were developed in late 1960s were formulated on an "idealized" traffic environment; on one hand congestion was not so frequently observed in road networks and on the other, individuals' need for high level services in terms of comfort, availability, flexibility and security of the travel mode used, was not so demanded.

In contrast to the conventional mode choice models, where traffic related indices are mostly being examined (e.g. observations on travel time, walk and waiting time, generalized cost of travel), the current approaches postulating the turn of the interest to more anthropocentric theories; the mathematical functions that aim to describe the mode choice procedure should include information regarding the attitude, the values and the behaviour of each individual.

Although travel time and cost can be easily observed and added in a mathematical formula, the above mentioned psychometric data, like the attitude and behaviour of the traveller, the need for comfort

and flexibility of the mode etc., cannot be easily observed and quantified under the framework of traditional Quantitative Engineering science.

For that reason, the modern interpretation of behavioural mode choice incorporates theories and techniques originating from the area of Social Sciences, and more specific from an ongoing developing subcategory, entitled *Mobility Psychology*. The science of Psychology deals with unobserved behavioural elements (like distress, euphoria, perspicacity etc) – known as "latent characteristics" in behavioural sciences – and can have a great potential in exploring which factors contribute on the way people are choosing or not an alternative for travel.

The need for investigation of individuals' background, the examination of perceptions, needs and tastes and how all these parameters are affecting the actual exogenous travel behaviour is more vital in cases where demand oriented schemes, such as the introduction of FTS, are tested and evaluated.

Taking all the above mentioned issues into account, the objective of the paper is divided into two main parts; first, to propose a Methodological Framework regarding the ex ante evaluation of Mobility Management (also referred as Transportation Demand Management) Measures like that of Flexible Transport alternatives. The second objective is to highlight the importance of unobserved latent characteristics of the traveller (like the environmental concerns and the need for flexibility and comfort) in the choice model utility functions so as to have more robust

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estimations regarding the potential of selecting Flexible Transport Modes (FTM).

The second part of the paper presents the investigation of a Flexible Transport scheme at the Aristotle University of Thessaloniki, Greece. Under the proposed methodological framework, a Stated Preference (SP) survey was conducted with the employees of the university and Integrated Choice and Latent (ICLV) models were developed. Various Flexible Transport Modes (FTM); collective taxi, carpooling, vanpooling (the university bus) and a non flexible mode – the Metro – were tested as alternative to the car for commuting trips. The ICLV models consist of hybrid binary choice models where utility functions incorporate behavioural characteristics of the responder, such as the readiness to change travel mode, his desire for comfort and flexibility etc.

The structure of the paper consists of 4 main parts:

Section 2 briefly presents theories and documentation regarding the new concept of Mobility Psychology and how this new area can related with Flexible Transport Modes and Services.

Section 3 presents the theoretical methodological framework proposed, for the ex ante evaluation of specific demand oriented measures like that of Flexible Transport Mode.

Section 4 presents in detail the application on this framework in a real life problem: the examination of the introduction of Flexible Transport Mode scheme for commuting trips at Aristotle University of Thessaloniki, Greece. In this section, special space has been given to the survey design and the development of the discrete choice models.

Finally, at the conclusion section, comments about the innovation of the proposed methodology are given as well as information about the available resources needed to evaluate and implement such initiatives in reality.

2. Human behaviour and Flexible Transport Services

Brake, Mulley, and Nelson (2006) refer that Flexible Transport Services (FTS), also known as Demand Respond Transport or Demand Respond Transit (DRT) or Dial-a-ride Transit Services, is an emerging term which covers services provided for passengers that are flexible in terms of route, vehicle allocation, vehicle operator, type of payment etc. In a more simplified definition originating from the Penelope (Promoting ENergy Efficiency to Local Organisations through dissemination Partnerships in Europe) Project (2002), a FTS is considered as an advanced user oriented form of public transport characterized by flexible routing and scheduling of small/medium vehicles operating in shared-ride mode, between pick-up and drop-off locations according to passengers needs.

Since FTS are demand oriented options, the human attitude, behaviour and personal needs play a vital role when such interventions are planned to be implemented. This comment, lead to the conclusion that objectives like that of effective/sustainable management of peoples' mobility as well as successful implementation of alternatives to the car such as Flexible Transport Modes, should take into account, human preferences, tastes and values.

Nowadays, the demand for investigation of the role of human factor in transportation is being increased. It is clear that the adoption of a new behaviour such as the selection of a new transport mode instead of car, is not just a matter of gaining time and cost, since other – psychological related – constructs are affecting the mode choice decision. For a demand response mode, individuals' endogenous characteristics significantly contribute in the mode decision making (and taking) process, since the selection of the mode, presupposes the self activation of each potential user.

The need for examination of peoples' attitude and behaviour in transport related problems, led to the development of a new research field, namely *Traffic and Mobility Psychology*, which incorporates theories and concepts from various sciences such as Psychology, Sociology, Transportation Engineering and Marketing. Behavioral Economics (Ben-Elia, Erev, & Shiftan, 2008; Gärling et al., 2000; McFadden, 2007) as well as Environmental Psychology (De Young, 2011; Edgerton, Romice, & Spencer, 2007) are considered as two of the main subcategories of Traffic and Mobility Psychology, with numerous applications worldwide. However, applications dealing with the issue of Flexible Transport Systems and Services and how they affect travel mode choice, are limited.

In literature, there are numerous explanatory psychological models aiming to interpret individuals' perception, attention and cognition, as well as the motivational and emotional determinant factors of travel mode choice and behavioural mobility (Balcetis & Dunning, 2007; Golledge & Garling, 2007). These psychological models – known as behavioural change models – were first developed and tested for other purposes, such as the analysis of smoking prevention, the interpretation of household consumption, the examination of environmental awareness, the intention to lose weight etc. Some of the most well known models are: the Need Opportunity Ability (NOA) Model (Meloni, Bez, & Spissu, 2009; Shiftan, 2008), the Health Belief Model (HBM) (Webb, Sanson-Fisher, & Bowman, 1988), the Protection Motivation Theory (PMT), (Sonmez & Graefe, 1998), the Theory of Planned Behaviour (TPB) (Bamberg & Schmidt, 2003), the Norm Activation Model (NAM) – (Hopper & Nielsen, 1991; Hunecke, Blobaum, Matthies, & Hoger, 2001), the Transtheoretical Model (TTM) – (Fergusson, Davis, & Skinner, 1999; INPHORMM, 1998; TAPESTRY, 2002) and the MaxSem Model (MAX Project, 2009).

Most of these models are using the concept of *behavioural stage*, in order to explain the way that people formulate, consolidate or change their behaviour (Darnton, 2008; Rose & Marfurt, 2007). The allocation of each individual in a stage, can help in understanding how aware this person is about a problem examined (e.g. thoughtless smoking, eating or using his car). In addition, this measure of the stage can help in formulating and implementing the most effective policies that can force people to other behavioural stages, e.g. changing their current unwanted behaviour.

Although there is an ongoing growing interest on how behavioural parameters affect mode choice and travel behaviour, there is poor literature evidence that the success of Flexible Transport Systems (FTS) are interelated with the endogenous characteristics, perceptions and beliefs of each individual.

In order to evaluate the impact of FTS in behavioural change, in this paper we are using the theories and methodologies, derived by the MaxSem Model. Since this model presupposes individual self (volunteer) intention for change, it is believed that it is the most suitable for explaining the potential of choosing (or not) a Flexible Transport Mode, where self activation behaviour is almost a prerequisite.

The MaxSem Model classifies peoples' awareness/readiness for changing travel habits, in 4 behavioural stages:

Stage 1: Pre-contemplative stage. Persons in this stage are habitual car drivers who have no intention to reduce their current car use. The aim here is to make this group think of possible change.

Stage 2: Contemplative stage. Persons in this stage are thinking about reducing their current car use: they have formed a personal car reduction goal. The aim here is to present to this group attractive options for changing their behaviour.

Stage 3: Preparation/action stage. Individuals in this stage have selected a concrete behavioural strategy for reaching their car reduction goal (e.g. using the bike instead of the car to go to work) or they have already occasionally tried the new behaviour. The aim here is to have the group actually try out new behaviour and to facilitate the maintenance of this new behaviour.