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The role of accessibility and connectivity in mode choice. A structural equation modeling approach.

Dimitrios Papaioannou^{a,*}, Luis Miguel Martinez^b

^a Instituto Superior Tecnico, Avenida Rovisco Pais 1, 1049-001, Lisbon, Portugal

^b Transport Analyst, International Transport Forum at OECD, 2-4 Rue Louis David 75016 Paris, France

Abstract

This study addresses the effect that characteristics of the Public Transport (PT) network layout and service provision have on mode choice, mainly focusing on accessibility and connectivity. Using data from a mobility survey conducted in Lisbon, Portugal we model the binary choice between PT and private car through a structural equation model. The results indicate a duality in the choice process; good accessibility of the system as a whole encourages PT use but poor connectivity on a particular trip might deter it. A convergence of good performance both in overall accessibility and trip specific connectivity seems necessary for an individual to choose PT over private car.

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* Corresponding author. Tel.: +1-347-948-3543.

E-mail address: dimitrios.papaioannou@tecnico.ulisboa.pt

1. Introduction

The expansion of urban areas around the world constantly creates new mobility challenges to transportation planners. Public transport – transit (PT) is perhaps the easiest and most efficient way to solve many of these issues, especially in dense urban areas. An efficient PT system can lead the way to a greener and more sustainable city, serving the peoples' mobility needs (Haghshenas & Vaziri, 2012). This however, clashes with the current social norm favorable to private vehicles; as well as the feeling of freedom and ease that they give to their users.

We come across mode choice decisions several times in our everyday life. Many of us are captives to a specific mode (Beimborn, et al., 2003), but this can change depending on the regularity and type of the trip. In order for PT to be a competitive alternative with private car, its overall quality of service needs to be improved. Quality of service is usually addressed as the overall performance of a given PT system. Operators and authorities frequently focus on improving service reliability, introduce new information services and provide better riding experience (i.e. safer and cleaner vehicles and infrastructure). The literature has explored these possibilities in depth, but it is the authors' belief that regular satisfaction assessment techniques are unable to find ways for PT to attract new users; a change in the structure of the network is required instead.

In this paper we examine mainly two aspects of PT operation and design: accessibility and connectivity. In the literature these elements are very closely related and often confused or mentioned as one. In this work we address accessibility at the strategic tactical level, and we define it as the ease of access to the PT system and the diversity of land use, both combining into the possibilities of a user to perform his desired activities. Connectivity on the other hand is the performance of the PT system in terms of time, speed, directness of travel and number of transfers for a specific origin-destination connection. We use travel data from a small mobility survey conducted in Lisbon in 2011 and examine whether these system's design concepts have an effect on the final mode choice.

This paper is divided in four main sections; after this brief introduction, a literature review about mode choice, captive and non-captive users, PT accessibility and connectivity is provided, followed by the description of our methodological approach and the calibration of the model as well as the discussion of the obtained results; finally the paper ends with some conclusions and thoughts for further research.

2. Literature

The modes that we use to cover our mobility needs can be categorized in several ways. Motorized vs. non-motorized; private vs. public; fixed route vs. variable route are just a few. For most trips or trip chains that we do, there are a number of possible alternative modes or combination of modes to pick from. Every time we have to choose how to make a trip there are several factors that influence our decision. Some of them are easier to spot and understand and others require a more in-depth analysis.

A commonly used term in mode choice research is captivity/captive to a specific mode (Beimborn, et al., 2003; Habib & Weiss, 2014). This expression refers to an individual that does not consider other transport alternatives for his mobility needs. There are two types of captivity, captivity by force or by choice (Jacques, et al., 2013). Captivity by force is the situation where there are no other viable transport alternatives. Usually a person is a car captive when PT stops are too far away from his origin and/or destination. A PT captive is usually an individual that doesn't have a private car or motorcycle and his travel needs can't be done by walking. The phenomenon of a user having the ability to use more than one transport mode, but completely disregarding all the options but one is called captivity by choice. This usually happens because of some personal attitude towards a specific mode, positive or negative (sensation of freedom when driving, ability to engage in other activities when using PT, etc.). Sometimes bad experiences on a random trip (accident, theft) can cause major dissatisfaction for that mode and the user doesn't consider it as a feasible alternative.

From a Travel Demand Management (TDM) perspective, captive by choice users are more difficult to influence than the others. In regards with sustainable transport in urban environments, the limited options of forced captives make them a factor to be considered in any case, while captives by choice are an ambiguous issue. Car captives can often cause problems to the application of sustainable policies, while captives to PT or non-motorized modes may be considered a positive influence. Understanding the dynamics behind choice captivity is one of the keys towards more effective and sustainable transport planning (Beimborn, et al., 2003).

Therefore, captivity plays a dominant role on the decisions regarding the transport mode of our trips. However not everyone is a captive user, and even those that are, are usually driven by different attributes of a mode. Understanding mode choice has been a research focus for many years and socio-demographic characteristics are used to understand the behavioral drives behind it (Klößner & Friedrichsmeier, 2011). But as Goodwin (1995) noted almost 20 years ago, the most important thing that we need to understand when talking about travel behavior is that every person is different. Many researchers have tried to segment the market into groups and distinguish the differences between them (Beirao & Cabral, 2007). Some of the methods used to do this task include: behavior change based on family, social status or location (Anable & Gatersleben, 2005); clustering of travel attitudes, preferences or motivations (Vredin Johansson, et al., 2006); and travel habits and behavior homogeneity (Gärling, et al., 1998). They all have their own explanation of how and why people in each group behave like they do. The psychological aspects in the behavior behind mode choice decisions have also been examined (Bronner, 1982; Donald, et al., 2014). From the available literature we may conclude the existence of a link between attitudes and socio-demographics. However the difficulty in identifying the composition of different user groups in the society and the variation between urban contexts makes this link harder to recognize and confirm.

The attributes of the trip itself play if not the most, one of the most important roles in our decision process; and trips can vary. Differences in distance (Scheiner, 2010) and travel agenda complexity (Bhat, 1997; Ye, et al., 2007) may change our mode choice, but trip purpose and timing are two of the most important variables. There are many factors that are interrelated with them, but perhaps the biggest difference is our attitude and behavior towards them (Azari, et al., 2013). There is an extensive body of literature on the mode choice differences between work and non-work trips, commuting and non-commuting trips (Whalen, et al., 2013), shopping (Bhat & Steed, 2002), leisure and other trip purposes, during peak hours or not. Characteristics like repetitiveness, lack of time flexibility (Nurul Habib, et al., 2009), are evident in commuting work or study trips and often cause a form of captivity for these specific trips.

Another interesting aspect of mode choice is the difference between objective and subjective choice sets (Van Exel & Rietveld, 2009). The objective choice set of a person is the total of transport alternatives that are available to him, while the subjective choice set is the subset of the alternatives that the individual knows off or considers plausible and desirable. Our modal decisions are done with the subjective choice set, and may sometime exclude us from an alternate option that may serve us better; for example a captive by choice may consider his mode as his only alternative, therefore making this his subjective choice set, ignoring the objective choice set that may include other possibilities (Srinivasan, et al., 2007).

In most urban areas in developed countries modal share is heavily favoring private modes, mostly private car. When trying to develop TDM measure to influence mode choice towards PT, two approaches can be taken. The first includes implementing policies and rules that restrict or reduce car use in the CBD, while the second aims to improve the quality of service of PT, thus

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