Habitat International xxx (2016) 1–7

Contents lists available at ScienceDirect

Habitat International

journal homepage: www.elsevier.com/locate/habitatint

Measuring the externalities of urban traffic improvement programs

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ARTICLE INFO

Article history:
Received 10 August 2015
Received in revised form
9 February 2016
Accepted 11 February 2016
Available online xxx

Keywords:
Park & ride
Externality
Choice experiment
Stated preference
Discrete choice

ABSTRACT

In this article we present a methodology to improve the economic analysis of urban transportation programs by measuring the externalities, and we demonstrate its application to a case study of a large scale park & ride facility in Buenos Aires, Argentina.

The externalities accompanying changes in transportation systems can be significant, even exceeding the magnitude of the intended benefits. Nevertheless they are difficult to measure, because they involve subjective values that are not traded in the market. We measure the subjective value of lower traffic congestion by means of three metrics: travel time, traffic accidents, and noise. A perceptual scale is created to make the latter metric operational for the first time, to the best of our knowledge. We implement a generic choice experiment to elicit the preferences of the individuals, and a mixed logit model to obtain the value rates of the externalities. The generic experiment, in contrast to specific modal choice stated preferences applications frequently used, focuses on the effects, then it is applicable to a wide range of transportation programs.

The case study involves a park & ride facility whose demand was determined in a previous paper. We show via stylized discounted cash flow analysis that the value for the users is not sufficient to justify the investment. However the positive externality generated by lower traffic congestion in the city, measured by means of the subjective value rates estimated in the present study, turns the net present value of the project highly positive.

1. Introduction

The city of Buenos Aires, like most other large cities in the world, faces traffic congestion problems, particularly at peak hours, but also throughout the whole range of working hours in the centre. The government has been working on traffic flow improvement. Significant changes in public transportation have been implemented, like adding 3 new subway lines to the 4 existing and concentrating the bus network in wider avenues with dedicated lanes. These changes have contributed to improve the locally generated traffic flow, however there is a second cause of traffic congestion that is yet to be addressed: the large traffic inflow from the greater Buenos Aires area. There is a conflict of interest between the city district and the province, as the problem in the former is caused by lagging investment in transportation in the latter. Park & ride facilities represent a solution to this second cause of traffic congestion, as they would deter commuters from entering the city by car, by offering them convenient connection with other transportation modes, namely railway, subway, bus and even charter vans (Dijk & Montalvo, 2011).

Demand estimation for a park & ride facility in the north access to Buenos Aires city at different price levels has been conducted in a previous study (Picasso, Bonoli Escobar, Stewart Harris, Peña, Mermoz et al., 2014). The proposed project achieved high public acceptance among northern suburbs residents. However park & ride facilities require large scale investments for acquiring several hectares of land, and heavy infrastructure works: a multi-level building structure, railway and subway lines extension, etc. The investment for the proposed facility would be in the order of

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http://dx.doi.org/10.1016/j.habitatint.2016.02.002
0197-3975/

magnitude of 1000 MUS$.[2] Despite the high public acceptance among commuters, the value generated for them would only cover a fraction of the investment and costs as explained below.

This is in agreement with the results in Risa Hole (2004) for an employee park & ride service, who finds that the value created is hardly enough to offset the reduction in flexibility for car drivers. Bos, Van der Heijden, Molin, Timmermans et al. (2004) also acknowledge that park & ride facilities in The Netherlands have not attracted the expected number of car drivers, then they implement a choice experiment to explore the potential reasons, finding that security, quality of the connection and travel times are the most influent ones. Mingardo (2013) and Duncan and Cook (2014) find that park & ride facilities may also attract transit users, especially if they are peripheral, offsetting the reduction in vehicle-km travelled. This effect would be prevented by a fee, which is the case proposed in Picasso et al. (2014).

The studies mentioned above focus on the value to the car driver, however there is another source of value created by the park & ride that remains unexplored. The city residents would not be using the park & ride facility, but they would get the positive externality of a more fluid traffic. Then they would probably be willing to contribute for the project to be implemented. The government can channel this willingness to pay via taxes, making this Pareto efficient project possible by means of a subsidy. The social value of the positive externality may or may not be enough to make the project economically viable, and it should be determined to answer that question.

The objective of this research study is to determine the subjective value of the reduction in traffic congestion for the individuals using the traffic network of the city of Buenos Aires.

The statistical methodology employed is discrete choice modelling. These models have been created to estimate the demand for a new transportation mode in the San Francisco Bay Area: the BART (Bay Area Railway Transit) (Mc Fadden, 1973, 1975, Mc Fadden et al., 1977). Since then, discrete choice models have been widely applied to different transportation problems, reaching the scientific community recognition as the best practice (Ben-Akiva & Lerman, 1985) (Bos et al., 2004), (Risa Hola, 2004) (Holguin-Veras, Reilly, Aros-Vera, Yushimito, & Isa, 2012).

The discrete choice models decipher the decision patterns of economic agents, individuals in this case, among a discrete set of alternatives. They are based on the theory of random utility, where this utility is modelled as a function of the characteristics of the alternatives and a random element accounting for unobserved variables and preferences.

The empirical base to estimate discrete choice models can be either natural information (revealed preferences or RP) or elicited in a choice experiment (stated preferences or SP). The second approach was selected for this research project as a natural database is not available.

In section 2.1 we describe the choice experiment implemented for this study. Then we specify the discrete choice model employed. The model estimation results are presented in section 2.3, and finally the application to the park & ride case study is discussed in section 2.4.

2. Development

The present study focuses on the effect of a generic transport improvement program on the congestion in the city. The choice experiment involves hypothetical programs defined by their effect on travel time, accidents and noise. The model estimates the subjective value of each of these metrics for the city network users, making it possible to measure the externality generated by any transport improvement program, in particular the case study of the park & ride facility mentioned above.

2.1. The choice experiment

The population under study is formed by the frequent users of the traffic network of the city of Buenos Aires,[3] even if they live in the suburbs. The sample was done in two stages. We have employed an Internet panel: a data base of individuals willing to participate in surveys, built with the objective to represent the population within the sampling frame of internet users, which is the first stage. The data collection instrument was distributed among a random sample of panellists, which is the second stage. Frequent traffic network users were selected by a filter in the questionnaire. 218 interviews were completed out of 443 invitations. Each interview includes 10 choice tasks, making a total of 2180 data units.

The sample is composed of 54% men and 46% women. This is aligned with the population data (census 2010[4]) taking into account that work incidence is higher for men. The geographical distribution is 62% residents in the city and 38% habitants of the suburbs. The age distribution of the sample shows 33% respondents below 30 years old, 28% between 30 and 40, and 39% above 40 years old. This is also aligned with the population. The distribution of the socioeconomic level[5] of the sample shows 29% for the high class, 61% for the middle one, and 10% for the low class. This is somewhat skewed upwards compared to the population, where the lower class represents 35%, meaning that the conclusions of the study are primarily representative of the middle and high classes, with a smaller weight for the lower one.

The measurement instrument is an online questionnaire including the choice experiment. The first part of the questionnaire contains the filter and an exploration of habits. The most relevant trip, due to frequency or length, is identified for each individual, as well as its frequency, transport mode, and travel time. The car tax and property tax levels of the individual are also collected. The second part of the questionnaire is the choice experiment, described below. The third part has the demographic questions.

The choice experiment consists of 10 choice tasks, each one having 4 alternatives representing generic hypothetical traffic improvement programs for the Buenos Aires city. The experimental design focuses on the effects on traffic congestion, characterizing each transport program by: travel time, noise level, traffic accidents, and cost. The details of the transport programs causing them remain generic. A typical screen of the data collection software, presenting the choice task to the respondent, is shown in Fig. 1 (translated from Spanish).

The average travel time of the most relevant trip is recorded for each individual and used as a realistic base value for the choice experiment. The travel time of each alternative in each choice task pivoted on the base value for each individual, varying across 5 points: −50%, −25%, 0, +25%, +50%.

The noise levels presented are the same for all individuals. A scale of noise was developed in a previous study. This study was based on a random sample of 116 individuals living in the Buenos

[2] US$ stands for United States dollars, and Ar$ for Argentine peso. Multiples follow the standard notation: K for thousand, and M for million.

[3] The “city” means the federal district, i.e. the “Ciudad Autónoma de Buenos Aires”. The metropolitan area includes the city and the Greater Buenos Aires.

[4] Instituto Nacional de Estadísticas y Censos.

[5] The methodology to measure the socioeconomic level in Argentina was developed by the Sociedad Argentina de Investigadores de Mercado y Opinión (SAIMO).

Please cite this article in press as: Picasso, E., et al., Measuring the externalities of urban traffic improvement programs, *Habitat International* (2016), http://dx.doi.org/10.1016/j.habitatint.2016.02.002