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Modelling perceived quality for urban public transport systems using weighted variables and random parameters

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ABSTRACT

In this paper a methodology is proposed to consider the importance attributed by users to individual variables in a perceived quality analysis. A two stage ranking based attribute survey is proposed. Firstly, the attributes belonging to each group are ranked and secondly, each group is ranked according to its importance.

A series of successive ordered probit models is proposed which also includes models considering systematic and random variations in user taste. The variables are weighted according to the individual and group rankings.

The article concludes that increasing the complexity of the models improves their capacity to represent reality, however, there comes a point when the effort required to obtain sufficient data to feed the complexity of the models is not efficient and the time taken is not compensated by the improved predictions.

1. Introduction

The analysis of user perceived quality for a public transport system is useful for defining possible improvements and maximising their influence on service quality. This article introduces a methodology based on econometric modelling which applies ordered probit models to establish the pertinent variables or attributes which have the greatest effect on overall service quality. Furthermore, various models have been analysed considering user heterogeneity and the importance of the variables.

The validity and utility of the proposed methodology have been tested in a real application: the public transport system in the city of Santander (Northern Spain), where the perceived quality has been determined for the 15 lines representing the city's public bus service. Following the calculation of all the models, a model fit comparison was made to establish the benefits of using more complex models against simpler ones.

This article is divided into 6 sections. A brief state of the art review regarding public transport service quality is provided in Section 2. The methodology followed is explained in Section 3 which is further divided into three parts: the data collection process, the theoretical background of the models used in the study and an explanation of the models that were developed. The results from the practical application are presented in Section 4 which is followed by a comparison between the estimated models. The article finishes with the main conclusions drawn from this research.

2. State of the art

Service quality has been widely studied since it was first introduced by Berry et al. (1990), Parasuraman et al. (1985), who defined the perceived quality of service as the difference between expected quality and the perceived service quality.

User perceived quality has been shown to have a positive effect on the demand for public transport services (Cascetta and Cartenì, 2014; Joewono and Kubota, 2007; Lai and Chen, 2011; Nilsson et al., 2001; Rojo et al., 2012; Tam et al., 2010; Wen et al., 2005). However, although users perceive a very good quality of service, this cannot be taken as a criteria of success of the public transport service and therefore cannot be used as the only reference when planning policies aimed at maintaining current usage and attracting new customers (de Oña et al., 2016a; Fellesson and Friman, 2009).

The first step for studying the quality of a public transport service consists of finding its defining variables or attributes. (Parasuraman et al., 1988) defined the SERVQUAL scale composed of 22 valid attributes for evaluating quality in different services. Later, Hensher (2003) developed the SQI (Service Quality Indicators) scale, aimed at public passenger transport services, formed of 13 attributes. In similar research, the QUATTRO project (EC, 1999) developed a three level classification based on 8 main groups with a total of 99 attributes to be evaluated. Various authors have adapted these foundations for many specific case studies about the implications different attributes have for a service (de Oña et al., 2012; del Castillo and Benitez, 2012; Eboli and Mazzula, 2009, 2012; Kim and Chung, 2016; Metri, 2006).

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The perception of quality in public transport services varies between the different kinds of users and variation in their tastes has been evaluated by using a diversity of methodologies. User characterisation for satisfaction surveys allows the researcher to associate the perception of quality to a specific type of user, classified according to their socioeconomic characteristics or those characteristics specifically related to the journey being made (de Oña et al., 2016c; Diana, 2012; Filipović et al., 2009; Joewono and Kubota, 2007; Minhans et al., 2015; Oña et al., 2016; Susilo and Cats, 2014). Another method for defining different user idiosyncrasies consists of considering that the variation in user perception can follow a statistical distribution which means that random parameters can be used to include it in modelling processes (Bordagaray et al., 2014; Hensher et al., 2010).

Other studies have tried to establish the importance users place on each service attribute (Baltes, 2003; Bolton and Drew, 1991; Cook and Kress, 1988; Garrido and Ortúzar, 1994; Grujičić et al., 2014; Nathanail, 2008). Although Grujičić et al. (2014) used a multicriteria analysis to establish a relationship between the importance of a variable and the value of perceived quality, most research has not found a clear relationship between importance and the values given to attributes.

The international literature provides many examples of methodologies for modelling perceived quality. A methodology based on structural equations was developed in (de Oña et al., 2016c, 2015; De Oña et al., 2013; Eiró and Martínez, 2014; Rahman et al., 2016). Another possibility was the application of decision trees (de Oña et al., 2012), which could be combined with an analysis of systematic variations through the use of clusters to generate models able to differentiate between different kinds of users (de Oña et al., 2016). Other methods for analysing perceived quality were not based on modelling but have provided some very interesting results, examples include descriptive statistics (Eboli and Mazzulla, 2011, 2007), multicriteria analysis (Nathanail, 2008), factor analysis (Fellesson and Friman, 2008) or neural networks (Garrido et al., 2014).

The methodology based on ordered probit models chosen for this research has proven to be an extremely versatile, efficient and useful tool for modelling perceived quality (Bordagaray et al., 2014; Çelik and Senger, 2016; dell'Olio et al., 2010; Hensher et al., 2010; Joewono and Kubota, 2007; Tyrinopoulos and Antoniou, 2008). This particular methodology allows ordered qualitative responses to be modelled, which means that the non linearity existing between the different replies can be considered (dell'Olio et al., 2010). Furthermore, this type of model is able to use interactions to incorporate systematic variations resulting from the different socioeconomic characteristics of users (Bordagaray et al., 2014). By considering randomness in model threshold parameters (Hensher et al., 2010) or in the parameters affecting the quality variables (Bordagaray et al., 2014), it becomes possible to consider the different socioeconomic characteristics and idiosyncrasies of the users assuming that they follow a known statistical distribution. However, no evidence has been found of the combination between systematic and random variations in the same model, nor of the inclusion of attribute importance within the model. Therefore, the present research aims to address this void and complete our knowledge about modelling perceived quality using ordered probit models which consider all the available information.

3. Methodology

3.1. Survey design

The representative quality variables for a public transport service have been defined from an analysis of the existing international bibliography and a series of focus groups (Ibeas et al., 2011) involving public transport users in the city of Santander. The resulting 24 variables are presented in the following table (Table 1). These variables have been grouped into 6 different clusters.

Table 1
Public transport service attributes.

Level of service	Walking time to bus stop
	Waiting Time
	Travel Time
	Time from the stop to final destination
	Ticket price
Supply	Ease of transfer
	Offered Service (Timetable, frequencies)
	Service reliability
	Special Lines for events, football, concerts, etc.
	Nocturnal/Weekend Services
	Coverage of lines
Information	Information at the bus stops
	Information at digital platforms
	Information on board buses
Comfort	Occupancy
	Air conditioning/heating system
	Space for people with reduced mobility
	Comfort of the buses (seats and grab handles)
	Bus cleanliness
	Possibility of carrying large objects: surfboards, luggage, animals, etc.
Driver behaviour	Driving style
	Driver kindness
Sustainability	Hybrid/Biofuel bus use
	Noise pollution

Table 2
Characterisation variables.

Gender
Age
Employment status
Driving license
Car ownership
Trip purpose
Number of trips made per week
Usual payment method
Monthly income

In addition, each one of the interviewees was asked to provide some characterisation information, as listed in the following table (Table 2). The possible replies were limited to a specific number of options, varying from one attribute to another.

3.2. Theoretical background

3.2.1. Ordered models

The book Modelling Ordered Choices: A Primer (Greene and Hensher, 2010) was taken as a reference work for this section.

The latest form of the ordered probit model, based on regression, was proposed by McKelvey and Zavoina (1975, 1971) for the analysis of ordered, categorised and non quantitative choices.

Ordered models are based on dividing a continuous utility space in discrete bands using a threshold based system.

$$\begin{aligned} q_i^* &= \theta' v_i + \varepsilon_i,\ i = 1, \ldots, n, \\ q_i &= 1 si \mu_{-1} < q_i^* \le \mu_{i1} \\ &= 2 si \mu_0 < q_i^* \le \mu_{i2} \\ &= 3 si \mu_1 < q_i^* \le \mu_{i3} \\ &= \ldots \\ &= J si \mu_{J-1} < q_i^* \le \mu_J . \end{aligned} \quad (1)$$

In a first approach, the assumption of constant coefficients and threshold parameters for all users is made. The key idea of the model