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What is behind fare evasion in urban bus systems? An econometric approach

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ABSTRACT

Fare evasion is a problem in many public transport systems around the world and policies to reduce it are generally aimed at improving control and increasing fines. We use an econometric approach to attempt explaining the high levels of evasion in Santiago, Chile, and guide public policy formulation to reduce this problem. In particular, a negative binomial count regression model allowed us to find that fare evasion rates on buses increase as: (i) more people board (or alight) at a given bus door, (ii) more passengers board by a rear door, (iii) buses have higher occupancy levels (and more doors) and (iv) passengers experience longer headways. By controlling these variables (*ceteris paribus*), results indicate that evasion is greater during the afternoon and evening, but it is not clear that it is higher during peak hours. Regarding socioeconomic variables, we found that fare evasion at bus stops located in higher income areas (municipalities) is significantly lower than in more deprived areas. Finally, based on our results we identified five main methods to address evasion as alternatives to more dedicated fine enforcement or increased inspection; (i) increasing the bus fleet, (ii) improving the bus headway regularity, (iii) implementing off-board payment stations, (iv) changing the payment system on board and (v) changing the bus design (number of doors or capacity). Our model provides a powerful tool to predict the reduction of fare evasion due to the implementation of some of these five operational strategies, and can be applied to other bus public transport systems.

1. Introduction

Fare evasion is a problem in many public transport systems around the world. A survey from the *International Association of Public Transport* (IAPT) found that fare evasion averaged 4.2% across their sample of (primarily) bus routes in 31 systems and 18 countries (Bonfanti and Wagenknecht, 2010). Policies to reduce fare evasion are generally aimed at improving control systems and increasing fines for offenders (Killias et al., 2009). Likewise, many studies have focussed on the design of punishment strategies to tackle fare evasion (Barabino et al., 2013; Lee, 2011; Thorlacius et al., 2010). However, viewing fare evaders as rational actors who maximise utility by weighting the costs of buying a ticket with the costs of being caught without one (Boyd et al., 1989; Kooreman, 1993), does not consider the different social and contextual aspects in which fare evasion takes place.

In February 2007 Chile's capital city inaugurated an integrated bus-Metro public transport system called Transantiago, which became widely unpopular due to its poor initial implementation (Muñoz et al., 2008). The bus services changed from

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passengers paying cash to bus-drivers in a fairly informal system, to a cashless system using smartcards (BIP cards) tapped on electronic fare collection machines located at the entrance of buses, but not handled by the driver. The old system, where many bus drivers owned their buses and drivers' wages were based partly on the fares collected, changed to buses operated by large companies overseen by a government authority with drivers paid a set wage and having much better working conditions.

Evasion was unmeasured in the previous system, but soon became a concern for the new system (Fig. 1). When chaos originally ensued at the system's implementation (i.e. radical changes to the routes were not properly communicated, etc.) some high officials in the government commented that perhaps a moratorium on payments should be enforced until the system "performed well"; this has given arguments to many evaders until today as the system is still perceived to work less than well. The rate of evasion in the system represents the ratio between the number of unpaid bus fares (evaders) and the total number of boarding passengers (DTPM, 2013a). The estimated monthly evasion rate on Transantiago buses during 2007 oscillated between 12% and 16%, whereas during 2012 it ranged between 20% and 27% (Fig. 1). Determining the reasons for this increase over time is outside the scope of this paper (a cross-sectional study), but there are a number of potential factors such as increases in the nominal bus fares (Fig. 1) or a *contagion effect* of the unethical behaviour (Gino et al., 2009) where potential fare evaders learn by observing others (Bucciol et al., 2013; Reddy et al., 2011).

In response to this problem, the authorities have implemented various plans to reduce evasion, such as developing advertising campaigns, increasing the number of ticket inspectors, and adding more off-board payment stations. Since the highest rates of evasion and use of public transport are reported in low-income areas, public policies could be focused on increasing fine enforcement in these areas. However, limiting the solutions of a phenomenon as complex as evasion only to enforcement strategies might overestimate the benefits of some measures and create higher than necessary implementation costs. We believe that fare evasion levels are a combination of a number of factors including, the level of income, the perceptions of the service, cultural components, level of enforcement and the operation of the public transport system, among others (Torres-Montoya, 2014).

The main objective of this paper is to jointly analyse and quantify the impact of different factors behind the high levels of fare evasion in Santiago, with the purpose of guiding public policy aimed at reducing this problem. Using available cross sectional data from October 2012 (collected by the Chilean authorities) about the monthly mean rate of fare evasion on buses in Santiago, we explain the phenomenon using regression models, a methodology widely used to model statistical data both in transport research (Ortúzar and Willumsen, 2011) and in other areas of high relevance to public policy (Osgood, 2000). In particular, we estimated a multiple linear regression model and two types of count regression models, Poisson and negative binomial models. Subsequently, after trying different specifications and performing appropriate statistical tests, we found that the negative binomial regression model was the best approach.

In the existing literature some variables such as the period of the day (Lee, 2011), the operation of the system and the level of income of passengers have been discussed (Torres-Montoya, 2014), but not considered jointly to model evasion rates or to design public policy to tackle this problem. The main contribution of our paper is to analyse and quantify the joint influence of variables related to the level of income of the area where bus stops are located, period of the day, level of service (headways and overcrowding) and bus door operation (entrance door and number of doors) on fare evasion. Our econometric approach will hopefully provide decision-makers with a useful tool to predict the impact of some public policies to deal with evasion and also a better understanding of this complex issue.

The rest of the paper is organised as follows. Section 2 describes the information available, the procedures involved to collect the data, the variables used for modelling and the limitations of the data available. In addition, we describe the econometric method employed to explain evasion and compare the three types of regression models used. In Section 3 we discuss our results and the variables that may affect evasion, select the best model and analyse the impact of changes in the independent variables on fare evasion. In Section 4 we discuss public policies to tackle evasion, give some further recommendations and suggest avenues for further research.

2. Methodology

2.1. Data description

In Transantiago, bus services are operated by a group of private firms overseen by the government authority. Each operating company manages several bus routes, which are identified by a number or number-letter combination, and serve a set of stops. In the Metro system component fare evasion is not a problem, but since the beginning of Transantiago the bus system component has faced high levels of fare evasion which are also increasing over the time (DTPM, 2014).

The Enforcement Commission of the Chilean Transport Ministry (MTT) collects data about evasion on a sample of bus routes of each private operating company every month using plain-clothes observers. Within the sample of bus routes a sample of runs (bus trips) are selected. Observers are stationed at each door of the sampled bus and register the number of people boarding and alighting at each bus stop, by each door of the bus, as well as other conditions such as bus occupancy. They also register the number of evasions, but do not interact with the passengers in an enforcement capacity.

In the database supplied by MTT, each observation was measured at a specific door and bus stop of each bus route sampled. With the variables supplied by the MTT we built evasion models using data from October 2012, which we chose