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Cost and fare estimation for the bus transit system of Santiago

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ABSTRACT

This paper studies the costs of the transit system of Santiago, Chile, and proposes pricing schedules to finance it considering a fixed amount of subsidy. We estimate a cost function for the firms providing bus services in Santiago and study their industrial structure. We also estimate a demand model using aggregate data, which delivers information on the demand price elasticity and the effect of other variables related to the supply (e.g., capacity and frequency). Finally, we compute four pricing schedules: uniform price with and without subsidy and two-part tariffs with and without subsidy. Our results show that: (i) the industry exhibits economies of scale when considering both demand-oriented and supply-oriented output measures; (ii) measures of technical efficiency are consistent with the observed exit of firms from the market; (iii) the budget-balanced fare without subsidy is higher than the actual fare, suggesting that subsidies are justified; (iv) the budget-balanced fare with subsidy is higher than the actual fare, suggesting that subsidies are insufficient; (v) two-part tariffs either with or without subsidy are the most effective means of increasing bus travel demand and user welfare; and (vi) a menu of tickets with two options (a uniform price and a two-part tariff) is a Pareto-improving pricing schedule that balances the budget and increases bus travel demand.

1. Introduction

In 2007 the city of Santiago, Chile, implemented a public transportation plan (Transantiago) that included a new urban bus transit system and fare integration with the Metro. Planners envisioned Transantiago as a subsidy-free system, but soon after the start, the government recognized that the system was running a financial deficit of 35%, which became a major political issue. Yearly the Congress has to decide on the subsidy; politicians, public agencies, and bus operators debate about the justification and the amount of subsidy for Transantiago. Technically, there is no real basis for this discussion since public transport subsidies are justified (for instance, Mohring, 1972; Parry and Small, 2009; Basso and Silva, 2014). Three factors justify subsidizing the system: existence of economies of scale and the Mohring effect in public transport services; price distortions or externalities in competitive modes; and distributional issues. Moreover, the level of subsidy in Santiago is low with respect to other cities. For instance, in New York City the operating subsidy was 48% in 2013 (MTA, 2014); in San Francisco it was 65% in 2015 (SFMTA, 2016); in Paris it was 70% in 2014 (STIF, 2014). The objective of this paper is to contribute technically to discussions about subsidies for public transport by studying the case of Santiago.

At the time of designing the Santiago transportation plan, there was no certainty about the costs involved in the new system. Although some studies were conducted, such studies were based on cost information from the previous bus system, which consisted of small firms organized in associations. Each association operated one or a few bus lines out of a total of approximately 350. Furthermore, the network structure was different from that of Transantiago, and it is known that operating costs differ depending on the system's network structure (Jara-Diaz, 2007). Hence, the cost estimation carried out to design the system may not necessarily describe the actual cost structure of Transantiago in operation. This fact has complicated discussions on the need for subsidies, the amount needed and the fares levels required to cover operation costs.

After nine years of operation, the information now available can be used to estimate the costs of the new bus system. Furthermore, knowing the industrial structure allows the authority to design better contracts for the next tender of services. In particular, it has been observed that some firms exited the market because of bankruptcy and other firms merged. From the point of view of cost reduction, it may be appropriate to change the organization of the system if large firms have advantages over small firms (economies of density) or merge firms operating trunk services with firms operating feeder services. It may also be necessary to introduce new industry regulations as service becomes concentrated in the hands of only a few firms.

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In this paper, we estimate the cost function of the firms operating Transantiago bus services. Our estimates allow us to compute the degree of returns to density and identify differences in cost structure between trunk and feeder services. Also, once the cost function is estimated, we contribute to the debate over the level of subsidy by computing the fare needed to cover operation costs given the actual subsidy versus no subsidy. Specifically, we compute a budget-balanced fare using Ramsey pricing and two-part tariffs and discuss their effect on bus travel demand. In doing so, we also estimate an aggregate demand model. Additionally, in the estimation of costs and demand models we control for fare evasion, which produces significant distortion in estimates if not considered. Even if this paper does not present new methodologies for the analysis of cost and fare computation (except for the two-part tariffs), it makes a case-study-based contribution to formalizing the economic analysis for policy implementation and delivers evidence of the industrial structure of bus systems.

Our findings are consistent with the reduction in the number of firms operating in Santiago. Indeed, production technology exhibits sizable increasing returns to scale with respect to both demand-oriented and supply-oriented output. As regards a multiproduct measure of scale economies, the returns are also increasing, but at a level comparable with other results in the literature. Our results are also consistent with the exit of some firms from the market since the exiting firms operate less efficiently (in economic terms) because of either the technology they use or the area they serve (we cannot disentangle these two effects). In terms of policy pricing, we find that two-part tariffs are the best option for increasing demand, either with or without subsidy, and that a menu composed of a unitary ticket and a two-part tariff may increase demand without welfare loss for any user.

This paper is organized as follows. Section 2 describes the market and the available data for estimation. Section 3 presents the methodology for estimating cost and demand models. Section 4 discusses the basic microeconomics of optimal pricing and presents the methodology we use to compute fares. Section 5 presents the results of the costs and demand model estimation. Section 6 reports the budget-balanced fare computation. Finally, section 6 summarizes, drawing conclusions and suggesting the policy implications of this research.

2. Market description and data

To put this research in context, we briefly describe the bus system in Santiago and point out some features that are useful for the analysis. Also, we describe the data available to carry out this research and present a brief analysis of the main variables we use.

2.1. Market description

The Santiago transport system is designed as a bus network of feeder and trunk services and a metro system with four lines. The operation of the bus system is organized into fourteen groups of services. Five of them consist of trunk services (hereafter identified as T1 to T5), and nine consist of feeder services (hereafter identified as F1 to F9). The trunk services have exclusive operation in main roads in the city, and their routes connect the edges of the city with the Central Business District (CBD) or traverse the city from one end to the other. The feeder services operate in exclusive zones (mainly residential or low-density land use areas) and connect to the trunk services and the metro system. Because of the new feeder-trunk structure, passengers transfer more often between buses and metro lines compared to the bus system before Transantiago was implemented. The only means of paying the fare is a smartcard, which permits fare integration over the entire trip (among buses and metro).

Each group of services, both feeder and trunk, was tendered and awarded to the highest bidder that fulfilled the requirements. The administration of the fare transactions generated by the system was also tendered and awarded to a consortium of banks and an information technology firm.

Every group of services was awarded to only one firm, but one firm can operate more than one group of services. At the beginning of the period of analysis, there were ten firms. Four firms operated only trunks (T1, T2, T4 and T5), five firms operated only feeder services (one of them operated the two groups F2 and F4), and one firm (Firm 4, see Table 3) operated two feeder groups and one trunk group of service (F5, F8 and T3). By the end of 2008, in a new tender, Firm 4, lost the concession of the feeder group F5, which was awarded to an entrant firm. In the last quarter of 2009, Firm 4 could not continue with the operation of the trunk group T3, which was awarded to another entrant firm. In October 2011, Firm 4 became insolvent and exited the market; its feeder group was awarded to an incumbent firm operating another feeder group. Thus, in the period of analysis, there are twelve firms operating in the market. We have data from nine of these firms for the estimation of the cost function. Since some trunk and feeder concessions have merged into larger firms, operating a mix of both types of services, once we estimate the operator's cost function our results should show the existence of economies of scale or spatial scope (Basso et al., 2011). In fact, currently only seven firms are operating the system, a fact that reinforces this assumption.

When Transantiago started in February 2007, the contract established an operating fleet of 5600 buses. In the second quarter of 2007, however, the actual observed operational fleet was 4600 buses (Beltran et al., 2012). The problem was that the contracts only established a commitment in terms of following the operation plan, but no punishment in case of failing to follow it. By mid-2007, the transport authority implemented a program of compliance measures and fines to enforce the fulfillment of the contracts. Such a program increased the operating fleet from 4600 to 5800 buses in only five months (Beltran et al., 2012). This implies that the actual total number of driven kilometers differs from those established in the contracts, mainly for the three first quarters of 2007. For purposes of estimation, we use the total number of driven kilometers in the operation plan corrected by the compliance measures as a proxy for the actual total number of driven kilometers.

In the original design, the supplied frequency and the bus lines were insufficient to cope with the demand. Therefore, the authority increased the supply through the operation plan. Table 1 displays the kilometers driven, the fleet size, and the number of bus lines from 2007 to 2011. It should be noted that after 2010 the transport authority started reducing the total kilometers supplied as a way to reduce the subsidy for the system.

Although Transantiago was designed to operate without subsidies, the new regulations to which the firms were subject along with the new operation scheme and the fare integration led to a higher cost than estimated. For instance, formal contracts for drivers increased labor costs, and the integrated fare implied additional collection and management costs. In addition, fare integration reduced the revenues of the system. Users swipe in to enter each bus of the network and may make up to two transfers for the price of a single fare over a two-hour period as long as they do not use the same bus line more than once. Moreover, the government decided not to increase fares during the first two years of operation (see Table 2) and to use the subsidy to cover the operational deficit. As a consequence, the total subsidy has increased incrementally since 2007, reaching around US$50 million per month (40% of the total costs) in 2012 (Coordinacion de Transportes de Santiago, 2012).

Table 1
Evolution of public transport commercial kilometers, fleet and bus lines in December of each year from 2008 to 2011.

Year	Driven km (million)	Fleet	Bus lines
2007(starting February 10)	371.1	4489	223
2008	481.4	6399	322
2009	487.2	6572	334
2010	512.4	6564	357
2011	483.0	6165	370