Cost, production and efficiency in local bus industry: An empricial analysis for the bus system of Santiago

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A B S T R A C T

The aggregate cost structure of the Santiago (Chile) urban bus transport industry is studied for the presence of economies of scale, return to scale and technical efficiency. Econometric models using both operator cost and revenue (fares plus subsidy) data show that larger operators under Transantiago had higher average operating costs than the smaller ones; we obtain a similar conclusion when analysing production and the efficiency of firms: we estimate decreasing returns to scale in production, and that larger operators would be more inefficient than smaller operators. The model results also indicate that cost per passenger carried for longer, articulated buses is greater than for shorter, conventional vehicles. These findings are important considerations for the design of the industry and its regulatory framework.

1. Introduction

In regulated markets such as public transport, the presence or absence of economies of scale (e.g. cost function), and return to scale (e.g. production function) is a fundamental consideration in achieving efficiency both in the transport system design and the regulatory framework. After reviewing the literature on returns to scale in public transport systems, the present study reports on an empirical study of the cost and production structure of the local bus service industry in Santiago, Chile for the period after its radical restructuring in early 2007.

Whereas the international evidence on bus industry economies of scale is mixed, our results for the Chilean capital's service suggest the presence of diseconomies of scale from a cost perspective, and decreasing returns to scale from a production perspective. In addition, using a stochastic frontier analysis (SFA) approach, we estimate that smaller firms are more efficient than larger firms.

The formalization of the industry with the advent of Transantiago, the new public transportation system introduced in 2007, has also made available much detailed official information on such phenomena as the supply and demand levels for each bus company. It is these data that have enabled us to contrast our hypothesis regarding the presence or absence of economies of scale, and they have also been used to design the contracts for the public tenders of the different bus lines, the next series of which will be held in February 2018.

A secondary but not unimportant result of this study, derived from an analysis of costs by type of bus after correcting for the number of passengers carried, is that articulated buses 18 m in length are significantly costlier to operate than conventional 12-m buses. This implies that future Transantiago contract designs should prioritize the latter type of vehicle.

The rest of this paper is organized into five sections. Section 2 surveys the literature on economies of scale in urban bus transport

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systems around the world; Section 3 discusses cost characteristics and company size for the Transantiago system and sets out some suggestive graphical evidence as the basis for the study's hypothesis on Transantiago's economies of scale; Section 4 specifies and estimates two alternative sets of econometric models based on annual operating costs and monthly payments to the companies to test the hypothesis; Section 5 estimates a production function for the industry, and develops a Stochastic Frontier Analysis to estimate relative technical efficiency among different firms. Finally, Section 6 presents our conclusions.

2. Literature survey

The issue of returns to scale in local public bus transport continues to be debated in the literature. From the standpoint of public policy, returns to scale play a role in determining fare regulation mechanisms, cost assignment, productivity and the structure of the industry. Views on the industry's returns to scale have also figured in arguments for subsidizing bus services.

As noted in the Introduction, empirical research on bus systems over the last few decades in various countries has produced mixed results in which all three possibilities (constant, decreasing and increasing returns) have been reported. Nevertheless, the studies do tend to suggest that in the majority of cases the conditions for economies of scale in urban bus service provision, where strict regulation is typical, do not exist.

That the evidence on scale returns is indeed mixed is evident from the review of previous studies in Lai et al. (2012), who also imply that the findings depend on the data available, the estimation methodology and the definition of the output metric variables. Earlier works by Berechman and Giuliano (1985) and Hensher (1987) had already cautioned that methodology and type of data would affect the outcome.

Williams and Dalal (1981) discovered decreasing returns for small firms and increasing returns for large ones, suggesting that the cost curve has an inverted "U" shape. By contrast, Button and O'Donnell (1985) reported increasing returns for small operators and decreasing returns for large ones. But Caves and Christensen (1988), using a multi-product function, found constant returns.

Studies by De Rus and Nombela (1997) for Spain, and Lee and Steedman (1970) for Britain, both concluded that returns to scale in the bus industry were constant while a second British study by Wabe and Coles (1975) as well as an investigation for the U.S. by Koenker (1977) pointed to diseconomies of scale. The latter conclusion was also arrived at for the U.S. by Obeng (1985) and for local services in Switzerland by Filippini and Prioni (2003).

Contrasting with the above are American studies by Williams (1979) and Viton (1981), an Israeli study by Berechman (1983) and a Swiss study by Farsi et al. (2007), all of which found that there were economies of scale both for buses and trams. The same result was reported for Taiwan by Shaw-Er et al. (2005), who concluded that returns to scale were increasing. Williams and Hall (1981), meanwhile, showed that there were potential economies of scale in U.S. intercity bus service.

For the UK bus industry, Cowie and Asenova (1999) estimated that small companies operating less than 200 vehicles experienced some economies of scale but also showed that the extent of these economies varied with the type of ownership (private limited company, public limited company, or municipal). Sakano and Obeng (1995) demonstrated that there were increasing returns to scale for the public urban bus industry in the U.S.

In general terms, there are a number of major empirical studies whose results are consistent with a U-shaped average cost function with increasing returns to scale for smaller operators that turn into constant and then increasing returns as the size of the operator grows. Fernández et al. (2005) consider congestion as a source of diseconomies to scale in large bus industries.

A study by Iseki (2008) concluded for the U.S. that there were diseconomies of scale for all bus agency sizes and levels of contracting. The author also noted that few studies report economies of scale whereas many have found that there are diseconomies. The rise in hourly unit operating cost as the size of a bus fleet increases is clearly observable in Iseki's data, graphed here in Fig. 1.

A recent review of the literature by Abrate et al. (2016) concluded that economies of scale exist only for companies that provide multiple bus services (urban, intercity, charter/for hire). This implies that relatively small companies specializing in one or other of these services would experience a reduction in costs by evolving towards a multi-service (urban and interurban) operation. For interurban operators, the best solution appears to be integration with urban operators.

In another recent publication, Ayadi and Hammami (2015) evaluated the cost structure of public transport in Tunisia. They used a translog variable cost function to identify the providers' technological characteristics, with data from a sample of 12 regional operators collected over the years 2000–2010. The authors found diseconomies of scale in both the short and the long term.

Avenali et al. (2016) used a regression model for estimating unit costs and their variability for local public transport in Italy. They showed that economies of scale are limited and only present for small-scale services. Their results revealed a positive correlation between investment in bus fleets and cost of service provision.

Finally, an analysis published by Fiorio et al. (2013), though containing no analysis of cost structure variations by company size, nevertheless demonstrated by means of probit models applied to data from 33 European cities that the highest levels of satisfaction are correlated with the existence of a single local public transport provider, as opposed to an industry structure in which multiple providers operate in the same market area.

The principal findings of the 41 empirical studies from the specialized literature reported in the preceding paragraphs are summarized in Table 1. They confirm that the evidence on economies of scale in bus service is mixed and varies with the specifics of the situation in question. Particularly influential are such phenomena are the size of the bus system, the specification of the variables in the model and the types of data analysed. The regulatory framework can also play a role in determining economies of scale. Regulation can affect the production function of bus operators by means of hampering flexibility and efficiency both regarding the input mix and the output. In the case of Transantiago, the main regulatory restrictions faced by bus companies are contained in the tender contracts. These include routes, frequencies, minimum fleet size and its technological equipment and parking areas. It is worth