



# A nonparametric efficiency analysis of German public transport companies

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## ABSTRACT

In this paper, we present a nonparametric comparative efficiency analysis of 179 communal public transport bus companies in Germany (1990–2004). We apply both deterministic data envelopment analysis (DEA) and bootstrapping to test the robustness of our estimates and to test the hypothesis of global and individual constant returns to scale. We find that the average technical efficiency of German bus companies is relatively low. We observe that the industry appears to be characterized by increasing returns to scale for smaller companies. These results would imply increasing pressure on bus companies to restructure.

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## 1. Introduction

European policy makers face increasing pressure to reform both regional and national public transport systems. In Germany, structural reform is particularly urgent, since financial pressure on this sector, which traditionally requires subsidies, is mounting, and competitive forces are ever more active. At the European level where general policy guidelines on state aid and other instruments are formulated, an important issue in public transport economics is whether the sector is characterized by increasing, decreasing, or constant returns to scale. A survey of the extant literature appears to reach the conclusion that within smaller and medium-sized bus companies, increasing returns to scale prevail, whereas the assessment on larger and very large firms is more uncertain. Thus, Berechman (1993) finds that smaller bus companies (those with as many as 200 buses) are characterized by increasing returns to scale, but that the opposite may be the case for very large companies. For example, Chicago (2500 buses) and New York City's MTA (3000 buses) can be characterized by decreasing returns to scale.

Increasing returns to scale for smaller companies are confirmed by Viton (1981), Cowie and Asenova (1999), Filippini and Prioni (2003) and Farsi et al. (2006), among others. For surveys on the topic see Berechman (1993), De Borger et al. (2002) and Piacenza (2001). Increasing returns to scale would suggest that smaller and medium-sized companies can increase their

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efficiency by growing, merging with other companies, or achieving the synergy effects in other ways. In fact, a concentration of smaller firms towards larger units can be observed in countries that have liberalized their public bus sectors, such as the UK (Cowie, 2002). Graham et al. (2003) who examined economies of scale and density in 17 urban rail transport systems around the world suggest constant returns to scale but increasing returns to density.

The German public transport system is traditionally small-scale, with about 1000 mainly communal service providers. Contrary to other countries, efficiency benchmarking has not been intensively carried out for the sector at large.<sup>2</sup> There is one study conducted by Hanusch and Cantner (1991) analyzing the performance of German bus companies within a multiple-sector analysis.

It is generally considered that a lack of transparency and an information asymmetry exist between the principal (public policy maker, “Aufgabenträger”) and the agent (public transport company). Public transport companies argue about specific institutional, economic and structural factors that justify a high level of subsidies. Cost-based compensation instead of incentive-based mechanisms still predominates. Traditionally, public bus transport was provided at the communal level, and rail transport was formerly the responsibility of the Federal State Railway (responsibility for public local rail transport was transferred to the 16 Federal States in 1994 under “Regionalization”). Public transport has a low cost coverage (estimated around 40%), with the bus system faring somewhat better than the rail system. Both bus and rail transport are highly regulated; in particular, bus licenses for regional transport services are difficult to obtain. As more local concessions are tendered, new entrants or larger bus companies obtain higher market shares. Communal bus companies also try to cooperate across borders, e.g. to obtain economies in third-party procurement.

Regarding the incentive structures, it is fair to say that – as in other countries – the industry is unionized, which is also due to the dominant communal ownership structure. Yet there has been a general tendency to reduce employment over the period under consideration. Bus companies are “agents” and act on behalf of a “principal”, regional or city administrations (“Aufgabenträger”) who order a certain level of service. Changing network length, therefore, is not in the simple discretionary decision power of the bus companies.

This paper provides a preliminary nonparametric efficiency benchmarking of public transport in Germany between 1990 and 2004 to an unbalanced sample of 179 medium and larger bus transportation companies. We apply recent theoretical developments in statistical inference for nonparametric efficiency estimation. In empirical efficiency analysis the tradeoff always exists between the restrictive (but when consistent, more efficient) parametric and the more robust (but inefficient) nonparametric approaches. There exists a wide range of literature comparing both approaches. Thus, Lovell (1993) provides a detailed introduction. Ferrier and Lovell (1990) e.g. assess the strength and weakness of both approaches by means of an empirical cost efficiency analysis in banking. Bjurek et al. (1990) compare both approaches within the framework of service production. A more recent example is Cullinane et al. (2006) who provide a technical efficiency analysis of container ports comparing the parametric stochastic frontier analysis (SFA) and DEA as a nonparametric approach, pointing out the strengths and weaknesses associated with each approach.

The goal of this paper is to provide an objective assessment of the comparative efficiency scores of public transport companies, thus decreasing the information asymmetry, and to contribute constructive input to the debate on public transport reforms. The paper is structured as follows: the next section describes the methodology, focusing on the latest developments of nonparametric estimation. The robustness of the results is analyzed by means of bootstrapping algorithms, and newly-developed returns to scale tests.<sup>3</sup> Section 3 introduces the data and the concrete model specifications, with a focus on supply-oriented models using seat and bus kilometers as different output variables. Most of the results confirm our initial hypothesis of increasing scale economies for small and medium-sized bus companies (Section 4). Section 5 concludes.

## 2. Methods

### 2.1. Data envelopment analysis (DEA)

To measure the relative efficiency of the German public transit bus companies, we apply nonparametric techniques that have proven useful in a number of other sectors and applications.<sup>4</sup> Applied empirical work on efficiency and productivity measurement of individual firms is always confronted with the sensitivity of the results to the different approaches and assumptions. Therefore, to present the most robust image, we apply different nonparametric model specifications and, in a second step, test our empirical results using recent developments and approaches in statistical inference for nonparametric frontiers (Simar and Wilson, 2000, 2002, 2007). This nonparametric approach of efficiency measurement of different decision-making units (DMUs) relies on a production frontier which is defined as the geometrical locus of optimal production plans (see Simar and Wilson, 1998). The individual efficiencies of the firms relative to this production frontier are calculated by means of distance functions. The input distance function  $d_i$  is defined on the input set  $L(y)$  as

<sup>2</sup> Business studies on efficiency have been carried out over the last 20 years by Helmut Leuthardt, and published in “Der Nahverkehr” (see e.g. Leuthardt 1986, 2005).

<sup>3</sup> A similar study is carried out for Canadian urban transit systems by Boame (2004) who uses a bootstrap data envelopment analysis for the period 1990–1998. He found that most Canadian transit systems experience increasing returns to scale.

<sup>4</sup> For a survey on the theoretical literature see e.g. Cooper et al. (2004).

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