Cost Efficiency and Subsidization in German Local Public Bus Transit

Maria Nieswand, Matthias Walter

Presentation at INFRADAY
Berlin, Germany
October 8-9, 2010

Analysis of German Local Public Bus Transit Companies

Context

- Public transport is a service of general interest
- Commonly unprofitability of these services is presumed
- In Germany, public financing of the public transit in total results in about 13 billion Euros each year

Hypothesis

- Specific forms of subsidies are firm-influenceable

→ These subsidies directly affect the (cost) efficiency of operators

→ Operators perform better when these subsidies are low

Approach

- Stochastic Frontier Analysis, cost function, panel data
- Include firm-influenceable subsidies as heteroscedastic variable into the one-sided inefficiency term

Outline

1. Introduction
2. Model specification and data
3. Results
4. Conclusions

The German Local Public Bus Transit

- Public transit is an important component of population mobility
- Bus companies supply more than two-thirds of the demand for general local public transportation (notably in rural areas)
- High market fragmentation, several hundreds of operators
- Dominantly publicly owned
- Average degree of cost coverage increased over the last decade (about 70%), the sector depends heavily on subsidies

The German Financing System for Local Public Bus Transit

Federal level

State level

Local level

Investment-related subsidies

- Infrastructure
- Vehicles

Non-investment-related subsidies

- Grants for operating costs
- Compensatory payments
- Tax reductions
- Deficit balancing

- Deficits, i.e. negative revenues from ordinary activities, can/must be balanced by shareholders (i.e. “loss absorption”)
- We theorize these payments to be **firm-influenceable**

Justification of Subsidies in Local Public Bus Transit

- Deficitary situation originates in the growing private car utilization during the second half of the 20th century

- Justifying arguments (Vickery 1980, Karlaftis and McCarthy 1998, Button 1993)
  - Economies of scale (marginal costs lower that average costs)
  - Subsidies to competing modes
  - Social requirements
  - Second-best instrument to address urban transit externalities (with the purpose to shift demand from private towards public transportation)

- Empirical evidence for cost-harming effects (see e.g., Karlaftis and McCarthy 1998, Bly et al. 1980, Bly and Oldfield 1986), the lower the governmental level is the lower are the cost-increasing effects (e.g., Anderson 1983)

Empirical Evidence on Subsidies in Local Public Bus Transit

- Empirical evidence from frontier analysis
  (for review, see e.g., De Borger and Kerstens 2008)
  - Shares by low-governmental bodies in subsidizing deficits and the amount of compensatory payments positively affects cost efficiency, (OLS regression) (Filippini et al. 1992)
  - Subsidies improve technical efficiency (subsidies are included as additional independent variables in DEA framework) (Obeng 1994)
  - Subsidies negatively affect technical efficiency (Tobit regression on nonparametric efficiency estimates) (Kerstens 1996)
  - No effects of operating and capital subsidies on allocative inefficiency between labor and capitol, (regression analysis) (Sakano and Obeng 1995)
  - Allocative inefficiency mainly due to firm internal factors not (only) subsidies, subsidies contribute to excess use of fuel and labor over capital, (net-of-subsidies cost minimization) (Sakano et al. 1997)

Outline

Cost Model

$$C = f\left(Y, p_K, p_L, di, D_{east}, t\right)$$

where

C … total costs

Y … output measure (seat-kilometers)

p_K … factor price for capital

p_L … factor price for labor

di … density index (population in operating area per km of network)

D_{east} … Dummy for companies operating in Newly formed German States

t … linear time trend

Translog Cost Function

- Translog cost function with approximation around the mean
- Imposition of linear homogeneity through dividing by a factor price
- Deterministic part of the function:

$$\ln\left(\frac{C_{it}}{p_{L_{it}}}\right) = \ln C^{*}_{it} = \alpha_0 + \beta_Y \ln Y_{it} + \beta_{p_K} \ln\left(\frac{p_{K_{it}}}{p_{L_{it}}}\right)$$

$$+ \frac{1}{2}\left(\beta_{YY}\left(\ln Y_{it}\right)^2 + \beta_{p_K p_K}\left(\ln \frac{p_{K_{it}}}{p_{L_{it}}}\right)^2\right)$$

$$+ \beta_{YpK} \ln Y_{it} \frac{p_{K_{it}}}{p_{L_{it}}} + \beta_{di} di_{it} + \beta_{D_{east}} D_{east} + \beta_t t$$

Econometric Models

- True Random Effects Model (TRE) (Greene 2004, 2005)

$$\ln C^*_{it} = \alpha_0 + \alpha_i + \beta_Y Y_{it} + \beta_{p_K} p_{K_{it}}{}^* + \ldots + v_{it} + u_{it}$$

with
$$\alpha_i \sim iid\ N\left[0, \sigma_\alpha{}^2\right]$$
$$v_{it} \sim iid\ N\left[0, \sigma_v{}^2\right]$$
$$u_{it} = \left[U_{it} \mid U_{it} \sim N\left[0, \sigma_{u_{it}}{}^2\right]\right]$$
$$\sigma_{u_{it}}{}^2 = \sigma_u{}^2 \exp\left(\partial' z_{it}\right)$$

Heteroscedasticity in one-sided inefficiency term
- Managerial determinants, i.e. factors under the control of firms
- Theorized to be firm-influenceable **"subsidies" (subsidy ratio z_1)** Bhattacharyya et al. 1995, Hadri et al. 2003

- Random Parameters Model (RP) with randomized β_Y and β_{pK}

$$\ln C^*_{it} = \alpha_0 + \alpha_i + \beta_{iY} Y_{it} + \beta_{ip_K} p_{K_{it}}{}^* + \ldots + v_{it} + u_{it}$$

with
$$\beta_Y \sim N\left[\beta_Y, \sigma_{\beta_Y}{}^2\right],$$
$$\beta_{p_K} \sim N\left[\beta_{p_K}, \sigma_{\beta_{p_K}}{}^2\right]$$

Firm-specific optimal (reference) technology

Data

Table: Descriptive Statistics

Variable	Mean	Std. dev.	Median	Min	Max
Total costs (C) [m Euro] [a]	39.47	24.22	33.47	3.82	95.04
Seat-kilometers (Y) [m km]	750	423	719	55	1,870
Labor price (p_L) [Euro/ FTE] [a]	46,896	11,566	46,689	10,693	86,243
Capital price (p_K) [Euro/seat] [a]	1,360	590	1,237	568	3,517
Density index (di) [head/ km] [b]	412	333	344	61	2,460
Dummy East (D_{east}) [c]	0.26	0.44	0	0	1
Subsidy ratio (z_1) [a,d]	0.14	0.14	0.14	0	0.55
Outsourcing share (z_2) [percent] [e]	22.63	16.21	17.58	2.16	76.52
N = 33, T = 12 (1997-2008), observation = 231					

[a] Base year 2008 [b] Population in operating area per km of network length [c] East = 1: Company operates in Eastern Federal States (59 observations), East = 0: Company operates in Western Federal States (172 observations) [d] Loss absorption in Euro/ total costs in Euro

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Regression Results

		TRE Model			RP Model		
Variable		Coefficient		Std.Dev.	Coefficient		Std.Dev.
Parameters of the cost function							
Constant	α_i	-7.042	***	0.014	-6.970	***	0.011
Std.dev. of α_i	σ_α	0.246	***	0.009	0.190	***	0.006
Output (Seat-km)	β_Y	0.457	***	0.019	0.622	***	0.013
Std.dev. of output	σ_y				0.263	***	0.009
Capital price	β_{pK}	0.413	***	0.012	0.415	***	0.011
Std.dev. of prices	σ_{pK}				0.320	***	0.013
$Output^2$	β_{YY}	-0.363	***	0.020	-0.215	***	0.015
Capital $price^2$	β_{pKpK}	0.074	***	0.019	-0.066	***	0.023
Output * Capital price	β_{YpK}	-0.285	***	0.021	-0.185	***	0.018
Density index	β_{di}	0.042	***	0.007	0.024	***	0.006
Dummy east	β_{Deast}	-0.235	***	0.015	-0.238	***	0.014
Linear time	β_t	-0.006	***	0.001	-0.011	***	0.001
Parameters of the inefficiency function							
Constant of σ_u	δ_0	-4.348	*	2.223	-4.567	***	1.675
Subsidies ratio	δ_{z1}	1.681	**	0.799	1.906	***	0.625
Std.dev. of v	σ_v	0.066	***	0.002	0.043	***	0.001
Lambda	σ_u/σ_v	0.326			0.483		
Wald test H_0: $\delta_0=\delta_{z1}=0$		5.533 (p-value = 0.063)			13.879 (p-value = 0.001)		
Loglikelihood function		218			263		

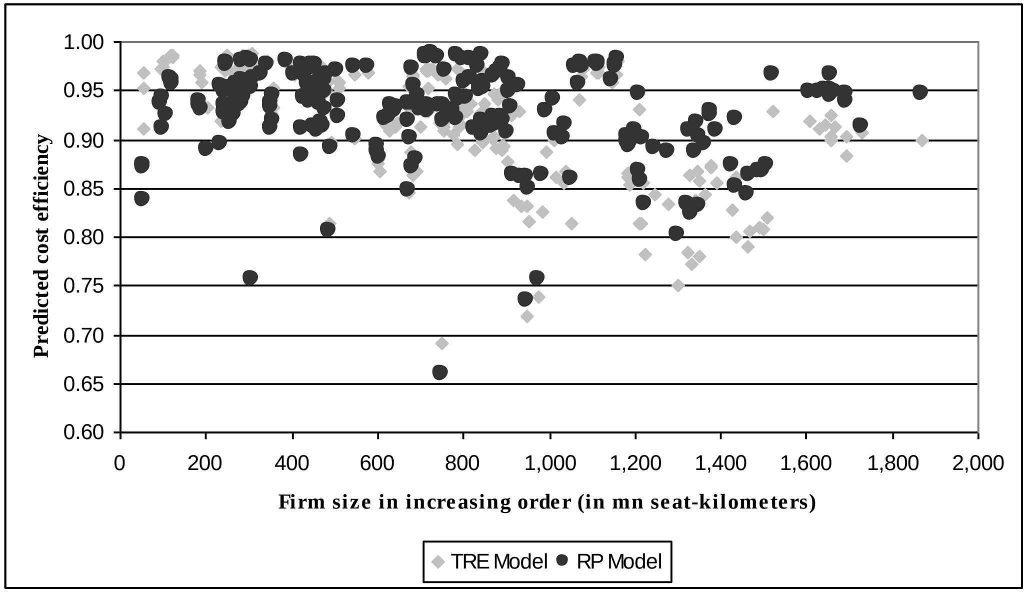
Note: *** indicates a significance level of 1%, ** indicates a significance level of 5%, and * indicates a significance level of 10%.

Cost Efficiency Estimates

Table: Descriptive Statistics of Cost Efficiency Estimates

Model	Mean	Median	Std.Dev.	Min	25% quantile	75% quantile	Max
TRE Model	92.14%	93.98%	5.82%	69.08%	89.34%	96.66%	98.86%
RP Model	92.80%	93.68%	4.75%	65.99%	90.98%	96.07%	98.73%

Figure: Cost Efficiency and Firm Size



- Larger firms benefit from flexible technology
- No clear indication for size-related differences of performance
- TRE Model misses important information on the technology

Cost Efficiency and Subsidization

- Welch test compares the mean cost efficiency of two groups:
  group 1 = no subsidies ($z_1 = 0$)
  group 2 = subsidies are positive ($z_1 > 0$)
- Non-subsidized firms significantly perform better

Table: Welch Test on Group Mean Cost

		TRE Model		RP Model	
	Group size	Mean	Std.Dev.	Mean	Std.Dev.
Overall mean efficiency	231	92.14%	5.82%	92.80%	4.75%
Mean cost efficiency for group 1*	95	93.22%	0.50%	94.23%	3.69%
Mean cost efficiency for group 2**	136	91.39%	0.54%	91.81%	0.44%
t-value		2.484		4.171	
p-value		0.014		0.000	

Note: * indicates that the subsidy ratio z_1 equals zero. ** indicates that the subsidy ratio z_1 is greater than zero.

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Conclusion

- Non-subsidized companies perform better in terms of cost efficiency
  → Can function as a regulatory tool to decrease subsidies and public budgets
- Other options for reductions in subsidies
  → Bind deficit payments to key performance indicators
  → Incentivize payments for managers more intense to give them a natural reason of cost efficiency compliance
  → Stronger involvement of private sector
- Reference technologies vary across operators
  → Variations in optimal marginal costs and optimal input combinations are present
  → Important information for comparing performance

Thank you for your attention.

Questions and comments are welcome.

Contact: mnieswand@diw.de

www.diw.de/en/