Economies of Scale and Scope in Germany's Urban Public Transport

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Abstract

With an increasingly competitive environment and tenders in local public transport it is important to empirically investigate the extent of economies of scale and scope. While I find increasing returns to scale for Germany's urban public transport in line with foreign experience, there seem to be diseconomies of scope. The existence of economies of scale for tram and light railway services needs furthermore particular attention for policy advice. The unbalanced panel data set for the analyses consists of 381 observations single- and multi-output companies offering bus, tram and light railway services in the period from 1997 until 2006. The specification includes three factor prices for labor expenditures, operating expenditures and capital expenditures. The results are consistent for a random and a true random effects model which are preferred to a fixed effects specification.

Keywords: Economies of scale, Economies of scope, Public transport, Stochastic frontier analysis

JEL-codes: L92, C13, C23, L11

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1 Introduction

Germany's urban public transport is in a phase of industry consolidation as well as change of market rules and structure. The market has traditionally been fragmented with up to 1,000 companies. This has started to alter through mergers and acquisitions of neighboring companies as well as through efforts of companies with a strong capital base to seek for growth opportunities. Moreover tenders have become an instrument for introducing competition for the market.

Mergers are on the one hand concentrated on multi-output companies in urban agglomerations with tram or light railway operations on a common network in order to reduce costs through exploiting size and synergy effects. Examples therefore are the merger RNV by the local public transport companies from Mannheim, Heidelberg and Ludwigshafen in the Rhine-Neckar area and the merger meoline by the local public transport companies from Essen, Mülheim and Duisburg in the Ruhrgebiet. The managements of the companies in Cologne and Bonn have also proposed mergers twice in the past, but have not been successful for political reasons. On the other hand, big urban operators acquire small-scale operators from the surrounding area, e.g. the company from Dresden took over the company from Meißen.

Companies with a strong capital base seek for growth opportunities. To name two examples: The company from Hamburg (Hamburger Hochbahn) was engaged in Hessian operators and the subsidiary of Deutsche Bahn for local public bus transport[1], DB Stadtverkehr, intensively applies for tenders and looks out for acquisitions candidates. The question will remain if a geographically random acquisition strategy can raise economies of scale.

Tenders have been established as a form of competition for the market in the federal state of Hesse (with its economic heart Frankfurt) and in the second and third largest German cities Hamburg and Munich, already before the replacement of the EU regulation 1191/1969 by 1370/2007. These tenders have indicated saving potentials as well as increased quality and have shown that small-scale private operators can also be competitive (see Beck et al. 2007), potentially through lower wages they pay. Tenders for bus lines in Hesse will be mandatory with the beginning of 2010, tenders for tram

[1] Additionally, DB Stadtverkehr is responsible for the S-Bahn in Hamburg and Berlin.

and light railways lines shall also become obligatory[2]. However there is clearly a lack of substantiated knowledge if some of these tenders damage more than they raise saving potential, namely if bus and rail-bound services should be separated and hence neglect the possibility to exploit economies of scope.

In this paper, I mainly pursue two objectives: First I want to further develop an appropriate framework for scientific benchmarking of multi-output companies with an application to local public transport in Germany. This can raise efficiency analysis to a tool for business controllers, policy makers and regulators; it can also help to determine the right extent of subsidies. Second I want to give estimates of economies of scale and scope to find answers and give recommendations for the above described trends of industry consolidation.

An extensive study on economies of scale and scope in Switzerland's local public transport was carried out by Farsi et al. (2007a). Their results for the provision of trolley-bus, motor-bus and tramway systems indicate such significant increasing returns to scale and economies of scope that they favor integrated operations to unbundling. Di Giacomo & Ottoz (2007) found fixed cost savings based on economies of scope for Italian urban and intercity bus transit operators. Viton (1992, 1993) evaluated economies of scale and scope for different means of transport in the San Francisco Bay Area, explaining that the extent of the saving potential depends on firm size, the type of transport modes and on wage levels.

The investigation of scale economies and cost efficiency of single-mode transport systems can be found more frequently in the literature because of the ease of modeling and data availability. E.g., Odeck and Alkadi evaluate the performance of Norwegian bus companies with Data Envelopment Analysis (DEA). Farsi et al. (2006) emphasize the need to distinguish between inefficiency and heterogeneity and therefore apply Greene's true random effects model (2004, 2005). The same model is used by Nieswand et al. (2008) to evaluate the cost efficiency of German bus operations. Their analyses are based on estimated costs and focus on rural and regional bus services, whereas this paper has a focus on urban services. Similarly Hirschhausen & Cullmann (2008) found significant economies of scale in Germany's local bus operations using Data Envelopment Analysis (DEA). DEA has also been used by Walter & Cullmann (2008)

[2] With the exact date to be determined.

to identify potential gains from mergers of bus, tram and light railway operators in Germany's most densely populated area, North-Rhine Westphalia, based on physical inputs and outputs.

The remainder of this paper is structured in the following way: Sections 2 and 3 provide the analytical framework. In Section 2 the model specification and the econometric methods are determined whereas in Section 3 the calculation scheme for economies of scale and scope is presented. Section 4 describes the data, Section 5 gives the results and interpretations and Section 6 concludes.

2 Model Specification and Econometric Methods

In local public transportation, there is no such differentiation like first class and second class in rail services or economy class and business class for flights in Europe, all passengers are treated equally. In general, the firm's control over marketing and the quantity and quality of services is limited. Efficiency can therefore be best determined by a cost frontier

$$C = C(y^{(1)}, y^{(2)}, w^{(1)}, w^{(2)}, w^{(3)}, n, t) \qquad (1)$$

depending on the output y. In order to evaluate the economies of scope the output is split into output of bus services ($y^{(1)}$) and output of rail-bound services ($y^{(2)}$), i.e. tram and light railway services[3]. We do not differ in the following between the different rail-bound services as there is not a clear distinctive criteria available for separation, e.g. one could use average speed as well as the existence of tunnels. The outputs are represented by the number of seat-kilometers (including both sitting and standing room). In comparison to the use of vehicle-kilometers, this has the advantage that the size of vehicles is also taken in account. For transport studies it is common to identify one input as personnel expenditures. Besides that input, Farsi et al. (2005a) in their study of Swiss railway companies suggests to use two more inputs: energy expenditures and capital expenditures with the latter calculated as residual costs after subtracting personnel costs and energy costs from total costs. When the share of energy costs is low

[3] I also estimated models where I included metro services in the second output. This lead to insignificant coefficients for the output parameter of bus services; hence the cost structure of metro and bus services seems to be too different to include in one analysis.

and hence coefficients of parameter estimates could be insignificant, the literature suppresses the energy input and summarizes capital costs and energy costs as a common second input (e.g. Farsi et al. 2007a). Economically, other specifications of residual costs are reasonable. E.g. capital costs for bus services on the one hand and rail-bound services differ substantially. Usually the provision of rail-bound services is preferred to the provision of bus services, inter alia because of increased customer attractiveness and increased capacity. However, rail-bound services clearly have higher infrastructure cost. However, in the absence of detailed information about the companies' cost structure concerning bus and rail-bound capital costs, it is difficult to implement such a differentiation. A common allocation with the same split for all companies can lead to collinearity problems in the estimation procedure. I therefore omit this possibility.

Another possibility is to part residual costs into operating expenditures and true capital expenditures. This gives the possibility to map the production process in more detail. Therefore the first input labor with the corresponding factor price is specified $w^{(1)}$. The second factor price ($w^{(2)}$) refers to operating expenditures and the third factor price ($w^{(3)}$) refers to true capital expenditures. As additional network characteristic I include the track length of the tram and light railway network n which heavily influences a company's cost[4]. A linear time trend t captures the shift in technology representing technical change.

For evaluating cost efficiency in a multi-output context where not all companies provide all kinds of outputs, it is convenient to use a quadratic cost function because it allows the incorporation of zero outputs.[5] The quadratic cost functions can be written as

$$C_{it} = \alpha_0 + \sum_{m=1}^{M} \alpha^m y_{it}^{(m)} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha^{mn} y_{it}^{(m)} y_{it}^{(n)} + \sum_{p=1}^{P} \beta^p w_{it}^{(p)} + \alpha^n n_{it} + \alpha^t t_t \qquad (2)$$

with subscript i denoting the company, subscript t denoting the year, superscript m denoting the output (with M being the maximum number of outputs, here two) and superscript p denoting the input. The variables $y^{(m)}$ are the output quantities and $w^{(m)}$ are

[4] I also tested the influence of two other possible structural variables: network length including line length of bus services as well as track length of rail-bound services and a density index calculated by the number of inhabitants in the influence area divided by the network length. Neither show significant coefficients in the estimation procedure.

[5] We hereby follow Baumol et al. (1982), Mayo (1984) and Farsi et al. (2007a and 2007b). See Pulley and Humphrey (1993) for an explanation why a quadratic specification should be preferred to a translog specification when some outputs can be zero. I also estimated a translog function for all multi-output companies. For the coefficient estimates the translog function showed a well behaviour but unfortunately the estimates of economies of scale and scope were unrealistic.

the factor prices. *n* represents the track length and *t* is a time trend. The factor prices and the structural variable are introduced in a linear way following Mayo (1984). α_0 is the intercept whereas all other α's and β^p give the estimation coefficients for the specific terms of the quadratic cost function.

Before I come to the econometric specification, it is necessary to adopt the data and hence the quadratic cost function with two operations:

1) Approximation at a local point: Flexible cost functions like the quadratic or the translog require the approximation at a local point. I follow Farsi et al. (2006) and normalize all variables by their medians.[6]
2) Linear homogeneity in input prices: This can be achieved by the normalization of factor prices, i.e. dividing the dependent variable and all factor prices by one factor price, in our case the factor price for labor (see Featherstone & Moss 1994, Jara-Diaz et al. 2003 and Farsi et al. 2007a).

The normalized quadratic cost function can then be written as

$$C_{it}^{'} = \alpha_0 + \sum_{m=1}^{M} \alpha^m y_{it}^{(m)} + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M} \alpha^{mn} y_{it}^{(m)} y_{it}^{(n)} + \sum_{p=2}^{P} \beta^p w_{it}^{'(p)} + \alpha^n n_{it} + \alpha^t t_t \qquad (3)$$

with C_{it} representing the normalized costs and $w'^{(p)}_{it}$ the normalized input prices.

The evolution of Stochastic Frontier Methods can be described in the following steps. Aigner et al. (1977) proposed a pooled model ignoring the possible panel characteristic of data. This shortcoming was eliminated with the random effects model (RE) developed by Pitt & Lee (1981) and Schmidt & Sickles (1984) and with the fixed effects model developed by Schmidt & Sickles (1984). In contrast to the random effects model, the fixed effects model allows the firm-specific effects to be correlated with the explanatory variables. I performed a Hausman test that confirmed the non-correlation in favor of the random effects model.[7] Hence the cost function's coefficients, which are in our main interest for the estimation of economies of scale and scope, of the random

[6] I did not apply pseudo-medians because in the majority of observations all means of transport are provided. Applying pseudo-medians would have meant to divide all variables by their medians calculated only with the non-zero data points.

[7] The difference matrix for the Hausman test statistic turned out not to be positive definite. According to Greene (2007) this favors the random effects model.

effects model can serve as an unbiased benchmark. The fixed effects model is therefore not used in the following. The random effects model can be specified as

$$C_{it}^{'} = \alpha_0 + (x_{it;} \begin{matrix}\alpha \\ \beta\end{matrix}) + v_{it} + u_i \tag{4}$$

with $v_{it} \sim iid\ N(0,\sigma_v^2)$ and representing a time variant, firm specific stochastic error term (also called noise, e.g. data measurement errors) and $u_i \sim iid\ N^+(0,\sigma_u^2)$ representing the time invariant, firm specific inefficiency.

Recent enhancements of stochastic frontier models pick up the problem that heterogeneity was commonly interpreted as inefficiency in the past. E.g. Greene (2004, 2005) proposed the so called true random effects (TRE) model. This model is also used in the following analyses in order to study the influence on the estimation of economies of scale and scope. The TRE model can be specified as

$$C_{it}^{'} = \alpha_0 + \omega_i + (x_{it;} \begin{matrix}\alpha \\ \beta\end{matrix}) + v_{it} + u_{it} \tag{5}$$

with $\omega_i \sim iid\ N(0,\sigma_\omega^2)$ and representing a time invariant, firm specific random term introduced to capture heterogeneity (e.g. firms situated in geographically unfavorable regions), $v_{it} \sim iid\ N(0,\sigma_v^2)$ and representing the time variant, firm specific stochastic error term and $u_{it} \sim iid\ N^+(0,\sigma_u^2)$ representing the time variant, firm specific true inefficiency.

3 Economies of Scale and Scope

In the definition of economies of scale and scope we follow Baumol et al. (1982). Global economies of scale in the two outputs case are defined as

$$SL = \frac{C(y^{(1)}, y^{(2)})}{y^{(1)} * (\partial C / \partial y^{(1)}) + y^{(2)} * (\partial C / \partial y^{(2)})} \tag{6}$$

with $y^{(1)}$ representing the amount of seat-kilometers provided in buses and $y^{(2)}$ representing the accumulated amount of seat-kilometers provided in trams and light railways. The production technology implies increasing global returns to scale if the expression above is greater than one and decreasing global returns to scale if the expression above is smaller than one. In the case of the global returns to scale being equal to one, the technology exhibits constant returns to scale. Global economies of scale indicate how total costs change when all outputs are simultaneously altered.

Product-specific economies of scale in the two outputs case are defined as

$$SL_m = \frac{C(y^{(1)}, y^{(2)}) - C(y^{(-m)})}{y^{(m)} * (\partial C / \partial y^{(m)})} \tag{7}$$

with $y^{(-1)} = (0, y^{(2)})$ and $y^{(-2)} = (y^{(1)}, 0)$. Product-specific economies of scale indicate how costs change when output *m* is altered. The numerator hereby represents the incremental costs of producing output m. The interpretation of results proceeds in the same way as for global returns to scale.

Economies of scope in the two-output case are defined as

$$SC = \frac{C(y^{(1)}, 0) + C(0, y^{(2)}) - C(y^{(1)}, y^{(2)})}{C(y^{(1)}, y^{(2)})} \tag{8}$$

Economies of scope exist if the expression above is greater than zero. For values smaller than zero there are diseconomies of scope. Economies of scope display savings from the joint production of several outputs.

The three expressions above indicate that there is some interaction between these terms: They do not stand alone. E.g. for global economies of scale, a consideration of a simultaneous increase in both outputs implies that some of the scope effect is picked up.

4 Data

The unbalanced panel data set consists of 381 observations for the 10-year period of 1997 until 2006. About two third (239 out of 381) of the observations are from multi-output companies, the remainder from bus only companies. The exact data structure is given in Table 1. In total the data set includes information about 69 companies resulting an average of approximately 6 observations per company. All except five of the smaller companies[8] are organized in regular public transport associations with zone tariffs. These public transport associations are usually responsible for a common marketing and ticketing, the exact assignment of tasks however differs between the federal states.

Table 1: Data Structure: Observations

	Total	Multi-output: **Bus, tram, light railway and metro**	Single-output: **Bus only**
1997	16	10	6
1998	12	9	3
1999	13	7	6
2000	46	27	19
2001	61	35	26
2002	52	32	20
2003	44	30	14
2004	44	29	15
2005	49	32	17
2006	44	28	16
Total	381	239	142

All cost data was collected separately for each observation from the annual reports and from balance sheets published in the Federal Bulletin (Bundesanzeiger). All physical data could be obtained through extracting the yearly published statistics of the Association of German Transport Undertakings[9] (VDV, Verband Deutscher Verkehrsunternehmen).

Total costs comprise material costs (also called purchases, consisting of expenditures for raw materials and supplies, purchased goods (inter alia energy) and purchased services), personnel costs[10], depreciations, other operating expenses and interests on borrowed capital as well as hypothetical interests on equity. These interests on equity were estimated as interest on corporate bonds plus two percent points risk premium. All companies considered in 2006 exhibited costs of over four billion Euros (see Table 2). The factor price for labor was calculated as personnel costs divided by the number of full-time equivalents (FTE). The factor price for operating expenditures was calculated as material costs and other operating expenses divided by the number of seat kilometers.

[8] These companies from the federal states of Thuringia and Saxony-Anhalt are: Arnstadt, Eisenach, Gera, Mühlhausen and Magdeburg. They are organized in less sophisticated tariff associations charging passengers for kilometers travelled.
[9] See VDV (1998): VDV Statistik 1997, Cologne; also for the following years.
[10] Including salaries and wages as well as social insurance contributions and expenditures for pensions.

The true factor price for capital was calculated as depreciations and interests on borrowed capital and equity divided by the number of seats. The number of seats was not directly available from the VDV statistics, but approximated by the number of seat-kilometers multiplied by the number of buses and cars divided by the number of vehicle-kilometers. The underlying assumption is that the deployment of each bus and railcar is uniformly distributed.

For comparison, I conducted all analyses also with a joint capital price for operating and capital expenses. Following Friedlaender & Chiang (1983) and Farsi et al. (2007a), this factor price for capital was calculated as residual costs (total costs subtracted by personnel costs) divided by the number of seats.

All costs are given in 2006 prices and were deflated with the German producer price index (see Destatis 2008).

Table 2: Descriptive Statistics

	Sum*	Min.	Mean	Median	Max.	Std. Dev.
Total cost (m EUR)	4,102	1	97	65	391	98
Share personnel costs		0.04	0.45	0.46	0.69	0.12
Share operating costs		0.15	0.39	0.35	0.95	0.14
Share capital costs		0.00	0.16	0.14	0.55	0.08
Labor price (EUR per FTE)		12,630	50,798	50,551	178,175	14,825
Models 1 and 2:						
Capital price (EUR per seat)		533	1,778	1,598	5,061	820
Models 3 and 4:						
Operations price (EUR per seat-km)		0.01	0.02	0.02	0.07	0.01
True capital price (EUR per seat)		1	517	472	1,831	303
Output (m seat-kilometers)						
Bus	31,090	4	721	528	2,402	518
Rail-bound	38,969	0	852	313	6,187	1,329
Vehicles						
Bus	7,440	2	173	126	1,003	131
Rail-bound	3,768	0	89	41	458	118

*Sum values for 2006

In contrast to Nieswand et al. (2008) and Hirschhausen & Cullmann (2008), this paper focuses on urban cost efficiency and in contrast to Walter & Cullmann (2008) this paper gives a full perspective on the whole local public transport in urban areas of Germany with 35 local public transport operators out of the 70 biggest cities included in the analysis.

5 Results and Interpretation

5.1 Regression results and model comparison

Table 3: Regression results shows the regressions results for the four considered models. Model 1 is a random effects model with one capital price following Farsi et al. (2007a), Model 2 is a true random effects model with one capital price following Farsi et al. (2007a), Model 3 is a random effects model with a true capital price and an operations price and Model 4 is a true random effects model with a true capital price and an operations price. The coefficient estimates across the different econometric specifications as well as across the random and true random effects models are quite similar, for the latter confirming observations made by Farsi et al. (2005a and 2005b). I conducted likelihood-ratio tests in order to find out which of the both factor price specifications fits best to the data. Both for the random effects and the true random effects model, the hypothesis of a better fit for the true capital and the operations factor prices could be approved at a very low p-level of 0.001. I therefore restrict the interpretation in the following to the models 3 and 4.

All coefficients, in particular for outputs and capital prices show the expected signs and are significant. The output coefficients for bus and rail-bound services are in a similar range, indicating that the cost of a 1%-increase in output is almost identical for both means of transport. One has to bear in mind that the capacity of buses is much smaller so that an output increase is always more costly for tramways or light railways. Decisions on output increases are hence dependent on demand functions. The much higher magnitude of the operations price than the true capital price shows that residual costs (total costs minus labor costs) are mostly dependent on operating costs and not on capital costs. The ordinary concept of residual costs as capital costs is therefore a little bit misleading.

The time trend shows a negative sign suggesting that restructuring that has happened in the sector[11] was successful and total costs tend to be lower in recent years. A detailed strategic efficiency analysis of individual firm scores could be interesting to further evaluate these trends. The coefficient for the network variable is positive implying that

[11] In particular in some of the larger companies like Rheinbahn (Düsseldorf).

the tracks for trams and light railways are a substantial cost factor and network extensions lead to higher total costs. The standard deviation of all significant coefficients is reasonable low in order to allow us the preceding interpretation.

Table 3: Regression results

Model	**1** **RE** **w/o operations price**	**2** **TRE** **w/o operations price**	**3** **RE** **with operations price**	**4** **TRE** **with operations price**
Parameter	*Estimate*	*Estimate*	*Estimate*	*Estimate*
α_0 (Constant)	-0.809 *** (0.091)	-0.614 *** (0.025)	-1.002 *** (0.128)	-0.611 *** (0.029)
α^1 (Bus)	1.046 *** (0.145)	0.938 *** (0.033)	0.944 *** (0.186)	0.893 *** (0.034)
α^2 (Rail-bound)	0.791 *** (0.112)	0.998 *** (0.035)	0.930 *** (0.122)	0.968 *** (0.031)
β^2 (Capital)	0.441 *** (0.026)	0.474 *** (0.012)	0.062 *** (0.025)	0.078 *** (0.010)
β^3 (Operations)			0.470 *** (0.024)	0.465 *** (0.010)
α^{11}	-0.307 *** (0.108)	-0.211 *** (0.027)	-0.243 * (0.128)	-0.239 *** (0.027)
α^{12}	-0.035 *** (0.051)	-0.001 (0.010)	-0.042 (0.051)	0.023 ** (0.010)
α^{22}	-0.072 * (0.038)	-0.147 *** (0.009)	-0.092 *** (0.031)	-0.144 *** (0.008)
α^t (Time trend)	-0.148 *** (0.019)	-0.134 *** (0.011)	-0.189 *** (0.024)	-0.169 *** (0.011)
α^n (Track length)	0.153 ** (0.067)	0.027 (0.026)	0.094 (0.071)	0.057 ** (0.023)
Log likelihood	83.7	127.9	104.1	147.8

*** significant at 1%, **significant at 5%, *significant at 10%; standard errors in parantheses

5.2 Estimates of Economies of Scale and Scope

Table 4 shows all defined measures of economies for the random effects model and the true random effects model, both with three factor prices: labor, operations and capital. The results are given for four hypothetical firms: A firm producing outputs at the 25%-quartile of all sample firms, a firm producing at the median of all sample firms, a firm producing at the mean output and a firm producing at the 75%-quartile.[12] As there are many firms in the sample with no rail-bound services, these firms are excluded from the quartile calculation of rail-bound output.

[12] The determination of an output at the 25% quartile means that 25% of all firms in the sample produce less output.

Looking at the specific scale economies one can observe increasing returns to scale for both bus services as well as tram and light railway services. These results are in line with the literature (Farsi et al. 2006 and 2007a). The models show higher magnitudes of specific economies of scale for bus-specific services than for rail-bound service (1.36 and 1.31 at the upper quartile for bus services in comparison to 1.13 and 1.19 for rail-bound services). The economies of scale at the mean output level are in general higher than those at the median output due to the fact that the variance in the upper output level is much greater. The increasing returns to scale indicate the saving potential by an increase in output levels or by a merger of single-output companies. The saving potentials can be raised by e.g. sharing maintenance facilities or by a joint procurement.

The estimates for economies of scope are negative for both models at all output levels, i.e. it is more costly to operate bus and rail-bound services in one company than to operate it in separate entities. This would encourage competitive tenders also for tram and light railway services. Farsi et al. (2007a) on the other hand found positive economies of scope for urban public transport in Switzerland. Part of that opposed observation can be explained by the different data structure. Whereas the dataset for Switzerland only includes one single-output company, one third of all companies in the German dataset consists of single-output companies. This could give a more realistic image of the cost structure of single-output companies. Furthermore the Swiss dataset differentiates between motor- and trolley-bus services.

For higher output levels the estimates for economies of scope converge to the zero point. Thus it seems more inappropriate and more complex for smaller firms to operate bus and rail-bound services in one company, especially as ticketing and marketing is centralized in the local public transport associations

Global economies of scale are for the mean and the upper output level, at least for the true random effects model, in the positive bandwidth. Global economies of scale depend on both product-specific economies of scale and economies of scope. In the short term, taking the existing industry structure as given and fixed, the big multi-output companies can still raise saving potential by increasing their output. They should hence do their best to develop new customer segments in order to increase demand.[13]

[13] The estimates for the economies of scale and scope for the Models 1 and 2 with only two factor prices labor and capital, not shown here, are quite similar to the results for the Models 3 and 4.

Table 4: Comparison of Economies of Scale and Scope for Different Econometric Specifications

	Fleet size		Bus-specific SL		Rail-bound specific SL	
Capital price	Bus	Rail	***M. 3: RE***	**M. 4: TRE**	***M. 3: RE***	**M. 4: TRE**
25% quartile	44	84	*1.06*	1.06	*1.02*	1.03
Median	86	126	*1.12*	1.12	*1.06*	1.08
Mean	142	173	*1.19*	1.17	*1.10*	1.16
75% quartile	221	251	*1.36*	1.31	*1.13*	1.19

	Fleet size		Economies of scope		Global economies of scale	
Capital price	Bus	Rail	***M. 3: RE***	**M. 4: TRE**	***M. 3: RE***	**M. 4: TRE**
25% quartile	44	84	*-4.78*	-0.49	*0.18*	0.70
Median	86	126	*-0.68*	-0.21	*0.65*	0.91
Mean	142	173	*-0.35*	-0.14	*0.84*	1.02
75% quartile	221	251	*-0.24*	-0.12	*0.98*	1.10

6 Conclusions

In this paper, I estimated random and true random effects stochastic frontier models for urban public transport in Germany, in particulate for evaluating the extent of economies of scope and global and product-specific economies of scale. The random effects model can serve as a benchmark for unbiased coefficients whereas the true random effects model is additionally able to represent unobserved firm heterogeneity. Scientific benchmarking has not yet found its way into practical regulation of local public transport in Germany. In the regulation of electricity and gas distribution and transmission however, the industry and even the regulator prefer to apply simple models to facilitate understanding and comprehension. This should be no alternative for stochastic frontier models as modern models are able to give a much more realistic and fair image of reality. It should also be pointed out that rich datasets with a timeframe of at least five or six years and as many firms as possible are another prerequisite to give useful estimations.

I proposed different factor price specifications in order to map the production process best possible. The advantage of using different factor prices for operations and capital is the richness in interpretation possibilities. The time trend indicates a positive behaviour for recent years. The product-specific estimates for economies of scale are positive, suggesting that the high fragmentation in the German market is not economically justified and mergers and acquisitions should be politically supported.

The finding of diseconomies of scope encourages the use of a competitive tendering scheme also for tram and light railway services. An oligopoly structure of this bidding market seems to be preferable as a high fragmentation would lead to the unexploited economies of scale problem again.

The presence of rail-bound increasing returns to scale and diseconomies of scope leads to a structural problem of tram and light railway services. Small tram networks with very few lines are expensive and an expansion too costly and not covered by enough demand. On the one hand, these small networks could be replaced by bus services (as it as happened in the past quite often) or, on the other hand, could be connected with the regional rail network according to the "Karlsruher Modell". The traction units are therefore equipped with two power systems, one for inner-city operations and one for interurban operations. Few crossovers between the rail and the tram network, e.g. in the near of the main stations, enable direct connections from the rural areas to the inner cities. Such a system can be a solution for the unexploited economies of scale problem of small tram networks, when the railway and tram gauge is consistent.

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Biography

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