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Tender Prices in Local Bus Transport in Germany – An Application of Alternative Regression Techniques

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Abstract

Competitive tendering of local bus services in Germany has received increased attention. Employing Seemingly Unrelated Regression analyses, we observe that prices have regionally varying determinants; for example, while prices throughout most of the federal state of Hesse increase over time, prices in the Munich area decrease. Optimisation of bus utilisation in general has a cost-decreasing impact, confirming that public transport authorities can reduce prices via adequate transport planning. Furthermore, Stochastic Frontier Analysis shows that tender prices in Hesse are slightly less efficient. Moreover we conclude that the public transport authority's experience has an efficiency-increasing impact which supports the introduction of overarching authorities.

Keywords: Public transport, bus, tendering, price, region, SUR analysis, SFA

JEL Classification: C12, C13, C31, H57, K23, L16, L92, R32, R48

1.0 Introduction

Local public transport in Germany is a costly enterprise. Although European regulation (EC) No 1370/2007 appeared to mitigate the need for restructuring through the possibility of direct awards, the unexpected global recession has been a major factor affecting the public budgetary crisis. Moreover, the nation's constitutional goal to achieve balanced budgets in the period 2011 to 2020 adds urgency to the need for fiscal reform of public transport.

Expecting diminishing capabilities of public co-funding, the application of instruments to improve efficiency is more important than ever for public transport authorities (PTAs). Many international studies confirm significant efficiency improvements when introducing competitive tendering to a previously monopoly situation (see among others Alexandersson et al. (1998), Hensher and Wallis (2005) and Sharaby and Shiftan (2008)). Thus, competitive tendering has received increased attention in recent years in Germany, especially where there is no municipal ownership of the incumbent operator. The major areas of competitive tendering activity are the federal state of Hesse including Frankfurt on the Main, and the agglomeration areas of Munich, Hamburg and Mannheim.

While tendering has shown positive results internationally, securing these results in the long run is difficult (for example, see Hensher and Wallis (2005)). Little is known about the factors that influence tender prices and the differences in tender prices. Knowledge of such factors will enable PTAs to set effective tendering conditions and to secure public transport services in an environment of decreasing public budgets. This paper aims to identify the influential factors and differences by analysing a unique and comprehensive data set of 157 observations for the period 1997 to 2009 explicitly collected for our research. We choose not to develop a cost function for bus operators, and instead focus on identifying the tendering conditions which, if properly set by PTAs, will help operators to improve efficiency and reduce costs.

We apply several regression techniques to differentiate between a general cost-impact and an efficiency-impact only affecting single observations, for example, potential overcompensations or winners' curses. We also examine whether price and efficiency differences exist between the regions, since market organisation and tendering policies differ significantly among the regions (see Beck 2010).

Numerous papers have analysed efficiency in public transport services by bus in a general perspective based on data of operators (usually annual reports), among them Brons et al. (2005), Dalen and Gómez-Lobo (2003), Farsi et al. (2006) and Walter (2010). Fewer authors have analysed the drivers of efficiency in detail (for example, Miller (1970) for some US cities). Wolanski (2009) compared the efficiency levels of direct awards and competitive tendering and analysed the drivers of efficiency for the Polish market. He found that PTAs will reach optimum efficiency levels when selecting contract terms between one to eight years; assigning a volume appropriate for small- and medium-sized operators; and by tendering numerous services in one area to support a dynamic market development. Wolanski confirms that tendering of public transport services results in considerable efficiency improvements.[1]

To our knowledge, no efficiency analysis has been published that is based solely on competitive tendering observations. By examining the drivers of efficiency in this market and separating different developments in the regions, we provide a

[1] The results of a comparison of several towns point to lower costs for services provided by private than by public operators. Nevertheless, public operators receiving part of their orders under the direct award procedure are able to tender services at lower than average prices.

comprehensive economic analysis that enables PTAs to realize further efficiency improvements in future tendering procedures.

The remainder of this paper is organised as follows. Section 2 describes the key characteristics of the data set and the explanatory variables, and explains our methodology to adjust prices for inflation, regionally differences in price levels, and subsidisation. Section 3 describes the SUR methodology and presents the results of our analyses with a special focus on regional developments. Section 4 describes the SFA methodology and the results. Section 5 concludes with a discussion and offers suggestions for future research?

2.0 Data

2.1 Database

Although Germany's PTAs are obliged to publish a minimum amount of information (see §§ 17, 19 (2) and 23 Official German Contracting Terms for Award of Service Performance Contracts, Part A (VOL/A) 2009), comprehensive data on competitive tendering, including prices, remain unpublished, nor are official statistical data available. For these reasons we construct a database in three steps to enable sophisticated empirical analysis: (i) identification of all criteria deemed to influence the price; (ii) development of a questionnaire; and (iii) collection and verification of the data.

A first catalogue of relevant criteria is developed based on a comprehensive literature review and our personal consulting experiences. The criteria are verified via interviews with thirty representatives of PTAs, operators, and consultants involved with competitive tendering of local bus services in Germany. The criteria are re-evaluated in a roundtable discussion with the Arbeitskreis Vergabe (AK Vergabe) der

Bundesarbeitsgemeinschaft der ÖPNV-Aufgabenträger in der Bundesvereinigung der kommunalen Spitzenverbände Deutschlands (BAG ÖPNV).[2]

The questionnaire is drafted, again followed by a roundtable discussion with the AK Vergabe, and we pre-test it with several PTAs to identify potential problems and misleading questions. The final questionnaire is distributed to all German PTAs via the BAG ÖPNV.

All major PTAs that have conducted numerous tendering procedures so far have provided data.[3] The final step, the reliability check of the data, identifies and clarifies incomplete or questionable information. Altogether, the database contains quantitative and qualitative data for 112 criteria for n = 157 batches[4] tendered by 16 PTAs in the period 1996 to 2009. Furthermore, we develop combined variables based on the collected criteria. The next two subsections discuss the dependent and relevant explanatory variables, and their designs, calculations, and expected influences.

2.2 Dependent variables

Analysing the factors with monetary impact in the competitive tendering market requires a sufficiently large and unbiased database. Our questionnaire asked PTAs to provide data on the price per vehicle kilometre to be paid by the PTA to the operator for batch i in the first contract year as a result of competitive tendering on a gross-cost basis (p_i).[5] When analysing this data our goal is to adjust any peculiarity with influence on the

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[2] The AK Vergabe is the workgroup for awarding within the BAG ÖPNV. The BAG ÖPNV is a joint association of local acting PTAs of the Deutscher Städtetag (German association of cities), the Deutscher Landkreistag (German association of rural districts) and the Deutscher Städte- und Gemeindebund (German association for small cities and towns).

[3] Special thanks go to all PTAs that provided data for this study.

[4] Also called lots or networks.

[5] Note that net-cost contracts are made comparable to gross-cost contracts by using their net subsidy payment plus the fare revenues of that batch. Furthermore, note that P_i in Table 1, which we define later, is different to p_i.

price per vehicle kilometre beyond the influence of the PTAs. Doing so allows us to identify the true factors of influence of PTAs when setting their tendering conditions.

Considering the observed period of thirteen years, the effect of inflation is a major bias that requires adjustment. To verify whether the consumer price index commonly used for reassessment in numerous studies fits with the real development of the operating costs for public bus transport services we develop our own index I to adjust p_i adequately. This index is based on data provided by the Federal Statistical Office, expert interviews with bus operators, representatives of the bus industry, and PTAs, and it is complemented by our research into the different regional cost levels that arise from structural differences, such as schemes of public co-funding and wage rates.

Total costs for an average batch are influenced by: (i) labour costs (*LC*, primarily bus driver costs); (ii) capital costs (*VC*, primarily vehicle investments); (iii) fuel or diesel costs (*DC*); and (iv) other costs (*OC*, primarily administrative or overhead costs). LC_t, VC_t, DC_t and OC_t represent the relevant index values for the public transport industry for a specific year t filled with data provided by the Federal Statistical Office.

Our examination of the collective labour agreements for states where tendering data is available shows that labour costs differ significantly due to labour rates and effective hours (we define effective hours as the sum of working hours for which the driver is effectively available). We find that working hours per week range from 38.5 to 40, the amount of leave days range from 20 to 31, public holidays range from 9 to 13, and we also note the various arrangements for breaks. In addition, monthly salaries per bus driver at the junior level of seniority, for example, range from 27,135 Euros to 32,540 Euros, whereas their development over time was in a similar range between the states.

Based on our examination we adjust LC_t by up to 23 per cent via the different weighting factors per state.

Regarding vehicle costs we find that a system of public co-funding for vehicle investments is effective in Bavaria[6] and North Rhine-Westphalia. Thus, we need to adjust VC_t by up to 50 per cent for these states.

The index I_{st} necessary to adjust p_i for batch i in state s in year t can be written as:

$$I_{st} = 0.7 \times LC_{st} + 0.15 \times VC_{st} + 0.1 \times DC_{st} + 0.05 \times OC_{st} \qquad (1)$$

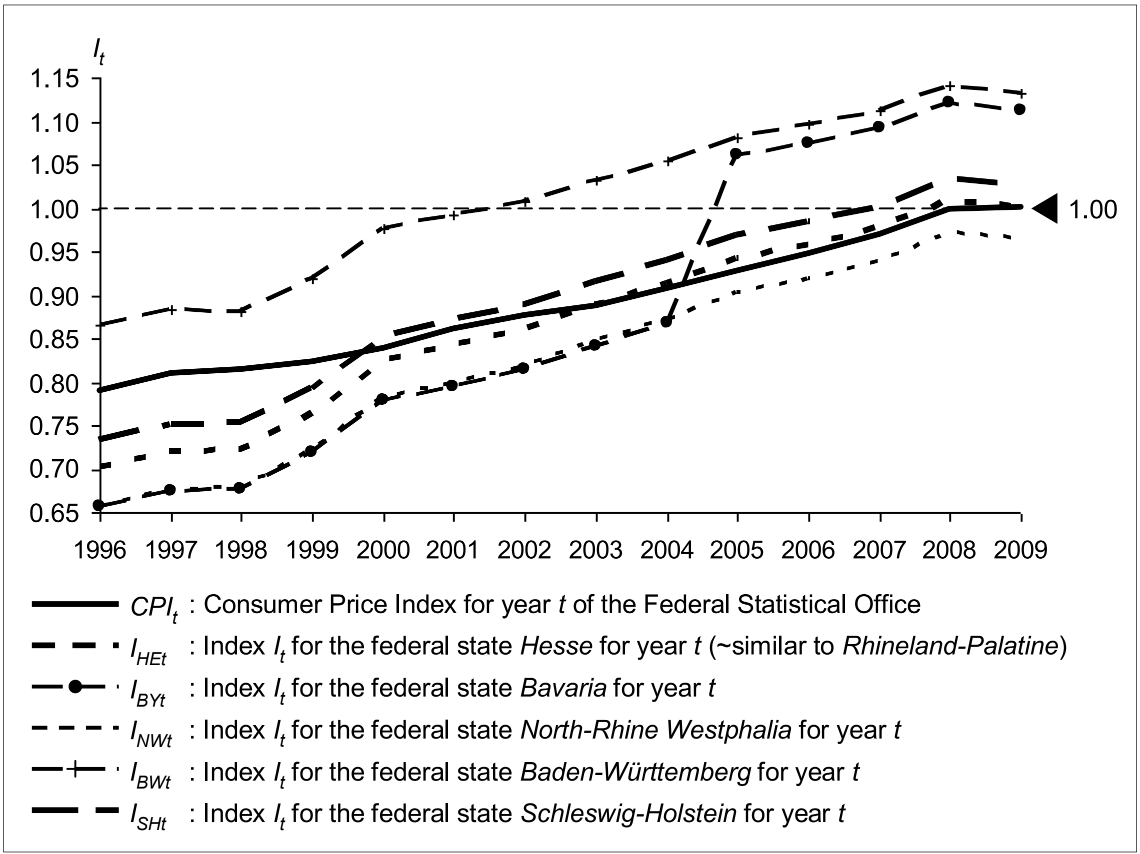
where 0.7, 0.15, 0.1 and 0.05 are the typical shares of total costs for an average batch according to experts and verified by our research. Figure 1 shows the real development over time t with I_{HE2009} representing point 1.0 since the analysis is based on 2009 prices.[7] We observe a significant difference between the development of the consumer price index CPI_t of the Federal Statistical Office and the index values I_{st} per state, with a jump of I_{BYt} due to the adjusted public co-funding of vehicles in Bavaria.[8]

[6] Bavaria undertook reforms within our observation period.

[7] Note that the index for Rhineland-Palatine shows values similar to those for neighbouring Hesse; thus, Figure 1 omitsthe less-relevant Rhineland-Palatinate.

[8] A simple OLS regression confirms that these index values show a correlation on a high significance level with the real development of the unadjusted prices per vehicle kilometre p_i.

Figure 1: Development of the total costs indexes I_{st} compared to the consumer price index CPI_t



Source: Own calculation

Consequently our analysis below is based on P_i, being the adjusted price per vehicle kilometre for batch *i* originated in state *s*. We portion the set *B* of batches ($i \in B$) into disjunct subsets B_{st} with $\bigcup B_{st} = B$. For every B_{st} there exists a unique I_{st}. The adjusted price P_i for batch ($i \in B$) is then given by

$$P_i = (1 / I_{st}) \times p_i \qquad (2)$$

for every $i \in B_{st}$ for every *s* and *t*.

As shown in Table 1 P_i varies from 0.81 to 4.38 Euros. The mean price is 2.09 Euros. We also investigate the full price to be paid by the PTA per annum (p.a.) to the operator per batch *i*, being $FP_i = P_i \times vkmpa_i$, where $vkmpa_i$ is the volume of vehicle kilometres p.a. (vkm p.a.) per batch *i*.[9] The mean value of FP_i is 1.1 m Euros.

Table 1: Descriptive statistics for 157 observations and for main criteria

	Mean	Standard deviation	Minimum	Maximum
Price variables				
Adjusted price per vehicle kilometre (P_i) in €	2.09	0.50	0.81	4.38
Full price per annum (FP_i) in €	1,059,349	1,366,135	40,299	8,673,811
Variables set by PTA				
Vehicle kilometres per annum (*vkmpa*)	508,970	599,962	9,200	3,706,757
Number of lines (*linesno*)	4.10	4.06	1	21
Number of vehicles (*novehcl*)	10.43	10.73	1	57
Average *vkmpa* per bus (*kmpervehcl*)	50,540	23,145	9,200	191,833
Labour agreement standard (*declwage*)	1. no requirements: 50, 2. closure of any labour agreement with employees required: 79, 3. specific labour agreement set as minimum standard: 28			
Average length per bus in metres (*lengthbus*)	12.37	1.44	7	18
Contract term in years (*term*)	6.51	1.83	1	8
Security deposit in percent of FP_i (*deposit*)	3.45	3.57	0	17
Days of submission (*submdays*)	55.65	18.38	25	145
Option for term extension foreseen? (*extopt*)	no: 137; yes: 20			
Renewal of vehicles during term? (*renewal*)	no, not necessary: 122; yes, renewal necessary: 35			
Revenue risk: contract type (*revrisk*)	gross-cost contract: 145; net-cost contract: 12			
Structural variables beyond PTA influence				
Experience: specific number of the batch tendered by the PTA over time (*expr*)	19.01	18.72	1	67
Sum of experience: sum of all batches tendered by the PTA (*exprsum*)	37.01	26.60	1	67
Start of operations (*startoyear*)	-	-	1997	2009
Number of bidders (*bidders*)	5.37	2.74	1	14
Change of operator? (*change*)	no: 43; yes: 114			
Winning bidder SME? (*sme*)	no: 67, yes: 90			
Spatial type of transport service (*spatial*)	1. major city: 8, 2. medium-sized town: 3, 3. small town: 15, 4. suburban: 21, 5. rural: 110			
Federal state (*fedstate*)	HE: 72, BY: 67, SH: 10, BW: 4, NW: 3, RP: 1			

HE: Hesse, BY: Bavaria, SH: Schleswig-Holstein, BW: Baden-Württemberg, NW: North Rhine-Westphalia, RP: Rhineland-Palatine; variable denotations are presented in italics, a full explanation is presented in the Appendix.

Source: Own calculation

[9] As *vkmpa* we count only those vkm p.a. provided on the specific lines of the batch according to the timetable usually set by the PTA. Other tours, for example, transfer between depot and start of a specific line, are excluded.

2.3 Explanatory variables

To discover the conditions with a significant impact on price, we classify the independent variables in three groups according to the general contract conditions with influence on: (i) operators' productivity; (ii) the risk level for operators; and (iii) variables capturing other factors beyond the PTAs' direct influence.

With respect to economies of scale, the chief factor in a contract is the volume tendered out. We theorise that it is a cost-decreasing influence when PTAs are able to increase the volume per batch or the volume per vehicle. An average batch in our database is characterised by a volume of four lines, 505,970 vkm p.a. and ten vehicles, yet there is much variation. The average *vkmpa* output per vehicle, a simple partial productivity measure, shows a mean volume of 50,540. Other conditions set by PTAs that probably limit operational flexibility of the winning bidder are assumed to have a price-increasing effect, most notably for labour agreements where the requirements set by PTAs are measured by an ordinal increasing scale.

For analytical purposes we assume that different risks also affect price. The average extent of investment risk, measured by the average length per bus per observation, is assumed to have a price-increasing impact as a market exit barrier. The mean value shows that most of the buses used are standard 12-metre vehicles. The risk level for market exit influenced by the contract period set by PTAs in the tendering conditions that is available for depreciation is assumed to have a price-decreasing impact.

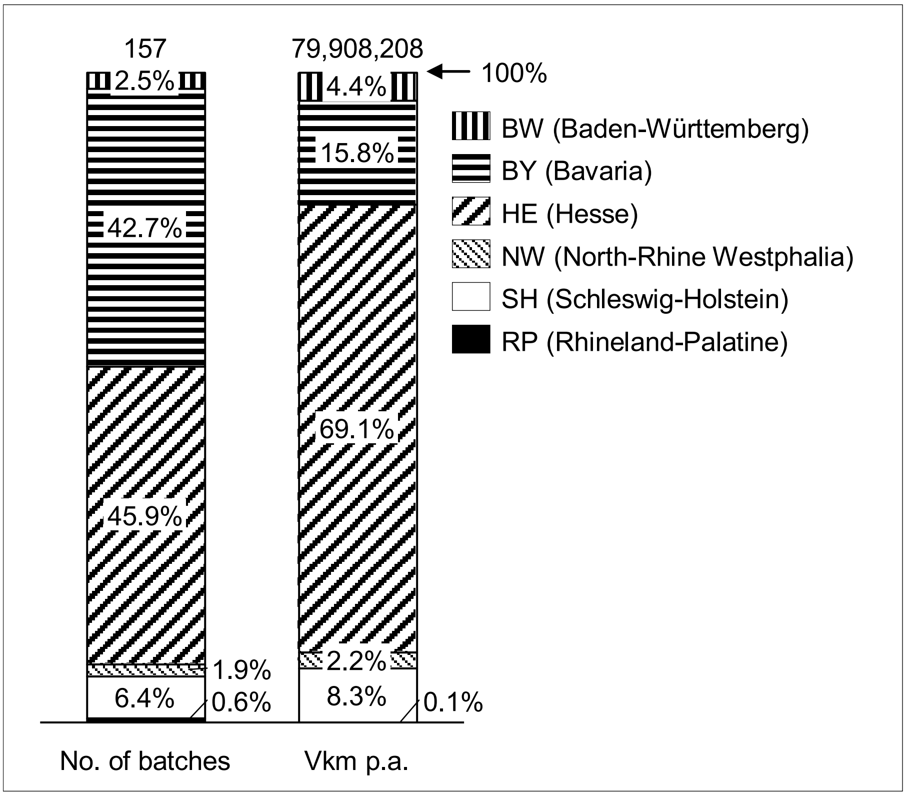
Net-cost contracts, where the PTA decides that the revenue risk shall be borne by the operator, are assumed to have a price-increasing impact. We assume the same for the volume of deposits given by operators to PTAs as security. The duration between the date of the public call for tenders and the date of submission set by PTAs is assumed to have a price-decreasing impact (the more time operators have to prepare and submit bids the lower the prices). Operators are assumed to need a sufficient period to develop a proper calculation; otherwise they must add a risk premium. Contract conditions set by PTAs that presuppose a renewal of vehicles during the contract period are assumed to have a price-increasing impact, also true for contract conditions that foresee PTAs' options to extend the contract period at the end of the contract term.

Variables usually beyond the direct influence of PTAs, such as level of expertise of PTA, time, level of competition, and spatial aspects, are also assumed to have an impact on prices. To date, only a few PTAs have conducted numerous tendering procedures. The Münchner Verkehrs- und Tarifverbund GmbH (MVV) has the most experience, having undertaken sixty-seven tendering procedures in suburban Munich area since 1996.[10] Previous or a higher experience level is assumed to have a price-decreasing impact, which is also assumed for the start year of operations.

Spatial aspects are measured by classifications of population density and transferred to an ordinal scale. Services in high density (city) areas (low ordinal scale) are assumed to be more expensive than services in low density (rural) areas (high ordinal scale). Most of the procedures analysed are in Hesse (73 observations or 46%), the only federal state to tender almost all bus services (see Beck 2010), as illustrated in Figure 2, which shows, too, that the average volume per batch is far lower in the Munich area than in Hesse.

[10] These are the sum of all Bavarian observations. To date, no competitive tendering was observed for the Munich city area.

Figure 2: Distribution of number of batches and vkm p.a. by state



Source: Own calculation

Analysing the level and structure of competition shows that, on average, five companies submit bids and that the incumbent is unable to regain the services in 114 of 157 cases. Small- and medium-sized enterprises (*sme*) which often claim diminishing opportunities to survive in this market, win fifty-seven per cent of the batches tendered (the highest success rates are in the Munich area).

The number of *bidders* is assumed to have a price-decreasing impact. Indeed, a simple OLS regression confirms that the number of *bidders* has a clear price-decreasing effect, highly significant on a 99.9% level (see Appendix). Since the variable, *bidders,* depends on contractual and structural factors (see Augustin and Walter 2009 and Beck 2010), we omit it as an explanatory variable.

3.0 Seemingly unrelated regressions

3.1 Methodology

Simple OLS regression is potentially able to identify the determinants of prices in competitive tendering. However, after the regionalisation of local public transport during railway reform in 1996, the federal states are now responsible for their own local public transport policies, and many responsibilities are delegated to the county or communal level (for more details on the regionalisation and the current framework see Beck 2009a).

This has important implications for the choice of the "right" regression technique: Clearly, the differences in the design of tenders, various price determinants, and other such factors cause us to consider a system of regression equations. In particular some structural factors may only be relevant in specific states or regions. We also bear in mind that our data set could inadvertently neglect some influential factors. The topography of the service area may be an example for a cost driver not covered by the data set. Assuming that the error terms of our regression equations are correlated leads us to the seemingly unrelated regression (SUR) model (Zellner, 1962).[11]

With a slight abuse of notation, the SUR model can be written as

$$P_{ri} = \alpha_r + x'_{ri}\beta_r + \varepsilon_{ri} \quad (3)$$

where P_{ri} represents the adjusted price per vehicle kilometre to be paid by the PTA to the operator for batch i in region r (which is located in state s), α_r the region-specific intercepts, x_{ri} the matrix of explanatory variables with region-specific coefficient vectors β_r and the error term ε_{ri}. The number of explanatory variables is different

[11] However, we did not assume that there is a spatial dependency measured by distances between service areas that determine tender prices. Hence, we do not pursue the path of spatial econometrics.

between regions, for example, because some variables exhibit no variation in some regions.

In contrast to many applications of the SUR model (see for example Wooldridge, 2002, pp. 143 ff.), it is obvious that the number of observations per equation, hence region, is different in our analysis, because we use tendered batches as observations. Therefore we use the algorithm proposed by McDowell (2004) that allows us to estimate a system of SURs with unbalanced equations using Stata's xtgee command. For this command, the iteratively reweighted least-squares estimator equals maximum likelihood.

3.2 Model, results and interpretation

Our SUR analysis concentrates on three regions: (i) the *Munich area* located in Bavaria; (ii) *HesseX* (most of the federal state *Hesse*); and (iii) *other regions*. Observations located in the *Munich area* are solely gross-cost contracts tendered out by the MVV. The batches are relatively small with a mean vkm p.a. volume of only 188,733. Observations located in *Hesse* are usually gross-cost contracts. Here, the state obligation to tender out almost all services and the high market volume in terms of vkm p.a. is expected to have a special influence.

Table 2: SUR results for independent variables on the adjusted price per vehicle kilometre P_i [12]

Variable \ Region	*Munich area*	*HesseX*	*Other regions*
vkmpa	1.98×10^{-7}	-1.67×10^{-7}	-9.35×10^{-8}
	(4.76×10^{-7})	(1.14×10^{-7})	(1.15×10^{-7})
kmpervehcl	-1.19×10^{-5}***	-7.59×10^{-6}***	-1.30×10^{-5}***
	(2.79×10^{-6})	(2.75×10^{-6})	(4.70×10^{-6})
lengthbus	0.1388***	0.1059***	0.0573
	(0.0470)	(0.0396)	(0.0637)
term	0.0036	-0.0513*	-0.0219
	(0.0292	(0.0303)	(0.0656)
extopt	-0.1889	-0.1033	0.3976
	(0.2666)	(0.1412)	(0.2424)
deposit			4.2164*
			(2.4481)
spatial	-0.1855***	-0.1402*	-0.2130***
	(0.0703)	(0.0849)	(0.0633)
startoyear	-0.0282	0.0539**	0.0460
	(0.0174)	(0.0250)	(0.0437)
exprsum		-0.0197***	-0.0013
		(0.0062)	(0.0253)
Constant	85.8647	-105.1419	-89.37328
	(34.6412)	(49.9640)	(86.7471)
Observations	67	60	30
Number of PTAs per group	1	6	9

*Significant levels: *** 99%, ** 95%,* 90%, Standard errors in parentheses*
Wald chi^2: 5,437,55, Prob > chi^2: 0.0000
Source: Own calculation

In forming the *HesseX* group, we correct the *Hessian* cases by 12 cases located in the Verkehrsverbund Rhein-Neckar (VRN) area and in Frankfurt on the Main (FFM) (*HesseX* excludes VRN & FFM). Different to all other areas, the VRN uses net-cost contracts with a high overall risk level for operators at any time and tenders out only in certain cases, namely if no offers to operate the requested services commercially have been put in place (see Beck 2010 for more details). Batches tendered out in FFM are characterised by comparatively high volumes (usually at least 40 vehicles), very high quality requirements, and long durations for submission. Furthermore, Frankfurt on the Main remains the only *major city* in Germany using tendering. Therefore the VRN

[12] Altogether we tested 29 SUR models for the three regions presented here; Table 2 shows the results for the model with the best fit with respect to e.g. significance levels, number of significant variables, and pairwise pearson correlation between the independent variables identified.

cases and the FFM cases, together with all remaining observations, form the group *Other regions*.

The results in Table 2 confirm our hypothesis that different influences are at work in different regions. This finding holds for both significance levels and directions of influences. Regarding the volume tendered out, measured by *vkmpa*, the results confirm economies of scale only on a very low and insignificant probability level of 85.9% and only for *HesseX*. We surmise it is because the average volume of a batch, which is 633,369 vkm p.a. in *HesseX* (range: 61,761 to 1,839,275), is considerably higher than the mean volume in the *Munich area* of 188,732 vkm p.a. (range: 9,200 to 668,800), but not high enough to be meaningful. On the other hand such an influence might not exist at all, for example, due to the contrary effects of overhead or administrative costs, or might be too low compared to other factors of influence presented in the following section. For *Other regions* the low number of observations might be a reason for an insignificant result.

One clear finding for all three groups is that a higher productivity, measured by the average *vkmpa* per bus (variable *kmpervehcl*), lowers the price significantly. The results show that operator ability to optimise circulation plans, blocks, and schedules (minimisation of dead mileage), based on the conditions set by PTAs (timetable, direction of lines, etc.), significantly impacts prices.

Regarding risk, several findings confirm that a higher risk level increases the price to be expected by PTAs, presumably due to the higher risk premia to be calculated by bidders. A first finding is that an increase in the average height of investment risk per bus, measured by *lengthbus*, has a price-increasing impact on P_i. This result is highly significant only for the *Munich area* and *HesseX*. Obviously, larger buses expose the operator to higher investment risks and they also imply higher investments and depreciations. Furthermore, the longer the bus lengths the higher the cost of maintenance.

For the contract *term*, where we assume a price-decreasing impact with respect to depreciation possibilities and the level of risk at the end of the contract period due to the remaining resale value (resale risk at market exit), a significant result is confirmed only for *HesseX*. For the *Munich area* the low volume per batch probably limits such risk in the view of the operators. For *Other regions* the limited variation in this variable (contract term: 5 to 8 years, compared to 3 to 8 years, for example, for *HesseX*) could prevent any significant results.

As discussed in Section 2.3, we assumed that the option for PTAs to extend the contract term has a price-increasing impact, but we find an insignificant level of probability of 89.9% only for the *Other regions* data. Due to the fact that usually the price fixed for the first treaty year is also used for the optional years (adjusted by the usual price index only), operators claim they must add a risk premium. They also claim they can only calculate the main contract term (excluding the extension option) since this is the only fixed and calculable period. Hence, adding an extension option has no price-decreasing effect, although the depreciation period could be extended. Nevertheless, with respect to quality delivered the option is generally assumed to have positive incentivising effects.

The significant result for *deposit* for *Other regions* confirms again that increasing the risk for operators, here via a higher security deposit, has an increasing influence on price. For this variable, we note that a missing variation for the *Munich area* and a very low variation for *HesseX* (only two observations with little differing values) impeded an admission of *deposit* into the SUR-model for the two groups.

In addition to contractual conditions influencing the price there are several structural variables beyond a PTA's influence that effect P_i. The results for the *spatial* type of service show a significant decreasing influence for the gross-costs per vkm for all the regions analysed here. An increasing population density therefore increases P_i, for example, due to a lower average speed per bus in city areas. Furthermore, several labour agreements foresee a mark-up for employees in urban areas (see, for example, ver.di hessen 2007).

The coefficient for the start year of operations (variable *startoyear*) has the expected positive sign, although only significant for *HesseX*, meaning that prices are increasing over time. Market participants in Hesse have claimed that the low prices realised by PTAs during the starting phase of competitive tendering were set at strategic levels by global players or were miscalculated. Some cases of the winner's curse became public since (see Beck 2009b and 2010). BSL (2008) has also mentioned that quality requirements have become more ambitious over time in the Frankfurt on the Main area in Hesse, which also could have led to increased costs.

Unlike *Hesse*, prices in the *Munich area* show a decreasing trend, but insignificant on a low level of probability of 89.5%, despite a clear increase in quality standards (since 2002 almost all procedures require new vehicles and a 100% low floor and air conditioning share). Most likely, the increasing experience level of the MVV over time enabled a gradual reduction of prices since the MVV is the only PTA in our database that has conducted more than 23 tendering procedures (MVV-sum: 67). Furthermore the high level of 98% pair wise Pearson correlation with *startoyear* impeded an admission of *expr* into our SUR model.

Finally, analysing the sum of experience of a PTA (the sum of all procedures per PTA until 2009, variable *exprsum*) confirms that a high level of experience of a specific PTA lowers the price. A high market volume with recurring opportunities for operators in a specific region, compared with an increasing experience share for operators, might also affect the price. This result is highly significant only for *HesseX*, but is remarkable since *startoyear* has a positive impact. The *Munich area* with only one PTA could not be analysed due to the missing variation.

4.0 Stochastic Frontier Analysis

4.1 Methodology

So far we have only looked at cost differences due to structural differences, either fully set by external circumstances or set by the transport authorities. Cost differences can also be caused by the inefficiency of bus service providers and the overcompensation due to a low level of competition. These cost differences are not identical for all firms and operating areas, but are individually specified by, for example, poor bus utilisation, excess labour, gold-plating, etc.[13]

The two main methods of scientific efficiency analysis are non-parametric data envelopment analysis (DEA) and the parametric stochastic frontier analysis (SFA).[14] We choose to rely on SFA for two reasons. First, since SFA and SUR are both regression techniques, SFA is much more comparable with SUR than with DEA. For SFA and SUR, we can interpret and compare coefficients and their impacts on dependent variables. Second, the significance of impacts for both can be evaluated by

[13] When we bear in mind that the winner in a competitive tendering is still the best offer in the market, these inefficiencies occur for all bidders.

[14] See Coelli et al. (2005) for a profound introduction to efficiency analysis.

looking at standard errors of the estimations. This is not possible with DEA, because DEA only looks at the efficiency of observations and does not assume a functional relationship between output and input. In other words, it is impossible to interpret the impacts of structural variables.

The concept of SFA was introduced by Aigner et al. (1977) and Meeusen and van den Broeck (1977) in a cross-sectional model.[15] It is a regression technique that estimates a best-practice efficiency frontier in contrast to average curves set by traditional econometrics. In a cost framework, the estimated equation can be written as

$$\ln FP_i = \alpha_0 + x_i' \beta + v_i + u_i \qquad (4)$$

where FP_i represents the full price per annum to be paid by the PTA to the operator for the i-th batch, α_0 is an estimated intercept, and x_i is a vector of explanatory variables with coefficient vector β. The stochastic term is given by a batch-specific error part v_i, which is independently and identically distributed following a normal distribution $v_i \sim iid\mathrm{N}(0,\sigma_v^2)$, and a batch-specific, non-negative, inefficiency component, which is independently and identically distributed following a half-normal distribution $v_i \sim iid\mathrm{N}^+(0,\sigma_v^2)$. The vector of explanatory variables usually includes outputs, factor prices and control variables, so that the resulting inefficiency component can be interpreted as cost inefficiency. Absent information on firm-specific input factor prices, we can only calculate the measure called 'technical cost efficiency' by Jamasb et al. (2008) in their study on productivity of US gas transmission companies.[16] To ensure a homoscedastic distribution of inefficiencies, the costs and explanatory variables are introduced in logarithms according to the Cobb-Douglas functional form. The

[15] Given that only twelve second-round batches are included in our data set, we are not able to analyse recurrent tender rounds, and cannot make use of more sophisticated SFA panel data models.

[16] A similar approach was taken by Agrell et al. (2008a, b) on the incentive regulation of German gas and electricity distribution companies.

inefficiency component is separated from the stochastic error term by applying the Jondrow et al. (1982) estimator.

Generally, cost functions in efficiency analysis of the local public transport sector are estimated with firm-level data assuming a cost-minimizing behaviour (see, for example, Farsi (2006)). In our approach, we look at the efficiency of winning offerings in public tenderings chosen from a set of competing offerings, which can amplify the cost-minimizing provision and easily reveal the appearance of over-compensation in the inefficiency component. We assume that FP_i represents the total costs of the transport firm for providing the tendered services per annum, acknowledging that these services may only represent a portion of the firm's business, plus an adequate profit. We observe that firms winning more than one batch can appear more than once in our dataset. However, each batch has to be calculated as its own imaginary subsidiary, because contractual lengths can differ and the potential economies of scale are hence uncertain. This is particularly valid for the newcomers that win 73% of all batches in our database.

4.2 SFA-results and interpretation

We confirm that increasing the productivity per vehicle per batch as measured by *kmpervehcl* decreases the full price to be paid per annum on a highly significant level. We also identify the influence for the variable *declwage*, which shows that tendering conditions that require operators to use any or even a specific labour agreement have a significant price-increasing effect. Matters of risk are confirmed to have a price-increasing effect. As presented in Section 3.2, the variable *lengthbus* as a measure for the relative investment risk per bus again has a highly significant price-increasing effect. Surprisingly, tendering conditions that make it necessary for operators to renew the fleet during the contract, for example, due to a maximum age of vehicles that is below the contract term, show no significant influence. It is likely that the amount of maintaining costs has a high influence, balancing out the risk of realising a selling price that is below the book value of the vehicle at the point of renewal.

Another relevant aspect is revenue risk as measured by the variable *revrisk* on a significant level. As expected, imposing an additional risk on the operators via net-cost contracts seems to increase the price.

Table 3: SFA results[17]

Dependent variable	*ln(FP$_i$)*
ln(vkmpa)	0.9674***(0.0163)
ln(kmpervehcl)	-0.2561***(0.0331)
declwage	0.0400*(0.0218)
ln(lengthbus)	0.5545***(0.1309)
renewal	-0.0413(0.0356)
revrisk	0.1064*(0.0592)
Ln(submdays)	0.0932*(0.0545)
spatial	-0.0748***(0.0151)
Constant	15.3464***(0.5779)
Observations	157

*Significant levels: *** 99%, * 90%, Standard errors in parentheses, ln: logarithm natural.*
Source: Own calculation

Surprisingly, and not as expected in Section 2.3, the variable *submdays* shows a price-increasing influence. Increasing the period between the date of the public call for tenders and the date to submit bids tends to increase the full price to be paid by the PTA per annum. It appears as though operators calculate more aggressively when there is a short period for submission. If there is a longer period to prepare bids, operators are able to perform more sophisticated calculations which could enable them to identify more uncertainties where a risk premium appears necessary, thus preventing the occurrence of a winner's curse. Furthermore, a short submission period induces the danger that bidders

[17] Altogether we tested 45 efficiency models, while Table 3 shows the results for the model with the best fit with respect to e.g. significance levels, number of significant variables, pairwise pearson correlation between the independent variables identified and sigma u.

miscalculate. Both cases may be problematical for PTAs should operators go bankrupt and services must be interrupted.

When comparing the efficiency levels Kruskal-Wallis tests confirm on a 91.05% significance level that batches tendered out in the federal state of *Hesse* (including FFM and the VRN area) show 0.25% less efficiency, on average, than procedures conducted elsewhere (see Table 4).

Table 4: Efficiency comparisons and Kruskal-Wallis tests

Non-Hesse vs. ***Hesse***	
Mean efficiency for *Non Hesse* (n = 85)	89.15%
Mean efficiency for *Hesse* (n = 72)	88.90%
χ_1^2-value	2.883
Probability	91.05%
expr < 6 vs. *expr ≥ 6*	
Mean efficiency for *expr* < 6 (n = 45)	88.38%
Mean efficiency for *expr* ≥ 6 (n = 112)	89.30%
χ_1^2-value	4.443
Probability	96.50%

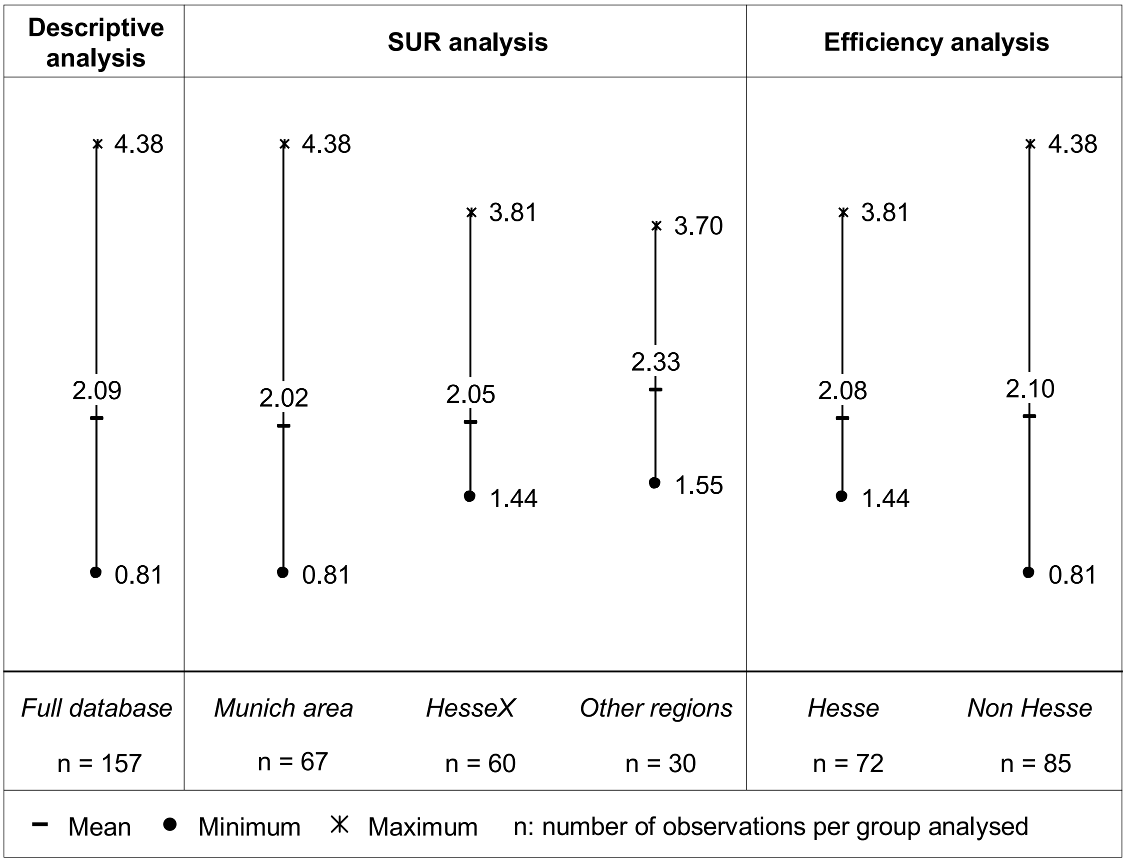
n: number of observations per group

Source: Own calculation

Comparing the mean prices of the different regions analysed as shown in Figure 3 reveal that on the other hand prices in *Hesse* are somewhat lower. We conclude that PTAs in *Hesse* probably tender out batches that enable lower prices than elsewhere (*Non-Hesse*) due to a low level of risk (for example, usually gross-cost contracts) and good productivity parameters (with respect to *kmpervehcl* or *vkmpa*).

The values in Figure 3 also show that, on average, the lowest prices are realised in the *Munich area* which is only slightly different to *Hesse*. Nevertheless, the result shows that producing services in *Hesse* is a little less-efficient than elsewhere due to factors not included in SFA. One explanation could be the lack of competition due to diminishing bidders per procedure and the trend to market consolidation observed in recent years in *Hesse* (see Beck 2010). A lack of competition due to oligopoly structures may then be a reason for overcompensating the winning bidder. With respect to the price-increasing effect over time shown for *HesseX* discussed in Section 3.2 we suggest examining whether the weak difference in the efficiency levels observed will become more distinctive in the near future.

Figure 3: Distribution of prices per vkm in € for the regional groups



Source: Own calculation

Regarding the experience level as measured by the variable *expr*, SFA reveals that PTAs' experience has an efficiency-increasing impact. The Kruskal-Wallis test confirms on a 96.50% significance level a 0.93% increase in the efficiency scale for procedures where PTAs have already conducted at least six tenders. The results show that an experience level higher than six tenders enables PTAs to set tendering conditions such that operators are able to deliver more efficient services. In testing numerous other variables like *revrisk, deposit, bidders* and*, startoyear,* we found that none show significant differences in the mean efficiency levels.[18, 19]

5.0 Conclusion

Based on a comprehensive data set of 157 observations and a detailed adjustment of price data with respect to the price differences between states due to peculiarities beyond the influence of PTAs, we identified three groups of impact factors on tender prices. These are the contract conditions set by the PTAs with direct influence on operator productivity; contract conditions set by PTAs with direct influence on the risk level for operators; and exogenous aspects beyond the influence of PTAs. Using SUR analysis and SFA analysis we identified numerous impact factors that partially differed among the regions due to specifics such as the level of experience and the tendering philosophy.

Based on our results, we conclude that properly setting the contract conditions for a given batch allows PTAs to realise added efficiency improvements. Directly, the improvements occur by contract conditions increasing productivity per batch and limiting the risk level assumed by the operator, and indirectly, by conditions increasing the level of competition. For example, optimisation of bus utilisation has a cost-decreasing impact, confirming that PTAs are able to reduce prices with adequate transport and (line) network planning. We suggest that PTAs should determine contract conditions in a manner that enables operators to improve productivity and minimize

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[18] We only see with a low probability of 82.30% that services won by small- and medium-sized enterprises show a 0.35% higher efficiency scale than services won by other operators, and that cases with a change of the operator show a 0.44% higher efficiency scale than other services with a low probability of 81.90%, indicating that further research is necessary for these two aspects.

[19] We also tried to include the variables turning out to be significant efficiency separators in the Kruskal-Wallis tests as heteroscedastic variables in the inefficiency function. However, this does not lead to significant coefficients.

their risk premia. Moreover, the result that an increasing level of experience has a price-decreasing impact may enable further efficiency gains by assigning the tendering process to one ore more overarching authorities per region vested with the expertise required.

Nevertheless, even such actions by PTAs are limited by exogenous factors that are outside their sphere of influence of PTAs, such as population density, or political aims, such as the aim to prevent dumping-wages for fair market conditions and social reasons. Furthermore several trade-offs have to be kept in mind. A major one is that net-cost contracts entail a higher risk level, but are generally preferable to gross-cost contracts with respect to incentives (see Beck 2011 for more details).

When looking at the different results for price developments over time for the regions Hesse and the Munich area, further research is necessary whether strategic prices or even a market consolidation might have an influence. This holds especially with respect to the efficiency level, which shows slightly less efficient prices in Hesse than elsewhere and though requires confirmation by future examinations.

Furthermore, efficiency studies usually reveal a cost reduction because of technological progress of around 1 per cent per year (e.g. Walter (2010)). This has to be kept in mind when analysing prices over time and could be included in further research.

Appendix

Table 5: OLS regression of the number of bidders on price

Dependent variable	P_i
Bidders	-0.0612***
	(0.0137)
Constant	2.4167***
	(0.0828)
Observations	157
F-value	19.79
Prob>F	0.0000
R^2	0.1132

*Significant level: *** 99%, Standard errors in parentheses.*

Table 6: List of main criteria

Variable	Explanation	Scale of measure-ment	Measured by
p_i	Price per vehicle kilometre (vkm) to be paid by the PTA to the operator for batch *i* in the first contract year as a result of competitive tendering on a gross-cost basis. Note that net-cost contracts were made comparable to gross-cost contracts by using their net subsidy payment plus the fare revenues of that batch	Ratio	€ per vkm
P_i	p_i, adjusted by the effect of inflation (inflation measured by the real development of the operating costs) and other major impacts that affect the price over time (for example, adjustment of public co-funding for vehicle investments)	Ratio	€ per vkm
batch	Lot: the smallest part of a network tendered out for which a bidder is able to hand in an offer	Nominal	1
FP_i	Full price to be paid by the PTA per annum (p.a.) to the operator per batch *i*: $FP_i = P_i \times$ sum of vkm p.a. per *batch i*	Ratio	€ per batch p.a.
vkmpa	Vehicle kilometres (vkm) p.a. per *batch* within the first year of operations. Note that we count only those vkm p.a. provided on the specific lines according to the timetable of the *batch* usually set by the PTA; other tours, e.g., transfer between depot and start of a specific line, are excluded	Ratio	Kilometres per batch p.a.
linesno	Number of lines per *batch*	Interval	Number
novehcl	Number of vehicles per *batch*	Interval	Number
kmpervehcl	Vehicle kilometres per annum per vehicle in a specific *batch* on average	Ratio	Kilometres per annum per vehicle
declwage	Minimum standard with respect to labour agreements as set by PTA with three occurrences: (i) no requirements, (ii) closure of any labour agreement with employees required, (iii) specific labour agreement set as a minimum standard	Ordinal	Number

lengthbus	Average length per vehicle in a specific *batch* on average	Ratio	Meters
term	Contract term in years per *batch*	Interval	Years
deposit	Deposit which needs to be given to PTAs by operators as a security (security deposit) in percent of FP_i	Ratio	Percentage
submdays	The duration between the date of the public call for tenders and the date of submission as set by PTAs (days of submission)	Interval	Days
extopt	Option for PTA for term extension foreseen at the end of the contract term? Yes = 1, no = 0	Dummy	Yes/No
renewal	Do contract conditions exist that presuppose a renewal of vehicles during the contract period? Yes = 1, no = 0	Dummy	Yes/No
revrisk	Does the operator have to bear the revenue risk? Yes = 1 (classified as net-cost contract), no = 0 (classified as gross-cost contract)	Dummy	Yes/No

Variable	Explanation	Scale of measure-ment	Measured by
expr	Experience of the PTA that has put out the *batch* to tender, measured by the specific number of the current batch tendered out by the PTA over time	Interval	Number
exprsum	Experience of the PTA that has put out the *batch* to tender, measured by the sum of all batches tendered out by the PTA	Interval	Number
startoyear	Year of start of operations	Interval	Year
bidders	Number of bidders per *batch*	Interval	Number
change	Has a change of the operator occurred due to the specific tender? Yes = 1, no = 0.	Dummy	Yes/No
sme	Is the winning bidder a small or medium-sized enterprise (SME)? Yes = 1, no = 0.	Dummy	Yes/No
spatial	Spatial type to assess population density measured by five agglomeration types: (i) major city, (ii) medium-sized town, (iii) small town, (iv) suburban area, (v) rural area	Ordinal	Number
fedstate	Abbreviation of the federal state where the batch is (primarily) located: BW: Baden-Württemberg, BY: Bavaria, HE: Hesse, NW: North Rhine-Westphalia, RP: Rhineland-Palatine and SH: Schleswig-Holstein.	Nominal	Abbreviation

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