1. Introduction

As part of the 1994 rail reform, Germany has introduced the principle of franchising for regional rail services. The major goal of this measure, known as so-called regionalization, was to achieve a decent level of regional rail services at as low subsidies as possible. The German regionalisation was based on a clear distinction between cost-covering (or even profitable) services to be provided at DB’s (incumbent) or any other rail operator’s own entrepreneurial risk (commercial services), and non-profitable PSOs (regional rail services) which have to be subsidised. It included an agreement between the federal government and the federal states on a stable and sound public financing for public service obligations (PSOs) which has been at a level of about €7 billion per annum. Since 1996 the federal states have been responsible for procuring regional rail services from transport companies and for financing them within franchise contracts. The federal states have considerable freedom to organise this process, and consequently the character of franchise contracts in Germany varies regarding the type of procurement (competitive tendering versus direct negotiations) and regarding contract features such as contract duration, network size and contract type (net versus gross contracts).

While there is evidence that the so-called regionalisation with the agreed sound financing of rail-PSOs in Germany had positive impacts on service provision, patronage, customer satisfaction and service quality (see Link and Merkert, 2011, Nash et al., 2013), the lack of sufficiently detailed data has so far not allowed to analyse the efficiency of using funds to subsidise these services and to identify the determinants of efficiency. Available studies for Germany such as Beck (2011), Lalive and Schmutzler (2008) and Hunold and Wolf (2012) rather focus on samples of contracts awarded under competitive tenders and study procurement design, potentials and barriers for market entry. Lalive and Schmutzler (2011) analyse procurement prices between lines which were competitively tendered and those which
were procured within direct negotiations. All these studies refer either to rather small samples or to samples covering rather short time periods, and in face the problem that it is unknown whether the subsamples used are representative.

Against this background, the analysis presented in this paper contributes to the existing research gap by analysing a unique dataset which includes for all regional rail services data at the level of federal states on traffic and patronage, monetary data and data on contract features and type of procurement. Specifically, the analysis is aimed at determining and explaining differences in efficiency of using subsidies between the federal states and establishing evidence on the impact of procurement strategies and contract parameters on the efficient use of funds.

2. The data
Potentially, an analysis of efficiency in subsidising regional rail passenger services could focus on three levels of disaggregation which imply the definition of the respective decision making units (DMUs): 1) The level of federal states which are responsible for the general decisions on franchising strategies and designs, for the adoption of passenger fares and which are also involved in decisions on the closure of unprofitable rail lines. 2) The level of PTAs which are responsible for the day-to-day management of franchise contracts. 3) The contract level, which would allow to study more specifically contract design, patronage and in addition reliability, punctuality and customer satisfaction (for which data covering all PTAs and all federal states is not available).

In Germany, centrally held and publicly accessible data is not available for any of these disaggregation levels. Therefore, a comprehensive data collection work was conducted whereby the level of federal states was chosen. The dataset includes variables on the volume of regional rail services (train-km and passenger-km), on the level of subsidies and fare revenues, and on the characteristics of the contracts (net versus gross contracts, tendered versus non-tendered contracts, contract size, contract duration). Data collection work included questionnaires and interviews with PTAs and the transport ministries of the federal states. This information was supplemented by data from various other sources such as business reports of rail companies (including DB), data from the Association of PTAs (BAG SPNV) and from the Association of Public Transport Operators (VDV), official statistics of the
federal states as well as own calculations. All monetary data was deflated with the price index for regional rail passenger services at constant prices of 2010.

Comprehensive own calculations were necessary for allocating infrastructure charges (charges paid for the use of tracks and stations which are part of the subsidy paid within the franchise contracts) to federal states, and for the treatment of fare revenues against the background that all federal states use a mixture of net and gross contracts within their franchising strategies. Information on revenues of DB Netz and DB Station (the track provider and the operator of stations in Germany) from user charges is only available as overall figures and had in a first step to be broken down to traffic types, based on earlier work on the different versions of the track access charging schemes and the charging schemes for rail stations during 1996-2010 (see Link, 2004, Link 2013). In a second step, infrastructure charges from regional rail services were allocated to federal states based on information from profit-loss statements of several rail companies, partially available regional information, the train-km of different traffic types and by considering the regional surcharges as applied in DB’s access charging scheme from 1999 to 2005.

Table 1: Descriptive statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population density</td>
<td>P_SKM</td>
<td>667.8</td>
<td>1012.8</td>
<td>71.0</td>
<td>3897.0</td>
</tr>
<tr>
<td>Track length</td>
<td>TRACKS</td>
<td>2440.3</td>
<td>1809.7</td>
<td>134.8</td>
<td>6589.2</td>
</tr>
<tr>
<td>Train-km</td>
<td>TR_KM</td>
<td>37.43</td>
<td>27.81</td>
<td>2.24</td>
<td>112.04</td>
</tr>
<tr>
<td>Passenger-km</td>
<td>P_KM</td>
<td>2546.61</td>
<td>2377.21</td>
<td>180.39</td>
<td>8725.81</td>
</tr>
<tr>
<td>Share of tendered train-km</td>
<td>TEND</td>
<td>6.87</td>
<td>9.63</td>
<td>0.00</td>
<td>45.66</td>
</tr>
<tr>
<td>Share of train-km under net contracts</td>
<td>NET</td>
<td>93.40</td>
<td>13.27</td>
<td>32.70</td>
<td>100.00</td>
</tr>
<tr>
<td>Average contract size</td>
<td>SIZE</td>
<td>5.31</td>
<td>6.90</td>
<td>0.44</td>
<td>88.80</td>
</tr>
<tr>
<td>Average contract duration</td>
<td>DUR</td>
<td>9.55</td>
<td>3.71</td>
<td>1.41</td>
<td>17.50</td>
</tr>
<tr>
<td>Subsidies*</td>
<td>S</td>
<td>225.86</td>
<td>158.00</td>
<td>10.37</td>
<td>721.47</td>
</tr>
<tr>
<td>Share of infrastructure charges** in total subsidies</td>
<td>INFRA</td>
<td>53.98</td>
<td>9.84</td>
<td>24.98</td>
<td>88.77</td>
</tr>
</tbody>
</table>

N=240. *) At 2010 prices. Adapted by fare revenues from gross contracts.- **)Infrastructure charges paid for the use of tracks and stations represent items which are paid by rail operators to rail rack providers (typically DB Netz). They are passed through to PTAs and are part of the subsidies paid by PTAs to operators within franchise contracts.

A partial adjustment of subsidies paid for regional rail services was necessary because the amount of public money finally to be spent by the PTAs for these services is influenced by the chosen contract type, e.g. the different treatment of fare revenues in net and gross contracts. While under gross contracts the PTA pays an overall subsidy to the rail operator and receives all fare revenues, in a net contract regime the rail operator keeps all fare revenues and receives
a subsidy to compensate for those costs not covered by rail fares. Analysing the efficiency of subsidising regional rail passenger services requires therefore considering the fare revenues collected by PTAs as a subsidy-minimising income of PTAs. Based on data from the VDV, fare revenues differentiated by federal states were allocated to pass-km and train-km operated under both types of contracts and the amount of subsidies paid was adjusted by subtracting fare revenues collected from gross contracts.

As a result of this comprehensive data collection work, a unique panel dataset with the federal states as cross-section units and a coverage of the period from 1996 (the start of franchising) to 2010 was elaborated.

3. Methodology

This paper employs a two-stage bootstrapped efficiency analysis with a DEA application in the first stage and a Tobit panel model for explaining the first-stage efficiency scores. The first stage DEA is a deterministic, non-parametric method to specify the efficient production frontier. Based on observed inputs \((w)\) and outputs \((y)\) for a set of \(N\) decision-making units (DMUs), relative efficiency scores for each unit are derived by searching for the most efficient DMUs in the sample, e.g. those units with the lowest input levels for a given level of output\(^1\). These form the efficiency frontier which envelopes all observed data points in the sample. Efficiency of each DMU is measured by the distance \(\Omega\) between the single observation and the frontier. Depending on the assumption imposed regarding the ability of firms to influence either inputs or outputs the distance function can be applied as input-oriented, e.g. reflecting a situation where the output set is fixed by exogenous factors, or as output-oriented which refers to the opposite situation. Given that the federal states have the decision power on the level of subsidies rather than over outputs such as train-km and passenger-km (which are substantially influenced by long-term planning and contracts as well as by macro-economic and demographic factors), the first stage DEA approach uses an input oriented distance function. It should be noted that according to Coelli and Perelman (1999) output and input-oriented models estimate exactly the same frontier surface and therefore, identify the same set of DMUs as efficient, however, the scores themselves differ. They also show that for railways the orientation does not matter as much as it does for other industries.

\(^1\) The performance of a DMU is defined as the ratio between the weighted sums of outputs and inputs whereby the weights are allocated within the DEA model.
The distance function can be estimated under alternative assumptions on the type of returns to scale; e.g. constant (CRS) versus variable (VRS). The input-oriented DEA model with constant returns to scale is (see Coelli et al., 2005)

Min wrt \( \Omega_i, \lambda_i \): 

\[
\sum_k \lambda_k y_k - y_i \geq 0, \quad k = 1, \ldots, N \\
\Omega_i w_i - \sum_k \lambda_k w_k \geq 0, k = 1, \ldots, N \\
\lambda_k \geq 0
\]  

(1)

where \( \lambda_k \) represent the optimal weights for inputs and outputs which are searched for each DMU by the optimisation program. The value of \( \Omega_i \) is the input-oriented technical efficiency score for the \( i \)th DMU. A VRS model is obtained by imposing the additional convexity constraint

\[
\sum_k \lambda_k = 1. 
\]  

(2)

Since the German rail sector is characterised by imperfect competition, budget restrictions and regulatory deficits regarding the entry of new companies, the CRS assumption appears to be not appropriate. Therefore, this paper presents efficiency scores both under constant (CRS) and variable (VRS), with the latter being the preferred assumption. As it is common in DEA studies, a bootstrapping approach based on Simar and Wilsson (1984) is applied in order to obtain confidence intervals and to overcome the potential problem of biased results in the second-stage regressions. The bias-corrected results for the efficiency scores were obtained from 1000 iterations.

For the analysis presented in this paper, two output variables and three input variables were defined. As it is common practice in studies of rail efficiency, this paper uses train-km and passenger-km as output variables. The definition of inputs contains two monetary variables, namely operating subsidies (directly to be influenced by the DMUs) and infrastructure charges to be paid (exogenously given by the infrastructure provider), and one physical variable, the track length. The paper presents results for four different DEA models. All of them use train-km and passenger-km as output variables but differ regarding the specification of the input variables: V0 considers only one input which is the total subsidy as the sum of

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2 Note that most DEA studies use the Farell(1957) measure which is obtained by the reciprocal of the Shephard distance function.
operating subsidy and infrastructure charges, V1 includes two monetary inputs (operating subsidy and infrastructure charges to be paid), V2 includes total subsidy and track length, and V3 includes the two monetary and the physical input variable.

Following previous studies such as (Merkert et al., 2010, Cantos et al., 2010), this paper regresses the efficiency scores obtained from the first-stage DEA approach against a set of independent explanatory variables in order to explain differences in the efficiency between the federal states. The explanatory variables contain two types of data. First, a set of policy variables which reflect the decisions of the federal states how to organise rail franchising. To these variables belong the share of tendered train-km, the share of train-km under net contracts, the average size of contracts (expressed in train-km) and the average contract duration. Second, environmental variables which cannot be influenced by the DMUs such as the population density.

The efficiency scores are bound in the (0,1) interval and represent a censored variable which requires an appropriate econometric treatment by means of corner solution, e.g. Tobit models (named after Tobin, 1958). The general formulation of a one-limit Tobit model with 0 as limit is usually given as index function (or latent variable model)

\[ y_i^* = x_i' \beta + \epsilon_i, \quad \epsilon_i \sim N(0, \sigma^2) \]

\[ y_i = \max(0, y_i^*) \]

where \( x_i \) represent the explanatory variables, \( \beta \) is the vector of parameters to be estimated, \( y_i \) is the observed dependent variable and \( y_i^* \) is the unobserved, latent variable. The log-likelihood for this model is a mixture of discrete and continuous distributions as follows

\[ logL = \sum_{y_i > 0} - \frac{1}{2} \left[ log(2\pi) + log\sigma^2 + \frac{(y_i-x_i'\beta)^2}{\sigma^2} \right] + \sum_{y_i = 0} log \left[ 1 - \Phi \left( \frac{x_i' \beta}{\sigma} \right) \right] \]

where the first term refers to the classical regression for the non-limit observations and the second term gives the relevant probabilities for the limit observations (see Greene, 2002). The Tobit model can be estimated by MLE procedures. Marginal effects are obtained by

\[ \frac{\partial E(y_i|x_i)}{\partial x_i} = \Phi \left( \frac{x_i' \beta}{\sigma} \right) \beta \]
and indicate that a change in $x_i^t$ affects the conditional mean of $y_{it}^*$ in the positive part of the distribution and in addition also the probability that the observation falls in that part of the distribution.

For the type of data used in this paper, the basic Tobit model has to be extended to a panel context. As common, the two standard approaches for incorporating individual heterogeneity are available, e.g. the fixed and random effects model. For incorporating individual heterogeneity, the basic Tobit model is modified to

$$y_{it}^* = \alpha_i + x_{it}'\beta + \epsilon_{it}, \quad \epsilon_{it} \sim N(0,\sigma^2)$$

$$y_{it} = \max(0,y_{it}^*)$$

where $\alpha_i$ represents unobserved individual heterogeneity. While the fixed effects model allows correlation between $\alpha_i$ and $x_{it}$, the random effects model assumes that heterogeneity is uncorrelated with the regressors. The fixed effects model is estimated by including a set of dummy variables $d_i$, $(i = 1, \ldots, N)$ which indicate membership in group $i$:

$$y_{it}^* = \sum_{i=1}^{N} d_{it} \alpha_i + x_{it}'\beta + \epsilon_{it}, \quad \epsilon_{it} \sim N(0,\sigma^2)$$

$$y_{it} = \max(0,y_{it}^*)$$

The corresponding log likelihood function is given by

$$\ln L = \sum_{i=1}^{N} \sum_{t=1}^{T} (1 - c_{it}) \ln \Phi (-\eta_i - x_{it}'\gamma) + c_{it} \ln [\phi \phi y_{it} - \eta_i - x_{it}'\gamma]$$

$$c_{it} = 1, \quad \text{if } y_{it} > 0$$

$$c_{it} = 0 \quad \text{otherwise}$$

with $\eta_i = \frac{\alpha_i}{\sigma}$. Following Olsen’s (1978) transformation, the parameters $\gamma$ and $\theta$ are

$$[\gamma,\theta] = \left[ \frac{\beta}{\sigma}, \frac{1}{\sigma} \right].$$

The random effects model is

$$y_{it}^* = \alpha + x_{it}'\beta + u_{it} + \epsilon_{it}, \quad \epsilon_{it} \sim N(0,\sigma^2)$$

$$y_{it} = \max(0,y_{it}^*)$$
Since in the random effects model the regressors are assumed to be uncorrelated with heterogeneity, a different approach to estimation is necessary. The conditional log likelihood in the presence of random effects is given by

\[
ln L_{\text{cond}} = \sum_{i=1}^{N} \ln \prod_{t=1}^{T} \Phi(-\tau w_i - x'_{it}\beta) [\theta \phi(\theta y_{it} - \tau w_i - x'_{it}\beta)]^c_{it}^{\xi_{it}}
\]  

(11)

where \(\sigma_i/\sigma\), \(w_i \sim [0,1]\) and \(\gamma\), \(\theta\) and \(\tau\) are unknown parameters to be estimated. Equation (11) includes the unobserved random effect and can thus not serve as the basis for estimation. The unconditional log likelihood is

\[
ln L = \sum_{i=1}^{N} \int_{-\infty}^{\infty} \prod_{t=1}^{T} \Phi(-\tau w_i - x'_{it}\beta) [\theta \phi(\theta y_{it} - \tau w_i - x'_{it}\beta)]^c_{it}^{\xi_{it}} \phi(w_i) \, dw_i
\]  

(12)

While the random effects model has the advantage that it is more manageable than the fixed effects model, its disadvantage is the probably unrealistic assumption of no correlation between heterogeneity and regressors. Therefore, Woldridge (2010) and Greene (2008) suggest applying the Mundlak (1978) correction by including the group means of regressors as additional explanatory variables. This leads to the correlated random effects model

\[
y_{it}^* = \alpha_i + x'_{it}\beta + \epsilon_{it}, \quad \epsilon_{it} \sim N(0,\sigma^2)
\]

\[
\alpha_i = \text{mean}(x_{it}')\pi + w_i, \quad w_i \sim N(0,1)
\]

\[
y_{it} = \max(0, y_{it}^*)
\]

(13)

Since it cannot be decided a priori which of these panel models is appropriate, this paper reports and compares the results of the three versions of a Tobit panel model summarised above, e.g. a fixed effects, a random effects and a correlated random effects model. Finally it has to be noted that, following Greene (1993) the efficiency scores \(\Omega_i\) were censored at zero by transforming

\[
y_i = 1 - \Omega_i
\]

(14)
in order to avoid concentrating of variables at unity.

Both the DEA models and the Tobit regressions were performed in NLOGIT.
4. Estimation results

Table 3 summarises the estimated and the bias-corrected scores for technical efficiency obtained with the four DEA models under different assumptions regarding returns to scale. The average bias-corrected technical efficiency scores as well as the corresponding standard deviations are for the CRS specification smaller than the uncorrected scores and for the VRS model roughly equal. The CRS results confirm earlier studies (Growitsch and Wetzel, 2009; Merkert et al., 2010) which indicate that DEA models without bootstrapping tend to overestimate technical efficiency, even though the difference in this application is not as distinctive as in other studies. The level of DEA scores is in line with previous literature on rail efficiency (see Growitsch and Wetzel, 2009; Merkert et al., 2010, Cantos et al., 2010).

Table 2: DEA results

<table>
<thead>
<tr>
<th></th>
<th>VRS</th>
<th></th>
<th>CRS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ES– bias corrected</td>
<td>ES– bias corrected</td>
<td>ES– bias corrected</td>
<td>ES– bias corrected</td>
</tr>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>V0</td>
<td>0.6006</td>
<td>0.2015</td>
<td>0.5989</td>
<td>0.1925</td>
</tr>
<tr>
<td>V1</td>
<td>0.6856</td>
<td>0.1784</td>
<td>0.6859</td>
<td>0.1865</td>
</tr>
<tr>
<td>V2</td>
<td>0.6982</td>
<td>0.2009</td>
<td>0.6988</td>
<td>0.1914</td>
</tr>
<tr>
<td>V3</td>
<td>0.7496</td>
<td>0.1828</td>
<td>0.7513</td>
<td>0.1763</td>
</tr>
</tbody>
</table>

V0: input is total subsidy.- V1: inputs are operating subsidy and infrastructure charges.- V2: inputs are total subsidies and track length.- V3: inputs are operating subsidy, infrastructure charges and track length.

The main result from the first stage DEA is that based on the preferred specification of variable returns to scale, the average federal state could save subsidies in a range of 25% to 40%. This, however, has to be interpreted as the maximum possible saving if all federal states would face identical conditions (population density, level of infrastructure charges to be paid etc.) as the most efficient states. As table 1 shows this is obviously not the case. To underline this argument, table 3 shows disaggregated technical efficiency scores for different characteristics of the German federal states: First, a distinction between the federal states of Hamburg, Bremen and Berlin which represent large urban areas with high population density allowing a bundling of rail traffic and interchanges with other public transport which makes regional rail traffic attractive, and the remaining federal states. Second, within the latter group, a distinction between East and West German states. The disaggregated efficiency scores shows that the federal states of Hamburg, Bremen and Berlin achieve a higher efficiency than the remaining states. Another observation is that the federal states in the Western part of Germany are more efficient in using rail subsidies than the East German states. There are several potential reasons for this difference, one of them is the
transformation process in East Germany, the lower population density and the higher infrastructure charges to be paid as a consequence of the regional surcharges levied by DB Netz from 2003 to 2011 for low-density lines in particular in East Germany.

Table 3: Disaggregated efficiency scores

<table>
<thead>
<tr>
<th></th>
<th>DEA-V0</th>
<th>DEA-V1</th>
<th>DEA-V2</th>
<th>DEA-V3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ES</td>
<td>SD</td>
<td>ES</td>
<td>SD</td>
</tr>
<tr>
<td>Hamburg, Bremen, Berlin</td>
<td>0.8244</td>
<td>0.2058</td>
<td>0.8875</td>
<td>0.1865</td>
</tr>
<tr>
<td>Other federal states</td>
<td>0.5489</td>
<td>0.2060</td>
<td>0.6694</td>
<td>0.1871</td>
</tr>
<tr>
<td>Out of these:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East German states</td>
<td>0.4364</td>
<td>0.2059</td>
<td>0.5497</td>
<td>0.1869</td>
</tr>
<tr>
<td>West German states</td>
<td>0.6177</td>
<td>0.2061</td>
<td>0.6917</td>
<td>0.1872</td>
</tr>
</tbody>
</table>

Bias-corrected efficiency scores, based on VRS assumption. - V0: DEA model with total subsidies as input. - V1: DEA model with subsidies and track length as inputs. - V2: DEA model with operating subsidies and infrastructure charges as inputs. - V3: DEA model with operating subsidies, infrastructure charges and track length as inputs. - All figures are based on VRS assumption and are bias-corrected scores obtained from 1000 bootstrapping iterations.

Tables 4 and 5 report the results of four Tobit panel models which are based on the efficiency scores obtained from DEA model V3 under the VRS assumption: 1) a fixed effects model with individual effects only, 2) a fixed effects model with individual and time effects, 3) a random effects model and 4) a correlated random effects model. The scale factors for obtaining marginal effects are given at the bottom of tables 4 and 5 and are near unity.

Since the dependent variable was obtained from the transformed efficiency scores, negative signs of the parameters indicate that the respective variables have a positive impact on efficiency. In all four models most of the coefficients are significant at 1% level and have the same sign. However, the size of coefficients in particular for the policy variables TEND and NET differ between fixed effects model with individual effects and the remaining three models. Choosing one model as the preferred one is difficult because each of the four models has methodological advantages and disadvantages. As Greene (2008) points out there is no simple test with known properties to choose between fixed and random effects specification, a Hausmann test of the random effects alternative against the fixed effects null hypothesis is inappropriate. A LR test of the null hypothesis of the fixed effects model with individual effects only against the alternative of the fixed model with individual and time effects does not reject the null. Within the random effects and correlated random effects alternatives, a LR test rejects the null hypothesis of random effects, e.g. would favour the correlated random effects, even though two variables of interest, the population-density and the contract duration are not significant.
The estimation results are intuitively plausible and confirm expectations from theory. Those federal states which use more competitive tendering for contract procurement use their available funds more efficiently than others, a finding which is in line with studies such as Driessen et al. (2006) and Lalive and Schmutzler (2011) but which contradicts studies which found no effect of franchising and competitive tendering (see Cantos et al., 2010; Mulder et al., 2005). When interpreting and comparing these results it should be noted that this paper analyses the effect of competitive tendering on the efficiency in using subsidies while the aforementioned studies focus on the effect of tendering on the efficiency of rail companies.

A further result is that federal states which award a higher share of train-km under gross contracts use their funds more efficiently than others. This finding which differs from Hunold and Wolf (2012), can be explained by information asymmetries in the net contract framework. Net contracts favour any rail operator which has knowledge on demand and therefore on the potential fare revenues. In Germany, most of train-km under net contracts are operated by the incumbent DB which is well positioned regarding this information and which is thus in a favourable position against the respective PTAs and federal states. It can therefore be assumed that operators under net contracts (mostly DB) were able to receive rather high net subsidies. PTAs had finally to spend more public money for net contracts than for gross contracts for which the fare revenues collected by the PTA reduce the subsidy level - even though the net subsidy per train-km is per definition lower than the gross subsidy when not considering fare revenues.

The results indicate furthermore, that those federal states which award contracts of a longer duration and a lower size (expressed in train-km p.a.) spent their subsidies more efficiently. This relates to on-going critiques of rail operators which are not able to amortise rolling stock within shorter contract periods and which have consequently to negotiate a higher subsidy. The positive effect of smaller contracts reflects the existence of a considerable number of very large contracts granted to the incumbent during the period of analysis which in combination with the direct awarding of these contracts and the aforementioned problem of information asymmetries in net contracts has negatively affected the efficient use of public money. However, it should be noted that the size of both the duration and the size effects is rather small. In addition, they have to be interpreted within the range of contract duration and contract size in German contracts during 1996-2010 (mean contract duration: 9.6 years, mean
contract size: 5.3 mill. train-km per annum) and do not imply that a continuous increase of contract duration and decrease of contract size would continuously increase efficiency.

As expected, a higher population density has a positive effect on the efficient use of subsidies, although this variable is only significant in the random effects model. Finally, the positive sign for the variable \( D_{East} \) (a dummy variable indicating that the federal state is an East German state) confirms the results from disaggregating the efficiency scores that East German states use their subsidies less efficient than West German states. Explaining this effect requires to take into account the transformation process in East Germany. In the 90es, the East German states have still possessed a very dense rail network with a decreasing patronage as a consequence of individual motorisation, changing settlement structures, negative demographic effects and high levels of unemployment.

A dummy variable for urban areas was not significant and is not reported here.

**Table 4: Results of the second stage Tobit regressions – fixed effects models**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fixed effects (individual effects only)</th>
<th>Fixed effects (individual and time effects)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coefficient</td>
<td>Std error</td>
</tr>
<tr>
<td>P_SKM</td>
<td>-0.00057</td>
<td>0.00051</td>
</tr>
<tr>
<td>DUR</td>
<td>-0.00841***</td>
<td>0.00253</td>
</tr>
<tr>
<td>NET</td>
<td>0.51488***</td>
<td>0.07623</td>
</tr>
<tr>
<td>TEND</td>
<td>-0.49429***</td>
<td>0.09016</td>
</tr>
<tr>
<td>SIZE</td>
<td>0.00427***</td>
<td>0.00096</td>
</tr>
<tr>
<td>Sigma</td>
<td>0.07680***</td>
<td>0.00388</td>
</tr>
<tr>
<td>Scale factor</td>
<td>0.999</td>
<td>1.000</td>
</tr>
<tr>
<td>LogL</td>
<td>206.5</td>
<td>230.9</td>
</tr>
</tbody>
</table>

*** significant at 1% level.- **significant at 5% level.

**Table 5: Results of the second stage Tobit regressions – random effects models**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Random effects</th>
<th>Correlated random effects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coefficient</td>
<td>Std error</td>
</tr>
<tr>
<td>P_SKM</td>
<td>-0.00017***</td>
<td>0.00002</td>
</tr>
<tr>
<td>DUR</td>
<td>-0.00720***</td>
<td>0.00108</td>
</tr>
<tr>
<td>NET</td>
<td>0.51295***</td>
<td>0.07766</td>
</tr>
<tr>
<td>TEND</td>
<td>-0.50932***</td>
<td>0.03914</td>
</tr>
<tr>
<td>SIZE</td>
<td>0.00439***</td>
<td>0.00101</td>
</tr>
<tr>
<td>D_East</td>
<td>0.10040***</td>
<td>0.03822</td>
</tr>
<tr>
<td>Const</td>
<td>-0.03181</td>
<td>0.10471</td>
</tr>
<tr>
<td>Sigma(v)</td>
<td>0.07826***</td>
<td>0.00263</td>
</tr>
<tr>
<td>Sigma(u)</td>
<td>0.09436***</td>
<td>0.01948</td>
</tr>
<tr>
<td>Scale factor</td>
<td>0.9986</td>
<td>1.000</td>
</tr>
<tr>
<td>LogL</td>
<td>177.8</td>
<td>181.3</td>
</tr>
</tbody>
</table>

*** significant at 1% level.- **significant at 5% level.
5. Conclusion

This paper has for the first time provided a systematic two-stage efficiency analysis for subsidising regional rail services in Germany which considers the total of these services and the relevant data for the period from 1996 to 2010. The analysis presented in this paper allows drawing conclusions for the franchising strategies of German PTAs and the federal states. First, the findings suggest that a higher share of tendered rail services would significantly increase the efficiency in using the available public funds to provide these services. Second, the paper provides evidence that a higher share of gross contracts has a positive impact on efficiency. The reason for this is the information asymmetry regarding patronage and fare revenues which has disfavoured PTAs in net contracts. They had (at least in the period of analysis) finally to pay a higher subsidy in net contracts than in gross contracts when considering the relevant fare revenues.

Third, the analysis suggests that contract duration should be longer than currently (on average 9.5 years) to guarantee a more efficient use of public funds, a finding which confirms debates and critiques in Germany on too short contract periods for amortising rolling stock. Furthermore, smaller contracts than in the period of analysis (on average 5.3 million train-km p.a.) would potentially increase efficiency, although it should be borne in mind that there is certainly a minimum contract size below this efficiency is negatively affected.

The analysis has also shown that rail subsidies are less efficiently used in East Germany than in the Western part of the country. Potential reasons for this are the negative demographic trend in East Germany and the transformation process. It has to be discussed to what extent East German states can achieve a more efficient use of subsidies in future, and to what extent the public interest of providing a (defined and agreed) level of regional rail services justifies a higher subsidy per train-km and per passenger-km in East Germany than in the Western part of the country.

Finally, it should be noted that the analysis presented here does not consider the quality of regional rail services. Quality indicators such as traveller satisfaction, punctuality and cleanness of trains would be an important input factor in the first stage DEA but are only available for a small set of federal states. Against the background that the federal states are currently establishing contract controlling and reporting systems which include quality indicators, future research should take quality into account in modelling.
References


