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Determinants of efficiency in child care provision

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Abstract

This article analyzes the efficiency in the provision of child care services at the municipal level and identifies the main determinants of inefficiency. We use a unique data set on the local child care expenditures in the eastern German State of Saxony. The analysis is performed in two stages. First, we measure the efficiency by using a Data Envelopment Analysis (DEA). Second, we consider political, fiscal and demographic variables in a truncated regression to identify the determinants of inefficiency. We find substantial differences in efficiency; the median municipality is up to 28% inefficient in expenditures on child care. Explanatory variables such as an uncompensated mayor or a larger share of over 65-year olds significantly increases inefficiency.

JEL Code: H42, H72, J13.
Keywords: Child care, efficiency analysis, municipalities, service provision.

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1. Introduction

Universal access to child care is welfare-enhancing. Through public child care provision governments can encourage both female labor market participation [Heckman (1974), Gustafsson and Stafford (1992)] and fertility [Björklund (2006), Del Boca (2002)]. In addition child care also has a positive influence on the children's future performance [Currie and Thomas (1995), Spiess *et al.* (2003), Waldfogel (2002)].

Whereas family policy is a national issue, the provision of child care is usually delegated to the local level. Given heterogeneities in the size and socio-demographic structure of municipalities, differences in the municipal expenditure decisions are to be expected. A municipality that is more efficient in the allocation of its resources may thus be able to provide more child care services with the same resources than a comparable, less efficient municipality. Efficiency in public expenditure is generally desirable. However, in the expansion of child care services the efficient use of the scarce resources is of particularly importance.

Since achieving efficiency implies a reduction in costs without a loss in provision levels, efficiency analysis has become an important instrument in investigating (municipal) expenditures.[1] In spite of the obvious importance of the child care sector, only few studies have attempted to analyze its efficiency. To our knowledge, the only study that analyzes the efficiency of child care centers is Bjurek *et al.* (1992). They investigate the efficiency of expenditures of child care facilities in the city region of Gothenburg in Sweden. Using data on the facility level they find potential output gains of about 10 to 15%, and that

[1] In recent years the studies analyzing local government efficiency have expanded. Some authors have considered the overall efficiency of the local public sector, such as De Borger and Kerstens (1996) Belgian local government, Sampaio de Sousa and Stosic (2005) Brazilian municipalities, Worthington (2000) Australian local government, Geys (2006) and Geys and Moesen (2009) Flemish municipalities and Afonso and Fernandes (2008) Portuguese local government (see also the last mentioned for a more comprehensive survey of relevant literature). However, since the definition of the appropriate output variables is difficult it may be advisable to only consider a narrow aspect of public goods, i.e. one specific activity [Pestieau (2009)]. Therefore others focus on the provision of specific services such as police protection [Drake and Simper (2003)], public libraries [Hemmeter (2006)], street-lighting [Lorenzo and Sánchez (2007)], county roads [Kalb (2008)] or public schools [Millimet and Collier (2008)].

centers in more affluent areas and ones with a more experienced director are more efficient.[2] Since we consider municipalities instead of the individual facilities, the factors that influence efficiency are not directly comparable to those considered here. Beyond child care, in the broader field of public education, numerous contributions have conducted efficiency analyses. Grosskopf *et al.* (2001) find no evidence of increased efficiency in public schools when faced with competition from private schools. However, when the strategic interaction between neighbouring school districts is controlled for, competition and a reduction in inefficiency are found [Millimet and Collier (2008)]. Furthermore, Millimet and Collier (2008) stress the importance of the school district as the financier of education as the correct level of analysis as opposed to the schools. Analoguously we analyze the efficiency of municipalities that finance child care centers.

First, we evaluate the efficiency of the municipalities in the provision of child care services. We find significant efficiency reserves, but differences between the municipalities are large. In the average municipality provision could be increased by about 20-30%. Second, we use economic and socio-demographic variables to explain the differences in efficiency. In particular, a lack of professionalism of the mayor and a larger share of the elderly population have a negative impact on the efficiency, whereas the number of child care facilites in a given municipality has a positive impact.

This contribution is structured as follows: section 2 presents both the methods of efficiency analysis, as well as the second stage regression. In section 3 we introduce the data and discuss the results of the efficiency analysis. The variables used in the second stage and results of the regression are discussed in section 4. The final section 5 concludes with a discussion and policy implications.

[2]The results they obtain in the second stage efficiency determination analysis are to be viewed with caution. Methodological developments in recent years have shown that the adopted Tobit specification, and the serial correlation of the efficiency scores may induce biased results [Simar and Wilson (2007)].

2. Methods

2.1. Efficiency analysis

Generally efficiency analysis is concerned with the measurement of an organization's ability to use its inputs to produce outputs. In the efficiency analysis literature, mainly two methods have been employed: the non-parametric Data Envelopment Analysis (DEA) and the parametric Stochastic Frontier Analysis (SFA).

Both the parametric and non-parametric methods have their advantages and disadvantages. The primary benefit of using a stochastic approach is that a deviation from the frontier can be disaggregated into either inefficiency or stochastic differences between the units under consideration. Contrarily, in DEA all deviation is considered inefficiency. The major advantage of the non-parametric approaches lies in the flexibility to model multiple inputs and outputs when prices are not available. When using SFA either a cost or a production function has to be estimated. Nonetheless a specific functional form still has to be chosen a priori. Since the form of the production function is not obvious when considering public units, it is in this case preferable to employ non-parametric methods where assumptions need only to be made with regard to the properties of the points in the production set (disposability, proportionality or convexity) [Pestieau (2009)].

Although the methods of efficiency analysis are derived from productivity analysis of private enterprises, some clear distinctions exist when considering production in the public sector. When competitive firms are analyzed, the prices of inputs and outputs can be used to aggregate inputs and/or outputs in the efficiency estimation. However, when the analysis is concerned with public sector productivity, the inputs and outputs are often not sold on the private market, and therefore price information cannot be employed in aggregation. For these reasons the nonparametric method has been prevalent among studies considering the public sector. In our study the efficiency will also be evaluated according to a DEA accounting for variable returns to scale.

Due to the well-known difficulties in defining inputs and outputs for public goods, the method of efficiency analysis is not beyond critique [Pestieau (2009)]. The risk of a misspecification of the efficient frontier can be reduced by two means. Firstly, the more narrowly the public service is defined, the more closely appropriate inputs and outputs can be matched to the service. Secondly, testing different combinations of inputs and outputs increases the reliability of the specified efficient frontier.

2.2. Data envelopment analysis (DEA)

Data envelopment analysis is a mathematical programming technique for measuring relative efficiency of similar production units (in this case municipalities). The frontier or envelope is constructed from empirically observable points. The input-output relation yields an efficiency score where the fully efficient units can be regarded as best-practice units.

In the application of a DEA, the efficiency of the units in the sample are assessed in two steps. In the first step, a frontier is generated based on those observations that use the lowest mix of inputs to produce their outputs (input orientation), or alternatively those observations that achieve the highest mix of outputs given the level of inputs (output orientation). The choice of the orientation depends on the objective or the dimension in which the policy-maker is believed to have more discretion [Worthington and Dollery (2000) and Fried *et al.* (2008)].[3] In the second step, each observation is compared to the piece-wise linear surface of the efficient observations derived in the first step, and then each is assigned an efficiency score. By solving a distinct linear program for each unit the efficiency of each is maximized by finding the best possible weights of inputs and outputs. The procedure is constrained by the condition that when all units receive the weights that maximize their respective efficiency none may receive an efficiency score greater than 1. Generally all weights are non-negative, and no set of other weights will render a higher efficiency. Thus the frontier is the set of efficient units "enveloping" those that

[3] Refer to section 3.4 for a detailed discussion of the results obtained from both the input and output orientations.

are not as efficient. The calculated frontier has the dimensions of the sum of inputs and outputs. In other words, in DEA efficiency is defined as the ratio of the weighted sum of outputs divided by the weighted sum of inputs of a given unit. The inefficiency of a unit is then the distance from the efficient surface, or its input-output ratio in comparison to the units that lie on the surface. Inefficiency (in input orientation) is how much a unit could reduce inputs while still achieving the current output level.[4]

The problem below formally describes the envelopment form of the input oriented variable returns to scale model according to Banker *et al.* (1984).

$$
\begin{aligned}
\min_{\theta,\lambda} \quad & \theta, \\
\text{s.t.} \quad & -y_i + Y\lambda \geq 0, \\
& \theta x_i - X\lambda \geq 0 \\
& N1'\lambda = 1 \\
& \lambda \geq 0.
\end{aligned}
\tag{1}
$$

θ is a scalar and is the efficiency score of the i-th unit. $\theta \leq 1$, where a value 1 indicates a technically efficient unit that lies on the frontier. A set of N municipalities, use M inputs and generate S outputs. Then for the i-th municipality the known inputs and outputs are represented by the vectors x_i and y_i respectively. For all N units the input matrix X has the dimensions $(M \times N)$ and the output matrix Y is represented by an $(S \times N)$ matrix. λ is a $(N \times 1)$ vector of constraints, and N1 is an $(N \times 1)$ vector of ones.[5] Thus a convex hull that envelopes the data points is constructed as described above.

The information contained in the computed efficiency scores shed only limited light on

[4] In the output orientation: how much it could increase its output while not employing more inputs.

[5] If constant returns to scale (CRS) are assumed, the model is computed without the convexity constraint $N1'\lambda = 1$ according to Charnes *et al.* (1978). The CRS specification is only valid when all units are operating on the efficient scale. When this is not the case, a variable returns to scale specification is more appropriate. The difference between the two models is illustrated for the one input one output case in appendix section A, and we test the scale efficiency in section 3.4.

the sources of inefficiency. Therefore a two-stage approach to analyze the factors that influence the efficiency scores beyond the direct production process may be of interest. Traditionally the decision making units (DMUs) are treated as a black box turning inputs into outputs at different levels of efficiency [Fried *et al.* (2008)]. However, recently the methods for conducting a statistically sound explanatory analysis have contributed to attempts at identifying the sources of (in-)efficiency. One way is to regress the efficiency scores on a set of explanatory variables in a second stage. Factors that influence the efficiency (explanatory variables) beyond the direct production process are regressed on the efficiency scores from the first stage to describe the conditions that are more and less suitable for efficient outcomes. The set of explanatory variables used in this study is discussed in section 4.

2.3. Second stage regression analysis: Estimation procedure

Most contributions that apply some form of efficiency or productivity analysis go beyond an estimation of efficiency scores and employ multiple methods and specifications as sensitivity checks. Some also seek to explain the differences in efficiency in a second stage regression. Although considering exogenous variables directly in an SFA is generally unproblematic, the naive regression of DEA efficiency scores in a two-stage approach is to be viewed critically [Fried *et al.* (2008), Simar and Wilson (2007)]. However, once the serial correlation of the efficiency scores is accounted for by an appropriate bootstrapping procedure, the use of a second stage regression becomes legitimate. When it is not possible to define an appropriate production or cost function for an SFA (as is the case for child care provision), then a two-stage semi-parametric analysis is clearly preferable.

The regression analysis here follows the procedure proposed by Simar and Wilson (2007). The basis of a two-stage approach is the assumption that the DMUs face certain environmental variables (z) that constrain their choices of inputs (x) and outputs (y). In other words, the variables in z influence the mean and the variance of the inefficiency process, but do not influence the production process itself.[6] Formally the observations stem from the set $S_n = (x_i, y_i, z_i)_{i=1}^n$, where x_i and y_i are the inputs and outputs used in the i-th unit (municipality) to derive the efficiency (θ_o) of each of the n observations in the previous section. Additionally the observations are characterized by certain environmental or exogenous variables, contained in the vector z_i.

The problems that arise when conducting a naive second stage regression include a slow convergence of the estimated parameters towards the true values when more than one input and output are included as well as serial correlation of an unknown form between the efficiency scores and the explanatory variables. Moreover, a change in one efficiency score can change the whole frontier, since the efficiency of a unit is dependent on all other units. The fact that several efficiency scores equal one may suggest a censoring at the probability mass of 1. Some authors therefore use a Tobit specification in the second stage regression [among others Bjurek *et al.* (1992), De Borger and Kerstens (1996), Kirjavainen and Loikkanen (1998), Worthington and Dollery (2001)]. However, since an efficiency score cannot exceed 1, the dependent variable is in fact truncated and not censored. Therefore a truncated regression is more appropriate, and has also been shown to perform better in simulations [Simar and Wilson (2007)].

In the input orientation the dependent variable (the inverse of the efficiency score) is obtained by the input distance function and hence $\theta = (1, \infty)$ [Shephard (1970)]. The efficiencies (θ_i) are in this case computed within the production possibilities (P) according to:

$$\theta_i = \theta(x_i, y_i | P)$$

with the Banker *et al.* (1984) assumption of variable returns to scale.

The model we estimate is the following: $\hat{\theta_i} = z_i \beta + \xi_i \geq 1$, where β are the parameters to be estimated and ξ is the error term. Since the true θ is not observable,

[6] For example, a municipality's source of revenues, whether from taxes or transfers, does not influence the production of child care but may influence the incentives to use the resources efficiently.

values corresponding to $\hat{\theta}$ were computed in the first stage and subsequently used in the analysis. Clearly since $\hat{\theta}_i$ is derived from x_i and y_i, it will also be correlated with z_i. Therefore a bootstrap procedure to correct for serial correlation is necessary in the maximum likelihood estimation in the second stage. To implement the bootstrap samples of pseudo-data, x_i^*, y_i^*, z_i^* are drawn from the density $\hat{f}(x, y, z)$. We follow the algorithm suggested by Simar and Wilson (2007).[7]

3. Empirical efficiency analysis

Municipalities have a set of resources (inputs) at their disposal with which they produce the required services (i.e. outputs). The municipalities that are relatively efficient determine the frontier to which the inefficient municipalities are compared. Since a municipality uses multiple inputs in the production of its outputs, the DEA provides a useful means of assessing efficiency. In the next section the data employed in the analysis is presented. Since it is not a priori clear whether the municipalities choose to adjust the inputs (expenditures) or the level of output (amount of child care services), we also test the orientation of the process.

3.1. Data and sample

We use cross sectional data for the year 2006 which pertain to the municipalities in the state of Saxony in Germany. In that year, the state had a total of 496 municipalities. About two-thirds (332) of all municipalities have a population of less than 5000 and there are only three larger cities.[8] In total 214.361 children were cared for in either public or non-profit facilities. However, municipality specific data on child care provision is only recorded for 282 municipalities [State Office of Statistics of Saxony (2008b)]. Municipalities with less than three individual child care providers are not disclosed in the statistic,

[7]Specifically we use Algorithm #1 with the suggested L=2000 replications, p. 41.
[8]Leipzig with 506,578, Dresden with 504,795 and Chemnitz with 245,700 inhabitants.

therefore many small municipalities are disqualified from the analysis but the remaining sample is more homogeneous. Non-parametric approaches are very sensitive to outliers, therefore it is important that potential outliers are removed from the sample. First municipalities that have less than three facilities cannot be included in the analysis. Second, observations that contain missing values in any of the potential inputs or outputs are excluded. Finally the outlier detection procedure proposed by Wilson (1993) is applied to eliminate additional influential observations. Ultimately a sample of 213 municipalities remains.[9]

In child care we distinguish between three distinct groups: the under 3 year olds, the 3-6 year olds and 6-12 year old participants in after school programs. The youngest of the three groups accounts for 13.8% of all children receiving care, the group of 3-6 year olds forms the largest group with 47.5% and 38.8% of children in child care are above the age of 6.[10] The differences in care intensity between the three groups are apparent in terms of the legally defined child-to-personnel ratio. For the youngest group one care person may assume responsibility over no more than 6 children, for the middle group the ratio is 1:10 and 1:18 for the group of the oldest children. In other words, the amount of personnel is dependent on the age structure of the children in care. Thus, even if relativley few under 3 year olds attend child care, the per child costs will be higher for a municipality.

If a parent is interested in child care for his or her child, there are three different types of child care services one can choose from. Type I contains all non-profit governmental (public) care centers. The non-profit non-governmental (e.g. the welfare organizations of the evangelical and catholic churches) centers define Type II. The municipalities subsidize the Type II providers for the number of places they offer. The final category, Type III,

[9]Of the sample of 282 municipalities with more than 3 facilities, for 226 observations the data on all inputs and outputs is available, after which 13 of the remaining sample are labeled as outliers.

[10]In the group of above 6 year olds, the aggregate statistic at the state level includes cohorts up to the age of 12. However from the population statistic at the municipal level we are only able to distinguish the age group as 6 to 10 year olds. Since the number of 10 and 11 year olds attending child care after school is relatively small, we use the population statistics on the 6-10 year olds.

are private for-profit child care centers. Type III facilities must cover their operating costs solely through tuition.[11] Most children who attend child care in Saxony do so either at Type I (1365 or 52%) or Type II (1257 or 48%) centers. Since we are interested in municipal expenditure efficiency and the municipalities may organize the required number of child care places either in fully public facilities (Type I) or through the non-profit providers (Type II), our focus is on the facilities of Type I and II.

3.2. Inputs and outputs

Expenditure variables that pertain to the provision of municipal child care services are plausible inputs. We only consider current expenditures (material costs and personnel), investment expenses do not enter the analysis. We exclude investment entirely to avoid distortions from one-time fixed costs. Instead we are interested in the regularly accruing costs from providing the service.

In some municipalities the provision of child care is also partially provided by Type II (non-profit) organizations that receive transfers from the municipality. These transfers are added to the expenditures for materials recorded for the Type I (public) facilities. Together these costs enter the analysis as the first input called "material expenditures".[12] Personnel expenditures are only recorded for the employees of the Type I centers. Therefore we do not include the personnel expenditures in the analysis. Instead the combined personnel (number of employed persons) in both Type I and Type II centers is included as the second input. Since the wages of the child care employees in Type I (public) and Type II (non-profit) centers are regulated, the aggregation should not introduce a bias. The second input is thus "personnel".

[11] The attendance in fully private facilities is not recorded separately in the official statistics. However, most of these are located in one of the large agglomerations and are therefore excluded from our analysis.

[12] Although the funds transfered to the Type II centers are included in the material expenditures, we cannot know whether these funds are solely used for materials or if some are also used to pay personnel. However, since the transfer payments account for less than 5% of all material expenditures and since only 10% of the municipalities in our sample engage in transfer payments, the potential bias is marginal.

	Variable	Mean	St. Dev.	Min.	Max.
Inputs					
Material expenditures (in €)	(x_1)	218037	193119	1584	1308953
Personnel # persons	(x_2)	41	32	9	171
Facility density[a]	(x_3)	0.15	0.13	0.02	0.90
Outputs					
assigned places	(y_1)	397.50	297.70	103	1589
weighted under 3 year olds[b]	(y_2)	72.29	59.84	11.03	336.36
weighted 3-6 year olds	(y_3)	147.60	113.90	17.76	589.35
weighted 6-10 year olds	(y_4)	133.75	98.52	23.52	549.47

[a]Facilities per km^2
[b]Number of under 3 year olds times the county share of children under 3 receiving child care. The corresponding calculation was performed for the weighing of the other age groups.

Table 1: Summary statistics of inputs and outputs

The third input considered is "facility density" and is measured as the number of centers divided by the municipal area in square kilometers. Since the municipalities can control how many facilities they operate, this variable accounts for size differences and differences in fixed costs from having multiple units. The potential inputs are summarized in the top section of Table 1.

The outputs are determined by the amount of service demanded. Since in the year 2006 only children above the age of 3 until school age (6 year olds) had a legal claim to a place in a child care facility, this group forms the largest group for whom services need to be produced. Two additional fractions remain, namely those above the age of 6 who receive after school care, and those below the age of 3. On the one hand, children under the age of 3 require significantly more supervision than older children and therefore care for this relatively small group is still costly and should also enter the analysis as an output. On the other hand, school age children above the age of 6 form the third large group and constitute 35% of children receiving care in public child care facilites. The state-wide average share of children enrolled in child care varies significantly betweeen the three age groups. Of all under 1 year olds only 3% were in child care in 2006, of 1 to 3 year olds 45.4%, of 3 to 6 year olds 92.6% and of 6 to 10 year olds 67.2%.

Data on the number of children receiving child care services disaggregated by the age of the child is not available. Therefore the potential output variable is limited to the total number of assigned places (i.e. the legally allowed capacity aggregated for all age groups in a given municipality), which may mask the differences in care intensity between the age groups. In two specifications the variable “assigned places” is the sole output.

To better account for the differences in the three age groups we construct a weighted output proxy. The county specific shares of children in each of the three age groups receiving care can be used to construct a demand index.[13] The shares are multiplied by the number of children in each age group in a particular municipality. These three indices, “weighted under 3 year olds”, “weighted 3-6 year olds” and “weighted 6-10 year olds”, are then used as outputs in two alternative specifications. The summary statistics of the potential outputs are found in the bottom half of Table 1.

The variable returns to scale DEA is conducted for four different specifications.[14] The four models that result from the different input-output combinations are summarized in Table 2. Models A and B only contain the two inputs on “materials” and “personnel”, whereas models C and D contain the additional input on “facility density”. With regard to the different output combinations models A and C only contain one output, namely the number of “assigned places”. The “weighted number of children” in the three relevant age groups constitute the outputs in models B and D.

3.3. Quality Considerations

The great difficulty in efficiency analyses is that output quality cannot be controlled for, since variables that describe quality are hard to define. This could be seen as a potential shortcoming when considering such a sensitive area of publicly provided goods as child care services. However, in this case this aspect does not jeopardize the analysis due to the

[13] We must resort to the figures at the county level since the corresponding data is not made available for the municipalities.

[14] Variable returns to scale (VRS) is our preferred specification, but we also use CRS to check scale efficiency.

	Model A	**Model B**	**Model C**	**Model D**
Inputs				
x_1	×	×	×	×
x_2	×	×	×	×
x_3			×	×
Outputs				
y_1	×		×	
y_2		×		×
y_3		×		×
y_4		×		×

Table 2: Overview of input and output combinations in the models

heavy regulation of the service in question. Quality in the context of child care pertains to both the endowment of each facility (equipment, furniture etc.) and the ability to teach children. In the literature it is argued that there is some asymmetric information in the market for child care so that parents are not able to observe the quality of a facility and therefore cannot differentiate between good or bad child care centers [Mocan (2007)]. Without governmental regulation, this raises the risk of a decline in care quality [Gormley (1999)]. Due to lack of data, the factors that actually drive the quality of a facility have so far only been investigated for child care providers in the USA [Blau (1997), Blau and Hagy (1998)]. Surprisingly these studies find a very weak influence of such factors as education of the personnel or the ratio of children to personnel on the human capital accumulation of the children. Instead the socio-economic background of the parents determines the outcome of the children. Moreover, in Germany the personnel-to-children ratio is fixed by law and the education of the personnel is comparable across the country. In addition, the Saxon law on child care services puts further restrictions on personnel with regard to advanced training. The endowment of the facilities can also be assumed not to vary much between facilities as the basic needs of facilities are defined in the same state law. All these factors indicate that there are only slight quality differences between facilities. Instead, they imply that the service quality is standardized within a narrow band, and that the productive efficiency can therefore be evaluated without adherence to specific quality measures.

3.4. Results of the efficiency analysis

With the described inputs and outputs we evaluate four different DEA specifications (models A, B, C, and D). For all four models we compute the VRS efficiency scores in both the input and output orientations. Furthermore, we test the level of scale efficiency using the CRS specification. Before selecting a specific model for the second stage regression we discuss the results of the efficiency analysis in this section.

Table 3 shows the results from four different specifications in the input orientation. The median efficiency of the four specifications ranges from about 72% to 78%. The standard deviation of the efficiency scores ranges from 13.1 to 15.3 points. Models A and B contain the same number of efficient units, 20, whereas models C and D deem 33 and 32 units fully efficient. The percentage of efficient municipalities therefore lies between 9% and 15% of the sample. The inclusion of the facility density as an input has a slightly larger influence on the efficiency than the disaggregation of the outputs with respect to the three different age groups. As is typical for DEAs, the efficiency rises the more variables are included in the model. Considering the range of output proxies, the variation can be deemed relatively small. The results are robust across specifications.

Model	Min.	Median	St. Dev.	Efficient	% efficient
model A	0.449	0.717	0.138	20	9%
model B	0.356	0.730	0.153	20	13%
model C	0.481	0.778	0.131	33	15%
model D	0.371	0.783	0.146	32	15%

Table 3: Considered models: input orientation

Table 4 contains the results of the same four models in the output orientation. The differences in the results from the input orientation are only slight. Logically the same number of units lie on the frontier. In models B and D the minimum efficiencies are smaller than those in the input orientation of the respective models. This indicates that there is more variation with three outputs than with one. With more outputs there may be larger divergence from the frontier in the extreme. This is also reflected in the slightly higher standard deviations in models B and D. The median efficiencies of all models, in both orientations, lie within 7% points.

Model	Min.	Median	St. Dev.	Efficient	% efficient
model A	0.465	0.749	0.136	20	9%
model B	0.261	0.758	0.150	20	13%
model C	0.485	0.772	0.139	33	15%
model D	0.261	0.786	0.156	32	15%

Table 4: Considered models: output orientation

Since it is not immediately clear whether the municipalities may choose to lower their outputs or increase their inputs, the production process may be either input or output oriented. To test this we run a constant returns to scale DEA for each of the four models in both orientations.[15] If the efficiencies are equivalent, then the orientation is irrelevant and the municipalities can be said to be operating on an efficient scale. If however a municipality deviates from the efficient frontier under either of the orientations, then either increasing or decreasing economies of scale are present and the municipality may be relatively more or less efficient depending on the orientation.

To test scale efficiency we compute for each unit the ratio of its constant returns to scale efficiency score to the variable returns to scale score, as defined by equation 2:

$$SE_i = \frac{CRS_i}{VRS_i}. \tag{2}$$

When CRS and VRS scores are equal a municipality is fully scale efficient and receives a score of 1. On average the municipalities are from 89% to 96% scale efficient, and thus operate close to constant returns to scale.[16] High scale efficiency is to be expected, because of the characteristic of child care services. Each addtional child requires a proportional

[15] The figure in appendix A depicts the different assumptions underlying CRS and VRS.

[16] The scale inefficiency is either due to decreasing or increasing returns to scale in the individual municipalities. We find low deviation from constant returns to scale in either direction.

increase in inputs (both in terms of personnel and materials). Having several smaller facilites does not necessarily induce scale inefficiency at the municipal level. However we cannot exclude that some scale effects can be realized at the facility level.

Clearly there are only small differences in the minimum and median efficiencies between the different specifications. In order to describe the potential differences between the models more precisely, we compute rank correlations. We use the Spearman rank correlation to test the correlation of the rank of individual observations in the different specifications. Models A and C render almost identical rankings; these models receive a correlation of 0.85. Models B and D are also very similar; the two specifications have a rank correlation of 0.84. The correlation between A and C respectively with B and D is therefore slightly lower. Nonetheless, all four models are highly positively correlated.

Models	A	B	C	D
A	1			
B	0.68	1		
C	0.85	0.63	1	
D	0.55	0.84	0.75	1

Table 5: Rank correlations between the four models in the input orientation

The orientation of the models does not alter the outcomes significantly. Since the economic interpretation of adjusting inputs to meet a specified level of output is more probable in this case, we will proceed in the second stage regression using the efficiency scores derived in the input orientation as the dependent variable. For the ensuing regression analysis the results from Model B in the input orientation are presented. This model contains two inputs and three outputs that capture the most important factors with respect to efficiency.[17]

[17] As shown in the previous section, the alternative models deliver very similar rankings. Therefore in specifications using one of the other three sets of efficiency scores as the dependent variable the results are very similar.

4. Second stage regression

We have shown that there are differences in the technical efficiency of child care provision. We now proceed to explain these differences systematically making use of variables in three broader categories: (1) variables that describe the political economy, (2) the demographic composition in each municipality and (3) variables that account for the fact that there may be competition among facilities within a municipality.

4.1. Explanatory variables

In the category of political economy, we consider the influence of the share of open-ended grants to own tax income, the status (full-time salaried or uncompensated) of the mayor, whether the same party remained the largest in two consecutive elections and a Herfindahl index of political concentration on the efficiency of child care provision. The open-grants compensate for the large economic heterogeneity among municipalities within the state. Depending on economic power, municipalities receive these grants to ensure sufficient public service provision. Since there are no restrictions on these grants with regard to investment decisions, it is possible that financial aid is not fully used to adjust expenditures to local needs (e.g. to adapt local expenditures to shocks, such as demographic change). The effect of such grants on municipal expenditure inefficiency is analyzed by Kalb (2008). He finds that in the provision of county roads in the state of Baden-Württemberg in southern Germany, higher intergovernmental grants typically lead to higher inefficiency (flypaper effect). Similar results are obtained by Silkman and Young (1982) and De Borger and Kerstens (1996).

Hypothesis 1: A larger share of grants increases inefficiency.

The second political variable is a dummy variable which takes the value "0" if a municipality has a full-time salaried mayor. Municipalities are required by law to have a full-time salaried mayor if their population exceeds 5000. If the population is smaller, the municipality is free to choose between a salaried and an uncompensated mayor. In Saxony, two-thirds of all municipalities have fewer than 5000 inhabitants.[18] Therefore the smaller municipalities are encouraged to form "administrative collectives" through which even smaller municipalities may share a full-time salaried mayor. Economic literature discusses the influence of the status of a municipality's mayor on expenditure efficiency [Deno and Mehay (1987), Hayes and Chang (1990), Stumm and Corrigan (1998)]. Usually, full-time salaried mayors may be more qualified, e.g. have degrees in business administration or experience in politics. Thus municipalities with a full-time salaried mayor are expected to be more efficient.

Hypothesis 2: Having an uncompensated mayor increases inefficiency.

Our third variable related to local politics is ruling party stability. We define a municipality as stable if the same party gained the largest share of votes in the two consecutive local elections in 1999 and 2004. If the same party remains in office the dummy variable takes on the value "0" and if a change in power took place, then the dummy variable takes on the value "1". We assume that a municipality in which frequent changes take place is more inefficient than one with a stable majority, because remaining in power allows the parties to follow their given agenda for a longer term. When changes are frequent short term adjustments may take place which may cause wasteful spending.

Hypothesis 3: A change in the ruling coalition decreases inefficiency.

The final political variable is a Herfindahl index of political fragmentation. The index H is constructed as the sum of parties' share of votes:

$$H = \sum_{i=1}^{I} p_i^2 \tag{3}$$

[18]In our sample almost 48% of the municipalities.

where p is the sum of the squared share of votes the parties received.[19] A high index value is indicative of strong leadership. A high political concentration implies low political fragmentation. High fragmentation has been shown to increase expenditures and deficits, whereas more concentration leads to lower spending [Ashworth *et al.* (2005), Roubini and Sachs (1989) and Roubini *et al.* (1989)].

Hypothesis 4: More political concentration increases inefficiency.

Another factor which is likely to influence efficiency of child care provision is the ongoing demographic changes. Almost all municipalities in Saxony already face a declining population and this development will continue during the next decade [State Office of Statistics of Saxony (2008a)]. Nevertheless, there is again strong heterogeneity: in the period 2005 to 2020 some municipalities will lose about one quarter of their population, whereas others will remain almost constant. The rate at which this population change occurs may influence the level of efficiency in child care provision. On the one hand, a decrease in the number of children attending child care facilities will immediately cause an increase in inefficiency if capacities are not adjusted. However, due to fixed costs this may not be possible in the short run (e.g. financing the building). On the other hand, an increase in the number of children should decrease inefficiency as more children are cared for given the existing capacities. Therefore we include the change in the age group of 0 to 10 year olds from 2000 to 2006 as an explanatory variable. Since 80% of the municipalities in our sample experienced growth in the number of under 10 year olds in the years 2000 to 2006, we expect this variable to lower inefficiency.

Hypothesis 5: Population growth decreases inefficiency.

To capture an additional demographic aspect, we also use the share of people over 65 in relation to the total population in 2006. This is not only a demographic but also a

[19]Independent candidates are collected in one category.

politico-economic variable. Since an increasing share of elderly implies that the median-voter gets older and thus interests in financing child care facilities decrease. Therefore less funding is made available to finance child care services and the efficiency of child care provision is expected to increase [Epple and Romano (1996), Gouveia (1997)].[20]

Hypothesis 6: An increase in the share of over 65 year olds decreases inefficiency.

Finally we use two variables to analyze whether there is competition in the provision of child care. First, we include the number of facilities operating in a municipality through the variable defined as "facilities per 1000 inhabitants". Due to potential economies of scale at the facility level, this variable should have a negative influence on efficiency at the municipality level. It is less efficient to operate more facilities.

Hypothesis 7: More child care centers increases inefficiency.

Second, we consider the transfers the municipalities make to Type II providers. The Type II (non-profit) providers are a potential source of competition for the Type I (fully public) centers within municipalities. When transfers are made administrative costs accrue, which lowers efficiency. Additionally when parents have a choice between different types of facilities, the facilities may have an incentive to spend inefficient amounts to remain attractive.

Hypothesis 8: The presence of transfers to Type II providers increases inefficiency.

Table 6 summarizes the above variables and their expected influence on day care efficiency. Table 7 contains the summary statistics of the explanatory variables used in the second stage regression.

[20]Simultaneously, a large share of elderly implies a smaller influence of younger cohorts (potential parents) on political outcomes.

Category	Variable description	Expected influence
Political economy	Ratio of grants to tax income	+
	Uncompensated mayor dummy	+
	Ruling party stability	+
	Party concentration	-
Demography	Change in under 10 year olds	-
	Share in over 65 year olds	-
Competition	Facilities per 1000 inhabitants	+
	Transfers to non-profit	+

Table 6: Variable description and expected influence on inefficiency

Variable	Mean	St. Dev.	Min.	Max.
Ratio of grants to tax income	1.24	0.73	0	2.99
Uncompensated mayor dummy	0.29	0.45	0	1
Ruling party stability	0.12	0.32	0	1
Party concentration	0.39	0.09	0.24	0.71
Change in under 10 year olds	37.59	68.27	- 322	378
Share of over 65 year olds	0.22	0.03	0.14	0.30
Facilities per 1000 inhabitants	0.87	0.36	0.34	2.38
Transfers to non-profit	10241.04	44167.89	0	43027

Table 7: Summary statistics of environmental variables

4.2. Estimation results

Table 8 shows the coefficients (bootstrapped standard errors in parentheses) of the truncated regression. The dependent variable is the efficiency score of Model B in the input orientation computed in section 3.4. Since the inverse of the efficiency scores was used as the dependent variable a negative sign is interpreted as reducing inefficiency (or increasing efficiency).

The coefficients of an uncompensated mayor, the change in the number of under 10 year olds, the share of over 65 year olds and the number of facilities are statistically significant. All else held equal, having a uncompensated mayor increases inefficiency in the provision of child care services by 13.5% compared to having a full-time salaried mayor. Although the state encourages cooperation among smaller municipalities to support them in installing a professional mayor, many municipalities still retain their uncompensated

Variable	Model B
Ratio of grants to tax income	0.036
	(0.046)
Uncompensated mayor dummy	0.135*
	(0.077)
Ruling party stability	0.162
	(0.126)
Political concentration	-0.406
	(0.370)
Change in under 10 year olds	-0.002*
	(0.001)
Share of over 65 year olds	4.648**
	(1.536)
Facilities per 1000 inhabitants	0.351**
	(0.126)
Transfers to non-profit	8.620E-07
	(8.880E-07)
Constant	0.097
	(0.473)
$\hat{\sigma_\xi}$	0.353**
	(0.000)
Log-likelihood	-3.401

Note: N=193. Bootstrap corrected standard errors in parentheses.
** (*) denotes a 5% (10%) level of significance.

Table 8: Truncated regression results

mayors. Still the smaller municipalities with uncompensated mayors are relatively inefficient.

A larger share of elderly population influences the inefficiency positively. Our hypothesis that municipalities with more elderly are more efficient in the provision of is not corroborated. When a municipality is relatively old, it tends to spend excessively on child care provision. An argument follows Montén and Thum (2010) who find that aging municipalities may have an incentive to have inefficiently high public spending for the young when the municipalities engage in fiscal competition over the more mobile younger population group. When this is the case a large enough share of elderly can have a negative impact on the efficiency of child care provision.

The number of facilities has a positive impact on inefficiency. One argument for having many facilities is that a low population density leads to costly accessibility and therefore justifies operating more facilities. However, in Saxony municipalities are relatively small and the distance to the facilities plays a subordinate role. Higher efficiency can thus be achieved with fewer facilities. A one point increase in facilities per 1000 increases efficiency by a whole 35.1%. This means that the municipality with the mean 0.87 facilities per 1000 inhabitants, would be about 19% more inefficient than the municipality with the minimum of 0.34 facilities per 1000, all else being equal.

The variable on the change in the number of 10 year olds has a negative influence on inefficiency. As expected, we do not find that additional adjustment costs accrue when services have to be expanded. Since both the coefficient (-0.002) and the change in the number of children are relatively small, the efficiency gains are moderate. For the mean municipality that gained 40 children over the 7 year period, this implies an efficiency increase of 8%. Given the legally defined personnel constraints our results show that more children can be cared for without increasing costs or reducing the quality of the care. This implies that in the past, when there were fewer children, excess capacities in child care must have existed. When in the future fewer children require care the capacities should be scaled back to meet the demand. The results show that municipalities are able to adjust to an expansion relatively flexibly, however we cannot show the effects of a contraction. It is probable that a downward adjustment would increase the costs per child.

In light of the insignificant coefficient on the share of grants, we find no support for the flypaper effect. The size of open ended grants a municipality receives does not influence the efficiency of child care provision. We interpret this result positively, as municipalities rather adjusting the supply of child care, than to channeling additional resources from state grants to cover over sized provision. The positive but insignificant influence of transfers to Type II (non-profit) facilities indicates that municipalities that transfer funds to Type II (non-profit) providers use the given resources less efficiently than municipalities that provide the service internally. One explanation may be that administrative costs reduce the effectiveness of transfer payments. Another reason may be that child care facilities of different types compete to convince the parents to choose their facility. Thus, in this case, competition would lead to higher expenditures, which could be interpreted by the parents as a quality signal. Furthermore, we do not find statistically significant effects of the two remaining political variables.

5. Discussion and policy implications

We have analyzed the efficiency of municipalities in the provision of child care services. Specifically we used data on the municipalities in the Free State of Saxony in Germany. We employed a two-stage analysis in which we first computed the efficiency scores using the non-parametric DEA method, and in a second stage we regressed the efficiency scores in a truncated regression. From a policy perspective it is reasonable to assume that the production process follows an input orientation. The expenditures are adjusted to the number of offered places, and not vice versa.

We identified differences in efficiency of the provision of public child care services. We find for the median municipality efficiency reserves of up to 30%. Different model specifications render similar efficiency scores, which supports the choice of the inputs and outputs. Scale efficiency at the municipal level is very high in all specifications (89-96%). The non-existence of returns to scale makes adjustment to changes in demand relatively flexible in this category. Moreover the positive influence of the number of facilities on inefficiency suggests that scale effects may instead be realized at the facility level. A municipality may be justified in maintaining many facilities if at the facility level sufficient scale effects are realized through specialization (e.g. age groups or profile).

The fact that the change in the number of under 10 year olds has a negative influence on inefficiency (positive influence on efficiency), is an indicator of the good adaptability in the provision of child care services (at least when capacities are expanded). This assertion is further corroborated by the insignificant influence of the share of matching grants. The municipalities seem to operate child care independent of the size of matching grants.

The demographic composition also influences efficiency. That aging municipalities over spend on family friendliness finds support in these results. In order to remain attractive to families with children, aging municipalities have an incentive to spend more on child care. A generous provision of child care is important in the location choice for families, in particular for those in which both parents are active in the labor market. Conversely these families contribute revenue to the municipalities through taxation.

Professionalism in administration is important. This aspect is particularly relevant in a state where many small municipalities are struggling with adverse demographic developments and dwindling resources. By encouraging cooperation and professionalizing administration, more appropriate expenditure decisions can be achieved at the local level. In terms of municipal amalgamation our results imply that child care is not an area in which cost savings can be achieved. However, the expenditures on child care are also not expected to rise when two municipalities merge. Therefore, if savings can be realized in other service areas then such a venture is beneficial.

In the future, an investigation of the facility level could complement our analysis. Although the municipalities are in charge of financing this service, a closer consideration of the facilities in selected municipalities could render more evidence with respect to competition and scale effects. Here we may only surmise what is happening at the facility level. However, due to lacking data a more detailed analysis is not feasible yet. Facilities in selected municipalities could be surveyed to conduct such a detailed evaluation. Due to data restrictions the analysis here is limited to a cross section. With the expansion of the supply of public child care in Germany the availability of more comprehensive statistics is also intended. In the following years, the statistics on child care centers are to be published annually and in more detail. This will allow for more detailed analyses in the future, and the incorporation of panel analyses and the monitoring of efficiency developments over time.

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Appendix

A. Returns to scale

Figure 1 depicts the CRS and VRS frontiers for the one input one output case. The input x is on the horizontal axis and the output y is on the vertical axis. The solid line forms the variable returns to scale (VRS) frontier, according to which units A, B, and C are efficient, and D is inefficient. The additional points depict additional inefficient units. The dashed line depicts the constant returns to scale (CRS) frontier which is a ray from the origin, and only deems one unit, namely B as fully efficient. The increasing and decreasing returns to scale are therefore computed as the the differences between the two frontiers. In the section "below" unit B (not including point B) units can realize increasing returns to scale, whereas units operating "above" unit B (not including point B) in terms of output operate under decreasing returns to scale.

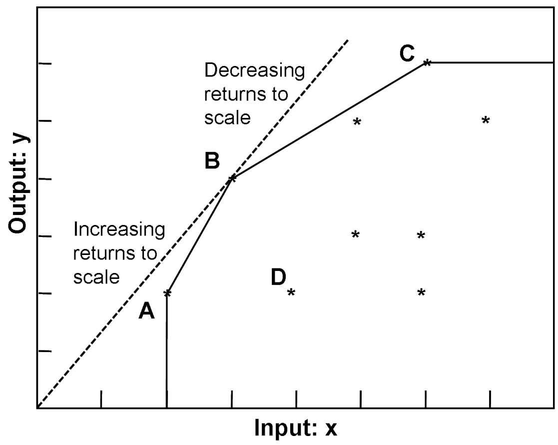

Figure 1: Returns to scale

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