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Intergovernmental Grants and Efficiency:

An Empirical Study on Administrative Discretion in German Municipalities

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DECLARATION

Except where appropriately acknowledged this thesis is my own work, has been expressed in my own words and has not previously been submitted for assessment.

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(Justus Nover)

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Abstract. How do intergovernmental grants affect the level of efficiency in lower-level governments? The existing literature on this topic provides inconclusive evidence regarding the underlying relations of cause and effect as well as its direction. We shed light on this question by suggesting a more general framework on administrative discretion within local governments. Two hypotheses are developed and tested for a panel of municipalities in the German state of Baden-Württemberg. Our dual estimation approach includes parametric Stochastic Frontier Analysis (SFA) and non-parametric Data Envelopment Analysis (DEA). This constitutes a valuable robustness check of the results regarding the choice of the reference technology. The findings confirm the decisive character of local administrative discretion and self-interest lead behaviour, inducing an either positive or negative efficiency effect of grants. Besides providing novel insights for the literature, the conclusions are relevant for the architecture of grant policies since intergovernmental transfers are nowadays among the most important sources of income at the local level.

Supervisor: Mandar Oak

Co-Supervisor: Florian Ploeckl

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Abbreviations

BW	Baden-Württemberg
CPE	State Centre for Political Education Baden-Württemberg
DEA	Data Envelopment Analysis
DMU	Decision-making unit
FDH	Free Disposal Hull
iid	Independently and identically distributed
OLS	Ordinary Least Squares
p.c.	per capita
SFA	Stochastic Frontier Analysis
UMP	Utility maximisation problem
US	United States of America
VAT	Value added tax
VRS	Variable returns to scale

1 Introduction

Numerous researchers have studied the changes in overall public spending on the local level when additional resources were supplied by higher-government institutions. One surprising result found in the literature on this topic is that increases in public expenditure far exceed the expected adjustments suggested by normal income effects. Arthur Okun termed this 'anomaly' (Hines and Thaler 1995) the *flypaper effect*, suggesting that grant money 'sticks where it hits'.[1] A more pressing aspect consists in incentive effects associated with intergovernmental grants since they might encourage a wasteful management of local resources. The question of interest is thus whether the allocation of lump-sum transfers is likely to deteriorate or improve the level of efficiency of local public goods provision.

Answering the above question is of particular interest since fiscal transfers play a major role in many federalist countries throughout the world.[2] For a tailored provision of local public goods and services, their amount and composition is commonly decided upon locally. However, financial distress and potentially a mobile tax base challenge local authorities to fulfil their assigned remits (see Bretschger and Hettich 2002 and Carlsen et al. 2005). As a counteracting measure, grants have long been identified to offset limited revenue generating abilities at the local level and are sometimes implemented to balance out differences in financial capacities across jurisdictions (see Mueller 2003, pp. 215). We argue that the institutional architecture and the agenda setting power between the involved agents is decisive in determining the direction and magnitude of the efficiency effects of intergovernmental grants.[3]

Contrary to the flypaper literature, the impact of grants on local public sector efficiency has received relatively little attention. Furthermore, evidence has so far been inconclusive in terms of identifying the exact underlying relation of cause and effect as well as the direction of the effect. A brief recapitulation of examples from the literature illustrates the contradicting conclusions.

One of the earliest studies is Silkman and Young (1982) who analyse local public libraries in 28 states as well as school bus transportation systems in 6 states within the US. In either case, their results suggest a lower degree of efficiency for a higher share of fiscal transfers relative to own revenues. An example looking at the overall efficiency of local governments is provided by De Borger et al. (1994). For a large number of Flemish municipalities in 1985, block grants are identified as having a detrimental effect on the local production performance. Other studies for European countries using more recent data and which find similar efficiency-reducing effects include: Loikkanen and Susiluoto (2005) for a broad panel of Finnish municipalities, Balaguer-Coll and Prior (2009) for observations on municipalities over four years in Spain, Kalb (2010) for the German state of Baden-Württemberg as well as Šťastná and Gregor (2015) for municipalities in the Czech Republic.

[1] See Bailey and Connolly (1997) for an overview.

[2] For an overview of the prevalence of the federalist government structure and the associated importance and functions of intergovernmental grants see Buettner (2006).

[3] In a related field of literature, many studies confirm that we differentiate between money brought to us by third parties and resources which we gained from personal effort. Examples addressing 'windfall gains' and the 'house money effect' include: Arkes et al. (1994), Clark (2002) or Epley and Gneezy (2007). According to their results, most of us tend to generously spend such money instead of carefully identifying its best application.

Worthington (2000) finds no significant impact of general purpose grants for local governments in the Australian state of New South Wales. This finding is robust across different parametric and non-parametric specifications. With a similar conclusion, Grossman et al. (1999) analyse 49 large US cities. Despite not showing any significant effect for state grants, their results in fact indicate a beneficial impact when considering federal grants.

Two studies which consistently suggest an efficiency-enhancing effect are Geys and Moesen (2009) and Bischoff et al. (2013). The former represents an empirical analysis of 300 Flemish municipalities in the year 2000. Their statistically significant and robust results show that grants indeed improve local efficiency. A very similar conclusion but presuming a deviating reference technology is obtained by Bischoff et al. (2013). Based on a sample of 203 municipalities in the German state of Saxony-Anhalt they equally find a positive correlation between grants and local efficiency.

Among the above studies, there are major differences in the nature of the data, the perspective (global efficiency versus specific expenditure area), the employed estimation approach and the suggested theoretical foundation. To explain the disparities in the results and to shed light on the underlying factors, we propose a more general hypothesis on the decisive role of 'local administrative discretion'. By this concept we understand the ability of bureaucracies to exploit local public finances for personal benefits such as more personnel and other work-related conveniences. Depending on the distribution of directive power between the political representatives (the mayor) and the associated bureaucracy, the effect of grants on local efficiency is expected to be positive or negative. We test our theoretical argument for a large panel of municipalities in the German state of Baden-Württemberg. For this purpose, we construct a simple index to measure administrative discretion. This approach goes beyond the existing literature in making an attempt to elucidate the different findings. The results indeed confirm the decisive character of the discretion factor. In light of this finding, the inconclusive results in the literature seem rather reasonable.

For our second contribution to the literature, we acknowledge the institutional design of local authorities as being equally likely to affect a local government's use of resources. In this vein, we suggest a new perspective on benchmarking possibilities among municipalities. The argument is that jurisdictions which share a bureaucracy have the advantage of being able to compare the bureau's performance. The benchmarking option stems from a shared bureau, providing its services to multiple jurisdictions but under the same production conditions. Regarding this second aspect, our results provide some evidence for the benchmarking hypothesis; municipalities with a shared bureaucracy tend to exhibit a higher degree of efficiency.

Additionally, to overcome another major issue – the choice of the reference technology – two approaches are employed for the empirical analysis. The first is the Stochastic Frontier Analysis (SFA); a parametric approach related to standard regression models. The second concept is the Data Envelopment Analysis (DEA); a non-parametric method which is widely used in management science. This dual estimation strategy contributes to the literature by providing insights into the robustness of the results across different reference technologies. It is to some extent a necessary approach, as the theory does not provide definite conclusions as to which model is superior in approximating local public production (see e.g. De Borger and Kerstens 1996). We find important differences between our SFA and DEA estimates, but the main results are robust to the method of efficiency measurement.

The study is structured as follows: Section 2 provides a discussion of the two identified theoretical models to lay the foundation for our administrative discretion and benchmarking hypothesis. For the empirical analysis, Section 3 recapitulates the relevant institutional aspects with respect to grants in the state of Baden-Württemberg. Section 4 introduces the estimation approaches and model specifications. Following a summary of the deployed variables to put the proposed hypotheses to the test, Section 6 reports the results. Section 7 elaborates on the differences between the estimated SFA and DEA estimates. Section 8 concludes.

2 Theory: Underlying Cause and Effect Relationships

In the following two subsections, the underlying relations for a positive and negative efficiency effect of grants are summarised to lay the basis for the suggested hypotheses and their more detailed formulation. The two formal approaches to model the internal dissent over the use of grants between a political representative and a bureaucracy both build on a similar setup as Niskanen (1971, 1975). The structure of the policy game includes three layers of agents: a higher-government level (federal state) allocates a fixed amount of lump-sum grants (g) to lower-level institutions (municipalities), which decide upon the use of g in internal decision-making processes. To direct and monitor the local bureaucracy, a representative (mayor) to advocate the population's interests is appointed and the electoral process is assumed to be dominated by the median voter.

The main concern is the interaction between the mayor and the (chief) bureaucrat as a bilateral monopoly. The mayor is devoted to maximise voters' utility, given by a standard quasilinear function:

$$U^V = X - \frac{(Q-\rho)^2}{2\theta}, \text{ with } \rho, \theta > 0, \tag{2.1}$$

where X denotes private goods and Q represents the local public output. ρ and θ are some parameters. Contrary, the bureaucrat who is directed to manage public provision seeks to maximise her utility by following personal preferences such as the expansion of the personnel, prestige, long breaks and so on. To do so, she is assumed to have access to the *fiscal residual*. Her utility is given by:

$$U^B = \alpha Q^\beta FR^\gamma, \tag{2.2}$$

where the *fiscal residual* (FR) is the amount of the public budget the bureaucrat is able to withhold for personal convenience. To some extend (2.2) illustrates the bureaucrat's remuneration structure and highlights how her utility depends on monetary and non-monetary perquisites. The bureaucrat faces minimum production cost of the form:

$$C(Q) = cQ + dQ^2. \tag{2.3}$$

Finally, a commonly contended concept to explain the flypaper effect, namely *fiscal illusion* or *discretionary profit* is employed to distinguish between efficiency effects of grants and own revenue. The term captures a widely accepted view[4] that more transfers reduce the tax price perceived by voters or makes them overestimate the actual amount. The essential aspects in modelling this phenomenon and related decision-making processes are briefly demonstrated to motivate the two novel hypotheses.

2.1 Bilateral Monopoly Model of Bureaucracy by Kalb (2010)

The model by Kalb (2010) follows Moesen and Van Cauwenberge (2000) in assuming a relatively strong agenda setting position for the bureaucrat. Within a soft-budget framework and based on voter's preferences, the mayor only approves the municipality's budget, whereas the bureaucrat has the ability to make a take-it-or-leave offer. Equivalent to a typical principal-agent problem, the agent

[4] See e.g. Mitias and Turnbull (2001) and Mueller (2003, pp. 221).

(bureaucrat) has an information advantage concerning the cost structure of public production and can exploit this knowledge to access the fiscal residual $FR = TB - C(Q)$, where TB is the total approved budget and FR measures the degree of production inefficiency. Hence, Q and FR are both choice variables of the bureaucrat. The agent's utility maximisation problem (UMP) is constrained by the median voter's preferences to approve certain cost-output combinations and public production will be inefficient from the allocative and technical perspective.[5]

Exogenous grants (g) affect the efficiency level of production through the voter's budget and thus the mayor's willingness to approve TB. Consumption of private and public goods is constrained by:

$$Y^V = Y + \bar{\tau}g = X + \tau(g)P_Q Q, \tag{2.4}$$

where Y^V (Y) denotes total (private) income, $\bar{\tau}$ is the true tax share and $\tau(g)$ its counterpart perceived by voters. In being a negative function of g, $\tau(g)$ with $\frac{\partial \tau}{\partial g} < 0$ captures the degree of fiscal illusion. Solving the voter's constrained UMP yields the following expression for their preferred output level:

$$Q^{V^*} = \rho - \theta\tau(g)P_Q \iff P_Q = \frac{Q^{V^*}}{\rho - \theta\tau(g)}. \tag{2.5}$$

Accordingly, an increase in g has two effects on their willingness to authorise a particular budget: (*i.*) the *income effect* causes Y^V to rise since $\bar{\tau}g$ increases, whereas (*ii.*) a *price effect* comes into play as the perceived tax price $\tau(g)$ of public output falls due to fiscal illusion. It is the latter effect which 'overproportionally' affects the preference to increase public output and extends the bureaucrat's discretion to exploit the larger FR. The effect on technical inefficiency can be assessed by computing the total budget according to $TB = P_Q Q$, plugging the result into U^B and maximising over Q. This yields an expression for the equilibrium inefficiency FR^* which is differentiated with respect to grants:

$$\frac{\partial FR^*}{\partial g} = -\frac{\partial \tau(g)}{\partial g}\frac{1}{\tau(g)^2}TB^{N^*} + \frac{\partial Q^*}{\partial g}\left(\frac{\partial TB^*}{\partial Q^*} - \frac{\partial C(Q^*)}{\partial Q^*}\right) > 0, \tag{2.6}$$

where TB^N equals the true budget. The first component is obviously positive as we assume $\frac{\partial \tau}{\partial g} < 0$. Furthermore, $\frac{\partial Q^*}{\partial g} < 0$ illustrates the well-known *flypaper effect* and the summand in brackets is larger or equal to zero since the budget constraint is required to be fulfilled. Therefore, the model suggests that when the amount of grants rises, this will increase the inefficiency or vice versa; the municipality will operate at a lower efficiency level.

2.2 Price-Setting Model by Bischoff et al. (2013)

Instead of Niskanen (1975), this alternative model follows Breton and Wintrobe (1975) and Bendor et al. (1985) in deriving a standard model of monopoly. Two aspects are of special interest: (*i.*) as the distribution of directive power and information works to the mayor's advantage, the bureaucrat can no longer make a take-it-or-leave-it offer and the mayor sets the equilibrium quantity Q^*. (*ii.*) Given the deviating initial positions, the bureaucrat makes use of her monopoly power to set the

[5] Details see Kalb (2010, pp. 25).

tax price τ (per capita & unit) to maximise U^B. In the end, voters still receive some fraction of the consumer's surplus compared to the case with a strong bureaucrat, able to claim it entirely for herself.

The structure of the game is slightly different since the choice variables of the agents and their available information are not the same. Based on voter's preferences and demand for Q, the tax price τ will be set to maximise the bureaucrat's benefits from accessing the fiscal residual. As τ is publicly announced it cannot be underestimated and voter's budget constraint reads as:

$$Y + \phi g = X + \tau Q, \tag{2.7}$$

where ϕ accounts for fiscal illusion. The misperception is thus about the amount of grants. For $\phi = 1$ fiscal illusion is absent, whereas when $\phi > 1$ voters overestimate g. Given the equilibrium tax share τ^* and quantity Q^*, the difference between the perceived amount of grants and the production cost $(\tau^* Q^*)$ is either positive or negative. Depending on this sign, voters will expect to receive a transfer $t < 0$ or they are willing to pay taxes $t > 0$ according to:

$$t + \phi g = \tau^* Q^*. \tag{2.8}$$

The above expression illustrates that voter's willingness to pay for public output decreases in the fiscal illusion parameter ϕ. The implication of this relationship is summarised below:

	Willingness-to-pay effect	**Unobserved-budget effect**
$\phi = 1$	Voters are correctly informed about the amount of grants received.	$(Y + \phi g)$ is the perceived budget of voters. They are willing to spend $(\tau^* Q^*)$.
$\phi > 1$	Amount of g is overestimated. High willingness to pay for Q which results in the expectation of a tax $t > 0$. (Income effect of Q as with a normal good.)	The bureaucrat receives the budget g but is held accountable for: $\phi g > g$ and therefore has to provide Q^* with grants which she never received.

The two effects thus work against each other and constitute a mixed blessing for the bureaucrat whose utility continues to depend and Q and FR with:

$$FR = [(1 - \phi)g + \tau Q] - C(Q). \tag{2.9}$$

The bureaucrat will set her choice variable τ such that the resulting output Q maximises her utility. Solving this UMP by backward induction, the voter's demand function is first obtained by maximising U^V over Q, subject to the perceived budget constraint. This yields:

$$Q^V = \frac{a - \tau}{b}, \tag{2.10}$$

where an increase in g leaves voter's demand for public output unaffected (only X rises). However, it is assumed that Q and X are normal goods and to account for the higher willingness to pay when more resources are at hand, it is assumed that a is a positive function of the perceived budget $(Y + \phi g)$ and thus of the received grants: $\partial a / \partial g > 0$. This implies that depending on ϕ, income and grants have different effects on the demand for public output. In fact, for $\phi > 1$ this is likely to lead to the well-known *flypaper effect* since: $\partial a/\partial g = \phi \partial a/\partial Y$.

Given voter's demand as a function of τ, the bureaucrat will announce a tax price τ^* which maximises her utility. This results in the following equilibrium level of public output:

$$Q^* = \begin{cases} \frac{a-c+\sqrt{(a-c)^2+4\alpha(2-\alpha)(b+d)g(1-\phi)}}{2(2-\alpha)(b+d)} & \text{if } a > c \\ 0 & \text{else.} \end{cases} \quad (2.11)$$

When focusing on the case with $Q^* > 0$, the two introduced effects will work against each other and cause Q^* to increase or decrease when additional grants are distributed to a jurisdiction:

Change	**Adjustments**	**Effect**
Increase in the amount of grants received ($g \uparrow$)	$\rightarrow a \uparrow \quad \rightarrow Q^* \uparrow$	Willingness-to-pay effect
	$\rightarrow g(1-\phi) \downarrow \quad \rightarrow Q^* \downarrow$ when $\phi > 1$ such that: $g(1-\phi) < 0$	Unobserved-budget effect

To answer the question about the effect of grants on the efficiency level, we can plug Q^* into the equation for the fiscal residual and then differentiate with respect to grants g, which results in a quite complex expression. Unfortunately, it is not possible to uniquely determine the sign of this derivative such that a case distinction between variable and parameter constellations is necessary.[6] For the large majority of the cases, the expected effect of additional grants on inefficiency is negative. Under the described structure, grants are thus most likely to have an efficiency-enhancing effect.

2.3 Administrative Discretion and Institutional Design Hypotheses

The reason for finding an efficiency-enhancing effect of transfers is particularly based on the *unobserved-budget effect* which drastically constrains the bureaucrat and forces her to give up a fraction of the fiscal residual. On the other hand, a detrimental effect on local production performance occurs when there is substantial slack or administrative discretion as the increased demand for public goods simultaneously enlarges the share of the budget which the bureaucrat is able to access via the fiscal residual.

For our purpose, we define administrative discretion as the ability of bureaus to exploit local public finances for personal benefits such as more personnel and work-related conveniences.[7] The bureaucrat's access to the fiscal residual is influenced by the local institutional structure, defining the decision-making processes. It likewise depends on the mayor's ability and willingness to constrain the bureaucracy's leeway by implementing (costly) monitoring tools and performance measures.[8] Subsequent to the discussion of the underlying concepts, we can now state our two hypotheses.

[6] Details see Bischoff et al. (2013, pp. 3).

[7] The interest thus lies on the local perspective and not on aspects usually considered in the field of 'bureaucratic capture theory', where the focus is on interactions between bureaus and/ or third parties (see e.g. Leaver 2009).

[8] In a related field of literature, similar arguments have been broad forward to equally explain possible inefficiencies in overall public output provision (see e.g. Bendor et al. 1985, Breton and Wintrobe 1975, and Borge et al. 2008).

Hypothesis 1*: A high degree of administrative discretion in local governments leads to a wasteful (i.e. inefficient) use of intergovernmental grants. By inversion of the argument, the effect is efficiency-enhancing whenever bureaucratic activities are closely monitored and effectively directed.*

The channel through which fiscal transfers affect the performance of public production is that of fiscal illusion among voters. In dependence of the distribution of information as well as agenda setting power between the mayor and the bureau, this misperception of transfers is expected to amplify or constrain the bureaucracy's leeway to pursue personal goals. Following this line of argumentation, the second hypothesis concerns deviating abilities of local governments to supervise the activities of their bureaucracy.

Hypothesis 2*: Local governments with the opportunity of benchmarking the performance of the associated bureau are relatively more efficient. The effect is strongest with identical regional characteristics and a largely congruent composition of the public goods and services provided.*

The distinction between types of institutional settings is most interesting with administrative associations. This form of institutional framework implies a shared provision of public services by a common bureaucracy, whereas the policies and provision decisions are decentralised. The crucial aspect is that of an additional monitoring tool for the mayor to control the self-interest lead behaviour of the bureaucrat. By sharing an administrative body, the mayor is able to benchmark the performance of the bureaucracy as it equally supplies its services to all members of the association. Due to the provision of largely identical goods in the same geographical region, arguments about deviant production preconditions are invalid and cannot be credibly contended by the bureaucrat. We therefore expect the degree of administrative discretion to be reduced when a shared bureaucracy is implemented. A formal representation of the benchmarking aspect is intended for future research.

3 Institutional Framework and Municipal Finances

Building on the theoretical discussion above, a brief overview of the institutional structures within the German state of Baden-Württemberg[9] (the example used in the empirical analysis) is provided below. This is crucial for the correct specification of the estimation model. Some aspects are similarly discussed in Kalb (2010).

Figure 1: State of Baden-Württemberg in Germany.

As many other countries, Germany exhibits a differentiated federal structure with a division of expenditure responsibilities and revenue collection (see Oates 1999). According to Tiebout (1956) and in the sense of the subsidiarity principle, this aims at utilising local competences to effectively manage and tailor public goods provision. However, it also challenges lower-level governments with often limited financial endowments (see Ministry of Finance BW 2006). This necessitates appropriate institutions and transfer mechanisms between involved decision-making units (DMUs). Figure 2[10] gives a schematic picture of the multilayered government structure in Baden-Württemberg with its 1,111 municipalities.

Germany is divided into 16 federal states. Within the state of Baden-Württemberg, there are four administrative regions with superordinated and coordinating responsibilities. Rural counties as the highest level of local authorities are responsible for interregional tasks such as the provision and maintenance of county roads. Urban counties are officially municipalities and therefore have the same revenue stream at their disposal. Yet, they are also responsible for tasks typical for rural counties which entitles them to receive additional revenues (see Ministry of Finance BW 2006, p. 51). It is thus advisable to treat them as separate DMUs in the empirical analysis. Municipalities constitute the lowest government level. Since the last administrative-territory reform in 1975 the majority is organised in administrative associations (see CPE 2008 and Waibel 2007 (pp. 27)).[11]

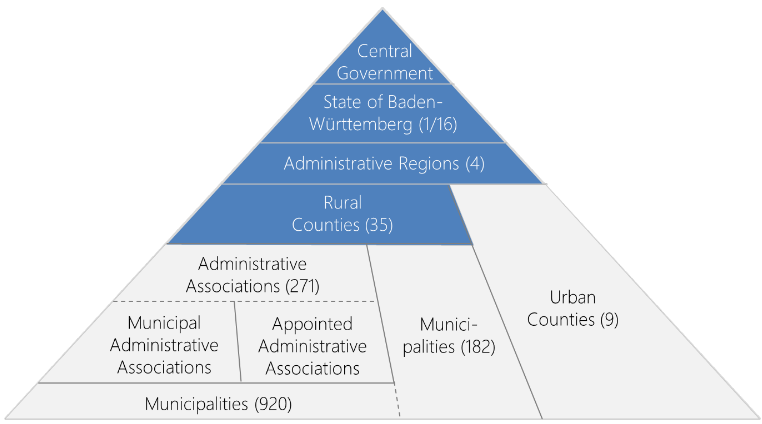

Figure 2: Federal Structure of the State of Baden-Württemberg.

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[9]Highlighted region in Figure 1. Source: Sven Knie, <http://alturl.com/w48ti>.

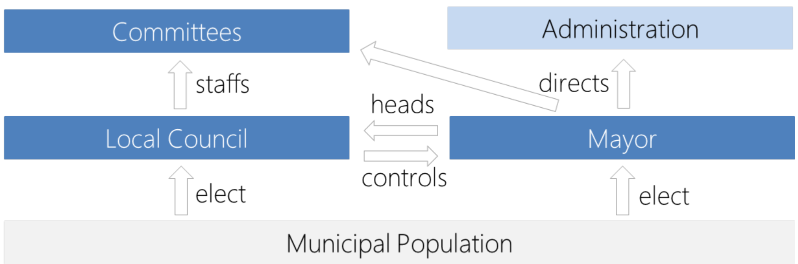
[10]Source: Own figure based on State Centre for Political Education Baden-Württemberg (2008) (hereinafter CPE).

[11]Two forms exist: (*i.*) a shared administration carries out the bulk of tasks for the members, or (*ii.*) an appointed municipality's bureau provides its services to all members (see §§ 59-62 of the municipalities constitution).

3.1 Political Structure of Local Jurisdictions

The two political agents governing the municipalities are the mayor and the local council. They are separately elected by the local population every 5 and 8 years, respectively. The mayor has a relatively strong position in fulfilling three main functions: (*i.*) she is the head of the local council and the committees and is entitled to vote in both institutional bodies, (*ii.*) she directs the local administration and (*iii.*) represents the population's interests. The council is, however, the main body where most political decisions are made. Moreover, the council monitors the activities of the mayor and the administration. Its members (except the mayor) work on a voluntary capacity, only receiving a rather symbolic financial compensation. This underlines their endeavour to act upon the best interest of the local population. Contrary, the civil servants which constitute the administrative body are official employees with at least one chief bureaucrat (per municipality or administrative association). Figure 3 schematically summarises the institutional framework and relations.[12]

Figure 3: Schematic Structure of Local Authorities.



Own figure based on CPE (2008, p. 78).

3.2 Municipal Scope of Tasks and Duties

Considering the expenditure side, there are three major types of tasks the municipalities (and consequently urban counties) are responsible for. The first type are *voluntary tasks* including e.g. the provision of cultural activities or leisure time facilities. Local authorities decide whether and how the provision of such public goods is organised. The second type are *compulsory tasks without stated instructions* (e.g. social security, local administration, schools, etc.) such that the 'whether' is predetermined by higher-level governments and only the 'how' is to be decided locally. The final and third category are *duties with instructions* and include e.g. the implementation of local police forces and elections.[13] In section 5, suitable and observed variables are introduced to approximate municipal production of the different public goods and services.

[12]Details see CPE (2008, pp. 76) and §§ 23-72 of the municipalities constitution.

[13]Details see Waibel (2007, pp. 37).

3.3 Municipal Finances

To finance the provision of public goods and services, municipalities have three sources of revenue. The sum of higher-government and own tax revenues constitutes the biggest share, followed by intergovernmental grants which play a substantial role (31% of total revenue in 2004) and finally user charges. The latter include fees for roads, a central water supply or waste and sewage disposal and represent the smallest proportion of overall revenue (9% in 2004).

With respect to their tax revenue, municipalities have the right to levy five different types of taxes themselves. Among these municipality specific taxes, the trade tax and property tax[14] make up the largest share. Some local governments additionally implemented so called bagatelle taxes which, however, play a minor role. The local share of the income tax roughly represents the remaining share of tax revenues (∼40%).[15]

In the following, we focus on the grant structures and thus our main concern. Their allocation scheme entails a vertical and a horizontal dimension. It is regulated by the Fiscal Equalisation Law and summarised in Ministry of Finance BW (2006). The motivation for its implementation was twofold: first, the state government is obliged to assist local authorities with their financial matters to assure the mandatory provision of public goods. Secondly it aims at balancing differences in available resources between municipalities. Table 1 summarises the types of grants and informs about their relative importance in 2004.

Table 1: Intergovernmental Grants for Municipalities in Baden-Württemberg (in 2004).

Grant type	Value in million €	Value per capita (in €)
1. Key grants	2,110.04	197.47
2. Grants for current expenditure	1,372.82	128.48
3. Grants for investments & investment assistance	649.14	60.75
4. Grants for municipalities with special financial requirements	1.09	0.10
5. Other general grants	454.19	42.15
$\sum$	4,587.28	429.31

Source: Kalb (2010) based on information from the Statistical Office Baden-Württemberg.

The majority of grants is covered by the so called fiscal equalisation mass. It combines the horizontal and vertical dimension since it is financed by tax revenue of the state and municipalities alike. Financially strong jurisdictions bear a larger proportion of the cost and receive less transfers.

About 50% of the fiscal equalisation mass is distributed via so called key grants (lump-sum grants). They are consequently the most essential type for the municipalities. Allocation is organised in a formula-based system. Individual grant assignment is then based on a partial compensation of the difference between a municipality's fiscal capacity and its fiscal needs. The former is approximated as the sum of overall tax revenues and some transfers from two years ago, however, based on a general

[14]They are based on business revenues and the basic value of the business or property, respectively (see Ministry of Finance BW 2006, pp. 5).

[15]For details on the composition of tax revenues see Appendix A1 and Ministry of Finance BW (2006, pp. 12)

measurement scheme rather than actual values. Fiscal need is measured by population size and a per capita multiplier to account for a quantitatively and qualitatively higher demand for public goods in more populous regions.[16] What is crucial for the empirical analysis is the formula-based character of the transfers which assures that they are entirely exogenous to municipalities. Otherwise, inferences about their efficiency effects would be misleading.

The rule-based allocation scheme differentiates between three types of municipalities. If the fiscal capacity exceeds the fiscal needs, the municipality is said to be 'abundant' and receives no key grants. If the fiscal capacity lies between 60% and 100% of fiscal needs, roughly 70% of the difference is offset by the distribution of key grants. For 'financially very weak' municipalities (fiscal capacity $<$ 60% of fiscal needs) the discrepancy to 60% is fully compensated (type 4 grants), whereas above this threshold a compensation of $\sim$70% is provided. The financial equalisation scheme ensures that there is no incentive to intentionally corrupt fiscal capacities since own tax revenues will leave the local authorities with higher overall financial endowments.

With regard to the remaining grant types, the second category comprises lump-sum transfers for public schools, roads and transport as well as general administrative tasks. With the exception of type 3 and type 5 grants, individual assignments are determined within a rule-based system. A large share of the grants for investment projects is only available for smaller municipalities and distribution depends on the suggested application. Since these jurisdictions are largely excluded in the empirical analysis, category 4 can be seen as exogenous as well.

The discussion in this section emphasised important differences between municipalities, both with respect to the institutional setting as well as municipal tasks. The presented theory suggests that such characteristics will decisively influence local efficiency and grant use. The subsequent section introduces two estimation approaches to account for the influence of such characteristics.

[16]Details see Appendix A2.

4 Estimation Approach

To evaluate the consistency of the theoretical arguments with real world data, an extensive empirical analysis is undertaken, employing the widely used frontier estimation technique. This implies specifying an efficient (cost) frontier, representing the 'best' combinations of input and output factors at a given production technology and then measuring deviations of single DMUs from this best-practice frontier. This concept was first introduced in the seminal work of Farrell (1957).

The literature on (relative) productivity and efficiency measurements provides two main methods which differ significantly concerning the underlying assumptions as well as the a priori imposed restrictions. Whereas *parametric* methods determine the production structure upfront and only some unknown parameters of a specified function have to be estimated, *non-parametric* methods only define a broad class of production functions or sets (making a *parametric* representation infeasible) and let the data determine the structure of the frontier (see Bogetoft and Otto, 2010, pp 17).

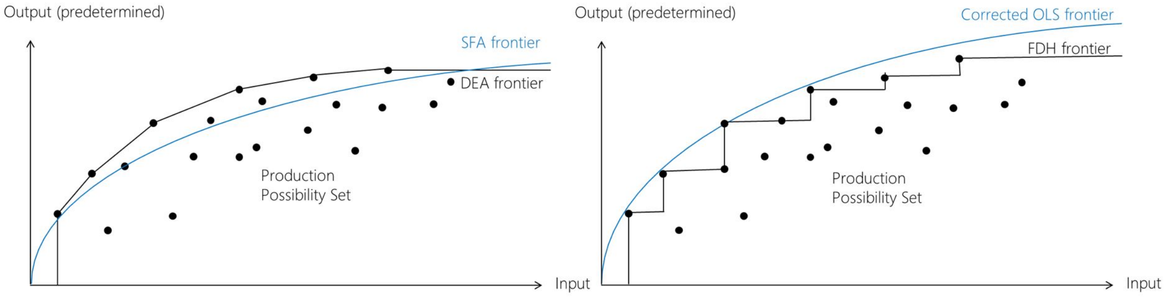
Given the different assumptions underlying these two methods where none of them has been shown to have universally superior properties over the other, it is desirable to assess the robustness of the findings with respect to the employed estimation method. Therefore, results obtained from both competing methods are presented. We employ the most popular approaches from both methods. They have become known as *parametric* Stochastic Frontier Analysis (SFA) and *non-parametric* Data Envelopment Analysis (DEA).

Among the class of *parametric* methods, the so called corrected OLS is sometimes used as an alternative to the SFA approach. Corrected OLS implies using standard OLS to fit a regression line based on a given set of observations. In a second step, the biased intercept is then corrected.[17] Contrary to SFA, this is a deterministic method which does not account for the fact that some of the variation in efficiency will be due to noise. Ruggerio (1999) shows that SFA does not outperform corrected OLS when using cross-sectional data but yields more reliable estimates when applying panel data. Since data for multiple years is available for this study, SFA is the better choice. It accounts for the within variation in the data and incorporates either fixed or random effects.

Considering the group of *non-parametric* methods, a sometimes attractive alternative to DEA is the Free Disposal Hull (FDH) approach, developed by Deprins et al. (1984). It drops the convexity assumption of the production technology embodied in DEA and only retains the free disposability assumption for inputs/ outputs. As a result, the efficient frontier typically has a stair-case shape and leads to some DMUs being 'efficient by default' (De Borger et al. 1994, pp. 346). Therefore, the number of efficient DMUs with FDH will usually exceed those from DEA. Despite the fact that this does not necessarily yield better estimates, to the best of the author's knowledge there is so far no FDH model which simultaneously corrects for robustness issues with noise or outliers in non-parametric methods (see e.g. Cazals et al. 2002) and equally accounts for the influence of environmental variables. Consequently, the DEA approach is identified as the best option for our purposes.

[17] This implies adjusting the intercept term until all residuals are on one side and at least one observation is on the efficient frontier. Details see Aigner et al. (1977) and Olson et al. (1980) who first introduced this concept.

Figure 4: Graphical Comparison of DEA and SFA.



Own figure based on Bogetoft and Otto (2010, p. 19) and Lovell (2000, p. 44).

Figure 4 provides a graphical comparison of the SFA and DEA (as well as the corrected OLS and FDH) approach for the one-dimensional input and output case. The graph depicts the best-practice frontier, based on observed input-output combinations. Individual inefficiency is measured as the distance between an observed DMU's production and the postulated frontier.

Using SFA, the frontier is obtained by specifying a functional form and then estimating unknown parameters in a single regression. Its stochastic nature allows to decompose deviations from the frontier into an inefficiency part and a component arising from noise or measurement error. This yields more accurate estimates than deterministic approaches, however, at the cost of potentially misspecifying the functional form (see Hjalmarsson et al., 1996).

Contrary, DEA eschews an a priori (yet flexible) specification of a functional form. This is convenient as the exact relationship between inputs and output is typically unknown to researchers (see Yatchew, 1998). Instead, linear programming methods are commonly employed to envelop the observed data as tightly as possible, constructing a convex hull. The linearity of the DEA programme leads to a frontier that is piecewise linear. With DEA, misspecification of the frontier might occur due to its deterministic nature, where deviations from the frontier are entirely interpreted as inefficiencies.

The strengths and weaknesses of SFA and DEA are summarised in Table 2 and discussed in more detail in the following subsections, where the model specifications are presented.

Table 2: Summary Comparison of the Stochastic Frontier and Data Envelopment Method.

Stochastic Frontier Analysis (SFA)	**Data Envelopment Analysis (DEA)**
Parametric approach (allows for hypothesis testing associated with regression estimation)	Non-parametric approach (largely unknown distributional properties; prevents hypothesis tests)
Mostly maximum likelihood estimation	Linear programming method
Requires specification of a functional form	No functional form specification required
Allows for only one dependent variable	Can accommodate for multiple inputs/ outputs
Separates stochastic influences/ measurement errors from (in)efficiency scores	Does not account for random noise (included in (in)efficiency scores)

Source: own table based on Lovell (2000, pp. 42), Webster et al. (2000, pp. 60) and Bogetoft and Otto (2010, p. 18).

4.1 Stochastic Frontier Analysis (SFA) – Model Specification

The SFA approach was almost simultaneously developed by Meeusen and Van Den Broeck (1977) and Aigner et al. (1977). In contrast to conventional regression analysis, the error terms of SFA models are skewed since they consist of a standard symmetric component to account for measurement error or statistical noise and a second one-sided component to capture inefficiencies in production.

As already mentioned, we intend to include environmental (exogenous) variables and expect them to influence the efficiency level at which the DMUs operate. This facilitates the evaluation of the efficiency effects of exogenous intergovernmental grants,[18] which are neither input nor output factors and thus not amenable to influence by the local government. There exist two methods to account for environmental variables in SFA models (see Lovell 2000, pp. 46):

1. Include the environmental variables in the *frontier model* such that public production not only depends on inputs factors but also on the production environment.
2. Incorporate the environmental variables in the *inefficiency model*. Consequently, they only affect the efficiency at which municipalities operate but not the production technology itself.

In view of our research question and the data to accommodate for heterogeneous municipality environments, the second interpretation is the appropriate choice in this case. Moreover, to make use of the data's panel structure, we employ the random effects model developed by Battese and Coelli (1995). Their model of technical inefficiency is an extension of the one-step approaches by Kumbhakar et al. (1991), Reifenschneider and Stevenson (1991) and Huang and Liu (1994) for cross-sectional data.[19] Using a standard Cobb-Douglas production function, the regression model is given by:

$$lnx_{i,t} \;=\; \beta_0 \;+\; \sum_{r=1}^{S} \beta_r lny_{r,i,t} \;+\; \psi_{1,t} \;+\; \varepsilon_{i,t}, \qquad \text{with: } \varepsilon_{i,t} = v_{i,t} + u_{i,t}, \tag{4.1}$$

where i denotes the DMUs and t indicates the time period (in years). Moreover, x represents the single input variable and y is a vector of S known proxies to approximate public goods and service production. The variable ψ_1 captures time fixed effects in the production technology (and therefore the efficient frontier). ε is a composed error term (details see below). The unknown β parameters determine the structure of the best-practice frontier.

To address the main drawback with SFA (having to specify a functional form), a second model is estimated using a more general framework for public production. Following Christensen et al. (1973), we use a translogarithmic (Translog) function to test the sensitivity of the results with respect to the assumed production technology. The model including square and interaction terms then reads as:

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[18]and other factors such as the population density or the rate of unemployment.

[19]Such one-step approaches overcome some issues intrinsic to two-step approaches where after having obtained individual (in)efficiency scores from estimating a frontier, they are regressed on the environmental variables using censored Tobit. As pointed out by Kumbhakar et al. (1991) and Reifenschneider and Stevenson (1991) two problems then are that the inefficiency scores have to be assumed to be *iid* (undermining the motivation for the second-step regression) and that the environmental variables have to be independent of the incorporated input and output variables.

$$lnx_{i,t} \;=\; \beta_0 \;+\; \sum_{r=1}^{S} \beta_r lny_{r,i,t} \;+\; \frac{1}{2}\sum_{r=1}^{S}\sum_{q=1}^{S} \beta_{r,q} lny_{r,i,t} lny_{q,i,t} \;+\; \psi_{1,t} \;+\; \varepsilon_{i,t}. \tag{4.2}$$

Turning to the composed error term ($\varepsilon_{i,t} = v_{i,t} + u_{i,t}$), v represents a standard error variable to capture statistical noise. It is assumed to be *iid* with $v \sim \mathcal{N}(0, \sigma_v^2)$ and independent of the second error component u. The latter constitutes technical inefficiency; a one-sided and non-random variable which is assumed to be independently distributed. The inefficiency component is defined as:

$$u_{i,t} \;=\; \delta_0 \;+\; \sum_{j=1}^{J} \delta_j z_{j,i,z} \;+\; \psi_{2,t} \;+\; w_{i,t}, \tag{4.3}$$

where the $(1 \times j)$ vector $z_{i,t}$ contains the environmental variables. Similar to the *frontier model*, ψ_2 controls for time-varying inefficiency effects. Finally, w is a random variable, defined by a truncation of the standard normal distribution with $\mathcal{N}(0, \sigma_w^2)$, where the point of truncation is $-z_{i,t}\delta$ such that $w_{i,t} \geq -z_{i,t}$. As a result, the inefficiency term u is obtained by truncation of the distribution:

$$\mathcal{N}\left(\delta_0 + \sum_{j=1}^{J} \delta_j z_{i,t} + \psi_{2,t},\; \sigma_u^2\right) \tag{4.4}$$

and can only take on values bigger than or equal to zero. A value of zero for any cross-sectional unit indicates the efficient production of public output.[20] Following Battese and Coelli (1995), the simultaneous estimation of the *frontier* and *inefficiency model* is approached via maximum likelihood.

At this stage, two remarks concerning the model specifications are important. Firstly, the u term for technical or cost inefficiency[21] is additive within the composed error term. A higher value therefore increases the regressand. This is one characteristic of an input-oriented model where the frontier determines the minimum required resources to produce a certain level of output (see Lovell 2000, p. 25, 45). Such a setup is more appropriate for municipal production in Germany since the main expenditure areas are rather predetermined and the financing is the actual choice variable of local authorities.

The second aspect concerns the use of the panel dimension in the data. As discussed, the specified model accounts for time fixed effects, both in the *frontier* as well as the *inefficiency model*. Naturally, one would prefer to use e.g. a true fixed-effects model as discussed in Belotti et al. (2013)[22] to eliminate municipality fixed effects and increase the accuracy of the inefficiency estimates. Unfortunately, the time variation in most variables is limited and even zero for a number of dummies. A fixed effects model is thus expected to yield inaccurate results. Hence, the random-effects time-varying inefficiency model by Battese and Coelli (1995) is the better choice to make use of the within and between variation and to account for heteroskedastic municipality environments.

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[20] w is not required to be identically distributed nor does it have to be non-negative (see Battese and Coelli 1995).

[21] Technical and cost inefficiency imply similar concepts in our case. When interpreting the regressand as an indicator for aggregate input, then the technical inefficiency perspective is appropriate. When (4.1/ 4.2) are seen as cost functions, the interpretation as cost inefficiencies is preferred, additionally involving an allocative aspect (see Kalb 2010).

[22] Such an approach has the advantage of disentangling time-invariant heterogeneity from time-varying inefficiency. This puts inferences from the inefficiency term on a firmer foundation. Details see Belotti et al. (2013, Section 5.3).

4.2 Data Envelopment Analysis (DEA) – Model Specification

The DEA approach was introduced by Charnes et al. (1978) to measure inefficiency under the assumption of constant returns to scale and was extended by Banker et al. (1984) to a variable-returns-to-scale specification. Similar to SFA, the analysis assumes that there is a frontier technology, be described by a piecewise linear hull that envelopes the observed input-output combinations. A major difference to SFA is that by construction some DMUs are efficient (see Figure 4). Since the linear programmes, which need to be solved for each DMU, are deterministic all observations lie below or on the best-practice frontier (see Lovell 2000, pp. 42). According to Färe et al. (1983) and described in Lovell (2000), the structure of the linear programme with a variable-returns-to-scale assumption[23] and input orientation reads as:

$$\begin{aligned} \min_{\theta,\lambda} \ \theta_0 \qquad s.t. \qquad & \sum_{i=1}^{N} \lambda_i y_{r,i} \ \geq \ y_{r,0}, && \text{with} \ \ r = 1,\ldots,S \\ & \theta_0 x_0 \ - \ \sum_{i=1}^{N} \lambda_i x_i \ \geq \ 0 \\ & \lambda_i \ \geq \ 0 && \text{with} \ \ i = 1,\cdots,N \\ & \sum_{i=1}^{N} \lambda_i \ = \ 1. \end{aligned} \tag{4.5}$$

As before, x and y denote the input and output variables. The θs are municipality-specific efficiency scores, ranging between zero and one (an efficient DMU is characterized by $\theta_i = 1$). θ_0 represents a hypothetical DMU for which the first constraint assures that it produces at least as many outputs as the studied DMU_i. Constraint two identifies how much less input the hypothetical DMU_0 would need for the production (hence the input orientation). Moreover, the λs represent weights for the single DMUs which are compared to DMU_0. The inclusion of the last constraint imposes the variable-returns-to-scale assumption. Solving the above sequence of linear programmes for each municipality yields a set of $\{\hat{\theta}_i\}_{i=1}^{N}$ estimates of efficiency scores.
As for the SFA approach, two alternatives exist to incorporate exogenous variables to account for varying operating environments among the municipalities:[24]

1. Include the environmental variables when fitting the efficient frontier by adding an additional constraint for each exogenous variable when compiling the linear programme.

2. Combine non-parametric DEA with a parametric second-stage regression where the efficiency score estimates are regressed on the set of environmental variables.

The problem with the first approach is that the sign of the effect of environmental variables on DMU_i's efficiency level needs to be known ex ante. This oftentimes problematic prerequisite is not required

[23] This assumption about the production technology seems appropriate considering the substantial differences in the municipalities' size. Nevertheless, we present adequate tests to evaluate its validity at the end of this section.

[24] Details see e.g. Lovell (2000, pp. 46).

for the second approach which follows a two-step procedure. Three problems (some related to those in the two-step approaches with SFA models) arise from such a model. Fortunately, appropriate techniques for this semi-parametric approach exist and are used to tackle the issues. In doing so we follow Simar and Wilson (2007) and specify the second-stage regression according to:

$$\varphi_i \;=\; \delta_0 \;+\; \sum_{j=1}^{J} \delta_j z_i \;+\; \varepsilon_i \;\geq\; 1, \tag{4.6}$$

where z is the vector of environmental factors, including a year variable to account for time-varying efficiency effects.[25] As in Simar and Wilson (2007), the Farell (1957) measures of technical efficiency are used for the second-stage regression. They are simply the reciprocals of the efficiency scores in (4.5) which are themselves based on the Shephard (1970) distance function. Thus, we have: $\varphi_i = 1/\theta_i$. This is why φ_i is specified as being larger or equal than 1 which is assured by a truncated maximum likelihood estimation. The error ε is normally distributed with $\mathcal{N}(0, \sigma_\varepsilon^2)$ and left truncated at $1 - \delta' z$. Using the estimates obtained from solving (4.5), the second-stage regression reads as:

$$\hat{\varphi}_i \;=\; \delta_0 \;+\; \sum_{j=1}^{J} \delta_j z_i \;+\; \xi_i \;\geq\; 1. \tag{4.7}$$

Crucial issues with DEA in general and the two-step approach in particular are discussed in Simar and Wilson (2007) and Ruggerio (2004). First of all, despite $\hat{\theta}_i$ being a consistent estimator for θ_i the rate of convergence is low and $\hat{\theta}_i$ is upward biased. As a consequence, inefficiency levels of the DMUs will most likely be underestimated in finite samples.

Secondly, the $\hat{\theta}_i$s are serially correlated in a complicated way since observations lying on the efficient frontier will often affect the efficiency scores of less well-performing DMUs. Finally, the error term ξ is not independent of z due to x and y being correlated with the environmental variables (which is the initial motivation for the second-step regression).

To address the problems with inferences from maximum likelihood for the coefficients and error variance in (4.7) we use the double-bootstrap method introduced in Simar and Wilson (2007). A correction of the estimates is achieved by estimating the bias in (4.7) and constructing a bias-corrected estimator for φ_i as well as robust confidence intervals for the estimated coefficients in the second-step regression.[26]

As the final aspect for this section, we test the variable-returns-to-scale assumption using the approach described in Simar and Wilson (2002) and a similar test using subsampling techniques (see Simar and Wilson, 2011).[27] They are solely based on the vectors x and y of the observed input and output variables. The results are presented in Table 3 below.

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[25] Note: we do not use time subscripts as in the SFA model. This is due to the fact that linear programming techniques are not able to make use of the time dimension in the data and treat each observation as a separate DMU.

[26] Note: all three perturbations disappear asymptotically, however at relatively low rate (see Simar and Wilson 2007). For a detailed description of the double-bootstrap procedure (algorithm #2) see Appendix A3.

[27] The authors use bootstrap procedures to obtain relatively accurate critical values for the test statistics. Details see Simar and Wilson (2002) and Simar and Wilson (2011, pp. 46).

Table 3: Simar and Wilson (2002, 2011) Tests for Returns to Scale.

Null Hypothesis (H_0)	Alternative (H_1)	Dataset 1 p-value	Dataset 2 p-value
Constant returns to scale (S.W. 2002)	Variable r.t.s	0.01	0.01
Constant returns to scale (S.W. 2011)	Variable r.t.s	0.01	0.01
Non-increasing returns to scale (S.W. 2002)	Variable r.t.s	0.55	0.01
Non-increasing returns to scale (S.W. 2011)	Variable r.t.s	0.53	0.01

For dataset 1: $N = 245$, $T = 15$, total number of observations = $3,675$. Dataset 2 contains an additional output variable and more details about the municipalities' production environment. Its dimensions are: $N = 245$, $T = 3$, total number of observations = 735. S.W. stands for Simar and Wilson.

An evaluation of the underlying economies-of-scale characteristics of the samples is an important aspect since respective assumptions strongly influence the structure of the best-practice frontier and therefore individual efficiency scores. For dataset 2,[28] all tests confirm the variable-returns-to-scale assumption. For dataset 1, the null hypothesis of constant returns to scale is similarly rejected, whereas non-increasing returns to scale cannot be rejected at any conventional significance level. In view of this finding, both a non-increasing and a variable-returns-to-scale specification (which is a combination of increasing and decreasing economies of scale) is estimated for dataset 1.

[28]Details about the employed datasets are provided in the following section.

5 Data and Descriptive Statistics

This section introduces the employed data to test the proposed hypotheses about local administrative discretion and institutional design differences. The data is a balanced panel of municipalities in the German state of Baden-Württemberg and covers the period 1990 – 2004. This example is attractive for two reasons: (*i.*) intergovernmental grants make up a large share of municipal revenues (∼30%) and (*ii.*) a broad and extended collection of relevant data is at hand to find answers to the posed research questions. The panel dimension in the data is of high value since inefficiency is most likely measured with some noise which varies within jurisdictions over time. Repeated observations are thus expected to increase the quality of the estimates.

Three data sources have been used. Most variables can also be found in Kalb (2010) on which this study builds on. Additional data about municipality characteristics and public production were taken from Michelsen et al. (2014) as well as the 'Official Statistics about the Municipalities' from the Statistical Office Baden-Württemberg. Section 5.1 focuses on the data for the *frontier model*, whereas the remaining part of Section 5 details the approach of modelling municipalities characteristics and therefore addresses the *inefficiency model.*

5.1 Local Resources and Output – The Frontier Model

Both, SFA and DEA require input and output variables to obtain an estimate for the efficient production frontier and to determine individual efficiency scores as deviations from this frontier. With respect to local output, Section 3.2 briefly introduced the major fields of local tasks and duties. Table 4 documents their official classification.[29]

Besides the 'General financial management' (including interest and amortisation repayments), the areas of 'Social security' (e.g. kindergartens and welfare services) and 'Public facilities and business management' account for the largest share. In line with the literature on public performance measurement, the last column of Table 4 lists a number of proxies for local output. For example, total population is used to approximate administrative duties and expenditures on 'Architecture, Housing and Traffic'. Similarly, the output variables (2) number of students in public schools, (3) share of the population older than 65, (4) recreational area and (5) number of social insured employees at their place of work, all approximate essential duties and some voluntary tasks of the municipalities. Observations on the sixth proxy (kindergarten places) were only available for some years and they are considered in a separate estimation. Unfortunately, proxies for three of the smallest expenditure areas were not available. Yet, a large proportion of local public output is captured by the observed variables.

With regard to the input perspective, the single variable 'net current primary expenditure' is used to approximate total municipal expenses per year (as in Kalb (2010) we use per capita values for the estimation). This includes the entire spending on the current budget. Only the debt service costs and the capital budget are excluded.[30] The focus on current expenses assures that large-scale

[29]The subsumption is based on the Administrative Regulation on the Classification of the Municipalities in 2004.

[30]The former equals the difference between interest and amortisation repayments as well as revenues from financial

Table 4: Allocation of Total Municipal Expenditure.

Public expenditure area	Expenditure (in € and p.c.)	Share of total expenditure (in %)	Proxy for municipal expenditure area
General Administration	191.85	7.85	Total population
Public Safety	75.99	3.11	–
Schools	161.00	6.61	Students in public schools
Science, Research, Culture	89.66	3.67	–
Social Security	280.76	11.49	Share of popul. older than 65 Kindergarten places
Health, Sport, Recovery	127.28	5.20	Recreational area
Architecture, Housing, Traffic	241.45	9.89	Total population
Public Facilities, Business Development	277.95	11.36	Recreational area Social insured employees
Commercial Companies, General Basic and Separate Assets	153.48	6.28	–
General Financial Management	844.14	34.55	Mainly debt and amortisation payments (excluded)
$\sum$	2,442.59	100	

Source: Kalb (2010) with data from the Statistical Office Baden-Württemberg.

infrastructure investments with year dependent payment streams and irregular occurrence do not distort the results.[31] Summary statistics for all variables are provided in Table 7 in Section 5.3.

At this stage, it is important to emphasise the limitations of such proxies to mirror the diverse areas of local public activity (see e.g. De Borger and Kerstens 1996 or Blank and Lovell 2000). Nonetheless, and in the absence of feasible alternatives, the introduced proxies contain valuable information about public goods provision by local authorities. Additionally, the summary statistics confirm substantial differences between the jurisdictions.

5.2 Modelling Administrative Discretion and Institutional Design

An empirical analysis which aims at testing the proposed hypothesis has to overcome the challenge of identifying a suitable strategy to measure administrative discretion which is not directly observable. The best feasible approach that was identified for our purpose is constructing a *power index* with: $0 \leq P_{i,t} \leq 1$. The introduction of such an index has the advantage of making local agenda setting power and leeway of the local bureaucracy comparable among municipalities.

The issue of measuring unobservable characteristics of cross-sectional units is often approached by finding appropriate variables as an approximation. In this vein, a number of proxies are introduced which are expected to be capable of differentiating between the essential characteristics of municipalities with respect to directive power and administrative discretion. Using equal weights and a uniform

investments. The results of Geys et al. (2008) suggest that efficiency measures are unchanged when excluding debt service costs which do not produce any public output.

[31]The approach of approximating physical inputs by cost variables is very common in the literature as data on physical inputs is widely unavailable (see e.g. Kalb 2010 and Bischoff et al. 2013).

unit of measurement, which is achieved by scaling the proxies, the index is constructed according to:

$$P_{i,t} \;=\; \frac{1}{Q}\sum_{q=1}^{Q}\frac{(\tilde{p}_{q,i,t}-\tilde{p}_{q,min})}{(\tilde{p}_{q,max}-\tilde{p}_{q,min})}, \tag{5.1}$$

where $P_{i,t}$ is the constructed index for municipality i in year t ($P_{i,t} = 1$ implies maximum discretion for the local bureaucracy). Moreover, Q is the number of proxies. Finally, $\tilde{p}_{q,i,t}$ is the observed value of proxy q in municipality i at time t. Its value is scaled by the minimum and maximum observed value of the proxy over all municipalities to assure that $\tilde{p}_{q,i,t} \in [0,1]$ $\forall i, t$ and q.

With regard to the employed approximating variables, they can be identified as belonging to either of three different categories. The first category comprises of a single backward-looking performance variable, namely a dummy being equal to one if a municipality is of the 'financially very weak' type (fiscal capacity $< 70\%$ of fiscal needs). The underlying argument is that the sponsor's capability of monitoring the local bureaucrat and enforcing policies which exclusively serve local interests instead of preferences of the administration is limited in such municipalities.

The second category includes two variables to capture the political ideology and preferences in the local councils. The first variable is a dummy to denote the existence of so called 'free voter unions'. Contrary to traditional political parties, free voter unions are rather loose collaborations of voters which are willing to invest personal financial resources, time and effort to advocate local interests without the backing of a major political party (see CPE 2008, pp. 31). As this requires substantial political devotion, it is expected that their presence indicates more target-oriented local policies and thus a more efficient use of received grants.[32] Following a conformable way of thought, the share of seats held by left-wing parties (Social Democrats and the Green Party) is included. The crucial relationship is that the typical agenda of those parties covers an enhancement of voter involvement and especially a higher fiscal transparency (see Piotrowski and Van Ryzin 2007 and Guillamón et al. 2011). Hence, a stronger position by left-wing parties is expected to limit the discretion of local bureaus to act upon personal preferences. One might object that left-wing parties commonly have a preference for larger overall budgets. Yet, it is not apparent why this should induce a lower level of efficiency (see Kalb 2010, p. 40).

The final category contains three variables to represent the working environment of local councils and their backing by the population. With particular focus on the first aspect, we make use of the Herfindahl index; a measure of political concentration or fragmentation.[33] Whereas lower concentrations of political power in local councils increase the competition for the 'best policies', we hypothesise that less political fragmentation leaves more resources to assure the efficient implementation of the chosen policies. At the same time, a mayor who has large support from the council members is likely to find it easier to implement a hard budget constraint.[34] Furthermore, the voter turnout as well as the share of eligible voters in a municipality is employed to approximate the council's backing by

[32] See Geys et al. 2010 for a theoretical and empirical discussion which supports this argument.

[33] The Herfindahl or sometimes Herfindahl-Hirschman index is calculated as: $\sum_{i=1}^{n} s_i^2$, where s_i is the share of seats of party i in the local council (see Rhoades 1993).

[34] For a similar line of argument and related empirical evidence see Ashworth et al. (2006) and Borge et al. (2008).

the population. As suggested by the literature (see e.g. Squire et al. 1987 or Brady et al. 1995), voter turnout strongly indicates the population's interest and knowledge of political topics and processes. This leads to the conclusion that an involved electorate sustainably monitors local public activity and holds local authorities accountable for the use of the available resources. Through a slightly different channel, the share of eligible voters mirrors the population's ability to strengthen the council's internal bargaining position (by representing more inhabitants). We hypothesise that a larger electorate increases the council's capability and incentive to assure an efficient application of resources by avoiding technical slack in the process of public goods provision.[35]

In a first step we exploit the rich information about municipality characteristics and their evolution over time by using the entire dataset from 1990 – 2004. An unfortunate trade-off with the 15 year data is the limited availability of proxies for the construction of $P_{i,t}$. Nonetheless, it is a good starting point and an opportunity to test the robustness of the estimates. Table 5 provides summary statistics for the available proxies in this dataset 1.

Table 5: Proxies for the Distribution of Directive Power. Data: 1998, 2002 and 2004.

			Quantiles				
Variable	**Mean**	**S.D.**	**Min**	**.25**	**Mdn**	**.75**	**Max**
Power index (1)	0.52	0.20	0.01	0.41	0.44	0.47	0.99
(Power index)(Grants)	194.94	133.57	1.80	113.42	149.37	218.07	1,788.07
Financially very weak municipalities	0.20	0.40	0.00	0.00	0.00	0.00	1.00
Herfindahl index	0.34	0.07	0.21	0.29	0.33	0.37	1.00

$N = 245$, $T = 15$. Total number of observations $= 3,675$. 'Power index (1)' denotes the limited $P_{i,t}$ with two proxies.

For the main analysis, only the later period of the 15 year data will be used. This facilitates the inclusion of additional variables, only available for the years 1998, 2002 and 2004. The second dataset thus combines the benefits of observing the municipalities over time and having detailed information about individual characteristics. Table 6 documents some summary statistics. The main interest lies in the interaction term of $P_{i,t}$ and the grant variable and exhibits substantial variation.

The second distinct contribution of this study is to suggest a theoretical foundation and empirical assessment of efficiency effects under alternative institutional settings. To account for expected differences in grant-related and overall efficiency for the three discussed municipality types, we include two dummy variables. The first (DA_i) is equal to one if a municipality is a member of an administrative association and zero otherwise. Accordingly, the second dummy (DU_i) is equal to one if a municipality is of the urban county type and zero otherwise.

The distinction between municipality types is most interesting with administrative associations. From a competition theory perspective, sharing an administration should have a detrimental impact on local efficiency since the formerly bilateral monopoly between the mayor and the bureaucrat is replaced by a unilateral monopoly. This should enable the bureaucrat to claim a larger share of the consumer

[35] For a similar theoretical discussion and empirical support of the above arguments see Geys et al. (2010).

Table 6: Proxies for the Distribution of Directive Power. Data: 1990 – 2004.

			Quantiles				
Variable	**Mean**	**S.D.**	**Min**	**.25**	**Mdn**	**.75**	**Max**
Power index (2)	0.44	0.08	0.27	0.39	0.42	0.48	0.69
(Power index)(Grants)	171.13	78.88	39.12	120.73	153.66	153.66	654.59
Financially very weak municipalities	0.17	0.38	0.00	0.00	0.00	0.00	1.00
Herfindahl index	0.34	0.07	0.21	0.29	0.33	0.37	1.00
Share of eligible voters	72.16	3.07	62.13	70.26	72.35	74.20	88.17
Free voter unions	0.94	0.23	0.00	1.00	1.00	1.00	1.00
Share of left	27.97	10.02	0.00	21.74	27.78	35.00	54.55
Voter turnout	57.29	7.90	37.22	51.53	56.13	64.17	75.54

$N = 245$, $T = 3$. Total number of observations = 735. 'Power index (2)' denotes the $P_{i,t}$ variable including all of the above proxies.

surplus and consequently reduce public efficiency. However, we argue that an opposing effect is potentially of even greater importance and will in fact enhance local efficiency in such associations.

The crucial aspect is that of an additional monitoring tool for the mayor to control the self-interest lead behaviour of the bureaucrat. By sharing an administrative apparatus, the mayor is now able to benchmark the performance of the local bureaucracy. It is therefore expected that the degree of administrative discretion is significantly reduced when a shared bureaucracy is implemented.[36]

With regard to the last group of municipalities – urban counties – a minor benchmarking effect might also apply since authorities operate at a subordinate level and might have better knowledge of the cost structures associated with public goods production. Albeit, it seems more likely that the broader scope of the authority's tasks has an efficiency-reducing effect as discussed in Section 3.3. Given the deviant financial framework and range of municipal duties it is without doubt preferred to treat urban counties separately in the empirical analysis to avoid a distortion of the results. Lastly, the following section introduces a number of additional environmental variables commonly used in the literature to account for crucial differences among municipality's operating environment.

5.3 Environmental Characteristics

The inclusion of further environmental variables mainly follows Kalb (2010). Their use is equally recommended in the literature on public sector performance measurement to account for essential systematic and non-random differences (see e.g. Lovell 2000, p. 47 and De Borger and Kerstens 1996, pp. 161). Furthermore, note that only municipalities with a population larger than 10,000 are considered to facilitate a higher degree of homogeneity with respect to the type of locally provided goods and services.

[36] It is certainly worthwhile to consider potential economies-of-scale effects. For Baden-Württemberg, their presence has been confirmed by Geys et al. (2008). However, they do not specifically look at administrative associations and in fact it is not only small municipalities which are organised in such associations (see Table 9 in Appendix A8). Nonetheless, to control for potential scale effects, the size of an association in terms of the number of member municipalities is included in the estimation.

The number of university students in a municipality is included since this is expected to alter the composition of provided goods (public transport or student accommodation and potentially less high-quality public goods and services). Moreover, Kalb (2010) suggests to account for the importance of local tourism in the region by including the number of accommodation facilities (like hotels and guest houses). The variable is thought to capture an increased demand for high-quality public goods (e.g. leisure and adventure facilities, cultural events or hiking trails).

The two final variables are the local unemployment rate and the population density. For the former, a cost and a preference effect are of relevance. Whereas a high unemployment rate induces higher spending on respective benefits, the demand for high-quality goods and services is likely to be lower and results in lower public spending. Lastly, the population density accounts for agglomeration effects. Table 7 reports the summary statistics for all variables in the dataset covering the years 1998, 2002 and 2004.[37] [38]

[37]Note: the output proxy 'kindergarten places' was only available for the years 1998 and 2002. Since until 2004 no major adjustments on the supply or demand side have been observed, the missing 2004 data were approximated by those from 2002. Moreover, the observed data includes public and private kindergarten (∼45/55%). Under this circumstances this is not necessarily suboptimal as private kindergartens are similarly associated with organisational liabilities for the municipalities (see Geys et al. 2008).

[38]The respective summary statistics for the dataset covering the entire period 1990 – 2004 which is used for the first estimation can be found in Appendix A4.

Table 7: Summary Statistics. Data: 1998, 2002 and 2004.

			Quantiles				
Variable	**Mean**	**S.D.**	**Min**	**.25**	**Mdn**	**.75**	**Max**
Net current expenditure p.c. (in €)	1,768.55	551.72	1,072.38	1,473.38	1,655.13	1,891.39	7,860.10
Total population	29,148	49,257	9,153	11,975	16,218	27,396	589,231
Number of students in public schools	1,725.40	2,301.37	417	822	1,072	1,795	27,126
Kindergarten places	1,077	1,461	272	501	666	1,109	17,554
Share of population older than 65	16.76	2.27	10.54	15.21	16.74	18.13	27.80
Social insured employees (at place of work)	12,168	28,033	663	3,072	5,047	10,152	355,535
Recreational area (in are)	6,571	10,684	438	2,221	3,667	6,798	110,841
Grants p.c.	378.71	129.67	105.99	296.71	373.56	440.23	1,242.94
Power index (2)	0.44	0.08	0.27	0.39	0.42	0.48	0.69
Association dummy	0.58	0.50	0	0	1	1	1
Association size	2.43	1.79	1	1	2	3	14
Urban county dummy	0.04	0.19	0	0	0	0	1
(Power index)(Grants)	171.13	78.88	39.12	120.73	153.66	153.66	654.59
(Association)(Grants)	225.63	213.49	0.00	0.00	270.29	398.91	1,242.94
(Assoc. size)(Grants)	944.93	821.78	113.42	363.83	743.79	1,316.17	8,338.85
(Urban c.)(Grant)	24.83	128.23	0.00	0.00	0.00	0.00	836.51
University students	860	4,017	0	0	0	0	35,152
Number of accommodation facilities	12.99	17.43	0	4	8	15	150
Unemployment rate	6.71	1.40	3.75	5.72	6.47	7.50	12.70
Population density	5.87	4.62	0.78	2.54	4.47	7.87	28.42
Abundant municipalities	0.08	0.28	0	0	0	0	1
Financially weak municipalities	0.74	0.44	0	0	1	1	1
Financially very weak municipalities	0.17	0.38	0	0	0	0	1
Herfindahl index	0.34	0.07	0.21	0.29	0.33	0.37	1.00
Share of left	27.97	10.02	0.00	21.74	27.78	35.00	54.55
Free voter unions	0.94	0.23	0	1	1	1	1
Year	2	0.82	1	1	2	3	3

$N = 245$, $T = 3$. Total number of observations = 735. 'Power index (2)' denotes the $P_{i,t}$ variable including all six proxies.

6 Results

This section reports the results of the empirical analysis. In a first step, we estimate a baseline model with the dataset covering the whole period 1990 – 2004 and excluding the constructed index $P_{i,t}$. This facilitates the evaluation of the overall efficiency effect of grants and sheds light on the differences between the three municipality types. Afterwards, two different specifications including $P_{i,t}$ are estimated to assess the validity of the administrative discretion hypothesis. Generally, the three model versions provide a valuable test of the result's sensitivity with respect to time, specification, and the estimation method. Naturally, minor changes should leave the main conclusions unaffected.

6.1 Intergovernmental Grants & Institutional Design

The results of the *inefficiency model* of the first specification are presented in Table 8.[39] Preceding the discussion of the major insights we would like to point to the high and significant values of the estimated gamma variable in both SFA models (Cobb-Douglas: 0.96 and Translog: 0.98). By construction, gamma ranges between zero and one. A value close to one implies that the majority of the variation in the composed error $\varepsilon_{i,t}$ is due to the inefficiency component $u_{i,t}$ and thus explained by the environmental variables instead of the random term $v_{i,t}$ ($\gamma \equiv \sigma_u^2/\sigma_\varepsilon^2$, see Battese and Coelli 1995, p. 327). This is reassuring as it confirms the relevance of municipality-specific characteristics.

The results largely back up those obtained by Kalb (2010). Especially the estimate of the grant variable is equally positive for all specifications and with the exception of the DEA model highly significant. This leads to the first conclusion according to which the overall efficiency effect of intergovernmental grants for independent municipalities in the German State of Baden-Württemberg seems to be positive.[40] The estimated coefficient itself is rather small in all specifications but given a mean variable value of 355, the effect is quite substantial and of relevance for local authorities.

Next, we turn to one of the major aspects; differences between municipality types. Interestingly, the SFA models show positive coefficients for the association dummy but negative and significant estimates for the interaction term with the grant variable. The DEA model yields significant coefficients with the opposite signs. The crucial common feature is, however, that with both methods the overall effect of an average administrative association is significantly negative (inefficiency reducing). The estimated effect is -2.474 for the variable mean of grants in the Translog specification.[41] This provides a first evidence for the suggested benchmarking possibility for municipality representatives which are a member of an administrative association. This holds particularly true as the association size variables are insignificant. The mentioned competition and economies of scale effects thus seem to be of little importance. Finally, the overall effect for urban counties is positive (efficiency reducing) and mainly significant. It remains to be seen whether this conclusion is generally valid as there are only nine municipalities of this type in the dataset.

[39] The results of the *frontier model* in the SFA approach can be found in Table 21 in Appendix A6.

[40] The overall effect of grants when abstaining from a separate treatment of administrative associations and urban counties was found to be 0.0024 (Cobb-Douglas) and 0.0059 (Translog), both significant at the 1% level.

[41] The overall effect in the other models is also significant and given by: -0.785 (Cobb-Douglas) and -0.012 (DEA).

Table 8: Estimation Results: Inefficiency Model ($P_{i,t}$ excluded). Data: 1990 – 2004.

	SFA		DEA
Variable	**Cobb-Douglas**	**Translog**	**S.W. (2007)**
Intercept	-7.02471***	-13.65400**	0.91592***
	(2.31537)	(5.38540)	
Grants per capita	0.00487***	0.00832***	0.00013
	(0.00164)	(0.00308)	
Association dummy	1.00594**	0.90977	-0.22774***
	(0.43419)	(0.59847)	
(Association dummy)×(Grants p.c.)	-0.00488***	-0.00674**	0.00035*
	(0.00185)	(0.00331)	
Association size	-0.14860	-0.25659	0.03589*
	(0.13708)	(0.24476)	
(Association size)×(Grants p.c.)	0.00058	0.00118	-0.00005
	(0.00042)	(0.00073)	
Urban county dummy	5.89034***	12.45800***	0.43302
	(2.18297)	(4.35520)	
(Urban county dummy)×(Grants p.c.)	-0.00591**	-0.01354***	-0.00120*
	(0.00272)	(0.00433)	
Students at University (ln)	-0.06461*	-0.27686***	-0.04335***
	(0.03537)	(0.09795)	
Accommodation facilities	0.00783**	0.01818*	0.00078
	(0.00397)	(0.00963)	
Unemployment rate	-0.02750	-0.06896**	-0.00103
	(0.01959)	(0.03049)	
Population density	0.00232	-0.06274	0.00187
	(0.01342)	(0.04536)	
Abundant Municipalities	4.50015***	8.58270**	0.53933***
	(1.45743)	(3.55680)	
Financially very weak Municipalities	-1.35263***	-4.92600**	-0.14661***
	(0.35069)	(2.16400)	
Herfindahl index	2.59587***	4.54500***	0.32972**
	(0.71975)	(1.17760)***	
Year	0.00272***	0.10100**	0.01510***
	(0.01325)	(0.04044)	
Sigma squared ($\hat{\sigma}^2$)	0.29747***	0.64445**	0.36788***
Gamma (γ)	0.95962***	0.98243***	–
Log-likelihood	2224.55	2311.46	–

$N = 245$, $T = 15$. Total number of observations = 3,675. Significance levels of 1%, 5% and 10% are denoted by ***, ** and *, respectively. Standard errors for the SFA estimates are given in parentheses. Given the characteristics of the inefficiency model, negative coefficients (a shorter distance between an observation and the efficient frontier) imply an efficiency enhancing effect. For the estimation, the *frontier* package by Coelli and Henningsen (2013) as well as the *rDEA* package by Simm and Besstremyannaya (2016) are used. Both are implemented in the statistical computing software R. For the DEA estimates, the specification accounting for non-increasing returns to scale is presented. The results with the variable returns to scale are presented in Table 23 in Appendix A5.

6.2 Local Administrative Discretion Hypothesis

At this stage, the existing literature typically concludes the empirical analysis and proceeds by providing meaningful policy recommendations to enhance local efficiency. In contrast to such an approach, we aim at further exploring the impact of grants by accounting for the relationship between the local bureaucracy and the policymakers. This strategy is implemented by including the introduced index $P_{i,t}$ into the above presented model. Since for the 1990 – 2004 data only two proxies (the Herfindahl index and the dummy for financially very weak municipalities) are available, the first results reported in Table 10 provide only limited, yet valuable insights on the impact of administrative discretion as they exploit the rich time dimension in the data.

The model yields a similarly significant and large gamma. Moreover, we carry out three likelihood ratio tests for both SFA models. The first tests the null hypothesis (H_0) of all coefficients in the *inefficiency model* being simultaneously equal to zero. The second evaluates the relevance of the institutional design variables ($P_{i,t}$ and municipality type dummies). Based on the obtained p-values, we reject the H_0s at the 1% level. Thirdly, the Cobb-Douglas and Translog model were tested against each other. The results indicate that the more general Translog function performs better in representing local production.[42] Nevertheless, the Cobb-Douglas model is retained as a robustness check.

Turning to the interpretation of the coefficients for the interaction term including the power index and the grant variable, the estimates point into the expected direction and they are significant across all models. Since the positive coefficient implies that a higher value of $P_{i,t}$ – representing relatively vast administrative leeway – leads to larger losses of efficiency, this finding supports the suggested hypothesis. Table 9 below reports the specific effects for the three municipality types.[43]

Table 9: Efficiency Effects of Grants for Municipality Types. Data: 1990 – 2004.

Municipality type	Dominant mayor ($P_{i,t} = 0$)	Dominant Bureaucrat ($P_{i,t} = 1$)
Independent municipality	$+0.0014/ -0.0004$	$+0.0144/ +0.0007$
Administrative association	$-0.0048/ -0.0004$	$+0.0082/ +0.0007$
Urban county	$-0.0137/ -0.0019$	$-0.0007/ -0.0008$

$N = 245$ and $T = 15$. Total number of observations $= 3,675$. The first value denotes the estimate from the Translog SFA specification and the second represents the estimate obtained with the DEA approach.

With a minor level of administrative discretion ($P_{i,t} = 0$) the efficiency effect of grants is mostly negative. Conversely, when a bureaucracy is able to pursue personal goals at the expense of local grant money, this increases inefficiencies. Despite the expected positive sign of $P_{i,t}$, the estimated effect of the index is not entirely consistent (with the theory as well as across models). For independent municipalities the effect is throughout positive.[44] Consequently, we estimate a final model using more detailed data for the years 1998, 2002 and 2004. The results are provided in Table 12.

[42]Details see Table 18, Appendix A5.

[43]Average association members with benchmarking opportunities remain being significantly more efficient. However, the coefficients for the association size variable in the Translog specification now hint to the existence of a competition/ monopoly effect since a higher number of members reduces efficiency in administrative associations.

[44]The positive effect of grants on inefficiency with independent municipalities could of course simply be due to the characteristics of this government type which is exogenous to the analysis.

Table 10: Estimation Results: Inefficiency Model (including $P_{i,t}$). Data: 1990 – 2004.

	SFA		DEA
Variable	**Cobb-Douglas**	**Translog**	**S.W. (2007)**
Intercept	-4.54591***	-9.62711***	1.43403***
	(1.69233)	(3.31985)	
Grants per capita	0.00135	0.00353	-0.00039*
	(0.00125)	(0.00225)	
Power index (1)	-4.44995***	-9.16353***	-0.90374***
	(1.67159)	(3.28963)	
(Power index)×(Grants p.c.)	0.00792**	0.01304*	0.00112***
	(0.00352)	(0.00689)	
Association dummy	1.29144**	1.54116**	-0.19030***
	(0.58731)	(0.65856)	
(Association dummy)×(Grants p.c.)	-0.00618**	-0.00951**	0.00023
	(0.00263)	(0.00374)	
Association size	-0.14339	-0.30055**	0.03458
	(0.11744)	(0.13866)	
(Association size)×(Grants p.c.)	0.00060	0.00135**	-0.00004
	(0.00043)	(0.00056)	
Urban county dummy	6.26227***	13.72526***	0.67407
	(2.27964)	(4.10871)	
(Urban county dummy)×(Grants p.c.)	-0.00679**	-0.01508***	-0.00155**
	(0.00277)	(0.00418)	
Students at University (ln)	-0.06535**	-0.29897***	-0.04362***
	(0.03046)	(0.07239)	
Accommodation facilities	0.00789**	0.01636**	0.00077
	(0.00321)	(0.00808)	
Unemployment rate	-0.03507	-0.08743**	-0.00142
	(0.02376)	(0.07187)	
Population density	0.00604	-0.06515	0.00149
	(0.01176)	(0.046410)	
Abundant Municipalities	4.34965***	9.24059***	0.52620***
	(1.51614)	(3.42964)	
Financially very weak Municipalities	-1.46056*	-4.41730*	0.06456
	(0.86835)	(2.29743)	
Herfindahl index	1.32599	1.35194*	–
	(0.82977)	(0.82243)	
Year	0.04124**	0.10780***	0.01519***
	(0.01785)	(0.02546)	
Sigma squared ($\hat{\sigma}^2$)	0.29437***	0.70101***	0.36788***
Gamma (γ)	0.95904***	0.98376***	–
Log-likelihood	2230.31	2314.51	–

$N = 245$, $T = 15$. Total number of observations $= 3,675$. 'Power index (1)' denotes the limited $P_{i,t}$ with only two proxies for local administrative discretion. The coefficients of the variables 'financially very weak municipalities' and 'Herfindahl index' are biased when including the $P_{i,t}$. Details see below.

As before, the gamma estimates are close to one and the likelihood ratio tests confirm the relevance of the institutional design variables as well as the better fit of the Translog model relative to the Cobb-Douglas one (see Table 19, Appendix A5). As the first important insight from the final results we find the estimated coefficient for the grant variable to be negative and highly significant for all models. Hence, when accounting for detailed and relevant characteristics in local governments and the municipalities in general, we indeed find an efficiency-enhancing effect of intergovernmental grants. To assess the validity of the proposed hypothesis regarding the role of local administrative discretion, Table 11 separately summarises the effects for the three municipality types.

Table 11: Efficiency Effects of Grants for Municipalities Types. Data: 1998, 2002 and 2004.

Municipality type	Dominant mayor ($P_{i,t} = 0$)	Minimum observed $P_{i,t}$	Maximum observed $P_{i,t}$	Dominant Bureaucrat ($P_{i,t} = 1$)
Independent municipality	-0.0196 / -0.0032	-0.0056/ -0.0011	$+0.0161$/ $+0.0022$	$+0.0322$/ $+0.0046$
Administr. association	-0.0196/ -0.0032	-0.0056/ -0.0011	$+0.0161$/ $+0.0022$	$+0.0322$/ $+0.0046$
Urban county	-0.0302/ -0.0076	-0.0162/ -0.0054	$+0.0056$/ -0.0021	$+0.0217$/ $+0.0003$

$N = 245$ and $T = 3$. The first value in each cell denotes the estimate from the Translog SFA specification and the second value represents the estimate obtained with the DEA approach.

The results are reassuring as for all three groups a minor level of administrative discretion ($P_i, t = 0$) implies an efficiency-enhancing effect of grants, whereas when gradually increasing $P_{i,t}$ towards one, the overall effect is detrimental for local efficiency levels.[45] The novel insight is not necessarily the positive of $P_{i,t}$ but its decisive impact on the effect of grants. The main conclusion from our analysis can be summarised as: Independent from the municipality type, the relationship between local policy-makers and the bureaucracy determines whether the assignment of intergovernmental grants benefits or corrupts the level of technical efficiency at which public goods are provided. A high degree of administrative discretion facilitates organisational slack and a waste of resources, and vice versa.

When considering the overall effect of $P_{i,t}$ with mean variable values, this is equal to 2.802 (Cobb-Douglas), 4.539 (Translog) and 0.345 (DEA). The positive and significant coefficients are in line with our hypothesis as well as with the general theory of bureaucracy by Niskanen (1971, 1975).

With respect to our second contribution, the results are a little less clear. The coefficients for the administrative association variables are no longer significant. An exception is the DEA model which continues to indicate an efficiency-enhancing effect. This is in line with the suggested benchmarking aspect among association members.[46] The analysis still suggests that the unique benchmarking feature of administrative associations is indeed of relevance. In fact, since to some extent the models control for economies of scale in the associations, it is the only aspect which we would expect to positively affect the level of efficiency. Lastly, the marked suboptimal use of resources in urban

[45]The overall effect of grants when abstaining from a separate treatment of administrative associations and urban counties was found to be 0.0037** (Cobb-Douglas), 0.0051* (Translog) and 0.0003* (DEA).

[46]The same conclusion is drawn when excluding $P_{i,t}$ in this specification. Details see Table 20 Appendix A6.

counties was found throughout all model specifications such that this seems to be a robust and valid finding. Inferences should, however, be made only with great care considering the small number of cross-sectional units in this group of municipalities.

Table 12: Estimation Results: Inefficiency Model (including $P_{i,t}$). Data: 1998, 2002 and 2004.

	SFA		DEA
Variable	**Cobb-Douglas**	**Translog**	**S.W. (2007)**
Intercept	0.72388	-0.60711	2.33382***
	(1.39631)	(2.39910)	
Grants (per capita)	-0.01527***	-0.01960**	-0.00323***
	(0.00584)	(0.00811)	
Power index (2)	-9.10641**	-9.32070*	-2.19806*
	(3.63798)	(4.9734)	
(Power index)×(Grants p.c.)	0.04083***	0.05181**	0.00787***
	(0.01417)	(0.02044)	
Association dummy	-0.09345	-0.42549	-0.30012*
	(0.34936)	(0.43920)	
(Association dummy)×(Grants p.c.)	0.00054	0.00121	0.00050
	(0.00126)	(0.00130)	
Association size	0.15832	0.21400	0.05884
	(0.18311)	(0.18136)	
(Association size)×(Grants p.c.)	-0.00056	-0.00066	-0.00010
	(0.00069)	(0.00067)	
Urban county dummy	5.91088***	7.79510**	2.36270*
	(2.13398)	(3.4952)	
(Urban county dummy)×(Grants p.c.)	-0.00773***	-0.01055**	-0.00434**
	(0.00294)	(0.00241)	
Students at University (ln)	-0.07869**	-0.14473**	-0.03995***
	(0.03280)	(0.06042)	
Accommodation facilities	0.01392**	0.01615**	0.00326**
	(0.00547)	(0.00704)	
Unemployment rate	-0.00022	-0.01573	-0.01454
	(0.04686)	(0.03996)	
Population density	-0.01348	-0.03460	0.00281
	(0.01606)	(0.02525)	
Abundant Municipalities	1.84151***	1.99180**	0.48580***
	(0.57032)	(0.78421)	
Financially very weak Municipalities	-4.11988***	-6.03470**	-0.48741***
	(1.46210)	(2.41040)	
Herfindahl index	1.87361*	3.16560*	0.05906
	(1.07704)	(1.68160)	
Share of left	0.01505*	0.03330**	-0.00016
	(0.00815)	(0.01529)	
Free voter unions	-0.21856	0.26684	-0.25784*
	(0.24452)	(0.46365)	
Year	-0.06758	-0.14219	0.00648
	(0.05048)	(0.09593)	
Sigma squared ($\hat{\sigma}^2$)	0.14756***	0.16035**	0.34440***
Gamma (γ)	0.91788***	0.92675***	–
Log-likelihood	426.58	452.92	–

$N = 245$, $T = 3$. Total number of observations = 735. 'Power index (2)' denotes the $P_{i,t}$ including all six proxies for local administrative discretion. The results of the inefficiency model can be found in Table 22 in Appendix A6.

Note: the coefficients for those control variables which are used as proxies in $P_{i,t}$ are biased. When considering their effect in the SFA specification, we have: $\partial u/\partial z = (\partial u/\partial P)\cdot(\partial P/\partial z)$. By including them we account for municipality-specific characteristics. The bias does not invalidate the analysis as their coefficient is not of interest and the effect of $P_{i,t}$ is unbiased. The crucial aspect is: $cov(P, z_j) = 1/6cov(\tilde{p}_j, z_j) = 1/6cov(z_j a, z_j) = a/6var(z_j) \neq 1$ (perfect multicollinearity), where $a = 1/(z_{j,min} - z_{j,max})$. With our data this inequality always holds.

7 Discussion and Comparison of the SFA and DEA Models

Section 7 has the purpose of providing a concluding comparison of the employed parametric and non-parametric approaches. In particular, three aspects are considered: (*i.*) descriptive statistics for the SFA and DEA approach to detect tendencies in the estimates and their links to the underlying assumptions, (*ii.*) graphical comparison of the efficiency scores and motivation for the applied bootstrap procedure and finally (*iii.*) a correlation analysis to numerically contrast the two approaches.

7.1 Summary Statistics for the Estimated Efficiency Scores

For a first impression, we calculate the efficiency scores for each individual DMU were – separately for both estimation methods and datasets. The SFA efficiency scores are estimated based on Farrel-type efficiencies (i.e. $E[exp(-u_{i,t})]$). Given the input-orientation of the model the estimated scores range between zero and one (see Olsen and Henningsen 2011). This enables a direct comparison with the efficiency scores $\hat{\theta}_i$ from the linear DEA programme in Equation (4.5). In both cases, a value close to zero denotes a relatively inefficient DMU. For a presumed production technology it is thus possible to reduce overall inputs while keeping the level of output constant. Summary statistics for both datasets are presented in Tables 13 and 14.

An immediate insight is that the estimates from the parametric SFA are on average higher, indicating a lower level of overall inefficiency. A potential explanation for this lies in the stochastic nature of the approach which decomposes deviations from the frontier into an inefficiency part and a component capturing statistical noise. As this distinction is ignored in the DEA estimation, estimated inefficiencies might be higher and supposedly less accurate. The variation among DMUs is, however, slightly higher with DEA. This is similarly likely to be an attribute of its deterministic frontier. It eschews a functional specification to reduce misspecification errors and lets the data determine the structure of the frontier. Consequently, some DMUs are 'spuriously efficient' (Du et al. 2015) and have an efficiency score of one. The number of efficient DMUs is larger in the smaller sample as the time-invariant frontier is less restrictive when considering 3 instead of 15 years.

Table 13: Summary Statistics of Efficiency Scores. Data: 1990 – 2004.

Estimation Model	Mean	S.D.	Min	Median	Max	# Efficient
SFA (Cobb-Douglas)	0.93	0.07	0.20	0.95	0.98	0 (0.0%)
SFA (Translog)	0.93	0.07	0.20	0.95	0.98	0 (0.0%)
Biased DEA	0.77	0.12	0.17	0.77	1.00	116 (3.1%)
Bias-Corrected DEA	0.74	0.11	0.16	0.75	0.98	0 (0.0%)

$N = 245$, $T = 15$. Total number of observations $= 3,675$. Efficiency scores are based on the full model in Table 10.

Table 14: Summary Statistics of Efficiency Scores. Data: 1998, 2002 and 2004.

Estimation Model	Mean	S.D.	Min	Median	Max	# Efficient
SFA (Cobb-Douglas)	0.92	0.09	0.25	0.94	0.98	0 (0.0%)
SFA (Translog)	0.93	0.08	0.28	0.95	0.99	0 (0.0%)
Biased DEA	0.81	0.12	0.26	0.81	1.00	76 (10.3%)
Bias-Corrected DEA	0.76	0.11	0.24	0.77	0.97	0 (0.0%)

$N = 245$, $T = 3$. Total number of observations $= 735$. Efficiency scores are based on the full model in Table 12.

7.2 Graphical Representation of the Estimated Efficiency Scores

In the following, we provide graphical comparisons of the efficiency scores to call attention to (*i.*) the importance of the employed bootstrap procedure, (*ii.*) the functional form specification with the SFA models, and (*iii.*) the relative distributions between the SFA and DEA models. The scatter plots on the left show the estimates for dataset 1 (1990 – 2004), whereas the figures on the right depict the efficiency scores including data for 1998, 2002 and 2004.

For the DEA estimation approach, Figure 5 shows the estimated scores before and after applying the bootstrap procedure. The scatter plots confirm that especially those observations close to the frontier are subject to the bias. The first bootstrap adjusts the input and output observations and yields corrected efficiency scores by solving (4.5) for a second time. Clearly, there are substantial differences and one is well-advised to correct for the bias in such semi-parametric two-step models.

Figure 6 shows the results for the Cobb-Douglas and Translog specification. The efficiency scores are similarly high for most cross-sectional units. Again, it seems recommendable to carry out different functional specifications as there are important differences in the results. A likelihood ratio test identifies the Translog form to be superior in our case.

Figure 5: Scatter Plots of Efficiency Scores from Bias-Correction with DEA Scores.

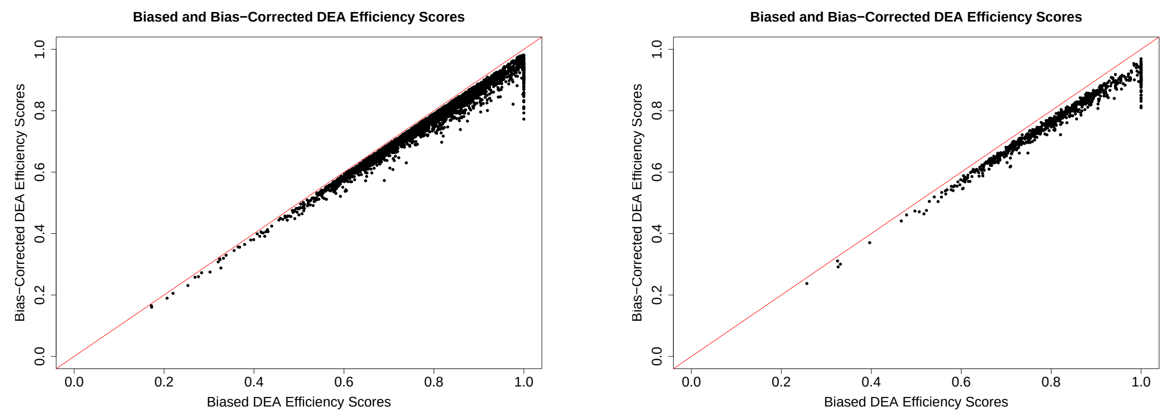
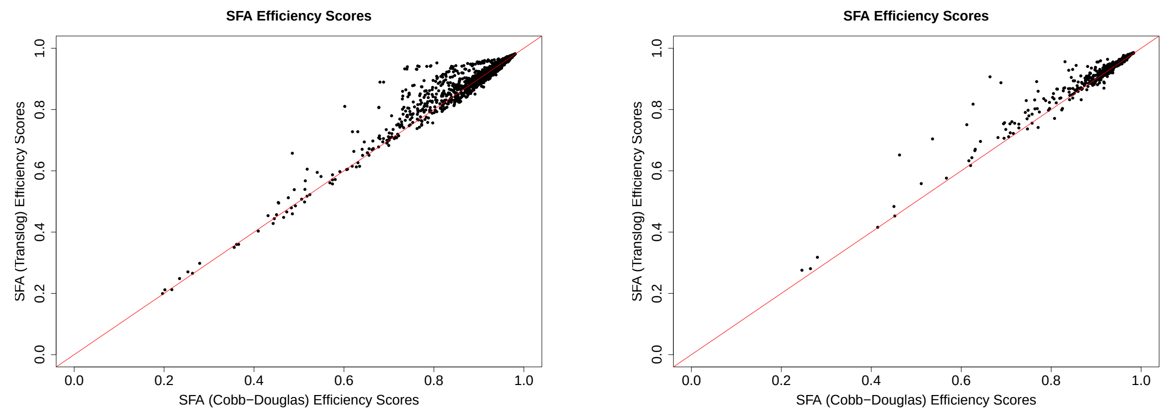
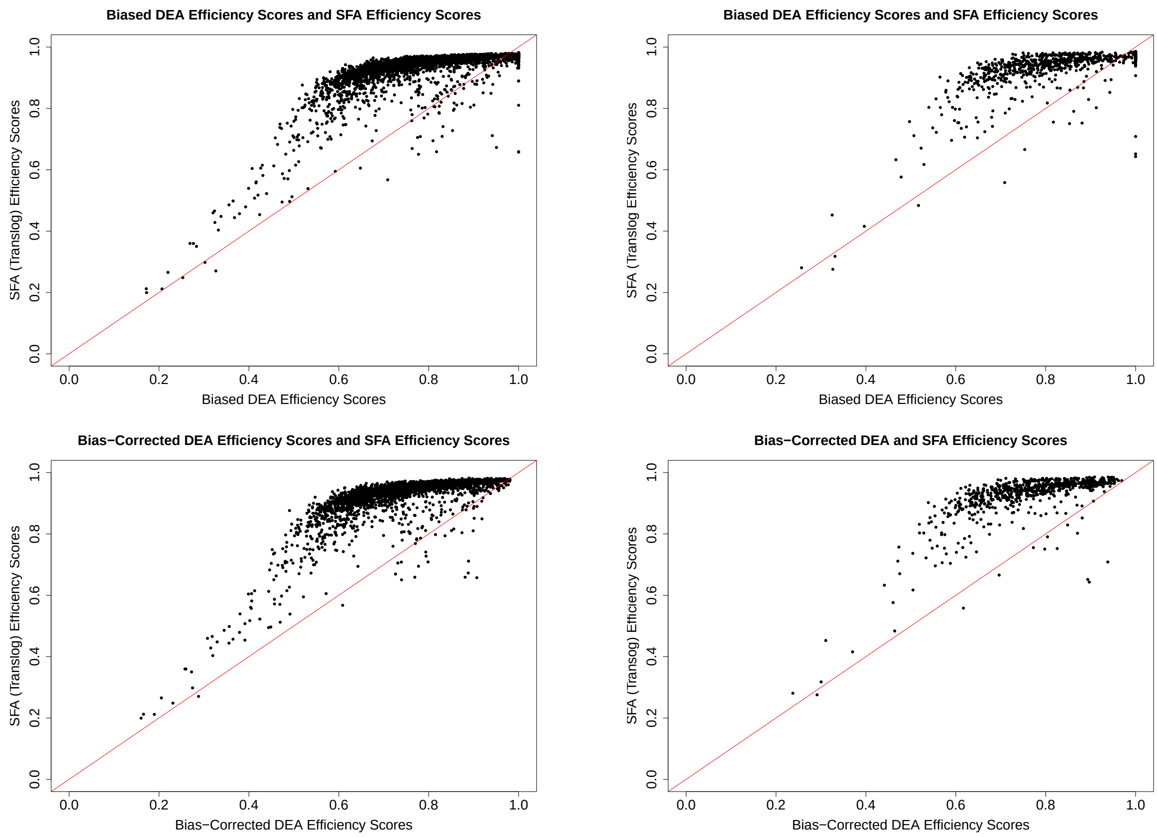


Figure 6: Scatter Plots of Efficiency Scores from both SFA Production Technologies.



Finally, the bias-corrected DEA efficiency scores were plotted against those from the SFA models. The graphs confirm the first impression from the above presented summary statistics about SFA models yielding on average higher efficiency scores. An additional insight concerns the relative distributional patterns. The SFA and DEA models suggest rather similar scores for DMUs located far away from the best-practice frontier and some that are very close to it. The curvature occurs since for some municipalities the DEA approach estimates an average score, whereas they are relatively efficient in terms of the SFA estimates.

Figure 7: Scatter Plots of Efficiency Scores from DEA and SFA Estimates.



7.3 Correlation Analysis

Lastly, we use two concepts of measuring correlation between two variables to numerically compare the two methodological approaches. The motivation for this dual course of action is again to check the sensitivity of the results as there are differences for example regarding variability or the robustness to outliers.[47] The first is the popular *Pearson product moment correlation coefficient* (r_P) defined by:

$$r_P \;=\; \frac{\sum_{i=1}^{N} \omega_i \varphi_i}{\sqrt{\sum_{i=1}^{N} \omega_i^2 \;\sum_{i=1}^{N} \varphi_i^2}}, \tag{7.1}$$

where ω_i and φ_i are the SFA and DEA efficiency scores for municipality i, respectively. Secondly, the *Spearman rank correlation coefficient* (r_S) is calculated in a very similar way but preceding its actual computation, the variables ω_i and φ_i are rank transformed such that each observation gets associated with an integer between 1 and N.[48] The coefficient is then given by:

$$r_S \;=\; \frac{\sum_{i=1}^{N} \omega_{i,r} \varphi_{i,r}}{\sqrt{\sum_{i=1}^{N} \omega_{i,r}^2 \;\sum_{i=1}^{N} \varphi_{i,r}^2}}, \tag{7.2}$$

where the index r denotes the rank transformed variables. The results are provided in Table 15. Naturally, the correlation between the specifications within one of the estimation methods are highest. More interestingly, a consistent finding is the increasing similarity between SFA and DEA scores after applying the bootstrap procedure. Moreover, their correlation is generally higher with the Translog specification. This is not very surprising since it is more general, though not as flexible as the DEA approach when it comes to modelling the best-practice frontier.

Table 15: Correlation Analysis for SFA and DEA Efficiency Scores.

	SFA (1)	SFA (2)	DEA (1)	DEA (2)		SFA (1)	SFA (2)	DEA (1)	DEA (2)
Pearson product moment correlations					**Pearson product moment correlations**				
SFA (1)	1.00				SFA (1)	1.00			
SFA (2)	0.96	1.00			SFA (2)	0.97	1.00		
DEA (1)	0.54	0.64	1.00		DEA (1)	0.56	0.62	1.00	
DEA (2)	0.58	0.68	0.99	1.00	DEA (2)	0.61	0.66	0.98	1.00
Spearman rank correlations					**Spearman rank correlations**				
SFA (1)	1.00				SFA (1)	1.00			
SFA (2)	0.97	1.00			SFA (2)	0.97	1.00		
DEA (1)	0.72	0.78	1.00		DEA (1)	0.68	0.69	1.00	
DEA (2)	0.75	0.80	0.99	1.00	DEA (2)	0.70	0.71	0.99	1.00

The left panel shows the results for the dataset covering the whole period 1990 – 2004. On the right, the equivalent results for the smaller dataset with data for 1998, 2002 and 2004 are documented. (1) and (2) denotes the Cobb-Douglas and Translog SFA specification as well as biased and bias-corrected DEA estimates, respectively.

[47] Details see De Winter et al. (2016).

[48] If e.g. the smallest numbers of one of the variables are identical, then both are ranked as: 1.5 = (1+1)/2. Moreover, for both coefficients, a mean centering procedure is performed first. Details see De Winter et al. (2016).

8 Conclusion

Acknowledging the contradicting findings in the existing literature about efficiency effects of intergovernmental grants, the first major aspect of our study is to provide a consistent framework (namely local administrative discretion) to explain the deviating results. A second question concerns the role of the institutional settings in local governments and their impact on authorities' abilities to achieve an efficient provision of public goods and services. In particular, the possibility of benchmarking the assigned bureaucracy's performance is emphasised and suggested as being a decisive advantage for municipalities which share an administrative body. Both proposed hypothesis are of high interest since fiscal transfers are a common tool in contemporary federalist systems and make up a large fraction of revenue among lower-level governments.

The stated hypotheses were tested using a large panel of municipalities in the German state of Baden-Württemberg. While accounting for deviating production preconditions across municipalities, an index to measure administrative discretion and agenda setting power by the chief bureaucrat is constructed using appropriate proxies. Moreover, the inclusion of municipality-type dummies facilitates the separate treatment of independent jurisdictions, administrative association members and urban counties. The estimated efficiency effects represent the possible proportional reduction in inputs that can be produced without altering the quantity of public output, given the current technology. The findings confirm that depending on the value of the developed index, additional grants distributed to local governments will have an efficiency-enhancing or reducing effect. With regard to the second aspect, the results are less clear but indicate that there is some validity in the proposed benchmarking aspect.

To test the robustness of the results with respect to the assumed reference technology and model specifications, a number of parametric SFA and non-parametric DEA models were estimated. The dual methodological approach proves useful since rather large differences in efficiency scores are observed when looking at the descriptive statistics, relative distributions, and rank correlations. Nonetheless, it is reassuring that the efficiency effects are consistent across the various specifications.

Regarding the principal-agent relationship between the mayor or local council and its bureaucracy, two conclusions can be drawn from the results. To improve the efficient application of locally available grant money, a higher level of transparency and monitoring efforts should be targeted. In view of the laid out arguments and results, less leeway for administrative negligence and a higher accountability of local authorities for own and external financial resources are expected from such measures.[49]

A second insight from the empirical analysis is that the overall effect of intergovernmental grants on technical efficiency is detrimental (when abstaining from a separate treatment of municipality types and their internal characteristics). For many municipalities the effect therefore seems to be unfavourable. Hence, a higher degree of municipal autonomy to levy own taxes might help to mitigate a wasteful use of resources.

[49] The effectiveness of such adjustments is to some extent illustrated by an example of Flemish municipalities. An aforementioned study found efficiency-reducing effects when using data for 1985, whereas a reversed effect was identified in a later analysis with data from 2000. The authors argue that a reform in the late 80's possibly intensified expenditure supervision. Details see De Borger et al. (1994) and Geys and Moesen (2009).

Lastly, the findings concerning the unique characteristics of administrative associations indicate a beneficial impact on the efficient management of local resources. However, the results also suggest that this efficiency-enhancing effect is likely to be due to unexpected reasons (the benchmarking option). Possible policy recommendations for further municipality mergers should be made with great care, especially since differences between voluntary and forced associations are likely.[50] Among other important factors, the municipalities' size is equally likely to influence the effect and the choice to join an association. Given the expected decline in population size in Germany (see Federal Statistical Office 2015), a shared bureaucracy among jurisdictions might nevertheless be an attractive strategy to cope with associated fiscal challenges.

Regarding further aspects of research, an advanced analysis of the benchmarking aspect would be beneficial to control for potential economies of scale in more detail. Furthermore, it is certainly worthwhile to develop a formal model of the benchmarking possibility. From the methodological perspective, it is desirable to develop a semi-dynamic version of our DEA approach, similar to Du et al. (2015). Unfortunately, we were not able to complete a fully functional code for such a new approach. In conclusion, the analysis emphasises the important aspect of internal incentive and decision-making structures in local governments. The suggested framework – though employing rather crude proxies due to data availability problems – provides an explanation for the inconclusive results in former studies and facilitates the development of more tailor-made policy guidelines.

[50]For an empirical analysis and results on this aspect see Blesse and Baskaran (2016).

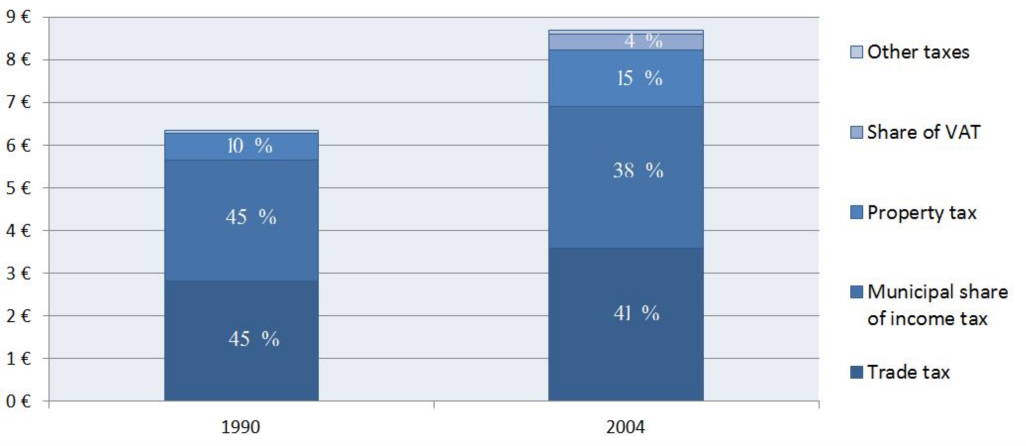
A Appendix

Appendix A1 – Composition of Municipalities Tax Revenue

Figure 8 provides an overview of overall municipal tax revenues in 1990 and 2004. An immediate insight is that overall income accruing from taxes increased by about 1.4 billion euro over the 15 years. This mirrors the qualitative and quantitative increase in municipal tasks for the last decades (see CPE 2008, p. 77).

The municipal share of national income taxes was introduced in 1970 to lower the dependency on the trade tax which fluctuates significantly and endangered balanced finances in the municipalities. It is nowadays one of their most important sources of revenue. Finally, municipalities receive 2.2% of the national value added tax (VAT) revenue.[51]

Figure 8: Composition of Municipal Tax Revenue in Baden-Württemberg (in billion €).



Source: Own figure based on information from Ministry of Finance BW (2006).

[51]Note: The municipal share of the VAT was only introduced in 1998 when the 'trade tax on capital' was abandoned. Up to then it increased the municipal share of the overall trade tax (see Ministry of Finance BW 2006).

Appendix A2 – Measurement of Fiscal Needs for Individual Municipalities

Section 1, § 7 of the Fiscal Equalisation Law Baden-Württemberg regulates that municipality-specific fiscal needs are to be determined according to the total population within a municipality and a multiplier which is used for scaling. The latter depends on how populous the municipality is. The multiplier is:

Table 16: Specified Multipliers to Determine Municipal Fiscal Needs.

Municipal Population	Multiplier
< 3,000	100%
10,000	110%
20,000	117%
50,000	125%
100,000	135%
200,000	155%
500,000	179%
600,000	186%

Soure: Fiscal Equalization Law Baden-Württember (FAG).

of a specified base value which is set by the Ministry of Finance as well as the Ministry of Internal Affairs every year to adequately account for the fiscal situation of municipalities in the state of Baden-Württemberg. For municipalities with a population size between the above ranges, a multiplier proportional to the above and below boundary applies.

Appendix A3 – Bootstrap Procedure by Simar and Wilson (2007, Algorithm #2)

Due to the issues with the presented second-step regression in the DEA model, bias-corrected estimates of the efficiency scores from the linear programme in (4.5) are computed according to:

$$\hat{\hat{\varphi}}_i \;=\; \hat{\varphi}_i \;-\; \widehat{BIAS}(\hat{\varphi}_i) \;=\; 2\hat{\varphi}_i \;-\; \mathcal{B}_1^{-1} \sum_{b1=1}^{\mathcal{B}_1} \hat{\varphi}^*_{b1}, \tag{A.1}$$

where $\hat{\varphi}_i$ are the corrected efficiency scores after the first bootstrapping and $\widehat{BIAS}$ is an estimate for the bias in φ_i due to the discussed issues with the second-stage regression. $\mathcal{B}_1$ equals the number of the first bootstrap replications and $\hat{\varphi}^*_b$ the bth hypothetical efficiency score simulated by the bootstrapping procedure.

The details of the second algorithm for the bootstrap procedure as presented in Simar and Wilson (2007) and adjusted to the structure of our model specifications is given by:

1. Using the available observations on the input and output variables x and y, calculate the estimates for the efficiency scores $\hat{\theta}_i$ according to the linear programme in (4.5) for all cross-sectional units. Obtain the reciprocals ($\hat{\varphi}_i$) of these estimates.
2. Obtain estimates for δ ($\hat{\delta}$) and σ_ε ($\hat{\sigma_\varepsilon}$) via truncated maximum likelihood for the regression model in (4.7), using only the $m < n$ observations for which $\hat{\varphi}_i > 1$.
3. Loop over the next four steps L_1 times[52] to get one set of bootstrap estimates $\mathcal{B}_i = \{\hat{\varphi}^*_{ib}\}_{b=1}^{L_1}$ for each individual DMU.
   - 3.1. Draw ε_i $\forall i$ from the normal distribution $\mathcal{N}(0, \hat{\sigma}^2_\varepsilon)$ with a left truncation at $(1 - z_i\hat{\delta})$.
   - 3.2. For each i, compute $\varphi^*_i = z_i\hat{\delta} + \varepsilon_i$.
   - 3.3. Set $x^*_i = x_i$ and $y^*_i = y_i(\hat{\varphi}_i/\varphi^*_i)$, again for all $i = 1, \ldots, N$. This is a projection of the observed inputs and outputs on the estimated best-practice frontier and a projection of the output variables (since an input-oriented approach is used) somewhere away from the frontier by using the randomly adjusted φ^*_i from above (see Bischoff et al. 2013).
   - 3.4. Compute $\hat{\varphi}^*_i$ for each DMU according the linear programme in (4.5) but replacing the observed inputs and outputs $(x_i,\ y_i)$ by their adjusted counterparts x^*_i and y^*_i from above.[53]
4. For all municipalities, compute the bias-corrected estimator $\hat{\hat{\varphi}}_i$ according to (A.1).
5. Finally, estimate a truncated regression of $\hat{\hat{\varphi}}_i$ on the environmental variables z_i via maximum likelihood to obtain bias-corrected estimates for δ and σ_ε, namely $\hat{\hat{\delta}}$ and $\hat{\hat{\sigma}}_\varepsilon$. Steps 1-5 complete

[52] L_1 was set to 200. Simar and Wilson (2007) suggest that 100 iterations are presumably sufficient.

[53] Drawing the errors randomly in step 3.1 and using them to calculate φ^*_i for the projections is more reliable than a naive resampling bootstrap where φ^*_i is simply drawn from the set of biased estimates of $\hat{\varphi}_i$ as used in related approaches and criticised by Simar and Wilson (2007, p.33).

the computation of bias-corrected estimates of the two above coefficients. The following steps 6. and 7. are used to calculate corrected confidence intervals for the bias-corrected coefficients in the second-stage regression.

6. Loop over the next three steps L_2[54] times to get a second set of bootstrap estimates $\mathscr{C} = \{(\hat{\delta}^*, \sigma_\varepsilon^*)_b\}_{b=1}^{L_2}$ this time for the coefficients in the second-step regression.
   - 6.1. For each DMU i, draw ε_i from the normal distribution $\mathcal{N}(0, \hat{\hat{\sigma}}_\varepsilon)$ with a left truncation at $(1 - z_i\hat{\hat{\delta}})$.
   - 6.2. Compute $\varphi_i^{**} = z_i\hat{\hat{\delta}} + \varepsilon_i \; \forall i$.
   - 6.3. Estimate a truncated regression of φ^{**} on the environmental variables z_i via the maximum likelihood method which yields the estimates $\hat{\hat{\delta}}^*$ and $\hat{\hat{\sigma}}_\varepsilon^*$.
7. In a final step, use the bootstrap values in $\mathscr{C}$ and the bias-corrected estimates $\hat{\hat{\delta}}$ and $\hat{\hat{\sigma}}_\varepsilon$ to construct estimated confidence intervals for all δ and for σ_ε.

The above algorithm is nowadays implemented in a number of statistical software programmes. In our estimations we used the rDEA package in R, implemented by Simm and Besstremyannaya (2016).

[54] L_2 was set to 2,000, following Simar and Wilson (2007, p. 44).

Appendix A4 – Data

Table 17 below documents the summary statistics for all variables in dataset 1, covering all 15 years from 1990 – 2004. The variables are used in the first two models presented in Section 6.1 and 6.2.

Table 17: Summary Statistics. Data: 1990 – 2004.

			Quantiles				
Variable	**Mean**	**S.D.**	**Min**	**.25**	**Mdn**	**.75**	**Max**
Net current expenditure p.c. (in €)	1,660.02	486.79	956.38	1,394.95	1,566.38	1,794.91	9,644.16
Total population	28,484	49,050	8,203	11,609	15,626	26,190	598,469
Number of students in public schools	1,691	2,293	417	797	1,049	1,762	27,625
Share of population older than 65	15.62	2.40	8.61	14.02	15.62	17.09	27.80
Social insured employees (at place of work)	12,339	28,713	663	3,156	5,116	10,235	385,197
Recreational area (in are)	6,116	10,242	376	2,049	3,343	6,040	110,841
Grants p.c.	354.59	132.71	33.48	272.14	349.04	421.50	1,898.35
Power index (1)	0.52	0.20	0.01	0.41	0.44	0.47	0.99
Association dummy	0.58	0.49	0	0	1	1	1
Association size	2.43	1.79	1	1	2	3	14
Urban county dummy	0.04	0.19	0	0	0	0	1
(Power index)(Grants)	194.94	133.57	1.80	113.42	149.37	218.07	1,788.07
(Association)(Grants)	211.26	203.06	0.00	0.00	249.30	377.03	1,898.35
(Assoc. size)(Grants)	887.64	789.87	50.28	341.46	665.44	1,251.97	9,077.73
(Urban c.)(Grants)	23.64	122.67	0.00	0.00	0.00	0.00	910.05
University students	870	4,161	0	0	0	0	35,152
Number of accommodation facilities	12.88	18.03	0	4	8	14	155
Unemployment rate	6.22	1.81	1.78	4.92	6.25	7.42	13.30
Population density	5.72	4.56	0.68	2.41	4.28	7.71	28.86
Abundant municipalities	0.08	0.28	0	0	0	0	1
Financially weak municipalities	0.71	0.45	0	0	0	0	1
Financially very weak municipalities	0.20	0.40	0	0	0	0	1
Herfindahl index	0.34	0.07	0.21	0.29	0.33	0.37	1.00
year	8	4.32	1	4	8	12	15

$N = 245$, $T = 15$. Total number of observations = $3,675$. 'Power index (1)' denotes the limited $P_{i,t}$ including the two proxies 'Herfindahl index' and 'financially very weak municipalities'.

Appendix A5 – Likelihood Ratio Tests

The tables below report the results of the three likelihood ratio tests for both SFA models. The first tests the null hypothesis (H_0) of all coefficients in the *inefficiency model* being simultaneously equal to zero (first two rows). The second evaluates the relevance of the institutional design variables (third and fourth row). Based on the obtained p-values, the respective H_0s are rejected at the 1% level. Lastly, we test the Cobb-Douglas and Translog model against each other (final row). Tables 18 and 19 document the results for dataset 1 and dataset 2, respectively.

Table 18: Likelihood Ratio Tests. Data: 1990 – 2004.

Model 1	**Model 2**	$\mathcal{L}(1)$	$\mathcal{L}(2)$	$Pr(>\chi^2)$
Full Model (Cobb-Douglas)	OLS (No Inefficiency)	2,230.3	1,510.7	0.00
Full Model (Translog)	OLS (No Inefficiency)	2,314.5	1,696.3	0.00
Full Model (Cobb-Douglas)	No Inst. Design Variables	2,230.3	2,176.2	0.00
Full Model (Translog)	No Inst. Design Variables	2,304.9	2,314.5	0.01
Full Model (Cobb-Douglas)	Full Model (Translog)	2,230.3	2,314.5	0.00

$N = 245$, $T = 15$. Total number of observations $= 3,675$. 'Full Model' denotes the specification including $P_{i,t}$ and the municipality-type dummies.

Table 19: Likelihood Ratio Tests. Data: 1998, 2002 and 2004.

Model 1	**Model 2**	$\mathcal{L}(1)$	$\mathcal{L}(2)$	$Pr(>\chi^2)$
Full Model (Cobb-Douglas)	OLS (No Inefficiency)	426.58	251.62	0.00
Full Model (Translog)	OLS (No Inefficiency)	452.92	324.67	0.00
Full Model (Cobb-Douglas)	No Inst. Design Variables	426.58	408.66	0.00
Full Model (Translog)	No Inst. Design Variables	452.92	436.56	0.00
Full Model (Cobb-Douglas)	Full Model (Translog)	426.58	452.92	0.00

$N = 245$, $T = 3$. Total number of observations $= 735$. 'Full Model' denotes the specification including $P_{i,t}$ and the municipality-type dummies.

Appendix A6 – Additional Results

Table 20 provides the estimates for dataset 2 (1998, 2002 and 2004) when the index $P_{i,t}$ is excluded. The results confirm the conclusions from the estimation model including the entire period of 15 years (Table 8). When excluding $P_{i,t}$, the efficiency effect of grants tends to be positive and thus efficiency-reducing. Similarly, the results continuously hint to a better performance regarding the local provision of public goods and services in administrative associations.

Table 20: Estimation Results: Inefficiency Model ($P_{i,t}$ excluded) Data: 1998, 2002 and 2004.

	SFA		DEA
Variable	**Cobb-Douglas**	**Translog**	**S.W. (2007)**
Intercept	-3.63254*	-5.42312	1.47725***
Grants per capita	0.00406**	0.00585*	0.00014
Association dummy	-0.39083	-1.18621	-0.43939**
(Association dummy)×(Grants p.c.)	0.00230	0.00445	0.00093**
Association size	0.32847	0.59424	0.07302
(Association size)×(Grants p.c.)	-0.00128	-0.00195	-0.00015
Urban county dummy	4.88465*	4.88465*	1.37231*
(Urban county dummy)×(Grants p.c.)	-0.00519	-0.01163*	-0.00270
Students at University (ln)	-0.05231	-0.13748*	-0.03610***
Accommodation facilities	0.01019*	0.01910*	0.00304**
Unemployment rate	-0.03419	-0.07880	-0.01664
Population density	0.00729	-0.00383	0.00545
Abundant Municipalities	2.61080***	3.09560**	0.52223***
Financially very weak Municipalities	-1.90387**	-3.15344*	-0.24370***
Herfindahl index	1.45622	2.40237	-0.03472
Share of left	0.00579	0.02104	-0.00177
Free voter unions	-0.88801***	-0.97357*	-0.30225***
Year	0.01292	0.03701	0.012289
Sigma (σ^2)	0.20123***	0.23932**	0.34849***
Gamma (γ)	0.93833***	0.94982***	–
Log-likelihood	414.96	440.80	–

$N = 245$, $T = 3$. Total number of observations = 735. Significance levels of 1%, 5% and 10% are denoted by ***, ** and *, respectively.

The two tables below report the estimates from the (first-stage) *frontier model* and thus the influence which the five (six) output variables have on the best-practice frontier. As can be seen from Table 22, the variable 'Kindergarten places' (only available for the model including the years 1998, 2002 and 2004) adds valuable information to the model and facilitates the classification of municipalities into efficient and less efficient DMUs.

Table 21: SFA Estimation Results. Data: 1990 – 2004.

Frontier Model – Battese and Coelli (1995)				
Variable	**Cobb-Douglas**		**Translog**	
	Coefficient	Stand. Err.	Coefficient	Stand. Err.
Intercept	6.43387***	(0.06676)	8.56759***	(1.08067)
(A) Students in public schools	-0.09025***	(0.01471)	-0.22618	(0.43514)
(B) Total population	1.00418***	(0.02396)	1.09359	(0.81288)
(C) Share of popul. older than 65	-0.00118	(0.01862)	-0.22030	(0.48377)
(D) Social insured employees	0.15200***	(0.00704)	-0.07121	(0.21643)
(E) Recreational area	0.00494	(0.00424)	-0.02696	(0.13605)
$(A)^2$	–		0.11680	(0.12846)
$(B)^2$	–		-0.38203	(0.32437)
$(C)^2$	–		-0.20910	(0.14337)
$(D)^2$	–		0.09291***	(0.02421)
$(E)^2$	–		0.04888***	(0.01061)
$(A) \times (B)$	–		0.37988	(0.34458)
$(A) \times (C)$	–		-0.38630*	(0.20777)
$(A) \times (D)$	–		-0.07250	(0.08429)
$(A) \times (E)$	–		-0.16859***	(0.05920)
$(B) \times (C)$	–		0.65382*	(0.37981)
$(B) \times (D)$	–		-0.22453	(0.14662)
$(B) \times (E)$	–		0.15417*	(0.08775)
$(C) \times (D)$	–		0.17018*	(0.08755)
$(C) \times (E)$	–		-0.17037***	(0.05877)
$(D) \times (E)$	–		0.03171	(0.02312)
Year	0.01420***	(0.01460)	0.64445***	(0.00062)

$N = 245$, $T = 15$. Total number of observations = 3,675. Significance levels of 1%, 5% and 10% are denoted by ***, ** and *, respectively. Standard errors for the SFA estimates are given in parentheses. The input and all output variables are in natural logs (except for the year variable). Note: The above coefficients correspond to the specification including $P_{i,t}$. When excluding this variable the coefficients are almost identical and are therefore omitted.

Table 22: SFA Estimation Results. Data: 1998, 2002 and 2004.

Frontier Model – Battese and Coelli (1995)				
Variable	**Cobb-Douglas**		**Translog**	
	Coefficient	Stand. Err.	Coefficient	Stand. Err.
Intercept	6.59307***	(0.19597)	2.44960	(4.53650)
(A) Students in public schools	-0.13761***	(0.04065)	0.94689	(1.44090)
(B) Total population	1.00742***	(0.07504)	7.20830*	(3.69800)
(C) Share of popul. older than 65	-0.00383	(0.04987)	-4.84450**	(1.98960)
(D) Social insured employees	0.16388***	(0.01619)	0.57168	(0.64603)
(E) Recreational area	-0.00752	(0.00990)	-0.53064	(0.42545)
(F) Kindergarten places	0.04185	(0.04919)	-3.01730	(2.14900)
$(A)^2$	–		-0.06060	(0.41782)
$(B)^2$	–		-3.09830*	(1.59300)
$(C)^2$	–		-1.27330**	(0.54679)
$(D)^2$	–		0.11677*	(0.05969)
$(E)^2$	–		0.05503**	(0.02491)
$(F)^2$	–		-1.16470*	(0.64197)
$(A) \times (B)$	–		-0.33007	(1.18040)
$(A) \times (C)$	–		-0.41233	(0.73275)
$(A) \times (D)$	–		-0.35004	(0.28713)
$(A) \times (E)$	–		-0.00000	(0.16052)
$(A) \times (F)$	–		1.24540*	(0.70681)
$(B) \times (C)$	–		4.32810**	(1.72940)
$(B) \times (D)$	–		-0.37260	(0.48745)
$(B) \times (E)$	–		0.50803	(0.31108)
$(B) \times (F)$	–		2.25790	(1.76150)
$(C) \times (D)$	–		0.08436	(0.28604)
$(C) \times (E)$	–		-0.32133*	(0.18208)
$(C) \times (F)$	–		-1.13850	(1.02750)
$(D) \times (E)$	–		0.04.467	(0.05556)
$(D) \times (F)$	–		0.35202	(0.28816)
$(E) \times (F)$	–		-0.40466*	(0.22397)
Year	0.02670***	(0.00730)	0.02744***	(0.00754)

N = 245, T = 3. Total number of observations = 735. Significance levels of 1%, 5% and 10% are denoted by ***, ** and *, respectively. Standard errors for the SFA estimates are given in parentheses. The input and all output variables are in natural logs (except for the year variable). Note: The above coefficients correspond to the specification including $P_{i,t}$. When excluding this variable the coefficients are almost identical and are therefore omitted.

Appendix A7 – Results (Variable-Returns-to-Scale Specification)

Tables 23 and 24 below document the results of the same model specification as in Tables 8 and 10 in Section 6.1 and 6.2 but with a variable-returns-to-scale assumption regarding the production technology. The single estimates are almost identical. This is not very surprising since the variable-returns-to-scale assumption is simply a combination of the case with non-increasing and increasing returns to scale.

Table 23: Estimation Results: Inefficiency Model (VRS/ $P_{i,t}$ excluded). Data: 1990 – 2004.

	SFA		DEA (VRS)
Variable	**Cobb-Douglas**	**Translog**	**S.W. (2007)**
Intercept	-7.02471***	-13.65400**	0.91101***
	(2.31537)	(5.38540)	
Grants per capita	0.00487***	0.00832***	0.00013
	(0.00164)	(0.00308)	
Association dummy	1.00594**	0.90977	-0.23399***
	(0.43419)	(0.59847)	
(Association dummy)×(Grants p.c.)	-0.00488***	-0.00674**	0.00037*
	(0.00185)	(0.00331)	
Association size	-0.14860	-0.25659	0.03771*
	(0.13708)	(0.24476)	
(Association size)×(Grants p.c.)	0.00058	0.00118	-0.00005
	(0.00042)	(0.00073)	
Urban county dummy	5.89034***	12.45800***	0.42562*
	(2.18297)	(4.35520)	
(Urban county dummy)×(Grants p.c.)	-0.00591**	-0.01354***	-0.00109*
	(0.00272)	(0.00433)	
Students at University (ln)	-0.06461*	-0.27686***	-0.04357***
	(0.03537)	(0.09795)	
Accomodation facilities	0.00783**	0.01818*	0.00085
	(0.00397)	(0.00963)	
Unemployment rate	-0.02750	-0.06896**	-0.00059
	(0.01959)	(0.03049)	
Population density	0.00232	-0.06274	0.00190
	(0.01342)	(0.04536)	
Abundant Municipalities	4.50015***	8.58270**	0.54175***
	(1.45743)	(3.55680)	
Financially very weak Municipalities	-1.35263***	-4.92600**	-0.14431***
	(0.35069)	(2.16400)	
Herfindahl index	2.59587***	4.54500***	0.31424**
	(0.71975)	(1.17760)	
Year	0.00272***	0.10100**	0.01547***
	(0.01325)	(0.04044)	
Sigma squared ($\hat{\sigma}^2$)	0.29747***	0.64445**	0.36932**
Gamma (γ)	0.95962***	0.98243***	–
Log-likelihood	2224.55	2311.46	–

$N = 245$, $T = 15$. Total number of observations = $3,675$. Significance levels of 1%, 5% and 10% are denoted by ***, ** and *, respectively. Standard errors for the SFA estimates are given in parentheses.

Table 24: Estimation Results: Inefficiency Model (VRS/ including $P_{i,t}$). Data: 1990 – 2004

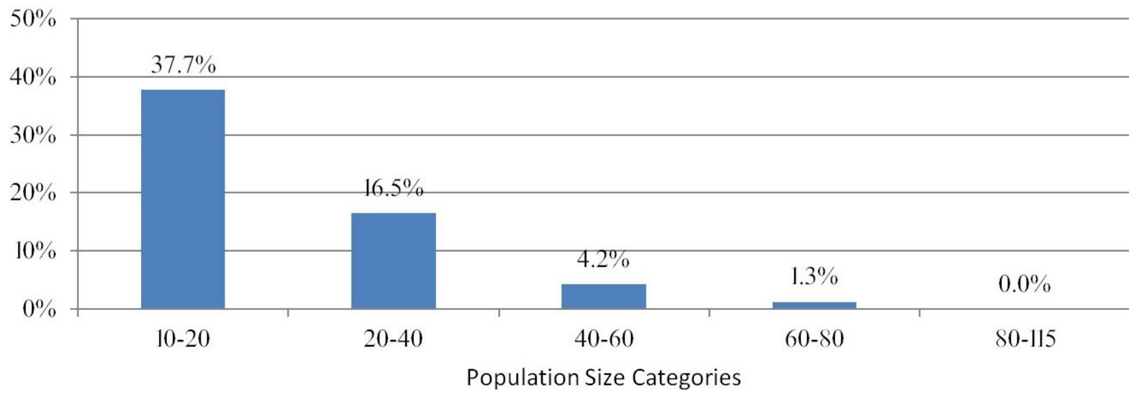
	SFA		DEA (VRS)
Variable	**Cobb-Douglas**	**Translog**	**S.W. (2007)**
Intercept	-4.54591***	-9.62711***	1.41270***
	(1.69233)	(3.31985)	
Grants per capita	0.00135	0.00353	-0.00045*
	(0.00125)	(0.00225)	
Power index (1)	-4.44995***	-9.16353***	-0.87542***
	(1.67159)	(3.28963)	
(Power index)×(Grants p.c.)	0.00792**	0.01304*	0.00110***
	(0.00352)	(0.00689)	
Association dummy	1.29144**	1.54116**	-0.19647***
	(0.58731)	(0.65856)	
(Association dummy)×(Grants p.c.)	-0.00618**	-0.00951**	0.00026
	(0.00263)	(0.00374)	
Association size	-0.14339	-0.30055**	0.03638*
	(0.11744)	(0.13866)	
(Association size)×(Grants p.c.)	0.00060	0.00135**	-0.00005
	(0.00043)	(0.00056)	
Urban county dummy	6.26227***	13.72526***	0.68139
	(2.27964)	(4.10871)	
(Urban county dummy)×(Grants p.c.)	-0.00679**	-0.01508***	-0.00155**
	(0.00277)	(0.00418)	
Students at University (ln)	-0.06535**	-0.29897***	-0.04379***
	(0.03046)	(0.07239)	
Accomodation facilities	0.00789**	0.01636**	0.00081
	(0.00321)	(0.00808)	
Unemployment rate	-0.03507	-0.08743**	-0.00085
	(0.02376)	(0.07187)	
Population density	0.00604	-0.06515	0.00154
	(0.01176)	(0.046410)	
Abundant Municipalities	4.34965***	9.24059***	0.52499***
	(1.51614)	(3.42964)	
Financially very weak Municipalities	-1.46056*	-4.41730*	0.05601
	(0.86835)	(2.29743)	
Herfindahl index	1.32599	1.35194	–
	(0.82977)	(0.82243)	
Year	0.04124**	0.10780***	0.01563***
	(0.01785)	(0.02546)	
Sigma squared ($\hat{\sigma}^2$)	0.29437***	0.70101***	0.36827***
Gamma (γ)	0.95904***	0.98376***	–
Log-likelihood	2230.31	2314.51	–

N = 245, T = 15. Total number of observations = 3,675. Standard errors for the SFA estimates are given in parentheses. 'Power index (1)' denotes the limited $P_{i,t}$ including the two proxies 'Herfindahl index' and 'financially very weak municipalities'.

Appendix A8 – Additional Information

Figure 9 below illustrates the distribution of municipalities which are organised in administrative associations across five different population size categories. Not surprisingly, the share of municipalities which are a member of an administrative association is largest among the less populous jurisdictions. They are presumably the ones which benefit the most from benchmarking possibilities, economies of scale and a reduction in fix costs. However, there are also a number of administrative associations among the bigger municipalities with a population larger than 20,000.

Figure 9: Share of Administrative Association Members Across Population Size (in thousands).



Source: Own figure based on information from the Statistical Office Baden-Württemberg. The nine urban counties have been excluded in the calculations.

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