Institut für Wirtschaftsforschung Halle *Halle Institute for Economic Research*

Does Intermunicipal Cooperation Increase Efficiency? Evidence from the Hessian Wastewater Sector

Frédéric Blaeschke
Peter Haug

November 2014 No. 11

IWH-Diskussionspapiere
IWH Discussion Papers

Authors: *Peter Haug*
Halle Institute for Economic Research (IWH)
Research Area Urban Economics
E-mail: Peter.Haug@iwh-halle.de
Phone: +49 345 7753 709

Frédéric Blaeschke
University of Kassel
Department of Economics
E-mail: blaeschke@uni-kassel.de
Phone: +49 561 804 3087

The responsibility for discussion papers lies solely with the individual authors. The views expressed herein do not necessarily represent those of the IWH. The papers represent preliminary work and are circulated to encourage discussion with the authors. Citation of the discussion papers should account for their provisional character; a revised version may be available directly from the authors.

Comments and suggestions on the methods and results presented are welcome.

IWH Discussion Papers are indexed in RePEc-EconPapers and in ECONIS.

Editor:
HALLE INSTITUTE FOR ECONOMIC RESEARCH – IWH
The IWH is a member of the Leibniz Association.

Address: Kleine Maerkerstrasse 8, D-06108 Halle (Saale), Germany
Postal Address: P.O. Box 11 03 61, D-06017 Halle (Saale), Germany
Phone: +49 345 7753 60
Fax: +49 345 7753 820
Internet: http://www.iwh-halle.de

ISSN 1860-5303 (Print)
ISSN 2194-2188 (Online)

Does Intermunicipal Cooperation Increase Efficiency? Evidence from the Hessian Wastewater Sector

Abstract

This paper analyzes the relationship between intermunicipal cooperation and efficiency of public service provision. The organizational arrangements, including self-provision, joint pro-vision or contracting, affect politicians' and bureaucrats' incentives as well as internal transaction costs. Hence, cooperation gains from scale effects have to be weighed against technical inefficiencies. We analyze wastewater disposal for a unique dataset of small and medium-sized Hessian municipalities. We employ a two-stage DEA (DEA = Data Envelopment Analysis) bootstrap approach to calculate relative efficiency measures controlling for organizational arrangements and further environmental variables. Jointly providing municipalities and contractor municipalities score lower in terms of technical efficiency than self-providing and contracting municipalities. The scope for increasing scale efficiency turns out to be limited and hence, only small municipalities may benefit from scale economies from cooperation. The findings suggest that small municipalities should rely on contracting or on joint provision with a high degree of vertical integration.

Keywords: municipal cooperation, local public finance, efficiency, DEA, sewage disposal

JEL Classification: D23, D24, D73, H72, R5

Wie wirkt sich interkommunale Kooperation auf die Effizienz der öffentlichen Leistungserstellung aus? Eine Untersuchung für die hessische kommunale Abwasserentsorgung

Zusammenfassung

In diesem Papier wird der Zusammenhang zwischen interkommunaler Zusammenarbeit und Effizienz der öffentlichen Leistungserstellung analysiert. Diejenigen Organisationsformen, die Eigenerstellung, gemeinsame Bereitstellung oder vertragliche Vergabe umfassen, beeinflussen sowohl die Anreizstrukturen für Politiker und Verwaltung als auch die internen Transaktionskosten. Folglich müssen Größenvorteile gegen technische Ineffizienzen abgewogen werden. Dazu wird die Abwasserentsorgung anhand eines singulären Datensatzes für kleine und mittlere hessische Kommunen analysiert. Hierbei kommt ein zweistufiges DEA-Bootstrap-Verfahren (DEA = Data Envelopment Analysis) zum Einsatz, um die relativen Effizienzmaße zu berechnen, wobei für die Organisationsformen und weitere Umweltvariablen kontrolliert wird. Es zeigt sich, dass gemeinsam bereitstellende Gemeinden und Auftragnehmergemeinden (d. h. Gemeinden, die das Abwasser anderer Gemeinden in eigenen Anlagen klären) hinsichtlich ihrer technischen Effizienz schlechter abschneiden als eigenerstellende Gemeinden oder auslagernde Gemeinden. Es stellt sich heraus, dass der Spielraum für eine Steigerung der Skaleneffizienz begrenzt ist, und daher möglicherweise nur kleine Gemeinden von Kooperationslösungen profitieren. Die Ergebnisse legen nahe, dass kleine Gemeinden die vertragliche Vergabe von Leistungen oder eine in hohem Maße vertikal integrierte gemeinsame Bereitstellung bevorzugen sollten.

Schlagwörter: interkommunale Kooperation, Kommunalfinanzen, Effizienz, DEA, Abwasserentsorgung

JEL-Klassifikation: D23, D24, D73, H72, R5

1. Introduction

Do cooperating municipalities provide public services more efficiently than those that provide services solely by themselves? Scholars and practitioners have emphasized potential efficiency gains as the primary reason for intermunicipal cooperation (e.g. Hulst and van Montford 2007). Intermunicipal cooperation has been considered as an alternative means of cost savings and efficiency improvements. Although the argument is intuitively appealing, efficiency gains from cooperative action tend to be assumed ex ante rather than to be evaluated or quantified ex post. Moreover, the major focus has been on size-related efficiency gains (economies of scale and scope) in the tradition of the German public administration literature (Wagener 1974). Little is known about how different arrangements affect the incentives of bureaucrats and politicians. Whereas the understanding for the determinants of different institutional arrangements has been continuously growing, we still know little about the consequences. Hulst and van Montford (2007) affirm this observation in their conclusion stating that "[t]here is hardly any evidence to make statements about the performance of joint standing organizations compared to stand-alone municipal agencies." (p. 228). With this contribution we want to help filling this gap.

In this contribution we analyze the effect of intermunicipal cooperation on the efficiency of municipal service provision. We distinguish between self-providing municipalities and two archetypical forms of cooperation: Joint provision and external production. The former is given when municipalities transfer a task to an intermunicipal body such as a single-purpose association or a joint venture owned by several municipalities. The latter type is given when a municipality transfers tasks to other municipalities by contract. A single-purpose association can be seen as a strongly institutionalized form of intermunicipal cooperation. Intermunicipal service contracts are rather weakly institutionalized as they do not require an additional intermunicipal body.

Insights from bureaucracy theory and transaction cost theory suggest that these organizational arrangements affect the incentives of municipal decision makers and the level of transaction costs. Therefore, there will be a trade-off between potential gains from economies of scale, on the one hand, and technical (in-)efficiency driven by organizational characteristics on the other. A given output is said to be provided *technically efficient* or X-efficient if it cannot be produced with fewer input factors. *Scale efficiency* is given if it is not possible for a municipality to improve the input-output-ratio by choosing a different output quantity, given that it already operates technically efficient (and does not change the input or output mix). Whereas scale efficiency is determined by the characteristics of the production process, technical efficiency depends to a great deal on the actors' incentives and the transaction costs of the organizational arrangement.[1]

Efficiency analysis of the public sector is often difficult due to data constraints (e.g. Blank and Knox Lovell 2000, 12-15), especially due to the measurement and definition problem of public outputs. Hence, we focus our analysis on a category of public services where these problems are less imminent: Sewage collection and treatment. In (West-)Germany, sewage-related services have been, at least since the 1960s, a well-established and widespread field of intermunicipal cooperation with internally homogenous and externally heterogeneous institutional forms. As the cooperation structures in this sector have been relatively stable the sector is well-suited to gain general insights about the different efficiency aspects of intermunicipal cooperation.

To the best of our knowledge, this paper is the first study on relative efficiency and intermunicipal cooperation for the case of the municipal wastewater sector (see section 2). The municipal wastewater treatment in the German state of Hessen can be seen as a good example to study the efficiency of organizational arrangements as alternative forms of public sector production. Since material privatization is uncommon in Hessian wastewater disposal and treatment, our analysis focuses solely on public sector arrangements.

The analysis sheds some light upon the real-world complexity of organizational arrangements within this field of public service provision. Our study provides evidence that municipalities that jointly provide wastewater services are technically less efficient than municipalities that self-provide wastewater services or contract with other municipalities. Our regression results suggest that cooperation in wastewater services is beneficial mainly for smaller municipalities (scale effects) and that – if cooperation is restricted to sewage cleaning – informal cooperation should be preferred to strongly institutionalized forms.

The paper is organized as follows: Section 2 briefly reviews related fields of research. Section 3 discusses theoretical implications from public choice and transaction cost theory for the nexus between the organizational arrangements and technical efficiency. Section 4 presents

[1] The definitions of scale and technical efficiency draw on Coelli et al. (2005, 2-4). Technical efficiency and scale efficiency of different decision-making units may be interrelated. For example, a municipality which contracts out the provision of a municipal service to a neighboring community or to a single-purpose association may benefit from economies of scale and hence, from a higher scale efficiency at the level of the other municipality/the association. This in turn will reduce ceteris paribus the inputs that can be allocated to the contracting municipality for the provision of an equal service quantity and quality and hence, will increase its technical efficiency. For the sake of clarity we address ths issue in section 5.1 in more detail.

the empirical method, data and the key characteristics of the Hessian municipal wastewater sector. Section 5 provides the main results. The final sections discuss and conclude.

2. Related literature

The schools of public choice theory and new institutional economics have had a major impact on the debate of how economic activity should be organized. Both traditions make use of the agency theory framework. Agency problems result from information asymmetries and are believed to be a central source of inefficiency. In modern representative democracies agency problems often take the form of two stage principal-agent relationships, namely between the citizens (principals) and the politicians (agents) and between politicians (principals) and bureaucrats (agents). The latter have an informational advantage regarding the true costs of their activity and may therefore exploit their position to pursue private objectives (e.g. Niskanen 1971; Moe 2006).

For analytical reasons two polar types of politicians can be considered: Benevolent politicians who act on behalf of their citizens' interest (i.e. they act as social planers trying to maximize local social welfare) and – in the public choice tradition - opportunistic politicians who pursue own objectives, most prominently career concerns and vote maximization . In the case of benevolent politicians the major agency problem arises only between politicians and bureaucrats. In the case of opportunistic politicians the information asymmetry between politicians and citizens becomes an additional source of inefficiency (e.g. Shleifer 1998). The polar cases affect the stages of the agency relationship: Under a benevolent politician inefficiencies will arise only from the second stage whereas under opportunistic politicians inefficiencies may arise additionally at the first stage. The true political behavior probably lies somewhere in between these extremes.

The main sources of bureaucrats' private utility are size- and career-related factors (large budgets, overprovision) or factors related to slack resources (extensive staff, expensive office equipment, official cars, prestigious technologies). While budget maximization (i.e. output maximization) is compatible with production efficiency - though not with allocative efficiency - slack maximization leads to inefficient production of public services through X-inefficiencies (Leibenstein 1966). In the private sector the problem of X-inefficiency is less imminent than in the public sector as – unlike private-sector managers -bureaucrats cannot transform additional work effort into salary (Button and Weyman-Jones 1994). The slack argument implies that the bureaucrats' utility is positively related to the fiscal residuum, the difference between the bureaucrats' budget and the minimum costs of production (Wyckoff 1990; Migué and Bélanger 1974; see also Bischoff et al. 2013).

Previous research has discussed ways to reduce X-inefficiencies in organizations. In his seminal contribution Leibenstein (1966) states that organizational characteristics affect efficiency. The scope for slack creation is negatively related to competitive pressures (e.g. Hart 1983) and monitoring activities (e.g. Nelson 1997; Breton and Wintrobe 1975). Measures to reduce X-inefficiencies are therefore the introduction of market competition or intensified monitoring activities to limit the bureaucrats' discretionary power (e.g. Bendor et al. 1985).

Whereas for the agency literature the unit of analysis is the individual actor and the costs of control, transaction cost theorists focus on the transaction itself and the costs of maladaptation to specific economic problems (Williamson 1996, chapter 7). Transaction cost theory has been the core framework to discuss the emergence and implications of different institutional arrangements, most prominently the degree of vertical integration (e.g. Williamson 1985; chapters 4-5; Powell 1991; Coase 1937). The market-hierarchy paradigm allows to distinguish different organizational arrangements by their associated transaction costs. Transaction costs depend on service characteristics, such as asset specificity, transaction frequency and uncertainty, and market conditions (Williamson 1989): Asset specificity is a crucial determinant for make-or-buy decisions.

The governance forms of hierarchy and market represent two polar cases. However, there has been no final consensus on how cooperation matches the framework: Whereas some authors view joint activities as an instance of a hybrid governance form in between market coordination and hierarchy (e.g. Ménard 2004; Williamson 1991; Chaddad 2012), others emphasize the role of cooperation or networks as a distinct third form of governance (e.g. Powell 1991; Richardson 1972).

Intermunicipal cooperation occurs in various arrangements ranging from informal 'handshake-deals', semiformal arrangements, such as contracts and agreements, to formal institutions, such as intermunicipal bodies or joint ventures (Warner 2011). Public service delivery can be contracted out to private providers or to other public entities (e.g. Boyne 1998; Megginson and Netter 2001), such as neighboring municipalities (e.g. Ferris and Graddy 1986; Mohr et al. 2010). The choice of a contract arrangement depends on the expected benefits and the sum of production and transaction costs. Internal transaction costs associated with coordination problems of self-provision are externalized to the contractor and replaced by transaction costs of using the market as institution, most prominently costs of negotiation, writing and enforcing contracts.

The literature lists several sources of efficiency gains from intermunicipal contracting, most prominently the reduction of bureaucratic inefficiencies by introducing substitutes for missing market competition and by gaining economies of scale and avoiding large personnel or capital investments (e.g. Ferris and Graddy 1991; Brown and Potoski, 2003). Although intergovernmental contracting can be seen as a form of public provision and therefore is characterized by monopoly problems and low market competition, efficiency gains may be likely.

Intermunicipal bodies have a long tradition in the joint provision of capital intensive services such as wastewater treatment and other network utilities. Contributions on intermunicipal cooperation have focused on the factors and decision-making processes that promote or prevent joint service provision and production. A coherent theoretical approach to intermunicipal cooperation, the institutional collective action framework, emphasizes transaction costs as one key determinant of cooperation decision making (e.g. Feiock 2007; Feiock and Scholz 2010; LeRoux and Carr 2007). Among the main justifications for cooperation is the presumption of size-related efficiency gains, most prominently economies of scale and scope (e.g. Hulst 2007; Bartolini and Fiorillo 2011). Most empirical studies have found support that fiscal pressures are one of the major driving forces of cooperation formation (e.g. Krueger and Bernick 2010; Kwon and Feiock 2010; Lackey et al. 2002; LeRoux and Carr 2007).

However, little is known whether cooperative solutions are more efficient than self-provision; efficiency gains from cooperation have largely been considered as given rather than empirically quantified. Few studies have made an attempt to empirically investigate the efficiency effects of cooperative action. An example is the Swiss study by Steiner (2003) which relies on qualitative methodology. A quantitative attempt with a focus on cost effectiveness, which is probably closest to our approach, has been conducted by Sørensen (2007) for the field of refuse collection in Norway. Another study that focuses on the effect of service delivery costs, but not on efficiency, of solid waste disposal in Spain has been conducted by Bel et al. (2012). Concerns have been raised against decentralized and service-specific intermunicipal bodies because of a lack of transparency and accountability (e.g. Dafflon 2012; Heinz 2007), but the literature has devoted little attention to the role of bureaucracy and potential technical inefficiencies of intermunicipal bodies. Our study addresses this issue and studies efficiency effects of cooperative organizational forms from a quantitative perspective with a special emphasis on technical efficiency of the wastewater sector.

Relative economic efficiency studies with respect to the public wastewater sector are very rare. For instance, Kalb (2010) does not list any in his quite exhaustive overview of the literature on public sector efficiency. The same applies to the surveys of De Borger and Kerstens (2000) or Dollery and Worthington (2000). Exceptions are the papers of Woodbury and Dollery (2004) on wastewater utilities in New South Wales, and Byrnes et al. (2009) on wastewater utilities in Victoria. Da Cruz et al. (2013) and Söderberg (2011) try to disentangle efficiencies of combined water and wastewater utilities.

Considering this "paucity" (Byrnes et al. 2009, 158) of relevant studies, a first step could be to utilize the results of the studies of the water industry.[2] However, even if the authors deal with institutional aspects, they primarily focus on the effects of different regulatory systems or efficiency differences between publicly and privately owned water utilities. The same applies to more recent studies of potential merger gains in the German water industry (Zschille 2012). Sauer (2005) and Haug (2008) examine the efficiency effects of the legal form of publicly owned water utilities. Furthermore, the focus of all the aforementioned studies lies on the efficiency of utilities, whereas our main research question is whether cooperation in wastewater disposal pays for the individual municipality in terms of relative efficiency.

3. Theoretical considerations

To discuss theoretical implications and derive the main hypotheses we proceed as follows: We start by introducing the three main organizational arrangements. Then, for the sake of clarity, we separately discuss the implications of the arrangements, first for technical and second for scale efficiency on a fairly general level. In the subsequent section we move on to the specific case of the Hessian wastewater sector. We will address the issue of potential interrelation between the two concepts of efficiency in section 5.1.3.1 Archetypical arrangements of service delivery

Since the units of interest in this study are the municipalities, we distinguish three archetypes of organizational arrangements with different degrees of delegation of political control: Self-provision (lowest degree of delegation), joint provision (intermediate degree of delegation) and external production (highest degree of delegation). In the case of self-provision the municipality entertains one or several departments, bureaus or enterprises to provide and produce a local public service in-house. In the case of joint provision at least two municipalities join forces to create one or more intermunicipal bodies, e.g. single-purpose associations or joint ventures, to share resources in order to plan, finance, operate and control public facilities. In

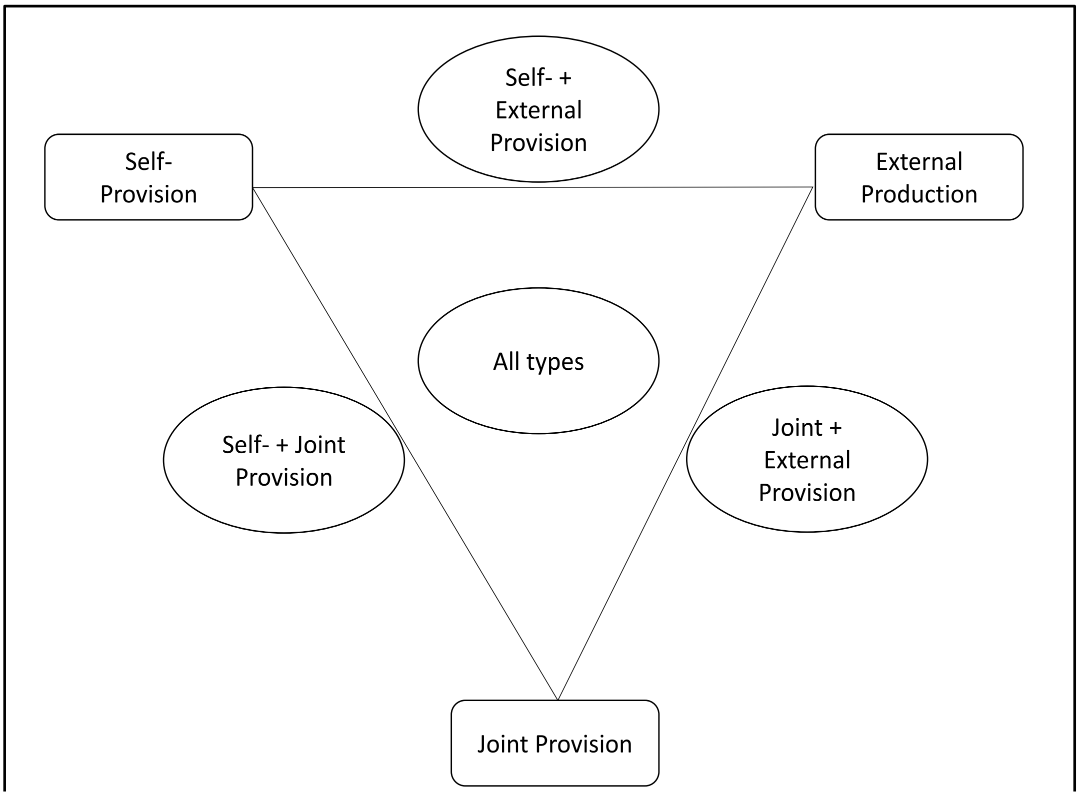
[2] Surveys of the literature can be found in Coelli and Walding (2005), Sauer (2005) or Kalb (2010).

contrast to contracting out it is possible for a municipality to transfer both, task responsibility and production, to an intermunicipal association.

In the case of external production the municipality relies on a service contract or agreement with an external provider, i.e. a neighboring municipality or a private contractor. Contracting out involves a transfer of service production, but not of responsibility. I.e., even if a service is contracted out, the original municipality will stay accountable. All service delivery arrangements can also appear as mixed forms of two or even all three pure form arrangements. In our analysis, we consider cooperations and mixed forms at the same stage of the service production process. Depending on the type of service under consideration, cooperation may also involve a vertical dimension, i.e. several stages of the production process. Figure 1 summarizes the dimensions of organizational arrangements of municipal service delivery.

Both joint provision and external production can also involve private providers. However, the forms can be seen as intermunicipal cooperation as long as the arrangement involves two or more municipalities as main actors. In the case of joint provision this means that the majority of the members/owners of the intermunicipal body are municipalities. In the case of external production this means that the task transfer must occur between municipalities or municipal units. Outsourcing to a private provider, for example, is a case of external production, but not intermunicipal cooperation. In the course of our analysis we only account for intermunicipal arrangements.

Figure 1: Dimensions of organizational arrangements



Source: Authors' illustration.

3.2 Organizational arrangements and technical efficiency

Let us consider municipal service delivery as a bureaucracy (principal-agent) relationship with slack-maximizing bureaucrats and politicians in charge of monitoring. The degree of X-inefficiency is affected by the politicians' incentives to exert control over the bureaucrats' activities. These incentives vary by the type of politician under consideration and the organizational arrangement.

Let us consider purely self-providing municipalities as base category: Self-provision is the most autonomy- preserving arrangement with a comparatively low degree of hierarchical complexity. The bureaucrats are held accountable only by the municipality's local government. Thus, this form incurs the ceteris paribus lowest monitoring costs. Politicians cannot free-ride on monitoring activities(Sørensen, 2007). Hence, under benevolent local politicians pure self-provision would be the technically more efficient than other arrangements.

This changes if we consider the case of opportunistic politicians. One major source of opportunistic politicians' personal utility is campaign support (e.g. Grossman and Helpman 1996; Bennedsen 2000). Furthermore, politicians may be inclined to use the bureaucracy for patronage (e.g. Shleifer 1998). The first point implies that the politicians make concessions to the bureaucrats' personal preferences or public sector unions' demands (Moe 2006) and reduce monitoring activities. This means, for example, that public service production uses higher labor inputs than necessary creating slack resources. The second point implies that the politicians appoint bureaucracy leaders based on political support rather than selecting staff based on qualification and merits. The scope for politically caused slack, however, is limited by reelection concerns. Thus even opportunistic politicians will exert a minimum degree of monitoring activities.

Joint provision lowers politicians' incentives to effectively monitor the bureaucrats. An intermunicipal body leads to a dispersion of ownership between the member municipalities. According to corporate governance theory, dispersed ownership creates an opportunity to free-ride on monitoring (Sørensen 2007; Jensen and Meckling 1976). The dispersed ownership problem arises regardless of the type of politician and increases X-inefficiency. Eventually, the negative effect is less severe if we consider a benevolent politician with intrinsic motivation to monitor.

Service provision by an intermunicipal body requires a transfer of power away from the individual municipality. Specifically, it limits the politicians' discretionary power of using bureaucracy institutions to pursue personal goals such as campaign support or patronage (Sørensen 2007). Individual municipalities' politicians will find it more difficult, for example, to select staff for political reasons rather than qualification.

Apart from agency-related issues, joint provision creates additional internal transaction costs, which will lower the degree of technical efficiency compared with self-provision or external production. Compared with other organizational arrangements, municipal associations or joint ventures require additional instances in the process of decision making to coordinate a higher number of stakeholder interests (see Heinz 2007). Decision-making boards are required to compromise on conflicting aims of the owner municipalities. Hence, control costs are higher compared with other organizational arrangements. Control costs rise with the number of municipalities involved and the number of intermunicipal bodies a municipality belongs to at the same time. Regarding technical efficiency the main advantage of joint provision is that it limits opportunistic politicians' discretionary power. The drawback is that this form increases political transaction costs and causes incentive problems regardless of the type of politician. Hence, we derive the following hypothesis:

> *Hypothesis (joint provision): Municipalities that jointly provide their services will exhibit a lower degree of technical efficiency than self-providing municipalities.*

Let us now consider the case of external production. External production exhibits the lowest degree of political control. This reduces politicians' opportunities to exploit local institutions for own purposes or patronage. Instead of monitoring their bureaucrat agents politicians are in charge of bargaining for the contract terms. Monitoring costs are (partly) replaced by bargaining costs. The outcome of the bargaining process, a monetary compensation, will be easier observable for the citizens than a complex budget that allows blurring or cross-subsidizing certain expenditures. Since the contractor will be in charge of organizing production, at least a share of his monitoring costs will be incorporated in the service fee calculation. Politicians will face incentives to devote high effort to bargaining activities that lower the costs of service provision for their citizens. This incentive applies to opportunistic as well as benevolent politicians: Opportunistic politicians will face higher pressure from the median voter since the outcome will be easier to observe. If external production involves only certain stages of the production process, monitoring duties will not be fully externalized and politicians still will have discretionary power over the remaining stages of service production left with the municipality.

Whether external production is in sum more technically efficient than self-provision for a single municipality, depends on the service characteristics, market conditions and the bargaining position. Small municipalities may only have access to a small number of providers and therefore have a weaker bargaining power (Brown and Potoski 2003). This is especially the case for location-specific service production (e.g. wastewater treatment and disposal) and services subject to contracts with neighbor municipalities rather than private contractors. Contracting opportunities are then predetermined by the geographic location. A low number of potential contractors weakens a municipalities ex ante bargaining position for contract terms.

In addition, small municipalities may lack managerial capacity to effectively write, monitor and enforce contracts (Mohr et al. 2010). Ex post the relationship between contractor and contracting municipality is likely to turn into a bilateral monopoly with mutual dependencies ("fundamental transformation", Williamson 1985, chapter 2). In this case both players, the contracting municipality and the contractor, may exploit the situation and try to reap the efficiency gains from cost reductions. The prediction on the total effect on efficiency for the contracting municipality is thus undetermined.

The efficiency effect of horizontally mixed form arrangements is particularly difficult to predict. The basic considerations for the pure forms apply to the mixed form arrangements as well. This means that the positive and negative effects of the polar arrangements on politicians' and bureaucrats' incentive structures are pooled in a mixed form arrangement. Additionally, the use of mixed form provision creates a higher degree of complexity and intransparency. Mixed arrangements increase monitoring costs irrespective of the politicians' motivations. Furthermore, a complex mixed form provision gives rise to additional leeway for opportunistic politicians to pursue personal objectives. The coexistence of municipal departments, contracts and joint bodies raises internal transaction costs. Thus, we conclude:

> *Hypothesis (mixed arrangements): Mixed arrangements exhibit a lower degree of inefficiency than pure forms.*

3.3 Organizational arrangements and scale efficiency

So far, our arguments have abstracted from economies of scale or scope. Economies of scope are an issue of internal organization rather than of contracting out or intermunicipal cooperation because all German municipalities have to provide a relatively homogeneous portfolio of public services. A large municipality may realize economies of scope by integrating different services (such as wastewater treatment and water supply and other utilities) into one large organizational unit.

Efficiency gains from economies of scale are determined by the production technology: Given that a municipality produces technically efficient (i.e. produces on the efficient frontier), economies of scale reflect the possibility to further improve the input-output-ratio by choosing a position with a higher (or lower) output level on the production frontier.

In the case of pure self-provision, small municipalities may struggle for a minimum number of users, whereas very large municipalities may find it difficult to balance scale efficiency against the rising internal transaction costs of a large bureaucracy (Posner 2010). Economies of scale are considered as a central argument for intermunicipal cooperation. In the case of contracting, both, the contractor and the contracting municipality, may benefit from the arrangement: Specifically, intermunicipal contracting can create a win-win situation for both, the contracting municipality and the contractor. The contractor municipality will be able to realize economies of scale and improve the degree of capacity utilization, whereas the contracting municipality will benefit from lower production costs. Likewise, joint provision may yield gains in scale efficiency.

In the course of our analysis we treat the production technology as given and isolate the technical efficiency effects of the organizational arrangements of public service production. From the theoretical arguments there is no per se most efficient organizational arrangement. Each form has its own advantages and drawbacks in how it affects the incentive structure and the level of transaction costs. It is possible that technical inefficiencies outweigh scale efficiency. As the overall effect is undetermined in theory we need to take a look at the empirical picture.

4. The municipal wastewater sector in Hessen

In the preceding sections, we presented some very general implications for the efficiency of IMC from the theory. In the course of our empirical analysis we turn to the subject of municipal wastewater treatment to test the main hypotheses. Compared to other municipal tasks, the task of wastewater treatment is relatively well defined and homogeneous across municipalities. Essentially it consists of 3 stages of production: Collection, treatment, and sludge disposal. Due to the high share of fixed costs, efficiency gains from economies of scale play a relatively important role in the political discussion and serve as the key argument for cooperation activities. Hence, intermunicipal cooperation is very common in the wastewater sector. Unlike other municipal activities with a strategic and regional focus (e.g., tourism) cooperation in wastewater treatment does not lead to spillovers. I.e., free-riding on other municipalities' cooperation activities is not a major issue in this field.

Our dataset regards the Hessian wastewater sector. The state of Hessen (capital: Wiesbaden, largest city: Frankfurt/Main) is situated in west-central Germany and was part of the "old" Federal Republic of Germany before the reunification. Since the last municipal reforms in the 1970ies the municipal level of Hessen consists of 21 districts ("Landkreise"), 5 district-free towns ("kreisfreie Städte") and 421 district-affiliated towns and municipalities ("kreisangehörige Städte und Gemeinden").[3]

According to §56 WHG ("Wasserhaushaltsgesetz", a national law) and §37(1) of the Hessian water law (HWG), the municipalities are responsible for the collection and treatment of the wastewater generated within their boundaries. However, they are allowed to cooperate with other municipalities or to contract with third parties to fulfill this task. The technical details of the collection and treatment process are regulated by additional laws, by-laws or regulations, e.g. the Hessian KomAbwVO ("Hessische Kommunale Abwasserverordnung"), which implements the EU Council Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment.

Broadly, the following legal forms of service delivery can be distinguished: Municipal departments (bureau, "Regiebetrieb"), public enterprises ("Eigenbetrieb", municipal corporations) and single-purpose associations ("Zweckverband"). Also possible are contractual arrangements (contracts, agreements) and joint ventures. We consider single-purpose associa-

[3] For a short introduction to the German local government system see e.g. Wollmann and Kuhlmann (2008).

tions as joint-provision form of intermunicipal cooperation whereas we count contractual arrangements between municipalities as external production form of intermunicipal cooperation.

One main advantage of the Hessian municipal wastewater sector is that the organizational structures have remained relatively stable, at least since the 1970s and 80s, so we can consider them as exogenous for the first decade of the 21st century. The median and average foundation year of the Hessian associations has been 1973 and 1975 respectively. Up to 95% of the associations have been founded before 1991.[4] Even a younger association such as the "Abwasserverband Main-Taunus" is the result of a merger of two older associations established in the 1960ies.[5]

To acquire information about which institutions are responsible for sewage disposal in which municipality, we extracted the necessary data from several publicly available sources: A list of single-purpose associations and their members provided by the Statistical Office of Hessen, the reports on sewage plant operators as well as a report on the sewage collection system operators (including information about which part of the municipality is connected to which sewage plant) published by the Hessian Agency for the Environment and Geology. Additional information (e.g. the population numbers for certain quarters/villages of a municipality) had to be collected via the internet pages of the municipalities. The following table gives an overview of the different institutional arrangements of sewage disposal:

[4] The numbers are based on a web search and represent only associations where the year of foundation has been available (70% of all associations). The numbers also hold for the final sample.
[5] Although sewage collection systems and sewage cleaning facilities had existed before in some cities (the first sewage plant on the European continent was built 1882 in Frankfurt/Main) the extension of sewage collection and cleaning facilities to more rural areas did not start before the 1960ies in West Germany.

Table 1: Institutional arrangements of wastewater collection and treatment in Hessen 2006 - District-affiliated municipalities -

	Num ber	Inhabit-ants (31/12/2005)	Average popula-tion per munici-pality	Estimat-ed waste-water c) 2006 (1000 cbm)	Aver-age esti-mated waste-water per munic-ipality (1000 cbm)	Num-ber of single-purpose associa-tions in-volved	Aver-age number of asso-ciation mem-ber-ships per munici-pality	Number of mu-nicipalities with at least one double-entry booking unit a) in-volved
Only own sewage plants b)	141	1,497,403	10,619.9	73,359	520.28	0	0	44
Only association mem-bership	150	1,787,654	11,917.7	88,523	590.16	184	1.23	68
Only contracting out	22	229,851	10,447.8	11,235	510.68	0	0	4
Mixed institutions								
Association + own plant b)	58	723,121	12,467.6	36,760	633.80	73	1.26	34
Association + con-tracting out	13	123,785	9,521.9	5,671	436.21	17	1.31	6
Own plant + con-tracting out	25	216,672	8,666.9	10,394	415.78	0	0	9
Association + own plant + contracting out	10	122,294	12,229.4	6,138	613.79	15	1.50	5
Others	2	10,645	5,322.5	474	237.04	0	0	0
Total	421	4,711,425	11,191.0	232,555	552.39	-	-	170

Notes: a) Municipal enterprise and/or one or more single-purpose associations. b) Including municipalities that also treat wastewater from outside their boundaries in their own sewage plants. c) See section 5.2 for details.

Source: Authors' calculations based on HMEEACP (2007), Hessian Agency for the Environment and Geology (n.d.), Statistical Office of Hessen (2006, 2007) and further data provided by the Statistical Office of Hessen.

The table shows that municipalities usually cooperate in wastewater issues by forming a single-purpose association, far less widespread are public contracts between municipalities. This contracting out is mostly restricted to treatment of own wastewater in sewage plants operated by the neighboring community. Material privatization of sewage collection and treatment is a rare exception in Hessen.[6] Hence, a detailed empirical analysis of privatization does not make much sense. The fourth and the sixth column of the table indicate that the average member of one (ore more) single-purpose association(s) is of above average in population and sewage volume, whereas self-providers and especially contracting municipalities are below average

[6] There are and have been only very few cases of sewage plants operated by (semi-)private operators like the energy provider e.on Mitte AG or the AWS GmbH.

size. In addition, some other features have to be considered that further complicate empirical analyses:

In most cooperations the partners do not take over joint responsibility for all production stages of wastewater collection and treatment. The most widespread arrangement is that associations are formed only to jointly operate one or more sewage plants and the central sewage collecting system, whereas the member municipalities are responsible for the local sewer systems (so-called “Teilzweckverband”). This arrangement can be expected to cause additional transaction costs.

The municipalities are free to choose between different institutional arrangements to fulfill their sewage collection and treatment tasks. Memberships in single-purpose associations seem to have been guided mainly by hydrological, geological and financial considerations and not by economic rationality. Hence, a municipality can in extreme cases - like the “city” (more like an accumulation of 14 dispersed villages) of Hessisch-Lichtenau - be a member of three single-purpose associations (only sewage treatment), have some of its wastewater cleaned by contracting out (to one neighboring municipality and one single-purpose association), operate one small sewage plant itself and be in charge of some of the local sewer systems.

5. Data and method

5.1 Efficiency measurement and estimation strategy

To investigate how organizational arrangements affect efficiency, it is necessary to select an appropriate measurement approach. In the context of intermunicipal cooperation is of utmost importance to distinguish between efficiency deficits caused by scale effects (scale efficiency) and technical inefficiencies due to incentive effects of the organizational structure or unfavorable environmental conditions. A municipality can be too small (scale inefficient) itself, but can benefit from scale effects at the cooperation level that ceteris paribus decrease the inputs attributable to the municipality’s given outputs and hence, increase the municipality’s technical efficiency. Therefore, technical efficiency of jointly providing or contracting municipalities is the result of potential scale effects at the cooperation level and the cooperation-related transaction costs or incentive effects (as well as other, partly unobservable (un-)favorable environmental conditions). Simple average cost comparisons or conventionally estimated cost- or production functions cannot tackle this issue.

If the underlying production technology has constant returns to scale, then any technically efficient production will be automatically scale efficient. However, in case of production technologies with decreasing or increasing returns to scale, the decision-making unit could increase its overall efficiency by increasing (or reducing) its scale of operation. Hence, overall relative efficiency or technical efficiency under constant returns to scale is the product of scale efficiency and technical efficiency under variable returns to scale. (The fundamentals of data envelopment analysis as well as the derivation of equation (1) can be found in appendix B.)

(1) $$TE_{CRS} = SE \cdot TE_{VRS}$$

Technical efficiency is usually expressed in the literature either in an input-oriented or output-oriented fashion. As for wastewater collection and treatment the output quantity and quality can be considered as fixed by intensive regulation (see above), we choose the input-oriented version.

As we are mainly interested in the two components of the overall efficiency, our empirical analysis involves two steps. First, we estimate the relative technical efficiency under variable returns to scale in public service provision – here: sewage disposal - for all municipalities in our sample. Second, we run a regression analysis to explain the intermunicipal differences in relative efficiency using a set of so-called environmental variables.

In step 1, we apply the concept of the input-distance function (Shepard 1970) to measure relative efficiency. The input-distance function δ describes the ratio between the actual input quantity to the technically achievable minimum input quantity for a given output quantity. Its possible values range from 1 (efficient) to infinity.

In order to estimate the unknown municipal production frontier empirically and receive a consistent estimator of the input distance measure $\hat{\delta}_i$ for each municipality in sewage disposal, we chose a nonparametric approach, the DEA-model suggested by Banker, Charnes and Cooper (1984), known as the BCC-model in the literature. The DEA method is well established in the literature on efficiency analysis of the public sector. The main advantage of this axiomatic linear-programming based method is that no production- or cost function has to be prespecified.

The main advantage of the nonparametric methods of efficiency analysis such as the DEA over parametric approaches, such as stochastic frontier estimation (e.g. Kumbakhar and Lovell 2000), is that often unavailable price data are not necessary.[7] Hence, we avoid the potential

[7] To be precise, price data are not necessary as long as we are not interested in separating technical efficiency from allocative (or cost-) efficiency.

bias of the estimation resulting even from sufficiently flexible cost functions (e.g. a translog function).

In step 2, given the DEA measures that inform us about the relative efficiency of the municipalities in our sample, we go on to analyze the impact of different forms of intermunicipal cooperation on relative efficiency. To account for the interdependence between step 1 and step 2, we apply the two-stage procedure ("algorithm 2") suggested by Simar and Wilson (2007). Essentially, it consists of a truncated regression of the input distance measures on a vector of environmental variables **z**. The method involves a bootstrap procedure to calculate the bias-corrected efficiency scores as well as the confidence intervals of the regression coefficients. The bootstrapping takes sampling variability into account and remedies the severe problems of unmodified two-stage approaches, e.g. serial correlation of the dependent variables, general upward-bias of nonparametric efficiency measures (Bogetoft and Otto 2011, 156-157) or the correlation between the error term and the environmental variables.

In addition, we also calculate the relative scale efficiency *SE* to check for the existence of economies of scale at the municipal level. This is important to see if small municipalities could improve their own technical efficiency by benefiting from scale economies of larger decision-making units. Relative scale efficiency can be calculated according to (1) as $SE = \hat{\delta}^{CRS} / \hat{\delta}^{VRS}$ where $\hat{\delta}^{CRS}$ is the estimator of the input-distance function resulting from the DEA-model with constant returns to scale and $\hat{\delta}^{VRS}$ is the estimator of the input-distance function of the BCC-model . As, by construction, $\delta^{CRS} \geq \delta^{VRS}$, *SE* ranges between 1 and infinity.[8]

5.2 Outputs, inputs and environmental variables

The final output of sewage treatment and collection is the quantity and quality of the cleaned wastewater after it leaves the municipal facilities.[9] However, having access to a convenient sewage disposal system is also an important output component from the citizens' point of view. According to the literature on efficiency of water provision (see section 2), the number of connections to public sewer systems could be considered as a fixed component of the output whereas the actual volume of wastewater represents the variable output component. However, due to the lack of data on the number of connections we focus on the sewage volume. Usually we find the following components in municipal sewer systems and plants: 1) waste-

[8] See e.g. Bogetoft and Otto (2011, 99-101).

[9] One could also argue that the final output of sewage collection and cleaning is its contribution to improve the quality of surface water and ground water and to help preventing the spread of infectious diseases.

water from private households, private and public enterprises and public institutions, 2) rain water and 3) infiltration water. The latter two can be considered as dead freight in the sewer systems and sewage plants. Therefore, according to Daraio and Simar (2007, 114-119) we classify them as unfavorable environmental variables that act as undesired outputs asking for additional inputs in the production process.

To estimate the only regular output, approximated by the volume of private and public wastewater, we use the volume of drinking water sold to private or public consumers. The figures are only available for the district level.[10] Hence, we run a panel data regression (fixed effects model) for an out-of-sample prediction:

$$(2) \qquad w_{it} = \beta_0 + \sum_{j=1}^{N-1} \beta_{1j} D_j + \sum_{t=1}^{T-1} \beta_{2t} D_t + \beta_3 pop_{it} + \beta_4 pop_{it}^2 + e_{it}$$

with w_{it} as the volume of drinking water sold per capita in district i at time t, pop_{it} as the population number of district i at time t, D_j as the district dummy (N = 21) and D_t as the time dummy (T = 6, $t \in \{1998, 2001, 2004, 2006, 2007, 2010\}$). The resulting regression coefficients (adj. R^2 = 0.94)[11] are used to predict w for each municipality at time t by inserting the population number and multiplying the result with the population number. To correct for the unavoidable difference between the aggregated predicted value of all municipalities located in a certain district and the actual volume for this district, the difference was allocated to each municipality proportionally to the predicted value. The results of this model specification take into account, that the per-capita volume of drinking water sold usually increases with increasing total population (though at a decreasing rate). Alternatively, we assumed identical per-capita volumes for all municipalities in a certain district at time t and simply multiplied the population number of each municipality at time t with the adequate w_{it}.

We do not account for output quality aspects. We assume that all municipalities have to collect and treat their wastewater according to the legal standards and that violations are not tolerated. If municipalities try to exceed the fairly strict minimum treatment standards, we do not count for this as additional output. Furthermore, we assume a similar degree of pollution for all municipalities.

Not included in our estimated output figures is sewage in public systems that results from ground and surface water that has been extracted from own wells or springs as well as rivers

[10] See https://www.regionalstatistik.de/genesis/online/online, table 514-42-4 (accessed 29/11/2013). The figures for 2006 are the weighted averages of 2004 and 2007.
[11] The regression results can be provided by the authors on request.

or lakes, primarily to be used in manufacturing. Despite of its relatively small share[12], we control for this additional industry wastewater - as well as for the potentially higher degree of pollution of all industry wastewater in the public systems - by adding the number of employees in manufacturing as an environmental variable in our regression analysis.

As mentioned before, we use cost data to approximate the physical inputs. The main advantage of cost data is that they also reflect differences in input quality that could be only approximated by physical quantities (e.g. age structure and the materials of the sewer system as weighting factors of the sewer length, treatment stages of sewage plants) otherwise. If we can reasonably assume identical factor prices for all municipalities, it will be possible to replace the (often unobservable) physical input quantities with cost data (Färe and Primont 1988) in the DEA-program. Since all municipalities in Hessen are parties to the same collective wage agreement and have access to the same capital and other input markets this assumption is not too unrealistic.[13] To approximate inputs, we construct three categories of input costs: labor costs, capital costs and costs of resources and intermediate inputs. Labor costs comprise of the expenditures for staff. Capital costs include rents and leases, imputed depreciations and imputed interests. Resources and intermediate inputs consist of all other current expenditures. For the calculation formulas please refer to appendix A.

Allocating inputs/costs to single municipalities is more difficult than outputs, especially for members of single-purpose associations. Self-providing municipalities and contracting municipalities are no problem, because we can assume, that the latter have to pay their cost share and hence, only substitute own staff and capital for intermediate inputs. For municipalities that treat water from outside their boundaries the assumed sewage treatment cost (approximately 20% of their total inputs) are reduced proportionally to the percentage of "foreign" wastewater. Members of single-purpose associations are attributed a share of the association's inputs according to their share in the association's total output.[14]

[12] Among the Hessian districts and district-free towns only the city of Darmstadt neither „imports" nor „exports" sewage. Consequently, the sewage that is treated in Darmstadt's sewage plants must have been generated within the city boundaries. In 2007 9.083 million cbm of drinking water have been sold in Darmstadt and 9.635 million cbm of sewage from private households, private and public enterprises and public institutions have been treated. Hence, the difference amounts to about 5.7%. See www.regionalstatistik.de/genesis/online tables 514-42-4 and 516-32c-4 (accessed 29/11/2013).

[13] Regional differences in land prices can be neglected because the average sewage utility`s asset value of land is rather small compared to the value of its buildings, sewage plants and - the most important item - of its sewage collection systems.

[14] At the submunicipal level only population data is available. Hence, the percentage of the total inhabitants belonging to a municipal association is assumed to be equal to the percentage of the municipality's wastewater that is treated by the association and thus, the municipality´s cost share.

Our main interest focuses on the effects of different institutional arrangements in wastewater disposal on municipal efficiency. To this end, we introduce dummy variables into the regression of the second stage of the efficiency analysis. To make the analysis more tractable, we condense the seven combinations in table 1 to five dummies: self-providing municipalities, self-providers that also clean wastewater from other municipalities, association members, contracting municipalities and mixed forms. The main criterion for allocating a municipality to one of the first three groups is that less than 20% of the wastewater is treated by the two alternative arrangements.

Furthermore, we include other variables that might affect efficiency. One important factor is settlement patterns because in densely populated areas the necessary sewer pipe length per inhabitant is lower than in rural areas. Therefore, sparsely populated rural municipalities ceteris paribus have to use more inputs per cubic meter of wastewater than urban areas. In addition, we also account for the impact of overall population change by using the relative population change between 2001 and 2005. This takes into account, that especially sewer capacities cannot be adapted proportionally to population change. Growing population improves the utilization of existing capacities, whereas population decline leaves a municipality with excess capacities and hence, ceteris paribus lower efficiency.

The number of employees in manufacturing is used as a control variable for additional industrial wastewater, which is more difficult to clean. However, the efficiency effect of the presence of large factories in a municipality is ambiguous: First, many industries that produce highly contaminated wastewater (e.g. chemical industry, metal-processing industry) either have their own treatment facilities and discharge the treated sewage directly into the next river or they have to pretreat their effluent according at least to the minimum standards in the appendix of the German Wastewater Ordinance (Abwasserverordnung; see also §58 WHG) before discharging it into the public system. Second, industrial wastewater might improve the capacity utilization of the sewer system and the treatment facilities.

Infiltration water is a quantitatively significant problem but there are no data on regional disparities in wastewater – infiltration water relations available for Hessen. Hence, we assume the same infiltration water load in all Hessian municipalities.[15] The potentially relevant volume of rain water for the public systems is estimated by multiplying the average precipitation height (only available at district level) with the residential and traffic area (minus green space

[15] For example, the average percentage of infiltration water in sewage plants in the German state of Baden-Württemberg was 35% in 2004 with percentages varying between below 25% and over 50% at the district level (LUBW 2007, 12).

and cemeteries). Financial data of the municipalities are not included because sewage disposal is mainly financed by cost-covering user fees and contributions. Furthermore, at least for members in single-purpose associations the causal chain how the fiscal capacity or the debt situation or the amount of received investment grants of one member might affect the total input quantities of the association and hence efficiency, is not clear.

5.3 Sample selection

Due to several institutional factors and data availability restrictions we cannot include all Hessian municipalities and cannot examine the years after 2006. First of all, some time restrictions in data availability exist. Due to the ongoing reforms of the municipal budgeting and accounting system the Statistical Office of Hessen has stopped publishing municipal budget data (for individual local governments). The last available data date back to the year 2006. We confine our analysis to a cross-section analysis of this year because 1) dynamic DEA methods are hardly applicable for our problem and 2) due to the potential reverse causality problems with cooperations it is advisable to make use of the longest achievable time interval between establishing a cooperation and the chosen period of the analysis.

The municipality can choose to operate sewage disposal within the core budget (a so-called "Regiebetrieb", the equivalent of a municipal bureau) or form a municipal enterprise ("Eigenbetrieb" or municipal company). Both mainly differ in their bookkeeping systems[16]: The first apply single-entry bookkeeping methods and record revenues and expenditures[17], whereas the latter use double-entry accounting and provide balance sheets, statements of profit and loss as well as statements of changes in fixed assets similar to private enterprises. This difference is vital for data availability and comparability and also applies to single-purpose associations: Some associations use double-entry accounting, whereas the majority sticks to the simpler single-entry method. Most difficult to deal with are multibranch associations or multibranch municipal enterprises (e.g. combined water and sewage disposal providers) because they make cost allocation impossible. Besides other general compatibility and comparability problems of the two bookkeeping systems the main drawback is that they do not in-

[16] This was the situation in 2006, the year of our empirical investigation. Meanwhile, there have been reforms in Hessen as well as in most other German states to merge the core budget and the annual reports of the local public enterprises into one double-entry accounting system with only one comprehensive annual report (balance sheet, statement of profit and loss and statement of changes in fixed assets) for the whole municipality. However, as no official data based on the new accounting system has been published yet, we will not go into further details here.
[17] However, they also have to calculate imputed interest and imputed depreciations for charging purposes, which are published in the municipal statistics. We use these figures for our purposes.

clude comparable measures for capital costs or asset values.[18] To avoid any incompatibility problems of different bookkeeping systems, we focus on municipalities and sewage-only associations that use the more widespread single-entry system (i.e. they have no municipal enterprises involved in wastewater collection and/or treatment) and are not members of single-purpose associations that use double-entry accounting. This applies to about 250 municipalities.

The number of municipalities in our sample is further reduced by the privacy policy considerations of the Statistical Office of Hessen. This means that the office does not publish staff expenditure data for small single-purpose associations with only few employees. Consequently, we cannot use the input data of 37 of all 80 single-entry bookkeeping associations.Finally, we exclude two self-providing municipalities, that report unrealistically low figures for imputed depreciations and imputed interest rates and the only municipality where treatment of municipal wastewater has been contracted out to the sewage plant of a private enterprise. We end up with a total of 193 observations.

In addition, we take care of a few important points when calculating a municipality's inputs in sewage collection and treatment: First, we add up the expenditure positions in the core budget for sewage disposal with (the estimated share in) the corresponding items of the single-purpose association(s) the municipality is a member. Second, in case of association membership we also take care of the cost flows between member municipality and association to avoid double-counting and hence, inflated inputs. Third, in case of inflows of wastewater from non-member municipalities or neighboring communities, we reduce the cost share allocable to the member municipalities or the receiving municipality proportionally to the wastewater inflows.

Compared with the total of all Hessian municipalities our sample reveals a bias towards smaller municipalities (see appendix A, table C for details). The descriptive statistics and test results indicate that the municipalities in our sample are significantly smaller in the mean and median area and population number. However, for population density the hypothesis of equal distribution can be rejected only at the 10% significance level.

[18] In the single-entry system we have imputed depreciation and imputed interests whereas the statements of profit and loss of the double-entry units only contain depreciation (according to commercial and/or tax law) and interest expenses. Hence, we could choose the net asset values statet in the blance sheet or – better – the production/aquisiton costs from the statement of changes in non-current assets. However, for the single-entry units there is no equivalent item and the application of the perpetual-inventory method to estimate the capital stock is complicated and only practical if long time series of investment are available – which is not the case.

Furthermore, the number of member municipalities of single-purpose associations reduces significantly to 55, which are also of above-average size. Although table 1 and table 3 are not directly comparable the results in table 3 indicate that the average sewage volumes in our sample are smaller for all institutional arrangements, but the decrease is stronger for the self-providers than for the association members. Moreover, due to the restricted data availability and the exclusion of double-entry booking entities only municipalities with at most 2 memberships in single-purpose associations remain in the sample. The descriptive statistics of the chosen inputs, outputs and environmental variables are shown in table 2:

Table 2: Descriptive statistics sewage disposal
Sample of Hessian municipalities 2006 (*N* = 193)

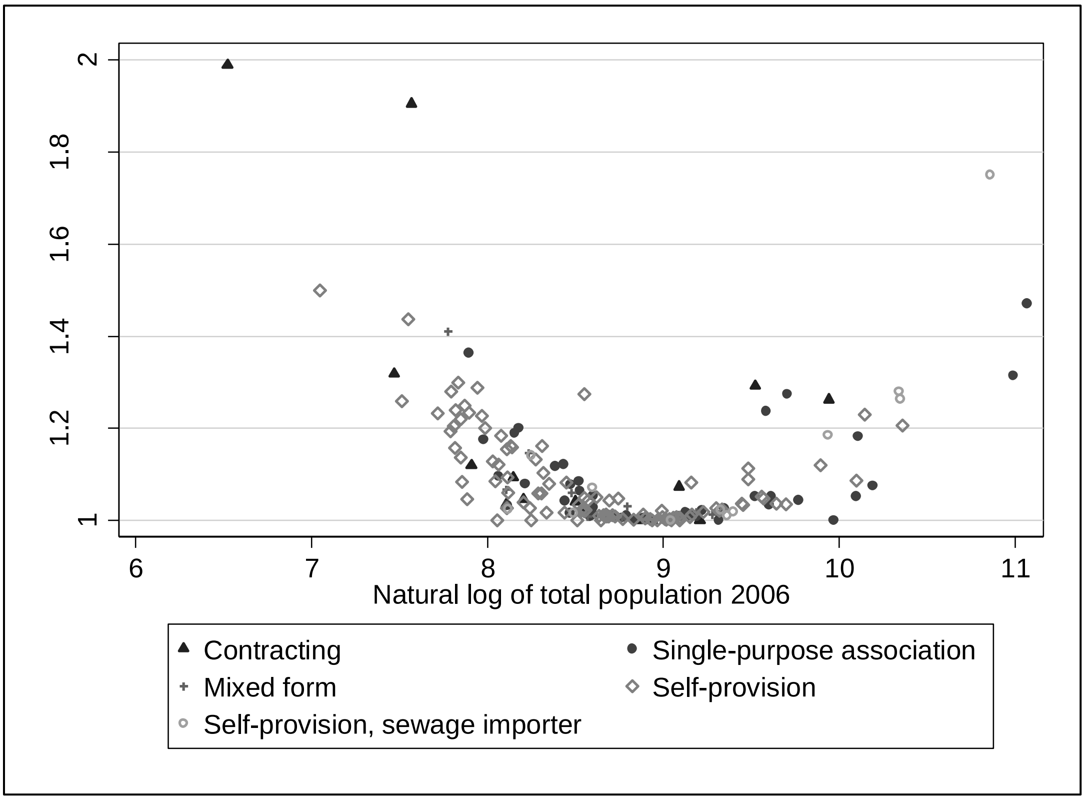
Variable	Mean	Std. dev.	Min	Max
Inputs:				
Labor (1,000 €)	148.08	245.68	0	2,755.45
Labor (1,000 €) Model VI	88.56	137.03	0	956.71
Capital (1,000 €)	764.41	836.60	103.53	6,008.40
Capital (1,000 €) Model VI	606.22	679.00	0	5,083.08
Resources and intermediate inputs (1,000 €)	434.17	527.44	53.69	5,561.82
Resources and intermediate inputs (1,000 €) Model VI	651.877	1,034.59	53.69	10,982.41
Outputs:				
Estimated sewage volume (1,000 m^3) I	407.19	478.4046	30.39	3,761.53
Estimated sewage volume (1,000 m^3) II	412.20	435.2194	32.14	3,238.00
Environmental variables:				
Population density (inhabitants per km^2)	283.10	333.6349	22.68	2,267.73
Employees in manufacturing	784.24	1,722.4	16.31	18,168.00
Relative population change 2001-2005	-0.0141	0.0285	-0.0872	0.1737
Rainfall (1,000 m^3)	4,248	2,705.54	1,050	23,367
Self-provider and sewage importer	0.062	0.2421	0	1
Single-purpose association	0.285	0.4526	0	1
Contracting out	0.083	0.2765	0	1
Mixed form	0.067	0.2513	0	1

Source: Authors' calculations.

6. Results

In step 1 of our empirical analysis, we calculated the bias-corrected relative technical input efficiency measures for the sewage disposal of the Hessian municipalities in our sample. The results display a vast dispersion of relative (technical) efficiency and hence, a significant potential for efficiency improvement. The resulting median value is 1. 596 (mean: 1.682), meaning that 50% of the municipalities in our sample could reduce their inputs by at least 37.3% while keeping their output constant. We also find that the majority of municipalities operate at a nearly scale-efficient level (median value of relative scale efficiency: 1.035[19]). Nevertheless, there is a slightly u-shaped relationship between output and scale efficiency and at least small municipalities (< 3,000 inhabitants) can expect efficiency gains from scale effects. The effect on larger cities (> 30,000 inhabitants) is not quite obvious due to the small number of cases and the outlier position of three cities (see figure 2).

Figure 2: Municipality sizes and scale efficiency in sewage disposal (Hessen 2006, *N* = 193)



Source: Authors' calculations.

[19] This means that for the median municipality the relation between maximum achievable total productivity (subject to the constraint that its input and output mixes cannot be altered) and actual total productivity (provided that production is technically efficient) is 1.035. Taking the reciprocal 0.9662 shows that the median municipality has already achieved 96.62% of its maximum productivity. Hence, it can increase its productivity only by 3.5% by choosing alternative input-output combinations on the production frontier. See e.g. Coelli et al. (2005, 58-61).

Table 3: Sewage volumes and scale efficiency

	Self-providing municipality	Self-provider + sewage import	Single-purpose association	Contracting municipality	Mixed forms
Scale efficiency (mean)	1.087	1.149	1.069	1.200	1.061
Scale efficiency (median)	1.044	1.049	1.022	1.059	1.018
Sewage (1000 cbm, mean)	315.0	848.9	536.2	297.7	314.8
Sewage (1000 cbm, median)	240.8	530.0	335.8	221.7	230.4
Group size	97	12	55	16	13

Source: Authors' calculations.

From figure 2 we cannot see whether differences in scale economies between organizational forms exist. Table 3 therefore tries to bring more enlightenment by comparing the mean and median values of scale (in-)efficiency. The (slight) differences of the organizational forms in scale efficiency are a consequence of their different output quantities.

We conducted a series of tests which show that the groups significantly differ in population size and output sizes at least for some organizational forms (see appendix A, tables D and E). Despite this result, our tests cannot reject the hypotheses that the group distributions of scale efficiency are all equal. These findings confirm the limited scope of scale effects for sewage disposal facilities.

In step 2 of our empirical analysis, we use the bias-corrected technical efficiency scores to evaluate the impact of environmental variables on municipal efficiency (see table 4) by a truncated regression analysis. The results of the baseline model indicate that of all different institutional arrangements only contracting out of sewage treatment (but only for the contracting municipalities) seems to have a statistically significant efficiency-enhancing effect in comparison to the self-providing municipalities. Other forms of cooperation such as the more common single-purpose associations are inferior in efficiency terms to the self-providers. Contracting seems to be a rather one-sided advantage for the contracting municipalities whereas the municipalities that clean wastewater of neighboring communities tend to be significantly less efficient.

Efficiency seems to be determined to a great deal by environmental factors, especially population density and population development in the past. Furthermore, we find a significantly negative coefficient for the number of employees in manufacturing and the contrary effect for the potentially sewage-relevant rainfall.

To check the robustness of our results, we run several model modifications. In model II we use the alternative output volume specification. The differences are rather marginal and hence, the results seem to be not very sensitive to different output specifications.[20] Model III is identical to model I. However, instead of the unmodified percentile method we use the more accurate "bias-corrected, accelerated" (BCA) percentile interval[21] to calculate the 90%, 95% and 99% confidence intervals of the regression coefficients – and found only minor differences in the significance levels.

[20] This result is not very surprising because the Mann-Whitney-U test (z = -0.803, p-value 0.476) cannot reject the hypothesis that both output specifications are equally distributed. In order to approximate the upper and lower bounds of the estimated output quantities we calculated two alternative out-of-sample predictions by using the upper and the lower bounds of the 95% confidence intervall of the coefficients β_3 and β_4 in equation (2) respectively. We also ran the regression without the squared population term and calculated the predicted and the corrected sewage volumes. However, the results of the Kruskal-Wallis Test (H= 5.087< χ^2 (4; 95%) =9.4877) do not reject the equal distribution hypothesis for all five output specifications. Therefore, we did not run further efficiency analyses with different output specifications because the results could be expected to be similar to model I and II.

[21] See Efron and Tibshirani (1993, chapter 14).

Table 4: Determinants of municipal sewage disposal technical efficiency
Results of the second-stage truncated regression

	Model I		Model II		Model III		Model IV		Model V		Model VI	
Variable	Coeffi-cients		Coeffi-cients		Coeffi-cients		Coeffi-cients		Coeffi-cients		Coeffi-cients	
Constant	1.49780	***	1.4867	***	1.49780	***	1.36772	***	1.62071	***	1.47521	***
Population density	-0.00042	***	-0.0004	**	-0.00042	***	-0.00036	**	-0.00020	***	-0.00079	***
Employees in manu-facturing	-0.00011	***	-0.0001	***	-0.00011	***	-0.00009	**	-0.00006	***	-0.00006	
Relative population change 2001-2005	-4.46297	***	-5.3121	***	-4.46297	***	-4.83554	***	-1.89787	**	-7.06434	***
Rainfall	0.00004	**	0.0001	**	0.00004	**	0.00004	*	0.00001		0.00001	
Sewage importer	0.56385	***	0.5616	***	0.56385	***	0.54933	***	0.27900	**	0.50751	***
Single-purpose association	0.17554	**	0.1741	**	0.17554	**	0.18251	**	0.08721		0.24240	**
Contracting	-0.44254	***	-0.4237	***	-0.44254	***	-0.36409	**	-0.23612	***	-0.23405	
Mixed form	0.00015		0.0024		0.00015		0.00826		-0.04317		0.12418	
	N=193		N=193		N=193		N=188		N=167		N=193	

Notes: * significant at the 10% level, ** significant at the 5% level, ***significant at the 1% level. The reported significance levels are based on the percentile confidence intervals (except model III). A negative sign of the coefficient indicates a reduction of the relative distance to the estimated production frontier, i.e. an efficiency improvement.

Source: Authors' calculations.

Furthermore, as the relative efficiency scores depend on the composition of the sample we search for the most influential observations. Actually, 19 peer units compose the reference units for the other observations. We exclude 5 observations that are peers to the other observations in nearly 60% of all peer cases. As a result (model IV), the dispersion of the bias-corrected relative efficiency scores changes only slightly (minimum: 1.094, median: 1.520, mean: 1.608, maximum: 3.490). Furthermore, the significance level of the coefficients does not change extremely.[22]

Alternatively, we exclude the most inefficient observations (bias-uncorrected efficiency scores > 2) from the sample. Hence, in DEA-models there will be no shift in the estimated production frontier, but probably a change in the regression coefficients (model V). As was to

[22] In case we excluded the 10 observations that are responsible for 83.5% of the peer cases the dispersion of the efficiency scores decreased further (minimum: 1.080, median: 1.386, mean: 1.494, maximum: 2.708) and the coefficient of the population density is only significant at the 10%-level.

be expected, the dispersion of the efficiency scores reduces significantly (bias-corrected efficiency scores: minimum 1.087, median 1.584, mean 1.598, maximum 2.319). It turns out that the impact of population density, population change and the contracting dummy decreases. Despite of the fact that our regression results are reasonably robust against dropping influential observations, one should bear in mind that the exclusion of observations is always problematic - unless there are obvious measurement or entry errors in their data.

Finally, we change the input mix for members of single-purpose associations to improve their comparability with the contracting municipalities (model VI). In models I to V we have added each member municipality's share in the association's labor, capital and intermediate inputs quantities to each input category of the municipality separately. This "reallocation" of contracting or outlay (which a single-purpose association actually is) expenditures into more "traditional" input categories is recommended e.g. by Coelli et al. (2005, 152-153) to avoid blurred factor intensities among a group of regulated enterprises. However, the same procedure cannot be applied to contracting municipalities.[23] Hence, we add the shares in labor and capital costs that have been allocated to the member municipalities of an association to their input category resources and intermediate inputs. The resulting dispersion of the efficiency scores is similar to the foregoing models (minimum: 1.061, median: 1.535, mean: 1.625, maximum: 3.714). Especially the regression coefficient of the association dummy has increased and the coefficients of rainfall, employees in manufacturing and the contracting dummy become insignificant.

As some results might depend on certain percentages that we have chosen ex ante we apply some further modifications to the baseline model. In order to assign municipalities to a certain organization dummy, we postulated that at least 80% of the estimated sewage has to be treated by this organizational form. E.g. a municipality qualifies as a single-purpose association member if at least 80% of its sewage is treated by one or more associations. Alternatively, we rerun the two-stage analysis with threshold values of 50%, 70%, 90% and 100% (Model I). The resulting changes in the coefficients are marginal and neither the significance levels nor the signs change.

Furthermore, in our baseline model I we assume 20% of the total inputs to be attributable to sewage treatment cost. Consequently, for self-providing municipalities that also treat

[23] It is possible, though, to allocate the principal municipality's shares in the contractor's or agent municipality's labor costs, capital costs and intermediate inputs to the principal. However, to avoid double counting, we would first have to subtract the principal's compensations paid to the agent from the principal's expenditures for resources and intermediate inputs. This is not practical with the given data.

wastewater from outside their boundaries this assumed sewage treatment costs have to be reduced proportionally to the percentage of "foreign" wastewater. We check the robustness of our results using a rather unrealistic percentage of 50%. Again, the distribution of the efficiency scores does not alter much (minimum: 1.093, median: 1.601, mean: 1.679, maximum: 2.893) and the regression coefficients as well as the significance levels show only marginal changes.[24]

7. Discussion

The main advantage of our input-oriented, nonparametric efficiency analysis is that it allows for distinguishing between scale effects and inefficiencies for a given sewage quantity (technical efficiency). The latter is the focus of our interest considering the effects of the organizational structure.

First, we find that joint production (single-purpose associations) is less technically efficient than self-provision. This reflects the high transaction costs and the negative incentives of dispersed ownership and confirms our hypothesis. Our main findings are in line with the literature (e.g. Sørensen 2007).

Second, the significantly higher relative efficiency of contracting out solutions reflects the assumption of better observability of bureaucratic actions, the higher incentives for monitoring and probably the higher bargaining power. However, somewhat puzzling is our finding that "contracting in" or sewage import does not seem to pay in efficiency terms. One possible explanation is that the contracting-in municipalities in our sample are of above-average size whereas some of the smallest Hessian municipalities are among the contracting municipalities. The limited potential for economies of scale in wastewater disposal seems to enable only small municipalities to benefit from intermunicipal contracts when efficiency gains from economies of scale at the contractor level outweigh the additional transaction costs and hence, increase their technical efficiency.

Third, in the case of the mixed forms we do not find support for our hypothesis. Advantages as well as disadvantages of all different forms accumulate and outweigh each other. Generally, the results for the mixed forms as well as for the contracting solutions have to be interpreted with some care due to the small number of observations.

Considering the slightly u-shaped relationship between scale (in-)efficiency and population/sewage, at least small municipalities (< 3000 inhabitants) might benefit from forming

[24] The results are skipped here due to space constraints but are available from the authors on request.

larger entities, either by municipal mergers or by transferring the complete task of sewage disposal to a single-purpose association. In the latter case the gains from scale effects might outweigh the disadvantages from technically inefficient organizational forms.

Furthermore, we find some interesting results for certain other components that municipal wastewater disposal has to deal with: First, rain water is mainly dead freight and hence, the additional measures (extra drain pipes, rain retention basins) to keep it out of the sewers and sewage plants reduce - ceteris paribus - technical efficiency. Second, industrial wastewater seems to improve the capacity utilization and hence, increases the efficiency of municipal wastewater disposal.[25]

Also important for the technical efficiency of sewage disposal are demographic changes and settlement patterns, mainly changes in population density and -number. The first indicates that rural municipalities are ceteris paribus less efficient than densely populated cities in sewage disposal. The latter implies that within some range of short- or medium-term population change, when either the existing capacities are sufficient for the growing population or the existing capacities cannot be reduced proportionally to the shrinking population, overall efficiency tends to increase with increasing population. The link between scale effects and technical efficiency is here that mainly rural regions suffer from decreasing population whereas population numbers in agglomerations tend to increase. Hence, the per se not very favorable (for network infrastructure) dispersed settlement patterns in rural communities become worse. The problem of infrastructure adaption to demographic changes is hotly debated in the spatial planning literature (e.g. Moss 2008; Koziol 2004; Carruthers and Ulfarsson 2003).

With regard to the external validity of this study we consider it to be representative for at least other German states, but also other industrialized countries. The applied technology is more or less the same everywhere although regional differences in demography and settlement patterns exist. The supranational legal framework is identical for EU-member states because they all have to achieve conformity with the European Wastewater Treatment Directive of 1991.

As it is common for all scientific work there are certain limitations of our study. First, it has not been possible to disentangle the incentive effects of certain organizational forms for poli-

[25] This interpretation may not seem straightforward because the improved capacity utilization by additional industrial wastewater (in addition to what we have already taken into account by estimating the municipal wastewater quantities via the volume of drinking water sold to private households, enterprises and public institutions) is mainly a scale effect. However, it might save the municipality other costs (e.g. flushing, reduced lifetime of sewers due to corrosion caused by low flow rates) that occur in regions with significant population decreases. See e.g. Koziol (2004).

ticians due to the lack of available data and the complicated causal chains of political decisions in single-purpose associations.

Second, there is the general problem of the high durability of capital goods in sewage disposal: Investment decisions determining the current capital costs might have been made years ago. How can they be properly related to some current environmental variables?

Third, some types of municipalities or organizational forms are underrepresented in our sample. We had to exclude municipalities with municipal enterprises and associations with double-entry bookkeeping. Furthermore, no public-private partnerships and other forms of privatization have been included because there are only very few cases in Hessen.

There might be a potential bias for the single-purpose associations caused by the exclusion of the double-entry bookkeeping associations (mostly large associations) and the single-entry bookkeeping associations for which no staff expenditures are published (mostly small associations). As a result, the average and median output of all Hessian single-purpose associations (1,100,000 cbm and 807,000 cbm) is significantly lower than the average and median output of the associations of which our sample municipalities are members (1,485,000 cbm and 996,000 cbm). Also, only municipalities with at most two association memberships are represented in the sample. A more balanced sample would include more large municipalities, which tend to be more scale efficient. Hence, we would expect a higher degree of scale efficiency for self-providing municipalities. We believe that the sample selection issue leads to slightly downward biased regression coefficients for the technical inefficiency of association municipalities. The reason is that there would be no additional gains from scale, but higher transaction costs of association membership. In sum, our results can be seen as a bottom line which might underestimate rather than overestimate the true inefficiency effects of joint provision.

Finally, although the organizational and institutional structures of sewage disposal have been relatively stable for decades (see section 4) we cannot rule out an endogeneity bias. However, even if the foundation of single-purpose associations had been driven by efficiency considerations some decades ago, the choice of the organizational form could be considered as exogenous nowadays. This is even more so because the main purpose of these associations is to finance, build and operate joint sewage plants that have a shorter technical life-time than sewer systems.[26] In addition, we expect that major investments in sewage plants have been made only during the last years in order to achieve compliance with the aforementioned EU directive.

8. Conclusion

Contributions from fiscal federalism and public administration research have emphasized efficiency gains, most notably economies of scale and scope, from intermunicipal cooperation. However, there have been only few attempts to quantify these effects, yet. In our empirical contribution we examine the relationship between different forms of intermunicipal cooperation in public service production and efficiency for the Hessian municipal wastewater sector.

Unlike other studies, we focus on the comparison of organizational forms of the public sector rather than on private provision or public private partnerships. The wastewater sector turns out to be particularly well suited to address this question because the output is more tractable. In contrast to other municipal services the Hessian wastewater sector is characterized by well-established and enduring cooperation structures. Another main and distinctive feature of our approach is that we measure inefficiency at the municipality level. This approach makes it possible to compare the gains and losses of organizational choices between different municipalities.

Our considerations reveal a trade-off: On the one hand, the fiscal federalism and public administration literature suggest that intermunicipal cooperation is a way for small and medium-sized municipalities to achieve economies of scale and scope at the cooperation level and hence, increase the individual municipality's technical efficiency. On the other hand, these efficiency gains might be offset by a decrease in technical efficiency due to rising agency costs and additional internal transaction costs from organizational complexity. Joint service production may lower politicians' incentives to effectively monitor local bureaucrats. Furthermore, joint provision will require additional decision-making bodies that weaken transparency and hence, increase transaction costs.

For scale efficiency, our empirical results suggest that the potential for further efficiency gains is limited for wastewater treatment. That is, from a technical point of view, most municipalities operate at a relatively scale-efficient level. Only small municipalities reveal potential efficiency gains from scale. Municipalities that cooperate in single-purpose associations tend

[26] For example, the state of Schleswig-Holstein recommends a depreciation period for public sewer systems of 50 years whereas the recommended depreciation periods for sewage plants range from 10 years (machinery) to 30-33 years (buildings).

to be larger than self-providing municipalities – at least in our sample and for the German state of Hessen in general.

Results of the truncated regressions show that self-providers score higher in terms of technical efficiency than those that transfer the task to a single-purpose association. Presumably, cooperative action would be more efficient if single-purpose associations were more vertically integrated: In the case of Hessen, we observe that only treatment services are being transferred to single-purpose associations whereas sewer systems and fee collection remain in the hands of the member municipalities. Such scattered hierarchies cause additional inefficiencies due to higher internal transaction costs and impede the realization of potential cost savings. Weaker institutionalized forms of cooperation such as intermunicipal contracting reveal a higher degree of efficiency for the contracting municipality. In the Hessian case, contractor municipalities are less efficient due to the fact that they are larger municipalities that do not benefit from further scale effects. If cooperation only regards sewage cleaning, small municipalities may benefit from less institutionalized forms such as intermunicipal contracting rather than from engaging in an intermunicipal body.

Furthermore, population development and settlement patterns have the expected effect. In the course of the ongoing demographic change in Europe and Germany (see Hamm et al. 2008), which affects peripheral municipalities more severely, these variables will gain importance for the network infrastructure in Western Germany as they already have in Eastern Germany.

Our contribution represents a building block to close the research gap on the economic effects of intermunicipal cooperation, but further research is needed. First, there is need for more theoretical research on the performance of intermunicipal cooperation: One challenge for theory will be to explicitly account for real-world complexities and path dependencies of organizational arrangements. For example, the effects of horizontal and vertical integration in intermunicipal relationships are still underinvestigated. Will cooperation be more efficient if it integrates all stages of the production process, i.e. a full transfer of the task? When are less formalized and more flexible cooperative forms such as intermunicipal contracting in general more efficient than cooperation in intermunicipal bodies?

Second, additional research is needed to understand how organizational arrangement affects the degree of efficiency of local public service production. Sewage treatment and disposal is a good example of established cooperation structures and sufficiently well defined outputs. It would be interesting to investigate further municipal services subject to cooperation, such as further fields of network infrastructure, public safety (e.g. fire brigades), culture and recreation (e.g. swimming pools, public libraries, theaters) and intermediate inputs from local administration functions. Insights from this interesting field of research will not only contribute to the ongoing scientific debate on the emergence of intermunicipal cooperation, but will also help practitioners and local politicians to develop realistic views on the consequences of institutional choices.

References

Banker, A. D.; Charnes, A.; Cooper, W. W. (1984): Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 30, 9, 1078-1092.

Bartolini, D.; Fiorillo, F. (2011): Cooperation among local councils for the provision of public goods. Rivista Italiana Degli Economisti, 16, 1, 85-108.

Bel, G.; Fageda, X.; Mur, M. (2012): Does cooperation reduce service delivery costs? Evidence from residential solid waste services. Journal of Public Administration Research and Theory, 1-23.

Bendor, J.; Taylor, S.; Gaalen, R. V. (1985): Bureaucratic expertise versus legislative authority: A model of deception and monitoring in budgeting. The American Political Science Review, 79, 4, 1041-1060.

Bennedsen, M. (2000): Political ownership. Journal of Public Economics, 76, 559-581.

Bischoff, I.; Bönisch, P.; Haug, P.; Illy, A. (2013): Vertical grants and local public efficiency. IWH Discussion Papers, 1/2013. Available at http://d-nb.info/1031813764/34 (accessed 24/07/2014).

Blank, J. L. T.; Knox Lovell, C. A. (2000): Performance assessment in the public sector, in: Blank, J. L. T. (ed.): Public provision and performance. Amsterdam, 3-19.

Bogetoft, P.; Otto, L. (2011): Benchmarking with DEA, SFA and R. Springer International Series in Operations Research & Management Science, 157, New York and others.

De Borger, B.; Kerstens, K. (2000): What is known about municipal efficiency? The Belgian case and beyond, in: Blank, J.L.T. (ed.), Public provision and performance – Contributions from efficiency and productivity measurement, Amsterdam and others, 299-330.

Boyne, G. A. (1998): Bureaucratic theory meets reality: Public choice and service contracting in U.S. local government, Public Administration Review, 58, 6, 474-484.

Breton, A.; Wintrobe, R. (1975): The equilibrium size of a budget maximizing bureau: A note on Niskanen’s theory of bureaucracy. Journal of Political Economy, 82, 195-207.

Brown, T. L.; Potoski, M. (2003): Transaction costs and institutional explanations for government service production decisions. Journal of Public Administration Research & Theory 13, 4, 441–468.

Button, K. J.; Weyman-Jones, T. (1994): X-efficiency and technical efficiency. Public Choice, 80, 1-2, 83-104.

Byrnes, J.; Crase, L.; Dollery, B. E.; Villano, R. (2009): An analysis of the relative efficiency of wastewater utilities in non-metropolitan New South Wales and Victoria. Australasian Journal of Regional Studies, 15, 2, 153-169.

Carruthers, J. I.; Ulfarsson, G. F. (2003): Urban sprawl and the cost of public services. Environment and Planning B: Planning and Design, 30, 4, 503-522.

Chaddad, F. (2012): Advancing the theory of the cooperative organization: The cooperative as a true hybrid. Annals of Public and Cooperative Economics, 83, 4, 445-461.

Coase, R. H. (1937): The nature of the firm. Economica, 4, 16, 386-405.

Coelli, T. J.; Prasada Rao, D. S.; O'Donnell, C. J.; Battese, G. E. (2005): An introduction to efficiency and productivity analysis. New York and others.

Coelli, T.; Walding, S. (2005): Performance measurement in the Australian water supply industry. CEPA Working Papers Series WP012005, School of Economics, University of Queensland, Australia. Available at http://www.uq.edu.au/economics/cepa/docs/WP/WP012005.pdf (accessed 24/07/2014).

Da Cruz, N. F.; Carvalho, P.; Marques, R. C. (2013): Disentangling the cost efficiency of jointly provided water and wastewater services. Utilities Policy, 24, 1, 70-77.

Dafflon, B. (2012): Voluntary amalgamation of local governments: the Swiss debate in the European context. International Center for Public Policy Working Paper Series, 426.

Daraio, C.; Simar, L. (2007): Advanced robust and nonparametric methods in efficiency analysis – methodology and applications. New York.

Efron, B.; Tibshirani, R. J. (1993): An introduction to the bootstrap. New York and others.

Färe, R.; Primont, D. (1988): Efficiency measures for multiplant firms with limited data. In: Eichhorn, W. (ed.): Measurement in economics – Theory and applications of economic indices. Heidelberg.

Ferris, J.; Graddy, E. (1986): Contracting out for what? With whom? Public Administration Review, 46, 4, 332-344.

Ferris, J.; Graddy, E. (1991): Production costs, transaction costs and local government contractor choice. Economic Inquiry, 29, 3, 541-554.

Feiock, R. C. (2007): Rational choice and regional governance. Journal of Urban Affairs 29.1, 47-63.

Feiock, R. C.; Scholz, J.T. (2010): Self-organizing federalism. Cambridge.

Haug, P. (2008): Effects of "democratic control" on the efficiency of local public enterprises: Empirical evidence for water suppliers in Eastern Germany. Public Finance and Management, 8, 1-35.

Grossman, G. M.; Helpman, E. (1996): Electoral competition and special interest politics. Review of Economic Studies, 63, 265-286.

Hamm, I.; Seitz, H.; Werding, M. (2008): Demographic change in Germany. New York.

Hart, O. D. (1983): The market mechanism as an incentive scheme. The Bell Journal of Economics, 14, 2, 366-382.

Heinz, W. (2007): Inter-Municipal Cooperation in Germany: The mismatch between existing necessities and suboptimal solutions, in: Hulst, R.; van Montfort, A. (eds.): Intermunicipal cooperation in Europe. Dordrecht, 91-115.

Hessian Agency for the Environment and Geology (n.d.): Tabelle der Kläranlagen mit zugeordneten Kanalnetzbetreibern und deren Kanalnetzen. Available at http://www.hlug.de/fileadmin/dokumente/wasser/abwasser/jb_ekvo/Kanalnetze.pdf (accessed 19/02/2014).

Hessian Ministry for Environment, Energy, Agriculture and Consumer Protection [HMEEACP] (2007): Beseitigung von kommunalen Abwässern in Hessen. Lagebericht 2006. Available at http://www.hlug.de/fileadmin/dokumente/wasser/abwasser/Lagebericht_2006.pdf (accessed 19/02/14).

Hulst, R.; van Montford, A. (eds.) (2007): Inter-municipal cooperation in Europe. Dordrecht.

Jensen, M. C.; Meckling, W. H. (1976): Theory of the firm: Managerial behavior, agency costs and ownership structure. Journal of Financial Economics, 3, 4, 305-360.

Kalb, A. (2010): Public sector efficiency - Applications to local governments in Germany. Wiesbaden.

Koziol, M. (2004): The consequences of demographic change for municipal infrastructure, in: Müller, B. (ed.), Demographic change and its consequences for cities, German Journal of Urban Studies (Deutsche Zeitschrift für Kommunalwissenschaften). Available at http://www.difu.de/node/6059 (accesed 07/07/2014).

Krueger, S.; Bernick E. M. (2010): State rules and local governance choices. The Journal of Federalism, 40, 4, 697-718.

Kumbhakar, S. C.; Knox Lovell, C. A. (2000): Stochastic frontier analysis. Cambridge.

Kwon, S.-W.; Feiock R. C. (2010): Overcoming the barriers to cooperation: Intergovernmental service agreements. Public Administration Review 70, 6, 876-884.

Lackey, S. B.; Freshwater, D.; Rupasingha, A. (2002): Factors influencing local government cooperation in rural areas: Evidence from the Tennessee Valley. Economic Development Quarterly 16.2, 138-154.

Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württenberg [LUBW] (2007): Fremdwasser in kommunalen Kläranlagen – Erkennen, bewerten und vermeiden. Available at http://www.lubw.baden-wuerttemberg.de/servlet/is/24195/fremdwasser_in_kommunalen_klaeranlagen_kurz.pdf?command=downloadContent&filename=fremdwasser_in_kommunalen_klaeranlagen_kurz.pdf (accessed 27/05/2014).

Leibenstein, H. (1966): Allocative efficiency vs. “X-Efficiency”. The American Economic Review, 56, 3, 392-415.

LeRoux, K.; Carr, J. B. (2007): Explaining local government cooperation on public works evidence from Michigan. Public Works Management & Policy 12.1, 344-358.

Megginson, W. L.; Netter, J. M. (2001): From state to market: A survey of empirical studies on privatization. Journal of Economic Literature, 39, 321-389.

Ménard, C. (2004): The economics of hybrid organizations. Journal of Institutional and Theoretical Economics, 160, 345-376.

Migué, J.-L.; Bélanger, G. (1974): Toward a general theory of managerial discretion. Public Choice, 17, 1, 27-47.

Moe, T. M. (2006): Political control and the power of the agent. Journal of Law, Economics and Organization, 22, 1, 1-29.

Mohr, R.; Deller, S. C.; Halstead, J. M. (2010): Alternative methods of service delivery in small and rural municipalities. Public Administration Review, November/December 2010, 894-905.

Moss, T. (2008): ‘Cold spots’ of urban infrastructure: ‘shrinking’ processes in Eastern Germany and the modern infrastructural ideal. International Journal of Urban and Regional Research 32, 2, 436-451.

Nelson, M. A. (1997): Municipal government approaches to service delivery: An analysis from transactions cost perspective. Economic Inquiry, Vol. XXXV, 82-96.

Niskanen, W. A. (1971): Bureaucracy and representative government. Chicago.

Posner, R. A. (2010): From the new institutional economics to organization economics: With applications to corporate governance, government agencies, and legal institutions. Journal of Institutional Economics, 6, 1-37.

Powell, W. W. (1991): Neither market nor hierarchy: network forms of organization, in: Thompson, G., Frances, J., Levacic, R., Mitchell, J. (eds): Market, hierarchies and networks: The Coordination of Social Life, London, 265-276.

Richardson, G. B. (1972): The organization of industry. Economic Journal, 82, 327, 883-896.

Sauer, J. (2005): Economics and efficiency of water supply infrastructure. Berlin.

Shepard, R. W. (1970): Theory of cost and production functions. Princeton.

Shleifer, A. (1998): State versus private ownership. Journal of Economic Perspectives, 12, 4, 133-150.

Simar, L.; Wilson, P. (2007): Estimation and inference in two-stage, semi-parametric models of production processes. Journal of Econometrics, 136, 31-64.

Söderberg, M. (2011): Firm-level inefficiency and its determinants in the Swedish water and wastewater sector. Applied Economics Letters, 18, 12, 1149-1153.

Sørensen, R. J. (2007): Does dispersed public ownership impair efficiency? The case of refuse collection in Norway. Public Administration, 85, 4, 1045-1058.

Statistical Office of Hessen (2006): Hessische Gemeindestatistik 2006. Ausgewählte Strukturdaten aus Wirtschaft und Bevölkerung 2005. Available at http://www.statistik-hessen.de/publikationen/download/496/index.html (accessed 19/02/2014).

Statistical Office of Hessen (2007): Hessische Gemeindestatistik 2007. Ausgewählte Strukturdaten aus Wirtschaft und Bevölkerung 2006. Available at http://www.statistik-hessen.de/publikationen/download/496/index.html (accessed 19/02/2014).

Steiner, R. (2003): The causes, spread and effects of intermunicipal cooperation and municipal mergers in Switzerland. Public Management Review, 5, 4, 551-571.

Wagener, F. (1974): Neubau der Verwaltung. Schriftenreihe der Hochschule Speyer. Berlin.

Warner, M. (2011): Competition or cooperation in urban service delivery? Annals of Public and Cooperative Economics, 82, 4, 421-435.

Williamson, O. E. (1985): The economic institutions of capitalism. New York.

Williamson, O. E. (1989): Transaction cost economics, in: Schmalensee, R.; Willig, R. (eds.): Handbook of industrial organization. Vol. I, 135-182, Oxford and others.

Williamson, O. E. (1991): Comparative economic organization: The analysis of discrete structural alternatives. Administrative Science Quarterly, 36, 269-296.

Williamson, O. E. (1996): The mechanisms of governance. Oxford and others.

Wollmann, H.; Kuhlmann, S. (2008): Federal republic of Germany, UCLG country profiles. Available at http://www.citieslocalgovernments.org/gold/Upload/country_profile/Germany.pdf (accessed 15/07/2014).

Woodbury, K.; Dollery, B. E. (2004): Measuring efficiency in Australian local government: An empirical evaluation of nsw municipal wastewater services. UNE Working Paper Series in Economics, Working Paper 2004-10, School of Economic Studies, University of New England (not available online anymore).

Worthington, A. C.; Dollery, B. (2000): Efficiency measurement in the local public sector: Econometric and mathematical programming frontier techniques. Brisbane, School of Economics and Finance, Discussion papers in economics, finance and international competitiveness, 78, available at http://external-apps.qut.edu.au/business/documents/discussionPapers/2000/Worthington_Dollery_78.pdf (05/03/2014).

Wyckoff, P. G. (1990): The simple analytics of slack-maximizing bureaucracy. Public Choice, 67, 35-47.

Zschille, M. (2012): Consolidating the water industry: An analysis of the potential gains from horizontal integration in a conditional efficiency framework. Discussion paper 8737, London Centre of Economic Policy Research.

Appendix A:

Table A: Type numbers used for input construction

Single-entry bookkeeping single-purpose associations

Input	Type number	Comment
Labor	4	Staff expenditures
Capital	53	Rents and leases
	680	Imputed depreciation
	685	Imputed interests
Resources and intermediate in-puts	50	Maintenance of property and buildings
	51	Maintenance of other immoveable property
	52	Equipment, basic commodities
	54	Management of property and buildings
	55	Expenditures for motor vehicles
	56	Special expenditures for civil servants
	63	Further administrative and operating expenditures
	64	Taxes, insurances, claims
	65	Business expenditures
	66	Further general business expenditures
	67 (including 672) Not 679	Reimbursement of expenditures of the current account to others 679: internal offsets 672 (reimbursement of expenditures to municipalities) includes at least partly cash flows to member municipalities Correction at the municipal level by deducting type number 163 (revenues from reimbursement of expenditures of the current account from single-purpose associations) from its inputs used for sewage disposal
	71	Grants for current aims to others No correction for 712 (grants for current aims to municipalities), because of the quantitative insignificance of the item

Source: Authors' compilation.

Table B: Type numbers used for input construction

Single-entry bookkeeping municipalities

Input	Type number	Comment
Labor	4	Staff expenditures
Capital	53	Rents and leases
	680	Imputed depreciation
	685	Imputed interests
Resources and intermediate inputs	50	Maintenance of property and buildings
	51	Maintenance of other immoveable property
	52	Equipment, basic commodities
	54	Management of property and buildings
	55	Expenditures for motor vehicles
	56	Special expenditures for civil servants
	63	Further administrative and operating expenditures
	64	Taxes, insurances, claims
	65	Business expenditures
	66	Further general business expenditures
	67 (including 679)	Reimbursement of expenditures of the current account to others including type number 679 internal offsets (= inputs "purchased" from other municipal departments)
	71	Grants for current aims to others
	Not 713	Grants to single-purpose associations (only deducted for member municipalities of single-purpose associations!) – consist mainly of the contribution(s) ("Zweckverbandsumlage") paid to one or more single-purpose association(s)
Correcting items	163	Revenues from reimbursement of expenditures of the current account from single-purpose associations (booked as 672 reimbursement of expenditures to municipalities by single-purpose association); to avoid double-counting the inputs of member municipalities are reduced by 163 in proportion to their factor intensities.
	$Input_i^{own} \cdot (1 - 20\%) \cdot (1 - ww_{own}))$	In case of wastewater from outside the municipality's boundaries that is cleaned in own sewer plants, 20% of each of the municipality's own inputs (the assumed input share attributable to the sewage plants) is reduced proportionally to the share of wastewater from outside the municipality.

Source: Authors' compilation.

Table C: Descriptive statistics
Comparison between all Hessian municipalities and the sample

	All Hessian district-affiliated municipalities (N = 421)			Sample (N = 193)		
	Area [a)]	Population [a)]	Population density [a)]	Area [a)]	Population [a)]	Population density [a)]
Minimum	4.05	680	22.68	4.40	680	22.68
1st Qu.	26.26	4,895	103.62	21.57	3,768	86.44
Median	40.83	7,842	196.43	37.45	5,937	178.12
Mean	47.65	11,152	322.73	42.49	8,406	283.10
3rd Qu.	63.80	13,693	407.41	55.00	9,269	303.64
Maximum	142.09	88,472	2,267.73	115.72	63,886	2,267.73
Wilcoxon rank-sum test	W=44,700; p-value= 0.04591	W=48,949; p-value= 0.000045	W=44,378; p-value= 0.066			

Notes: [a)] Date of measurement: 31/12/2005.

Source: Authors'calculations.

Table D: Results of the Kruskal-Wallis Test

H_0:*	Kruskal-Wallis Test Equal group distributions
Scale efficiency	Cannot reject H_0 H= 4.795 < χ^2 (4; 95%) =9.4877
Population size	Reject H_0 H=17.112 > χ^2 (4; 95%) =9.4877
Output size (sewage volume)	Reject H_0 H=17.015 > χ^2 (4; 95%) =9.4877

Source: Authors' calculations. * All results reported for α = 5%.

Table E: Results of the Wilkoxon-Mann-Whitney Tests by pairs for sewage volume and population size figures

H_0: The pair of groups are equally distributed*	Self-provider	Self-provider + sewage import	Single-purpose association	Contracting municipality
Self-provider + sewage import	Reject H_0			
Single-purpose association	Reject H_0	Cannot reject H_0		
Contracting municipality	Cannot reject H_0	Reject H_0	Reject H_0	
Mixed forms	Cannot reject H_0	Reject H_0	Cannot reject H_0	Cannot reject H_0

Source: Authors' calculations. * All results reported for α = 5%.

Appendix B:

Basic principles of DEA calculation

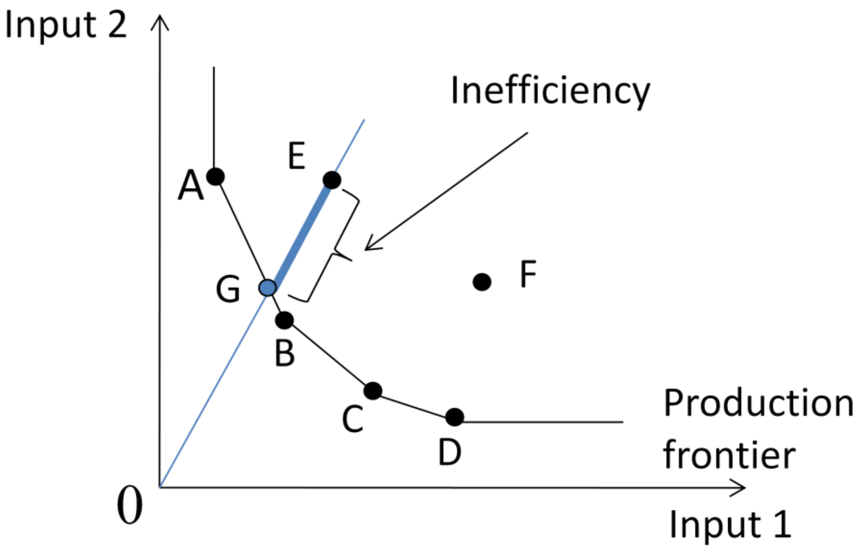
In this section we explain the fundamentals of Data Envelopment Analysis (DEA) with focus on the input-oriented approach. The interested reader is referred to introductory textbooks such as Coelli et al. (2005) or Bogetoft and Otto (2011).

In applied research basically two approaches have been developed to measure relative efficiency: on the one hand, parametric approaches, in particular stochastic frontier analysis (SFA) (Aigner et al. 1977 and Meeusen and van den Broeck 1977) and on the other hand, non-parametric methods like Free Disposal Hull (FDH) (Deprins et al. 1984) and DEA (introduced by Charnes et al. 1978, based on the seminal work by Farrell 1957) are used. Although the SFA has the advantage of allowing deviations from the frontier due to measurement error or stochastic influences, it is usually not appropriate for measuring cost efficiency when price data are not available: In case of the mostly used flexible functional forms like the translog the omission of prices leads to omitted variable problems. In contrast, the non-parametric approach does not require the specification of a functional form at all.

Due to this consideration we choose the non-parametric approcach. The basic difference between FDH and DEA is that the latter relies on the assumption of a convex underlying production technology set. In practice, this means that DEA measures relative efficiency of one decision-making unit (DMU), e.g. an enterprise or a municipality, in relation to a linear combination of the input- and output vectors of the best-performing DMUS (the so-called "peers"). FDH skips the convexity assumption, but this comes at the price of a significantly reduced number of comparison units with the result that in small samples often more than 80% of the observations are classified as efficient.

In the DEA model a convex hull is constructed from the data by applying linear programming techniques, resulting in a piecewise linear frontier which represents the production possibilities. We choose the input-oriented approach because municipalities are expected to have more discretion in choosing their input mix while the quality and quantity of the output is often fixed by regulation. Thus, the frontier is based on the observations that need the least inputs to generate a certain output quantity. The following figure A illustrates the basic principle for the 2-input-1-output case:

Figure A: DEA (input-oriented approach)



Source: Authors' illustration.

Consider the observations A, B, C, D, E, F that are assumed to produce the same output quantity by different input combinations (in physical units). A, B , C, D and their linear combinations form the (observable) convex hull of the production technology and thus the production frontier. These DMUs are called input-efficient because there are no other observations that produce at least the same output quantity with fewer inputs. An observation´s relative inefficiency can be measured by the relative distance between the observation and the production frontier, for example $\delta_E = \|OE\| / \|OG\| \geq 1$ for observation E. This illustrates the fundamental characteristic of the DEA that the reference unit for observation E is neither A nor B but a linear combination of both. The reciprocal of δ is the input-oriented Farrell measure $0 < \theta \leq 1$ which expresses to what percentage of the original inputs the inputs could be radially contracted. Both measures state the relative technical efficiency. If we had information about input prices, we could also calculate the allocactive efficiency and the overall cost efficiency.[27] However, this is not the case. Thus, we confined ourselves to calculating technical efficieny and replaced the unobservable physical input quantities by the corresponding expenditure categories.

[27] In this case, the reference point for *E* would be no longer *G* but the point of tangency of the corresponding isocost line with the production frontier. Cost efficiency is defined as the ratio of the actual input vector quantities multiplied by the factor price vector (actual cost) to the cost-minimizing input vector multiplied by the factor price vector (minmum cost). Allocative efficiency is defined as the ratio of the technically efficient input vector multiplied by the factor price vector to the minimum cost. It can be shown that cost efficiency can be expressed as the product of technical efficiency and allocative effiency (e.g. Coelli et al. 2005, 52-54.)

To calculate the relative efficiency measures for the multi-input-multi-output case the following linear programme[28] (Banker, Charnes an Cooper 1984) has to be solved for each observation *i*:

$$
\begin{aligned}
&\min_{\theta,\lambda} \theta \\
&s.t. \\
&\theta C_i \geq C\lambda \\
&Y\lambda \geq y_i \\
&\lambda \geq 0 \\
&I\lambda = 1
\end{aligned}
$$

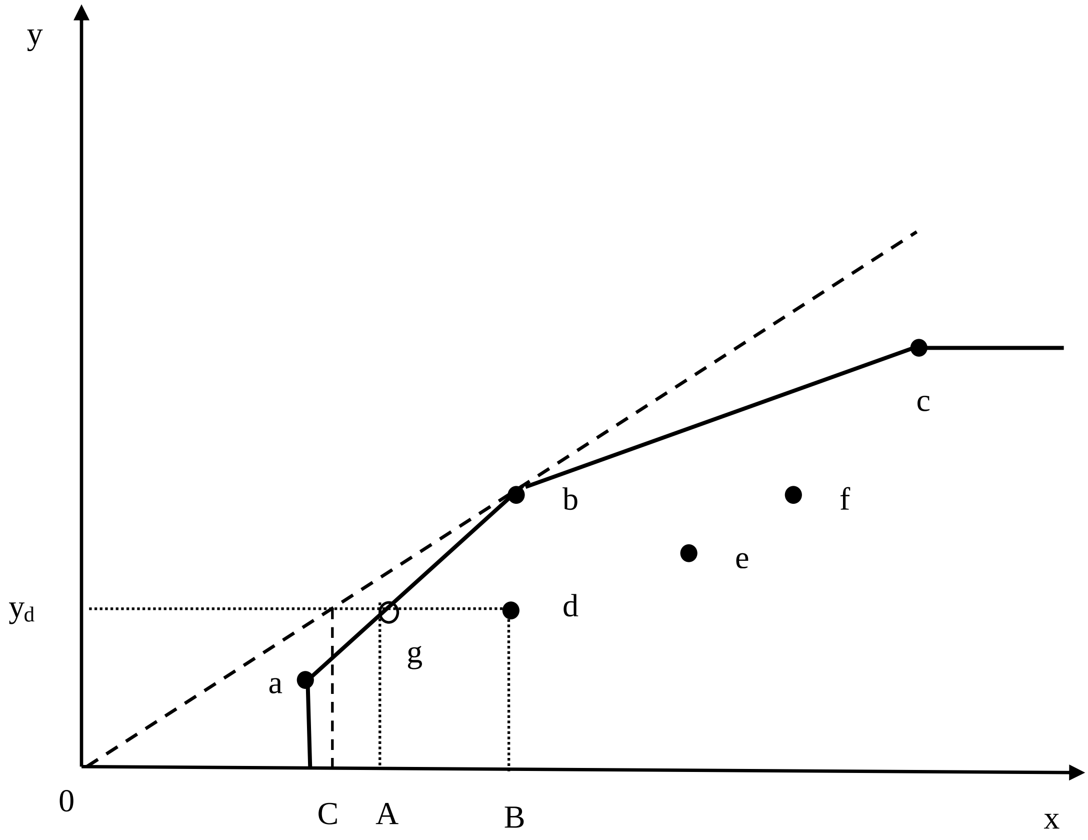
This linear programme involves searching for the minimum percentage θ to which all inputs of input vector C_i (in monetary units) of observation i can be contracted radially subject to the conditions that a) that the resulting input quantity θC_i is higher or equal to all inputs of a linear combination $C\lambda$ of the inputs of all DMUS and that b) observation i`s outputs y_i do not exceed a linear combination of all DMUs´outputs $Y\lambda$. The last equation after the nonegativity constraint for λ is the convexity constraint to allow for variable returns of scale.[29] It essentially ensures that inefficient firms are only benchmarked against DMUs of similar size.

The relation between technical efficiency, returns to scale and scale efficiency can be illustrated graphically for the one-input-one-output case (figure B):

[28] Actually, it is the dual programme (or envelopment form) of the multiplier formulation of the DEA problem. The multiplier formulation is based on the ratio formulation of the DEA programming problem. The latter is more closely linked to total productivity analyis because it involves finding the optimal weights in order to maximize the ratio Σweighted outputs/Σweighted inputs for each observation.

[29] If the convexity constraint is omitted, constant returns to scale are assumed for the underlying production technology.

Figure B: Scale efficiency measurement in DEA



Source: Authors' illustration.

Again, we have the DMU observations *a* to *f* which employ one input *x* to produce one output *y*. In case of variable returns to scale the observations *a*, *b* and *c* form the VRS production frontier. If we assume constant returns to scale than the dashed line passing through *b* is the CRS production frontier with *b* having the highest observable factor productivity. Consequently, *b* is technically efficient and scale efficient because it is located on the production frontier and factor productivity cannot be further increased by choosing different input-output combinations. Observation *d* is technically inefficient and scale inefficient. Scale efficiency of observation *d* can be expressed as the ratio of the factor productivity of *b* to the factor productivity of *g* (i.e. the factor productivity if *d* produced y_d technically efficient), which can be written as:

$$SE_d = \frac{y_b / x_b}{y_g / x_g} = \frac{0y_d / 0C}{0y_d / 0A} = \frac{0A}{0C} = \frac{0A/0B}{0C/0B} = \frac{0B/0C}{0B/0A} = \frac{\delta_d^{CRS}}{\delta_d^{VRS}} \geq 1.$$

This equation also holds for a multi-input, multi-output setting and leads to equation (1).

Additional quoted literature not included in the references:

Aigner, D.J.; Lovell, C.A.K.; Schmidt, P. (1977): Formulation and estimation of stochastic frontier production function models, Journal of Econometrics, 6(1), 21-37.

Charnes, A.; Cooper, W.W.; Rhodes, E. (1978): Measuring the efficiency of decision-making units, European Journal of Operational Research, 2(6), 429-444.

Deprins, D.L.; Simar, L.; Tulkens, H. (1984): Measuring labor-efficiency in post offices, in: Marchand, M.; Pestieau, P.; Tulkens, H. (eds) The performance of public enterprises: Concepts and measurement, North-Holland, Amsterdam, 243-268.

Farrell, M.J. (1957): The measurement of productive efficiency, Journal of the Royal Statistical Society, Series A (General), 120(3), 253-290.

Meeusen, W.; van den Broeck, J. (1977): Efficiency estimation from Cobb-Douglas production functions with composed error, International Economic Review, 18(2), 435-444.