Institut für Wirtschaftsforschung Halle
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February 2007 No. 3

IWH-Diskussionspapiere
IWH-Discussion Papers

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Local Government Control and Efficiency of the Water Industry: An Empirical Analysis of Water Suppliers in East Germany[1]

Abstract

The paper deals with the effects of local governments' interference with business affairs of publicly owned utilities. A partial model is presented to illustrate the consequences of "democratic control" for the public managers' effort and the efficiency of local public production. To check the theoretical results empirically, a two-stage data envelopment analysis (DEA) is carried out for a sample of East German water suppliers. The organisational form is used as a measure for the degree of municipal control. The results of the OLS- and Tobit regression indicate an efficiency-enhancing effect of organisational forms with less distinctive control options for local politicians.

JEL-Classification: L95, L32, D73

Keywords: efficiency, water industry, local governments, data envelopment analysis

Zusammenfassung

Die vorliegende Arbeit beschäftigt sich mit den Auswirkungen kommunalpolitischer Einmischung in die unternehmerischen Entscheidungen öffentlicher Versorger. Dazu werden in einem partialanalytischen Modell die Folgen der "demokratischen Kontrolle" für die Motivation eines repräsentativen öffentlichen Managers und damit für die Effizienz der kommunalen Produktion untersucht. Zur Überprüfung der theoretischen Ergebnisse wird eine zweistufige Data Envelopment Analyse (DEA) für eine Stichprobe ostdeutscher Wasserversorger durchgeführt. Dabei wird die Rechtsform als Indikator für das Ausmaß der kommunalen Einflussnahme verwendet. Die Ergebnisse der OLS- und der Tobit-Regressionsanalyse deuten auf eine effizienzsteigernde Wirkung bei Rechtsformen mit geringeren Kontrollmöglichkeiten für Kommunalpolitiker hin.

Keywords: Effizienz, Wasserwirtschaft, Kommunen, Data Envelopment Analyse

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1 I would like to thank (in alphabetical order) Ulrich Blum, Christian Growitsch, Joachim Wilde and Götz Zedies for their helpful comments on earlier versions of this paper.

Contents

I. Introduction

Despite of some trends towards privatisation and liberalisation of the national water markets in the past, the liberalisation and privatisation of the water sector seem to stagnate: According to calculations by Lauber (2006, p. 17) about 36% of the EU-25 population was supplied by 'private' water providers in 2003/04. But this percentage has to be interpreted cautiously. First of all, as Lauber points out, it exaggerates the extent of privatisation because for some countries it includes public-private companies with less than 50% of the shares held by private investors or in some cases even publicly owned companies under private law. Furthermore, the inclination to privatise water and sewage services is unevenly distributed in Europe. Especially in Central Europe (including Switzerland) and the Scandinavian countries (including Norway) the market share of private and public-private water suppliers is rather marginal. The Netherlands even prohibited the privatisation of their water systems by law in 2000 and Sweden is currently drafting a new water law to make privatisation more difficult. The market share of private water utilities is also negligible in most of the new EU member states. In Southern Europe (Greece, Portugal, Spain, Italy), but also in Hungary and Estonia a weighted average of one third of the population is supplied by private or public-private water companies. A majority of the population in France (79%), UK (87%) and the Czech Republic (70%) get their water from private companies. Except for England/Wales and the Czech Republic, in most EU countries the relevant facilities are usually publicly, mostly municipally owned and the privatisation is restricted to management and operation.

There are some indications that further liberalisation of the European water market seems to be not very likely.[2] The plans of the European Commission on 'services of general interest' (SGI) have caused fierce resistance and protests among the member states. Up to now, the Commission has not yet prepared a draft directive on the liberalisation of the water sector as well as no draft SGI framework directive. This might indicate that the Commission has given up its former plans to enforce the liberalisation of the European water markets.

In other important industrialised countries, no steps seem to have been taken to accelerate the privatisation of the water sector. For example, about 85% of the water is currently provided by municipal water systems in the USA and this percentage has remained quite stable since the end of World War II (NRC 2002). Other countries such as Canada, Japan and Korea rely on public ownership and public management of their water facilities.[3]

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2 See *Hall* (2006).

3 See *OECD* (2004), pp. 32-33 for an overview of the institutional arrangements of 29 OECD countries.

In general, the prevalent public attitude towards privatisation and liberalisation especially in the water sector tends to be quite negative, in developing as well as in industrialised countries. According to Hall et al. (2005) some symptoms of increasing international public resistance against privatisation of water utilities could be found.

In Germany, not only outsourcing of municipal services to private firms is hotly debated but also the so-called "formal privatisation" of municipal services (turning former municipal departments into municipal companies). Critics argue that this would cause a "loss of democratic control". The interesting question is how this would affect the efficiency of public service provision.

The focus of this paper lies on the impact of "democratic control" exercised by the local governments on the efficiency of the water sector if privatisation is no option. If it was assumed that the local governments were still responsible for water provision and drinking water was produced and distributed by some municipal entity, how would different levels of public interference (excluding privatisation) or more leeway for public managers affect the efficiency of water provision? Particularly, if municipal control was not replaced by alternative regulation systems such as cartel offices or other regulation authorities?

The paper is structured as follows. In section II an overview over the previous literature in this field will be given and in III a partial model considering the effects of municipal control on public management's effort and efficiency of production will be introduced. Sections IV to VI will present the results of a two-stage DEA focusing on the impact of the organisational form on the efficiency of East-German water utilities. In section VII tentative conclusions will be drawn from the results.

II. Previous literature

The previous work on institutions and efficiency in the water sector does not contribute very much to the main issue of this paper. The bulk of this literature focuses on the question whether private or publicly owned water suppliers provide and produce water more efficiently. Two strings of the literature can be found: on the one hand, cross-section or panel-data comparisons of private and publicly owned water suppliers and on the other hand "before-and-afterwards" studies of privatisation effects on efficiency. The first group includes mostly studies of US water suppliers such as Feigenbaum and Teples (1983), Fox and Hofler (1986), Bhattacharyya et al. (1994, 1995), but also for Brazil (Faria al., 2005) or the Asian/Pacific region (Estache and Rossi, 2002). Ex-post analyses of privatisation effects on the efficiency of UK water suppliers were conducted by Ashton (2000) or Saal and Parker (2001). The authors of these studies apply a variety of methods including econometric estimations of cost functions, stochastic frontier analysis and data envelopment analysis (DEA). According to Dupont and Renzetti (2003) the results of these studies do not provide evidence for higher productivity or efficiency of private water utilities.

Obviously, privatisation did not turn out to be the magic cure against the supposed efficiency problems in the water sector. Besides historical, political and cultural constraints this is mainly due to the fact that water markets have a monopolistic structure. Former local or regional public monopolies would have to be replaced by private monopolies causing considerable regulation cost to guarantee competitive prices and sufficient facility investment.

Except for the aforementioned studies dealing with ownership and efficiency few empirical studies on other aspects of the relationship between institutions and efficiency of water supply exist. Aubert and Reynaud (2005) investigate the impact of different regulation systems applied in the Wisconsin water sector (price cap versus rate of return) on cost efficiency by using a cost frontier approach. They found for example that utilities (municipally owned as well as private) under the rate of return system work most efficiently provided the state regulation authorities gather full information.

Based on the work of Wolak (1994) Brocas et al. (2006) estimate the welfare losses caused by regulation of private Californian water suppliers due to asymmetric information. They find that the actual rate of return regulation provides a superior result to price cap regulation. Generally, the results for the system of regulation by public utility commissions in certain US states are very instructive but cannot be transferred even to other US states because, as Aubert and Reynaud (2005, p. 383) point out, unobservable characteristics might blur the results. Furthermore, regulation of water utilities by public utility commissions is not the standard procedure of regulation in the USA. 44 of 50 US states are currently regulating water utilities, most of them only larger investor-owned suppliers.[4] Therefore, regulation of municipally owned water suppliers by the local government seems to be the by most widespread form of regulation in the USA.

Garcia and Thomas (2002) deal theoretically and empirically with the problem of a local community willing to delegate the management of its water facilities to a private company. They develop a theoretical model of the optimal contract under asymmetric information and simulate their results for a sample of French municipalities. Although the results are quite interesting, they are of limited value for the situation in many countries where outsourcing of water provision is usually not very common.

The theoretical foundation of the papers of Brocas et al. and Garcia and Thomas is often referred to as mechanism-design theory in regulatory economics, beginning with Baron and Myerson (1981) and strongly promoted by Laffont and Tirole (1986, 1993). The authors assume some benevolent regulation authority or benevolent local government which can use information from firm accounts about actual costs. Efficiency losses and the need for regulation arise from asymmetric information causing the usual principal-agent problem. The regulators offer some information rent to the suppliers as an incentive for cost minimisation. The adequacy of this assumptions will be discussed further in section III.

In this paper, a malevolent (e.g. vote-maximising) local government is implicitly assumed, which has no incentives to maximise social welfare. Furthermore, the principal(s) are confronted with information asymmetries between principal and agent. In the theoretical model as well as in the real world water sector in Germany both local governments (principals) and public managers/bureaucrats (agents) are restricted in their actions by budget constraints. An increased leeway of decision-making for public managers or bureaucrats in publicly owned enterprises might lead to more efficiency due to two factors: First, it would be more difficult for the local government to follow its own agenda, e.g. by fixing the capital stock or the labour force of the relevant water supplier. Second, on the one hand assuming slack-maximising behaviour (Wyckhoff 1990) bureaucrats or public managers could intensify their shirking and rent-seeking activities. But on the other hand, things are not that simple because reduced municipal control might lead to increasing non-monetary benefits for managers from what is called "job enlargement" or "job enrichment" in the business administration literature (e.g. Hackman and Oldham 1980): Primarily their greater leeway for decisions may increase job satisfaction and thus manager's effort. Efficiency gains in public production of that kind are very likely for budget-maximising (Niskanen 1971) and effort-minimising bureaucrats as could be seen from the model in section III.

4 See *NRRI* (2006) for an overview. According to *NRC* (2002), pp. 94-95, in 1995 only about 21 state public utility commissions (PUC) regulated beyond investor-owned utilities and only 11 state PUCs regulated municipally owned water utilities. For wastewater utilities the numbers are even lower.

To shed more light on this issue, after illustrating the effort and efficiency effects in a partial microeconomic model, a two-stage data envelopment analysis (DEA) is conducted for a sample of East German water suppliers. Democratic control is operationalised by the organisational form of the municipal enterprise. One essential advantage of using this non-parametric approach is that assumptions about production technologies, profit maximisation or cost minimisation can be avoided. The last two points are not very realistic assumptions for public enterprises but crucial for the application of stochastic frontier analysis or other purely econometric methods. Furthermore, this two-stage approach is particularly suited to control for environmental variables, which are factors that might influence efficiency but are not under the control of the managers.

Although it has been applied to a wide range of fields the DEA approach has not received overwhelmingly much attention yet in the water sector. Most authors (Lambert et al. 1993, Bhattacharyya et al. 1995) focus their DEA studies on efficiency differences between private and public US water suppliers. In the UK, DEA is used as a benchmarking tool for regulated water utilities. See Cubbin and Tzanidakis (1998) or Thanassoulis (2000) for this subject. Only Puwein et al. (2002) also integrate the organisational form as an environmental variable in their two-stage DEA of a sample of Austrian municipal water suppliers. But they do not find a significant effect on efficiency for this variable. Especially for Germany, except for Sauer's (2005) econometric cost study of rural German water suppliers, no other comprehensive efficiency analysis of the German water sector exists.

III. Some theoretical considerations

This section deals with some theoretical considerations about the effects of municipal control on management effort and efficiency of local public enterprises. To illustrate the welfare effects of institutional changes on efficiency of public production, a model in the tradition of Rees (1984) is used to analyse public managers' incentives and behaviour. The prevalent principal-agent models with hidden action of the "mechanism design literature" (see e.g. Laffont and Tirole, 1993) seem to be no adequate tools for the central questions of this paper.[5]

First of all, they belong to the field of normative theory. Their main target is to develop optimal incentive schemes to reduce the information asymmetries between principal and agent. They usually do not investigate existing institutional arrangements and their effects on the actual behaviour of public managers. Bös (1994, 369-70) agrees with other critics that the underlying utility function *U(T, E)* with monetary transfer *T* and effort *E* does not describe the objectives of an European bureaucrat or public manager with a fixed salary that is more or less independent of his activities. Thus, according to Niskanen's (1971) theory of the budget-maximising bureaucrat in the following model the representative public manager is assumed to maximise his utility function *U (X, E)*[6] with output *X* of the relevant good.

Finally, the underlying assumptions about the principals' or regulators' information seem to be too unrealistic even in a necessarily simplifying model world so that the derived results could be of any use in practise. Regulators are assumed to be fully informed about the production technology (except for one external parameter of which only the probability distribution is known) and they are also supposed to be able to reveal and measure the manager's utility in monetary units.

The assumptions of the following model are less demanding. First, the principal (the local government) shall have no or only vague information about the production technology and the representative manager's utility function is unknown to the principal, except for the fact that the manager loves output and dislikes effort. Revenues, output and input quantities except for effort as well as the exogenously given factor prices can be observed. Second, the only regulatory instrument used by the local government is a budget constraint.

(1) $$p(X)\cdot X - r\cdot C = 0$$

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5 For a critical evaluation of this approach see *Crew* and *Kleindorfer* (2002), pp. 10-13.

6 Other possible utility functions might include the capital stock, the labour force, total cost or a combination of bureaucrat-trade union objectives.

The water utility is a local public monopoly and *p(X)* represents the inverse of the citizens' demand function, which shall be known to the public managers but not to the local politicians. In this static model setting the revenues have to cover the long-term costs of capital *r·C*.[7] Although subsidies by higher levels of the government are quite relevant for financing the capital stock, they are omitted here. Other constraints such as a maximum/minimum capital stock or labour force fixed by the local politicians, who follow their own interests, are of course relevant in practise but will also be omitted in this model.[8] Trivially, they are further sources of inefficiencies in the provision and production of public goods and services, which could be confined by reducing the influence of these principals on the economic activities of local public firms.

The representative water utility uses a production technology *F(C, E)* with the usual properties: substitutability of inputs and diminishing marginal products. The production is assumed to be efficient in the sense that no excess capacity exists and any *X* is produced at the production frontier.[9]

(2) $$X = F(C,E) \;\Rightarrow\; C = C(X,E)$$

To simplify the analysis especially with regard to the empirical verification of the hypothesis, the output quantity is taken as exogenously given. Consequently, the price and the turnover revenues are constants and the manager's utility maximising problem reduces to effort minimization. To avoid the degeneration of the solution (*C* would be determined solely by the budget constraint and therefore *E* by the production technology), the budget constraint in (1) has to be loosened allowing for a deficit *D*.

(3) $$p(\overline{X}) \cdot \overline{X} + D = r \cdot C$$

This deficit is also a decision variable for the public manager but it is subject to negotiations with the local government as well as with the municipal supervisory authorities. It is assumed that the manager's difficulties in achieving acceptance increase with the size of *D*. This is reflected by an increasingly negative utility derived from the deficit. According to the principal-agent literature an additive separable utility function is assumed.

7 For simplicity, labour and other inputs are neglected as well as the manager's fixed salary.

8 One example of an excess capital stock fixed by the local government, which even attracted the attention of the European Commission, was the sewage plant of the city of Meißen, East Germany. The capacity of the plant turned out to be far too large for a decreasing population and the latest but redundant technology was installed.

9 *Rees* (1984), pp 183-184 derives this result from the optimisation behaviour of the public manager in a similar model. Thus, it is not necessary to introduce the less binding constraint $X \leq F(C,E)$. Furthermore, efficiency of production is an explicit function in similar studies such as by *Friedrich* et. al. (2004), p 17.

(4) $$U(E, D) = \psi(D) + \pi(E)$$

with ψ (*D*), π (*E*) < 0, ψ' (*D*), $\pi'(E)$, < 0, ψ'' (*D*) ≥ 0 and π''(E) ≥ 0 for *D*, *E* > 0.

Maximising the negative utility U(*E*, *D*) is equivalent to minimizing –U(*E*, *D*). The maximization problem of the manager therefore consists of minimizing –U(*E*, *D*) subject to (2) and (3). Unfortunately, the constraint set is convex and so the objective function (the indifference curve) has to be at least strictly quasiconcave for a unique constrained minimum. Thus, the following disutility function with constant marginal disutility is assumed.

(5) $$U(E, D) = \psi \cdot D + \pi \cdot E$$

with ψ, π > 0 for *D*, *E* > 0.

Assuming *F*(*C*, *E*) to be of the Cobb-Douglas type $X = C^{\alpha} E^{\beta}$ with $0 < \alpha, \beta < 1$ and inserting (2) into (3) leads to the following Lagrange function:

(6) $$L = \psi \cdot D + \pi \cdot E + \lambda(p(\overline{X}) \cdot \overline{X} + D - r \cdot \overline{X}^{\frac{1}{\alpha}} \cdot E^{-\frac{\beta}{\alpha}})$$

Minimisation of (6) yields the first order conditions for a constrained minimum:

(7) $$-\frac{\frac{\partial U}{\partial E}}{\frac{\partial U}{\partial D}} = -\frac{\pi}{\psi} = -r \cdot \frac{\alpha}{\beta} \cdot \overline{X}^{\frac{1}{\alpha}} \cdot E^{-\frac{(\alpha+\beta)}{\beta}} = r \cdot \frac{\partial K}{\partial E}$$

(8) $$p(\overline{X}) \cdot \overline{X} + D - r \cdot \overline{X}^{\frac{1}{\alpha}} \cdot E^{-\frac{\beta}{\alpha}} = 0$$

The first condition implies that the slope of the indifference curve (the marginal rate of substitution) has to be equal to the slope of the factor transformation curve[10] multiplied by the capital price. Solving (7) for *E* yields

(9) $$E^{*} = \left(\frac{\psi \cdot r}{\pi}\right)^{\frac{\alpha}{\alpha+\beta}} \cdot \overline{X}^{\frac{1}{\alpha+\beta}}.$$

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10 The implicit-function rule of differentiation shows that the slope of the transformation curve equals the negative ratio of the marginal product of effort to the marginal product of capital.

Inserting this into (8) results in

(10) $$D^* = \overline{X} \cdot \left(r^{\frac{\alpha}{\alpha+\beta}} \cdot \left(\frac{\pi}{\psi \cdot \overline{X}} \right)^{\frac{\beta}{\alpha+\beta}} - p(\overline{X}) \right).$$

The key to increase the efficiency of production, which means to produce any given output with lower capital input C^* (lower D^*) and higher effort E^*, would be to reduce the marginal disutility from effort π for public bureaucrats and managers.[11] Analytically this would mean that the slope of the set of indifference lines $E = \frac{1}{\pi} \cdot \overline{U} - \frac{\psi}{\pi} \cdot D$ increases and the set of indifference curves shifts upward. The manager could reduce his total disutility level by substituting effort with deficit (capital) because the "shadow costs" of effort have decreased. The partial derivation of (5) with simultaneous consideration of (9) and (10) shows that the manager's optimum disutility level decreases The new tangent point of the budget curve and the indifference line has a lower disutility level.

(11) $$\frac{\partial U(E^*, D^*)}{\partial \pi} = \left(1 - \frac{\alpha}{\alpha + \beta} \right) \cdot E^* + \psi \cdot \frac{\partial D^*}{\partial E^*} \cdot \frac{\partial E^*}{\partial \pi} > 0$$

This might be achieved in practise by increasing the manager's leeway for decision making, i.e. to reduce control and interventions by the local politicians. This kind of job enlargement or job enrichment could have positive effects on effort for any given output level.

The theoretical results in this section are based on special assumptions considering the preference structures and budget restrictions of public managers and bureaucrats. Thus, the hypothesis of the efficiency-enhancing effect of reduced public intervention has to be tested empirically. In the following sections the input efficiency of water provision will be compared for water suppliers with different degrees of political intervention. As effort is an unobservable input, one could expect that the efficiency of production for any given output quantity with respect to the observable input quantities (labour, capital, intermediate inputs) will be higher for publicly owned water providers with ceteris paribus lower intensity of political intervention.

11 Although this assumes changing the manager's preference structure it is analytically more convenient. Instead of reduced disutility one might also think of the reduction of the negative non-monetary income from effort and therefore of a shift of the manager's additional budget line of non-monetary consumption from effort.

IV. Methodology of the empirical analysis

First of all, the term efficiency has to be specified further. The focus of the theoretical as well as the empirical analysis lies on the technical efficiency or cost efficiency, both from an input-oriented perspective. *Technical efficiency* means providing a given output quantity by minimum input quantities. *Cost efficiency* involves varying input proportions to produce certain output quantities at minimum cost. The empirical analysis is restricted to the production side of the water industry, whereas the demand side (households, other firms) has to be neglected. Although it was assumed in section III that output is produced at the production frontier, that is technical efficiently, this applies only to combinations of the observable and unobservable factors of production. According to the theoretical results in section III, technical efficiency with respect only to the observable factors might be higher for enterprises with less political interference than otherwise.

To investigate the potential impact of political interference with management decisions in local public water utilities – and therefore to test the hypothesis put up in section III – a two-stage data envelopment analysis (DEA) approach is applied. In the first step, a technical efficiency score is calculated for every water supplier. In the second step, these scores are regressed with variables considered exogenous for the single firm, including an indicator for local government intervention.

This method has been chosen to avoid several problems with analysing cost data. Especially the technical efficiency score is not distorted by mixing up efficiency gains that result mainly from an extension of output quantity (economies of scale) and efficiency gains which result from optimisation of factor quantities and –combinations.[12] Furthermore, it has been already pointed out that the main advantage of the data envelopment analysis is to avoid problematic behavioural assumptions regarding production technology, profit maximisation or cost minimisation. This is very convenient for publicly owned enterprises where profit maximisation or cost minimisation are no plausible targets for the management.

The standard DEA approach assuming variable returns to scale in equation (12) permits to separate efficiency into technical and scale efficiency. For the subject of this paper technical efficiency is the relevant efficiency measure because scale efficiency or economies of scale do not necessarily result from optimising input combinations or or-

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12 There is quite a number of international empirical studies dealing with the existence or non-existence of economies of scale in the water sector including the USA, UK, the Netherlands, Japan, Korea, France or Italy. Though sample sizes and methods vary significantly, most of the studies either reject the hypothesis of increasing returns to scale or their estimated measures suggest only minor economies of scale. For an overview of this literature see for example *Mizutani* and *Urakami* (2001) or *Sauer* (2005). For an empirical analysis of economies of scale in the German water industry see *Sauer* (2005) and *Haug* (2006).

ganisational structures, that is from increased management effort in the broadest sense. To calculate the relevant technical efficiency measure ρ, the following linear programming (LP) problem has to be solved for each firm:

(12) $$\min_{\rho,\lambda} \rho,$$

$$\text{s.t.}$$

$$-\mathbf{y_i} + \mathbf{Y\lambda} \geq 0,$$
$$\rho\mathbf{x_i} - \mathbf{X\lambda} \geq 0,$$
$$\mathbf{I1'\lambda} = 1$$
$$\mathbf{\lambda} \geq 0$$

In case there are *I* water utilities, *M* outputs and *N* inputs, then the *M* x *I* output matrix **Y** and the *N* x *I* input matrix **X** contain the input and output quantities of all *I* water utilities. ρ is a scalar, $\boldsymbol{\lambda}$ is an *I*x1 vector of constants and **I1** an *I*x1 vector of ones. This formulation was suggested by Banker, Charnes and Cooper (1984) and is usually referred to as the BCC-model in DEA. A derivation of this LP problem is given in Coelli et al. (2005, pp. 160-181).[13]

In the second stage of the DEA, technical efficiency ρ as the dependent variable is regressed with some potential determinants of efficiency *z*. The estimation of the regression equation $\boldsymbol{\rho} = \boldsymbol{\beta}\mathbf{Z} + \boldsymbol{\varepsilon}$ by applying OLS might involve several problems. First of all, the observed values of the dependent variable vary between 0 and 1, but the disturbance ε can take any values between $+\infty$ and $-\infty$. Therefore, the additive structure of the linear regression model does not allow ρ to be confined to 1. The estimated values $\mathrm{E}(\hat{\rho}_i|\mathbf{z}) = \rho_i - \varepsilon_i$ might be higher than 1 or lower than 0.

Furthermore, in smaller samples there is some concentration of the values of the dependent variable at the upper margin. Hence, according to the literature[14], a censored Tobit model is estimated. The standard Tobit model is defined as

(13) $$\boldsymbol{\rho}^* = \boldsymbol{\beta}'\mathbf{Z} + \boldsymbol{\varepsilon}.$$

The latent variable ρ_i^* cannot be observed directly, only the technical efficiency index ρ_i and the dependent variables $\mathbf{z_i}$. But ρ is censored at the lower margin 0 and the upper margin of 1, thus partly masking the true value of ρ_i^*. For $\rho_i^* \leq 1$, ρ_i and $\mathbf{z_i}$ are observed reflecting the true value of ρ_i^*. But for $\rho_i^* > 1$, the $\mathbf{z}_i$ are observed and ρ_i equals the limit value 1.

13 For a more detailed introduction to the DEA methods see also *Charnes* et al. (1994).

14 See for example *De Borger* and *Kerstens* (1996).

V. Data

Before the process of data generation will be described, a short overview of the German water sector will be given.

Germany's water industry is highly decentralised. In 2001 about 6300 water utilities providing water to consumers (or 76 utilities per 1 million inhabitants) existed, most of them municipal suppliers. There are very few privately owned providers. Most water suppliers are organised as municipal companies, municipal departments or special purpose associations. It is important to stress that there is de facto neither an effective price regulation nor an economic performance control beyond the local level. The effectiveness of the price control by the cartel offices of the German Länder as well as by the municipal supervisory authorities seems to depend on the eagerness and frustration tolerance of the employees within this institutions. Public benchmarking is an obligatory part of the regulation process in the UK or in the Netherlands, whereas German water suppliers are benchmarked only voluntarily and without any results published.

The empirical analysis in this paper focuses on East German water utilities for several reasons. Even 16 years after the reunification significant structural differences exist. First of all, there is less continuity in the structure of public water provision in East Germany, whereas in West Germany no significant structural changes in the water sector have occurred for at least a century. Hence, some Western water utilities have been continuously providing water for 100 years or longer. In the former GDR, water provision was centralised. From at last 1964 until 1990 the former municipal tasks of providing water and sewage disposal were transferred to 16 state-owned water and sewage combines (WAB). After the German reunification, the former WABs were transformed into limited companies. Although this was discussed controversially, the re-established municipalities or associations of municipalities were granted an option of taking over the plants and networks from the former WABs. In addition, huge investments mostly funded by the federal government and the German Länder were necessary to raise the standard of public water provision to an acceptable level and to connect some remote rural areas to public water systems for the first time ever.[15] Consequently, the structure and development of the capital stock of East German water suppliers is totally different from that of their West German counterparts. Furthermore, the East German water market is less scattered than in West Germany because only 530 of the aforementioned total 6300 German water suppliers are located in East Germany.

In the paragraphs before, some arguments were listed that give reasons for separating East and West German water suppliers for the empirical analysis. Restricting the inves-

15 For more information about the history of the East German water sector from 1945 to the mid-nineties see *Seidel* (1998).

tigation sample to East German water suppliers had more practical reasons, primarily to reduce the costs of data collection because no publicly available database for economic data on German water utilities exists.

Between October 2004 and April 2005 a standardised questionnaire was sent to 275 of the 530 water utilities in East Germany, except for Berlin. This number includes approximately all water companies and a majority of the special purpose associations. Other organisational forms such as municipal departments were not included because for many of them the addresses were not available. It was also doubtful that those mostly small enterprises were able to provide the necessary data.[16] All technical and commercial data collected refer to the year 2002.

43 questionnaires were sent back including 9 municipal and mixed companies and 34 special purpose associations. The total response rate was 15.64%. 37 of them could be used for the data envelopment analysis and 34 (7 companies and 27 municipal associations) for the regression analysis. The low response rate resulted partly from the insufficient willingness to cooperate of lobby groups and private water companies as well. Hence, no water suppliers with a majority of the shares held by private investors are represented in this sample. But this lack of private suppliers does not restrict the informational value of the empirical analysis because the main issue of the paper was to investigate the effect of different levels of political control on the efficiency of publicly owned utilities.

Due to the lack of information concerning the distribution of the population of all East German water utilities, it is not possible to check whether the sample is representative or not. The representativeness could only be tested for the total volume of water supplied. Although the means in table 1 do not differ very significantly, without further information about the distribution of the population the hypothesis that the IWH sample is representative can not be confirmed or rejected.

One of the most demanding practical problems in DEA is to specify outputs and inputs. For this analysis, only one output is used that is the volume of revenue water including the total volume of billed authorised consumption plus exported water. Water losses and consumption by water plants are not included.

16 With hindsight, those doubts were not justified. The good quality of the data provided by some small special purpose associations showed that the quality of accounting and other internal statistics depends on the qualification of the staff rather than on firm size.

Table 1:
Descriptive statistics referring to the firm size of East German water suppliers

Year of reference	2001	2002
Data source	Federal Statistical Office	IWH water-survey 2004
Mean (Mio. m^3)	1.1	1.86
Standard deviation	?[a]	3.27
Median	?[a]	0.97
Number of observations	530[b]	42[b]

Notes: [a] Statistics cannot be calculated because only the aggregated volume of water supplied is available for East Germany and the single German Länder- [b] Only utilities providing water to end consumers are included.

Source: Statistisches Bundesamt (2003), IWH water survey 2004, author's calculations.

Product- and service quality are also relevant output components for customers, which should be included in any proper output analysis of the water sector. But although it was part of the questionnaire, the service quality cannot be quantified. The results for the questions regarding the number of complaints on interruptions, pressure, billing and other service indicators turned out to be contradictory, fragmentary and probably downward-biased. To evaluate product quality, data has been collected for several physical, chemical and microbiological indicators. In order to compare water quality between utilities, an aggregated quality index has been calculated. Applying several methods of statistical interference including the Kruskal-Wallis test no significant differences between the quality indicators of several subgroups could be found. One potential explanation are the rigorous standards for German drinking water leaving no room for significant quality discrepancies. Hence, product quality is assumed to be homogenous on average for the sample utilities and the unmodified product volume can be used as the output measure in the following DEA.

According to the standard theory of production, labour, capital and intermediate products will be included in the DEA model. Labour is measured by the number of employees, real capital by the current book value of property, plant and equipment and intermediate goods by the expenses on material (including imported water) and purchased services. All inputs, even in multiproduct utilities, refer solely to the drinking water branch of the provider. One advantage of this model specification is that the efficiency of utilities with different degrees of outsourcing can be compared. If for example a water provider decided to import all the raw water instead of abstracting it from own sources, real capital and labour would be partly substituted with higher expenses for intermediate inputs. The following table 2 shows the descriptive statistics of the inputs and the output used in the model.

Table 3 contains the descriptive statistics of the environmental variables included in the estimation for the second step of the DEA analysis. The number of observations varies

Table 2:
Descriptive statistics of variables included in the first stage of the DEA

	Output	Inputs		
	Volume of billed water (million m³)	Employees (number)	Property, plant and equipment (million Euro)	Intermediate inputs (million Euro)
Mean	1.97847	26.973	24.39	1.8283
Standard deviation	3.46167	41.164	33.6858	3.09846
Median	0.97596	15	14.3222	1.11005
Minimum	0.084	1	0.648	0.0922
Maximum	19.3294	233	186.150	18.068
Number of observations	37	37	37	37

Source: IWH water survey 2004, author’s calculations.

Table 3:
Descriptive statistics of the data included in the regression analysis

Variable	Scale unit	Mean	Standard deviation	Mini-mum	Maxi-mum	Median	Obser-vations
Company	Dummy variable (0,1)	0.216216	0.417342	0	1	0	37
Population density	Inhabitants per km² of the supplied area	191.037	237.212	25.61	1134.3	101.85	36
Imported drinking water	Ratio of imported treated water to total water input (%)	43.5627	43.5474	0	100	29.00	37
Multiutility firm	Dummy variable (0,1) 0: only drinking water supplied, 1: at least drinking water and sewage disposal	0.756757	0.434959	0	1	1	37
Hardness	°dH	13.807	8.06643	4	46	12.10	37
Benchmarking	Dummy variable (0,1), 1: water utility was benchmarked at least once during the last five years, 0 otherwise	0.228571	0.426043	0	1	0	35
Age of the distribution system	Weighted mean in years	32.4714	17.4116	6	66.3	31.63	36
Average quantity of water supplied per service connection	m³ billed consumption per service connection	159.448	81.5055	60.67	506.01	144.44	33
Portion of distribution system 1960-1989	Percentage	31.4594	20.0292	0	74.75	27.21	36
Outsourcing	Dummy variable = 0: (partially) outsourcing of less than 5 functions; 1: (partially) outsourcing of ≥ 5 functions	0.378378	0.491672	0	1	0	37

Source: IWH water survey 2004, author’s calculations.

due to data availability. To measure democratic control, the organisational form of the water supplier is chosen as an indicator. This concept has also been applied in an empirical study of the impact of the organisational form on innovativeness in the German wastewater sector by Tauchmann and Clausen (2004). The data include the organisational forms "municipal company" and "special purpose association". Special purpose associations (Zweckverbände) are associations of municipalities to accomplish a certain task and they form corporations of public law. Municipal companies are subject to private company law[17] and organisationally as well as legally independent from the municipality. The city councils can exercise only limited control via the supervisory board. Therefore, the effective political power of local politicians to control managers' decisions is greater in special purpose associations than in the rather independently acting municipal companies.

One might argue that potential efficiency losses in municipal associations are rather caused by multi-principal problems than by the short lead for the management. But this multi-principal problem does not distort the empirical results as much as it seems at first glance for several reasons. First, even if they include occasionally 20 or 30 members, most municipal associations are dominated by one or two large members. In 41% of the 29 municipal associations in the sample one member provides water to more than 50% of the inhabitants, in 59% to more than 40%, in 69% to more than 33% and in 76% to more than 25%. The percentage of supplied customers corresponds with the share of votes in the general assembly of the association. Usually, the mayor or some leading city councillor of the most important member municipality is also chairman of the association.

Second, especially in larger cities, water is often provided by multiutility suppliers organised as municipal companies under private law. The effectiveness of local government control is significantly reduced by the complex firm structures (holding company with many subsidiaries and affiliates) and the large number of seats in different supervisory boards occupied by mayors and city councillors.[18] Therefore, efficiency losses caused by multiple principals in associations could be neglected and there seems to be no reason why the possibility of political intervention should not be smaller in municipal companies compared to municipal associations.

It should be noted that there are no indications that the organisational form could have been chosen according to the relative efficiency of the water suppliers, that is the organisational form might not be an exogenous variable. In fact, special purpose organisations were founded as a means of organising water provision for a group of independent

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17 The preferred organisational form is the „Gesellschaft mit beschränkter Haftung" (GmbH, corporation with limited liability of shareholders) which is (roughly) similar to the Anglo-Saxon „limited company" or the French „SARL".

18 For example, the mayor of the East German city of Halle (240,000 inhabitants), is member of about 20 supervisory boards of municipal enterprises.

cities and communities. Municipal companies were often established to enable private investment especially in local public utilities.

Several indicators for the spatial distribution of customers (population density), economies of scope (multiutility firm), the quality of raw water (hardness of water supplied as approximation), alternative control mechanisms (participation in voluntary benchmarking activities), outsourcing (imported water, outsourcing dummy) and the age and quality of the network (age and portion of water pipes laid during the GDR era) are included in the regression. The main source of raw water was not included because all providers in the sample use groundwater as their main source (except for the imported water). One potentially relevant variable, the number of service connections per square kilometre, was omitted because it correlated perfectly with population density. All in all, the most common and important exogenous variables are included in the estimation.

VI. Estimation results

The solution of the LP in (12) yields an average technical efficiency of 0.7336 for 37 observations in the sample. Further descriptive statistics are shown in table 4.

Table 4:
Technical efficiency – descriptive statistics

Variable	Mean	Standard deviation	Minimum	Maximum	Median	Observations
Technical efficiency	0.733595	0.234521	0.231	1	0.730	37

Source: IWH water survey 2004, author's calculations.

It should be stressed that no general conclusions about the extent of efficiency deficits in the German water sector can be drawn from this number. That is due to the fact that only actual stocks or costs of existing firms can be compared and not ideal standards. Hence, even enterprises with technical efficiency score 1 might have considerable leeway to increase their technical efficiency.

Table 5 gives the results of the OLS and the Tobit estimation for the variables included in the regression. Two variables listed in table 3, benchmarking and average quantity per service connection, are omitted because they have no significant effect on the dependent variable and do not improve the goodness of fit measures. The statistical significance of the municipal company dummy is robust for all variable combinations at least at the 95% level. The signs and significance levels of the independent variables do not differ fundamentally between the OLS and the Tobit model.

If the company dummy is omitted, the F-test for the OLS model (F[7, 26] = 1.56) reveals that the remaining variables have no explanatory power at all. Primarily, no significant linear or nonlinear relationship between the population density and the technical efficiency can be found.

It was tested if the formulation as a Tobit model is necessary or if the OLS regression is sufficient. The latter would be the case if the censoring probability went to zero. To check the model specification, two indicators are applied: the number of predicted values of the dependent variable exceeding the censoring margins of 0 or 1 and the convergence of some proposed goodness of fit measures for Tobit models with standard OLS-R^2.

The first criterion does not confirm the hypothesis of censored data because for the chosen OLS regression equation in table 5 only one case can be observed where the predicted value (1.041) of the dependent variable (1.00 observed value) exceeds the upper limit.

To verify the second criterion, two fit measures suggested by Veall and Zimmermann (1994) and Greene (2002, E21-10), R^2_{ANOVA} and $R^2_{DECOMPOSITION}$, are applied to the Tobit model. Both measures converge with the standard R^2 of a linear regression without censoring for the sample. Hence, the similarity of the three R^2[19] measures suggests that censoring is not really relevant for the model. Nevertheless, the results of the Tobit estimation are also presented in table 5.

Table 5:
OLS and Tobit estimates for potential determinants of technical efficiency

	OLS			Tobit model		
	Coefficient	Standard error	t statistic	Coefficient	Standard error	z statistic
Constant	0.5829	0.1341	4.3477***	0.6399	0.1460	4.3819***
Company	0.4552	0.1310	3.4742***	0.8311	0.2600	3.1970***
Imported drinking water	0.0007	0.0010	0.7313	0.0007	0.0010	0.6395
Portion of distribution system 1960-1989	0.0014	0.0019	0.7437	0.0010	0.0021	0.4985
Multiutility firm	0.0411	0.0876	0.4685	0.0493	0.0930	0.5300
Hardness	-0.0029	0.0045	-0.6343	-0.0046	0.0048	-0.9696
Population density	-0.0003	0.0002	-1.2078	-0.0006	0.0004	-1.5292
Age of distribution system	-0.0006	0.0022	-0.2887	-0.0003	0.0024	-0.1361
Outsourcing	0.2024	0.0792	2.5562**	0.2231	0.0854	2.6125***
	R^2: 0.52484	Adjusted R^2: 0.37279	Akaike criterion: -0.276	Log likelyhood: 0.4416		

Notes: The number of observations included in both models is 34. *** significant at the 99% level. ** significant at the 95% level

Source: IWH water survey 2004 and author's calculations.

Due to the small sample size it is necessary to check if the disturbance term of the OLS estimation is normally distributed The hypothesis of normal distribution is confirmed by

19 The relatively small adjusted R^2 and the small number of significant variables do not allow conclusions regarding the quality of the efficiency analysis. They simply indicate that the variation in technical efficiency might rather result from e.g. different effort levels of the management or internal efficiency-enhancing measures at the production level (endogenous factors) than from exogenous circumstances.

the Jarque-Bera test[20]. Therefore, the results of the t-, z- and F-tests could be considered as valid. The Breusch-Pagan-Godfrey (BPG) test statistic does not indicate heteroscedasticity and no hints for significant multicollinearity problems could be found, so that the OLS method should be applicable without modifications.

The estimation results suggest that the organisational form has a significant effect on technical efficiency in the water sector. According to the results of the F-Test, the relevance of outsourcing activities is not quite clear. Surprisingly enough, the effects of population density, structure of the customers and age structure of the networks are not relevant for technical efficiency. Participation in voluntary, non-public benchmarking activities, which are organised for example by the German Association of Local Public Enterprises (Verband Kommunaler Unternehmen VKU), does not seem to have any efficiency-enhancing effects in the short run. Furthermore, the existence of economies of scope cannot be confirmed.

20 The skewness of the distribution of the disturbance term is -0.2837, the kurtosis is 2.667 and they both do not deviate significantly from the measures for normal distribution 0 and 3. The Jarque-Bera test statistic is 0.6128 and the p-value of obtaining such a value from a chi-square distribution with two degrees of freedom is 0.7361.

VII. Conclusions

The paper deals with the issue of the adequate degree of municipal control for local publicly owned firms, especially water utilities. This aspect has been neglected yet in the relevant literature regarding the relation between efficiency and institutions for the water industry, which mostly concentrated on comparisons of private and public water utilities or the effect of different regulation systems. The hypothesis that less political interference with business activities in publicly owned utilities would increase efficiency was checked by a two-stage DEA approach for a sample of East German water suppliers. The organisational form was used as an indicator for the extent of local government's control in the empirical analysis.

The empirical results confirm that a reduction of "democratic control" may increase technical efficiency. It prevents local governments from abusing their water utilities as instruments of vote maximisation or redistribution. The greater autonomy of decision-making for public managers seems to be effort-enhancing and does not necessarily encourage shirking, overmanning or overcapitalisation. Therefore, organisational forms should be preferred for the local public production units that reduce the scope for municipal interventions in daily business activities. Especially for the German water sector, this might involve transforming municipal departments into municipal companies or establishing management companies for special purpose associations.

But some important aspects have to be left to future research work. First of all, the results of this paper are based on a relatively small cross-section sample and have to be confirmed by using panel data of a larger sample of German water suppliers. The ideal data set should also contain data of other organisational forms than municipal companies and municipal associations. Second, the impact of private participation in the production process on efficiency could not be investigated for the German water sector because no private water providers could be included in the sample. Third, differences in service quality ought to be integrated into future efficiency analysis of the water sector. The experiences from the IWH survey show that it would be better to collect the necessary quality data by customer survey instead of interviewing the water utilities.

This future research work, however, requires a greater spirit of openness and transparency primarily for the German water sector. Therefore, it is recommended that some national authority such as the German Federal Statistical Office should take over the collection and publication of technical and economic data for the water sector. The German water industry and their representatives seem to be unable to cope with the need for transparency in this vital industry.

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