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Abstract
In the German wastewater sector, innovations are often regarded to be the key to both more efficient service provision and reduction of environmental and health-related problems. However, it is unclear what factors foster these innovations. One possible candidate factor is increased competition in this sector and the entry of private service providers. So far, there is no empirical evidence to answer the question of whether private firms are, in fact, more innovative than others. To address this question, we conducted a survey among German firms that provide wastewater services and estimated a structural model to explain firms' innovativeness. Our results suggest that firm size improves innovativeness; however, private service providers are not significantly more innovative than providers operated by local governments. We conclude that restructuring the sector to form larger units may foster innovative activities even without any changes in the legal framework.

JEL-Classification: L95, O31

Keywords: Wastewater services, innovativeness, structural econometric model

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1. Introduction

It is a common assessment that German water services meet high technical standards. Nevertheless, the sector faces severe problems that have yet to be solved: First, the grid-type network is partly outdated and requires enormous future investments; second hormones and drug residua are currently filtered from neither sewage nor drinking water, even though both are considered potentially harmful to the environment and human health; last but not least, growing wastewater charges have trigger ed disputes over the economic efficiency of service provision. In fact, there is an intense discussion in Germany on the issue of whether the liberalization of its wastewater services would help improve economic efficiency. However, no political decision has yet been made to substantially open the sector to market forces. This raises the question of how the sector's performance could alternatively be improved.

Irrespective of the concrete market form, innovations are often considered as possible means to solve the sector's problems. While technical innovations may be the key for solving environmental and health problems and may also reduce the average costs of corresponding investments[1], organizational innovations may improve the economic performance in general. However, it is far from clear whether innovations can, in fact, be regarded as substitutes to liberalization or privatization, rather than complements, as privatized firms may exhibit more innovative activities than those operated by the local authorities. Moreover, it is not clear what factors drive the generation and diffusion of innovations, and how innovativeness can be fostered by policy measures.

This paper attempts to empirically assess the external factors that determine the innovativeness of firms operating wastewater services. Our main focus is on the question of whether firms less directly controlled by municipalities are more innovative than those directly controlled by the authorities. We are chiefly interested in the innovative performance of privately run firms as opposed to those run by local governments, since allowing for more commitment of private firms on the one hand, and reducing the municipalities' influence on the other, might improve the sector's performance.

The following section describes the role of local governments in the German wastewater sector. The main focus is on organizational arrangements between the service provider and the local authority. Section 3 outlines the concept of innovativeness. Section 4 discusses the econometric model. Section 5 introduces the survey data used to estimate the econometric model, presents descriptive analyses and discusses our estimation results. Finally, Section 6 offers conclusions and policy advice that are based on our empirical results.

[1] E.g. decentralized sewage disposal might supersede costly grid-type networks.

2. Organizational Arrangements and the Role of Local Governments

According to German law, wastewater services belong to the sovereign duties of the municipalities, although these services do not necessarily have to be provided by the local government itself. In fact, the municipality may even transfer the task, but always remains responsible for proper sewage disposal (Boscheck 2002: 142).[2] In effect, local authorities are able to determine the degree of control they exercise on the provision of wastewater services, by choosing the organizational arrangement for the public utility.

Possible arrangements range from "municipal departments" that is complete integration of wastewater service provision into the local government, to firms held by private owners. Between these extremes, several organizational forms such as "semi-autonomous municipal agencies", "public law incorporations", "inter-municipal agencies", and formally privatized but municipal held "municipal enterprises" reflect gradual differences of the direct influence local governments have on the provision of wastewater services. Appendix 1 provides a brief description of these organizational arrangements.[3]

Wastewater services are still protected from direct competition in Germany. Therefore, there is no way to directly measure the effects that liberalization and exposure to market forces would have on firm's innovative activities. In addition, the share of private firms is still very small. Nevertheless, numerous changes in organizational arrangements have been observed in recent years, leading to a substantially reduced share of municipal departments (BGW, ATV-DVWK 2003: 12). It seems that municipalities increasingly regard the provision of wastewater services an entrepreneurial rather than administrative task. We interpret the reduction in municipal influence as the first step towards opening the sector to private commitment and market forces and exploit the variation in organizational forms for identifying the effects of an increased degree of market-orientation on firm's innovativeness.

3. Innovations and Innovativeness

According to the OECD (1997: 8) Oslo Manual, innovation stands for technical improvements of products and processes, as well as organizational innovations. Since technical innovations, such as new products, have to be judged as rather exceptional in the wastewater sector, and because information about

[2] The Federal Water Act has only recently allowed the delegation of responsibility; however, most of the federal states have not yet adopted the corresponding legislation.

[3] Several legal terms – such as organizational forms – that appear in this paper are specific to the German case. For this reason, the English translations that are used here often are not unique. For clarification, the appendix lists the original German expressions along with the English translations.

new processes is weak in the data, our focus is on organizational rather than technical innovations. Organizational innovations include measures to improve the organizational structures of the firm and the work flow within firms as well as the implementation of advanced management techniques, such as Total Quality Management, and new or substantially changed corporate strategic orientations (OECD 1997: 36).

Typical innovation surveys provide information on both the input for a firm's innovative activities and on the resulting output, as well as on the modalities of these activities (Mairesse, Mohnen 2001: 5). The input side of innovative activities encompasses, for example, R&D expenditures, the share of staff that has a tertiary degree, and expenditures on new technologies. Our analysis solely focuses on the *output* of innovative activities, that is, the implementation of certain novelties.

We define innovativeness as a firm's general affinity and capability to carry out innovative activities whose explanation is the ultimate aim of this paper. Obviously, innovativeness represents a theoretical concept that lacks an observable counterpart. Nevertheless, firms reveal their innovativeness through the generation of single innovations. In order to operationalize the concept of innovativeness in our empirical application, we now employ a structural econometric model that incorporates the firms' unobservable innovativeness as a latent variable, while the observable occurrence of several organizational innovations serves as dependent variables.

4. An Econometric Model of Innovativeness

The model we employ for explaining firms' general innovativeness was originally designed by Fertig/Schmidt (2002) to analyze attitudes towards immigrants. Although the topic of our paper is a completely different one, there are strong methodological links between both analyses. In both cases, the attempt is made to identify the determinants of a latent variable from a wide range of answers to survey questions that are more or less loosely related to the latent variable of interest.

4.1 The Structural Model

It is assumed that the propensity X_{li}^{*} of firm i to implement a certain innovation l is determined by a vector of exogenous firm-specific variables $z_i \equiv [z_{1i} \ldots z_{Ki}]'$ and the unobservable variable "innovativeness" Y_i^{*}:

$$
\begin{aligned}
X_{1i}^{*} &= \alpha_1 + \delta_1 Y_i^{*} + \beta_{11} z_{1i} + \ldots + \beta_{1K} z_{Ki} + \varepsilon_{1i} \\
&\vdots \qquad\qquad \vdots \\
X_{Li}^{*} &= \alpha_L + \delta_L Y_i^{*} + \beta_{L1} z_{li} + \ldots + \beta_{LK} z_{Ki} + \varepsilon_{Li}\,.
\end{aligned} \tag{1}
$$

Here, $i = 1,...,N$ indexes the firms. $l = 1,...,L$ indexes those L organizational innovations that the firms were asked if they had implemented any of them. Finally, $\varepsilon_{1i},\ldots,\varepsilon_{Li}$ represent normally distributed mean-zero error terms that may be correlated across equations.

For the latent variable Y_i^*, we assume that it is determined by the same firm-specific characteristics z_i that enter (1):

$$Y_i^* = \gamma_1 z_{1i} + \ldots + \gamma_K z_{Ki} + \eta_i . \tag{2}$$

The additional random variable η_i is assumed to be mean-zero normally distributed, too. Again, it may be correlated with any of the equation-specific errors $\varepsilon_{1i},\ldots,\varepsilon_{Li}$. By measuring $z_{1i},\ldots,z_{Ki}$ in terms of deviations from sample means, we normalize innovativeness so that Y_i^* takes the value zero for firms that display average characteristics.

We proceed by replacing Y_i^* in equation (1) by equation (2) in order to get a reduced-form representation:

$$\begin{aligned} X_{1i}^* &= \alpha_1 + \theta_{11} z_{1i} + \ldots + \theta_{1K} z_{Ki} + \nu_{1i} \\ &\vdots \qquad\qquad \vdots \\ X_{Li}^* &= \alpha_L + \theta_{L1} z_{1i} + \ldots + \theta_{LK} z_{Ki} + \nu_{Li}, \end{aligned} \tag{3}$$

where

$$\begin{bmatrix} \theta_{11} \\ \vdots \\ \theta_{L1} \end{bmatrix} = \begin{bmatrix} \delta_1\gamma_1 + \beta_{11} \\ \vdots \\ \delta_L\gamma_1 + \beta_{L1} \end{bmatrix}, \ldots, \begin{bmatrix} \theta_{1K} \\ \vdots \\ \theta_{LK} \end{bmatrix} = \begin{bmatrix} \delta_1\gamma_K + \beta_{1K} \\ \vdots \\ \delta_L\gamma_K + \beta_{LK} \end{bmatrix}, \text{ and } \begin{bmatrix} \nu_{1i} \\ \vdots \\ \nu_{Li} \end{bmatrix} = \begin{bmatrix} \delta_1\eta_i + \varepsilon_{1i} \\ \vdots \\ \delta_L\eta_i + \varepsilon_{Li} \end{bmatrix}.$$

4.2 Identification of the Structural Parameters

Our interest is on the structural model parameters $\gamma \equiv [\gamma_1 \ldots \gamma_K]$, which capture the effects the exogenous variables have on a firm's innovativeness. However, without further restrictions, estimating the coefficients θ_{lk} of the reduced-form model (3) does not allow for the identification of γ. In order to obtain the necessary identifying restrictions, we follow Fertig/Schmidt (2002: 9) and assume that the cross-equations averages of the structural coefficients β_{lk} take the value zero:

$$\frac{1}{L}\sum_{l=1}^{L} \beta_{lk} = 0 \quad \text{for} \quad k = 1,\ldots K. \tag{4}$$

That is, although we allow for direct effects of the explanatory variables z_i on the propensity to implement that do not operate through the latent variable

"innovativeness", we rule out that the variables in z_i can systematically influence the attitude towards all single innovations in any other way than by influencing the firms' innovativeness. In other words, an exogenous variable z_{ki} may directly increase the propensity to implement one innovation and decrease the propensity to implement another, but it cannot increase the likelihood for the implementation of all, or even the majority, of innovations without increasing the firms' innovativeness. This restriction allows for a separate identification of direct and indirect effects of the explanatory variables.

However, in order to identify the structural parameters γ, an additional restriction is needed that can disentangle the effects of the exogenous variables on Y_i^* from the effect Y_i^* has on the dependent variables, i.e. a high estimate of θ_{lk} may reflect a high value of δ_l as well as a high value of γ_k. To deal with this problem, we follow Fertig/Schmidt (2002: 10) and assume

$$\frac{1}{L}\sum_{l=1}^{L}\delta_l = 1. \tag{5}$$

That is, we normalize the average effect of innovativeness on the propensity to innovate to take the value one.[4] Since there is no obvious way to metrically measure the propensity to innovate, and since the absolute size of the coefficients, therefore, has no obvious interpretation, this normalization is less restrictive than one might think at first. On basis of (4) and (5), and with estimated reduced-form coefficients θ_{lk} in hand, one can calculate estimates for the structural parameters γ_k:

$$\frac{1}{L}\sum_{l=1}^{L}\theta_{lk} = \gamma_k \underbrace{\frac{1}{L}\sum_{l=1}^{L}\delta_l}_{=1} + \underbrace{\frac{1}{L}\sum_{l=1}^{L}\beta_{lk}}_{=0} = \gamma_k \quad \text{for} \quad k = 1,\ldots,K. \tag{6}$$

Equation (6) states that the effect of a variable z_{ki} on firms' innovativeness can be expressed as the average effect this variable has on the propensity to implement any innovation. This result has quite an intuitive interpretation: Since we cannot observe innovativeness, we focus our attention to single innovations and estimate how exogenous variables influence the likelihood for implementing them. However, we then face the problem of how to aggregate this set of estimated effects to a single effect on overall innovativeness. Equation (6) simply suggests taking the average. One might argue in favor of calculating a somehow weighted average rather than the simple un-weighted one. However, if the reduced-form coefficients θ_{lk} are estimated by discrete choice models, e.g. by probit, the parameters already contain an implicit weighting

[4] This choice does not result in any loss of generality. Any other positive value could be chosen just as well.

scheme. In such models, only the ratio $\theta_{lk} / std(\nu_l)$ is identified. Therefore, the effects are implicitly weighted by the standard deviation of the error term. In other words, equations with high explanatory power receive more weight in the calculation of the aggregate effect on innovativeness.

4.3 Estimation

The reduced form model (3) cannot be directly estimated, since $X^*_{1i}, \ldots, X^*_{Li}$ – the propensities to implement the L single innovations – are latent variables. However, the answer to the question of whether a certain organizational innovation has been implemented can be interpreted as an observable counterpart to the latent variable "propensity to implement". More specifically, it is assumed that the possible answer categories ("not implemented", "implementation planned", and "already implemented" – coded $x_{li} = 0, 1,$ or 2) correspond to certain levels of the latent variable. That is, if the "propensity to implement" is low, a firm does not implement an innovation; if its propensity is high, the firm does implement; and finally, if its propensity is somewhere in between, a firm may consider the implementation of an innovation for the future. This reasoning can be formalized as follows:

$$x_{li} = \begin{cases} 0 & \text{if} \quad X^*_{\text{li}} < 0 \\ 1 & \text{if} \quad 0 \le X^*_{li} < \mu_l \\ 2 & \text{if} \quad \mu_l \le X^*_{li} \end{cases} \qquad \text{for } l = 1, \ldots, L. \tag{7}$$

This formulation allows for estimating the reduced-form coefficients θ_{lk} along with the threshold parameters μ_l using conventional ordered probit models.

The resulting system of ordered probit models would be estimated efficiently if all L equations of the system were simultaneously estimated. However, such an approach would require the evaluation of multiple integrals. Simulated maximum likelihood generally allows for this, but estimating the equations simultaneously remains extremely involved.

In order to reduce the estimation procedure's complexity, the equations of system (3) are separately estimated. This means that the efficiency of estimation is reduced, while consistency is preserved. Yet, one problem remains: independently estimating the reduced-form coefficients θ_{lk} through conventional *ML*-techniques allows for calculating the structural model parameters γ_k, but not for calculating the corresponding standard errors. This problem arises because the error-covariance structure of the reduced-form model

$$\text{var}(\nu_l) = \text{var}(\varepsilon_l) + (\delta_l)^2 \, \text{var}(\eta) + 2\delta_l \, \text{cov}(\varepsilon_l, \eta) \tag{8}$$

$$\text{cov}(\nu_l, \nu_m) = \text{cov}(\varepsilon_l, \varepsilon_m) + \delta_l \delta_m \, \text{var}(\eta) + \delta_l \text{cov}(\varepsilon_l, \eta) + \delta_m \, \text{cov}(\varepsilon_m, \eta)$$

exhibits non-zero cross-equation covariances, which are ignored by estimating the model equation by equation. In order to tackle this problem, bootstrapped rather than analytically determined standard errors are calculated for the structural parameters. The reported standard errors are based on 250 bootstrap iterations.

5. Data and Empirical Results

Our empirical analysis rests on a survey among German firms that provide wastewater services which was conducted in 2003 (cf. Clausen et al. 2003 for a comprehensive descriptive analysis). The members of the "German Association for Water, Wastewater and Waste Services" (ATV-DVWK) were used as the data base for this survey. These approximately 2,000 organized firms represent only about one fourth of all 8,000 assumed suppliers in the sector (Clausen/ Rothgang 2004: 156). Systematically addressing unorganized service providers proved to be a rather ambitious task. As a consequence, we restricted our attention to the organized providers. Out of the ATV-DVWK members, 683 firms were randomly drawn. The sample was stratified by location and firm size, whereas large firms were systematically over-sampled. 237 firms returned completed questionnaires.[5]

5.1 Organizational Innovations

In addition to a few firm-specific characteristics, several innovation-related questions are addressed in the survey. Firms were first examined on their subjective perception of different factors encouraging or impeding innovations. Here, we are more interested in behavioral facts than in stated perceptions, so we focus on questions referring to innovation-related behavior. While the questionnaire did not directly address specific technical novelties, firms were asked about organizational innovations. In addition to a few sector-specific novelties, we especially focus on those organizational novelties that are widespread in the private industry. With particular respect to a specific set of eight organizational innovations, firms were asked if they had already implemented them, plan to implement them, or whether they are not considering implementation at all.

Only firms that responded to the full set of questions concerning the eight organizational innovations are used for estimating the model. Because of item

[5] This raises the question of whether survey participation might be correlated with innovativeness, rendering any analysis biased. Unfortunately, well-suited instruments for survey participation could not be found, obstructing any attempt to fix this potential problem. Surprisingly, participation in earlier surveys not related to innovations could not explain participation in the survey considered here. Therefore, all reported results refer to specifications that do not correct for sample selection.

Table 1

Distribution of the dependent variables

Organizational innovation	Neither planned nor implemented	Implementation planned	Already implemented
Split wastewater charges	93	24	44
Success-related fees	133	21	7
Service and operation directions	50	33	78
Cost and activity accounting	80	30	51
Internal performance indicators	105	24	32
Benchmarking	117	16	28
Management systems	128	20	13
Incentive wages	137	13	11

non-response, the sample effectively used consists of only 161 observations. Table 1 displays the distribution of answers in the sample. Appendix 2 provides a brief description of organizational innovations considered.

Obviously, none of the organizational novelties considered is already used on a regular basis. Only "service and operation directions" and, to a smaller extent, "cost and activity accounting", as well as "split wastewater charges" are widespread among the firms in our sample, whereas , "management systems", "incentive wages", and "success-related fees" still seem to be rather exceptional in the sector.

5.2 The Explanatory Variables

The key concern of this paper is to assess whether direct municipal influence, measured by a firm's organizational form, has an effect on firms' innovativeness.[6] The relevance of this question is underpinned by the fact that in the survey many firms report that political interventions from local authorities are regarded as major obstacles for implementing new technologies and organizational reforms (Clausen et al. 2003: 1568). To capture the effects of organizational forms, a set of dummy variables characterizing organizational arrangements enters the vector z_i . Here, "municipal department" serves as the base category. Table 2 displays – along with descriptive statistics for other explanatory variables – the distribution of organizational forms among those observations that are used for estimating the model.

One might argue that the organizational form is an endogenous variable somehow related to innovations, rather than a determinant of innovativeness. Changes in organizational arrangements, which have frequently occurred in

6 This corresponds to the theoretical literature concerned with innovations in other industries, e.g. Arrow (1962) or Aghion et al. (2002), which often regards market conditions and, in particular, the degree of competition – in addition to the regulatory framework – to be the key determinants for innovations.

Table 2

Descriptive statistics for the explanatory variables in the sample

Explanatory variable	Mean	Std. Deviation	Measuring Unit
Municipal department	0.2733	0.4470	indicator
Semi-autonomous municipal agency	0.3602	0.4816	indicator
Inter-municipal agency	0.2360	0.4260	indicator
Public law incorporation	0.0621	0.2421	indicator
Private law	0.0683	0.2531	indicator
Population	0.1198	0.4031	10^6 people
Population density	0.0490	0.0673	10^4 people/km^2

recent years, might even be regarded as innovations themselves.[7] From this point of view, indicators for organizational arrangements are ill-suited to explain innovativeness. However, we regard organizational arrangements as the result of political decisions: the organizational form is a matter of local policy and, therefore, is determined independently from the innovation-related behavior of the firm that actually operates wastewater services. Additionally, our identification strategy requires us to assume that municipalities' influence on service providers operates purely through the organizational form, but not through other unobserved channels.[8]

In addition to its organizational environment, the size of a firm might determine whether or not innovations will be successfully implemented. A lot of anecdotic evidence is circulating about firms being either too small or too large to innovate. Small firms are often assumed to lack the necessary human and financial resources, while large firms may lack the flexibility to implement innovations. Because firm size is typically endogenous in standard markets, it might be a rather problematic regressor. This problem does not apply to wastewater services, where firm size is exogenous, because the disposal areas are fixed, and each firm's size can be measured in terms of the number of customers. That is, we equate firm size and population size and employ the popu-

7 To control for changes in the organizational form, some specifications were estimated that contained indicators for "form of organization recently changed" and/or "change of organizational form planned". Both variables turned out to be insignificant, while all other estimation results did not change qualitatively.

8 To test these assumptions, the test procedure suggested by Rivers/Voung (1988) was employed with state-specific dummies serving as instruments. The reasoning behind this choice is that differences in state policy and legislation are likely to affect the choice of the organizational form (e.g. with respect to delegating the duty of wastewater disposal), but are unlikely to have a direct effect on the adaptation of specific innovations. The joint hypothesis of organizational arrangement being exogenous in all equations cannot be rejected. Equation-specific tests reject exogeneity with respect to "cost and activity accounting", "internal performance indicators", and "split wastewater charges". Estimation results, however, do not change qualitatively if these three equations are excluded from the model. Nevertheless, since it is questionable whether state dummies are well suited instruments, test results have to be treated with reserve. Results for the original full model are presented in Table 3.

lation size of the corresponding disposal area as a regressor. Its distribution is extremely skewed to the right.

Since disposal areas are exogenously determined, regional characteristics are able to serve as regressors. We included the population density in our model, since draining wastewater from highly populated areas appears to be a different task than providing the same service in rural areas that possibly even lack comprehensive common grid-type networks for draining sewage.

To cope with the quality of wastewater, which firms have to drain and purify, firms might rely on technical innovations. Therefore, wastewater quality might determine innovativeness with respect to both technical and organizational innovations. Unfortunately, we do not have detailed knowledge about the wastewater qualities.

Finally, environmental policy regulations, such as water quality or technical standards, are generally considered as key driving forces for innovations. However, although environmental policy regulations typically vary across time, they do not within cross-sections. For this reason, our data are ill-suited for identifying such effects on innovations and this aspect has to be excluded from the analysis.

5.3 Discussion and Interpretation of Estimation Results

Table 3 displays estimates for the structural model parameters γ. Estimation results for the reduced-form parameters can be found in Table 4. Other variants of the model besides the specification presented in Table 3 were also estimated. None of the explanatory variables additionally included proved to be significant. Therefore, results for a rather small model serve as the basis for our discussion.

None of the individual coefficients attached to dummies indicating organizational arrangement significantly deviates from zero[9]. Therefore, municipal departments cannot be judged to be more or less innovative than any other organizational form. However, since we are not interested in the base category "municipal department" in its own right, this result may be of secondary interest. More importantly, these coefficients are also jointly insignificant, with the p-value of the corresponding Wald-test being as high as 0.8801. That is, we cannot find any evidence in the data to support the hypothesis that innovativeness systematically differs for different organizational forms. This outcome comes as a surprise, bearing in mind our argument that the organizational form captures the degree of interference from local governments to utilities' business.

[9] If the results are presented alternatively in terms of "deviations from the share-weighted mean", on the basis of appropriate Haisken-DeNew/Schmidt (1997) standard errors, all parameters are insignificant, too.

Table 3

Estimated structural model coefficients

Explanatory variable	Estimated coefficient	Standard error
Semi-autonomous agency	0.2689	0.5545
Inter-municipal agency	0.2164	0.5636
Public law incorporation	–0.1255	0.8335
Private law	0.7389	0.8221
Population	1.4746*	0.7085
Population density	4.2511**	1.2862

Authors' calculations. – ** and * indicate significance at the 0.01- and 0.05-level, respectively.

Since many firms regard interference from local authorities to be a major obstacle to the introduction of novelties, we expected firms less directly controlled by local municipalities to be more innovative. Three distinct arguments might explain why this hypothesis is not supported. Firstly, firms may incorrectly perceive local authorities as obstacles to innovations due to a severe subjectivity bias.

Secondly, the influence of local authorities might be innovation-specific, i.e., local authorities may obstruct one individual innovation and promote another, but do not influence the firms' innovativeness in general. In terms of the structural model, this hypothesis corresponds to $\beta_{1k} \ldots \beta_{Lk}$ deviating from zero, while the respective parameter γ_k equals zero.[10] The parameters $\beta_{1k} \ldots \beta_{Lk}$ are not identified; hence, we are unable to test this hypothesis.[11] Nevertheless, since local political and administrative influence is often mentioned as both a driving force and an obstacle to the implementation of innovations, this explanation has some intuitive appeal.

Finally, organizational arrangements might just be labels that do not indicate actual independence from political or administrative interference. In other words, even a privatized firm operating wastewater services might still heavily depend on the decisions made by local authorities. This argument is particularly relevant, since several private firms in the sample are privatized in form only, not materially.[12]

[10] Since organizational form is specified by a set dummy variables and *not* a single variable, things are slightly more involved. That is, four regressors – $k = 1,\ldots,4$ – must be simultaneously considered.

[11] In the case of "cost and activity accounting" and "internal performance indicator systems", the reduced form parameters θ_{lk}, attached to the indicators of organizational arrangement (see Table 4), are jointly significant. This might be regarded as an argument in favor of the latter hypothesis. Nevertheless, this argument is not fully consistent with the structural model, since the structural parameters of interest, i.e. $\beta_{1k} \ldots \beta_{Lk}$, coincide with $\theta_{1k} \ldots \theta_{Lk}$ only if $\gamma_k = 0$ holds. However, even though we cannot rule out $\gamma_k = 0$ on the basis of our test results, we also cannot prove that $\gamma_k = 0$ holds.

Table 4

Estimated reduced-form coefficients

	Split waste-water charges	Success related fees	Service and operation directions	Cost and activity accounting	Internal performance indicators	Benchmarking	Management-systems	Incentive wages
Constant	-0.1888 (0.1012)	-0.9548** (0.1184)	0.7369** (0.1627)	0.0672 (0.1078)	–0.3744** (0.1127)	–0.4339 (0.6337)	–0.9252** (0.1275)	–1.1988** (0.1414)
Semi-autonomous agency	0.1188 (0.2411)	-0.1271 (0.3016)	–0.0312 (0.2388)	0.5992* (0.2389)	0.5240 (0.2721)	0.4113 (0.2925)	0.3349 (0.3190)	0.3215 (0.3731)
Inter-municipal agency	-0.1758 (0.2761)	0.2012 (0.3202)	–0.1269 (0.2637)	–0.0205 (0.2757)	0.3801 (0.3098)	0.2666 (0.3432)	0.4366 (0.3616)	0.7699 (0.3972)
Public law incorporation	0.1133 (0.4632)	0.2962 (0.5066)	0.3909 (0.4866)	0.1885 (0.4682)	0.4187 (0.5111)	–2.5919 (10.0365)	–0.0286 (0.7274)	0.2089 (0.7417)
Private law	0.5204 (0.4196)	0.0919 (0.4803)	0.7408 (0.4766)	0.7400 (0.4136)	1.5621** (0.4440)	0.6455 (0.4679)	0.8131 (0.4600)	0.7972 (0.5096)
Population	0.2705 (0.4346)	–0.0810 (0.4072)	2.1250 (1.6985)	1.2696 (0.7214)	1.2100 (0.6893)	6.0530** (2.1079)	0.7751 (0.6096)	0.1743 (0.4160)
Population desity	2.5690 (2.1632)	2.2943 (2.4681)	5.6571 (3.1608)	1.9681 (2.3029)	4.0118 (2.3463)	3.4591 (3.3184)	6.8318** (2.3622)	7.2177** (2.4199)
Threshold μ	0.4293** (0.0814)	0.7871** (0.1612)	0.5954** (0.0936)	0.5570** (0.0930)	0.5627** (0.1055)	0.5169** (0.1206)	0.7990** (0.1653)	0.5964** (0.1552)

Authors' calculations. – Standard errors in parentheses. – * and ** indicate significance at the 0.01- and 0.05-level, respectively.

In contrast to the dummies indicating organizational forms, the coefficients attached to the population within the disposal area, i.e. the size of the firm, and the population density are both positive and significant. That is, larger firms and those operating in highly populated areas are significantly more innovative than smaller ones and those operating in rural areas.[13] In fact, the density of population in the disposal area turned out to be the most highly significant regressor in any specification of the model that was estimated.

Since the German wastewater sector is characterized by a huge number of, mostly, very small service providers, which are likely to lack the recourses for being innovative, the result that large firms are more innovative than small ones may not come as a surprise. To explain, however, why innovativeness is so strongly determined by the density of population requires some discussion. The main reason to include population density is to account for differences in physical environment in which firms operate, but the coefficient might also capture another effect. Areas of high population densities are typically found in large cities. Cities, however, may provide not just a natural but also a social environment that enhances innovativeness. Research facilities, firms that al-

12 The sample comprises just a very small number of firms operated under private law. Therefore, the econometric application, unfortunately, cannot distinguish between formal and material privatization.

13 Because of the structure of the model, the coefficients' absolute size has no natural interpretation.

ready have experienced technical or organizational novelties, and other institutions that can provide information about innovations, are typically located in large cities. Therefore, population density might be a rough proxy for a firm's integration into innovation-enhancing networks.

This interpretation is supported by results obtained from slightly modified models, for example one model, in which "length of the grid per inhabitant" is substituted for "population density". In other words, population density is replaced by a closely related, but purely technical, variable. Even though both variables are negatively correlated, "grid per inhabitant" turns out to be insignificant, in contrast to the original regressor.[14] Another specification adds the share of highly qualified employees within a firm's region of location to the set of explanatory variables, emphasizing how important the access to human capital is to innovation. This modified model yields similar results than the original model.[15] In short, it can reasonably be concluded that it is in fact the socio-economic, but not the physical environment that drives the effect. Nevertheless, it seems difficult to pin this effect down to a single, clearly defined determinant.

6. Conclusions and Policy Implications

The aim of this paper was to identify determinants of the innovativeness of German firms that provide wastewater services. Surprisingly, the organizational form, i.e. legal dependency from local authorities, cannot explain firms' innovativeness: Our estimation results, therefore, do not support the hypothesis that a change in organizational arrangement and, in particular, a reduced influence of municipal councils will improve the innovation-related performance of service providers. Thus, reforms directed towards increased legal autonomy do not seem to be the first policy choice to foster innovativeness.

However, with respect to the question of privatization, this conclusion should be interpreted cautiously. The German wastewater sector displays only the early signs of privatization. Correspondingly, our sample is comprised of just a few private firms that often do not even exhibit actual private ownership. For this reason, one cannot expect that effects of the commitment of private service providers can easily be identified in the data. Nevertheless, such effects could still be substantial if a higher level of private commitment were actually reached.

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14 All other results remain qualitatively unchanged: Organizational arrangements are still insignificant, while the impact of size appears even to be more pronounced.

15 Including both explanatory variables simultaneously leads to individually (marginally) insignificant coefficients, while jointly they are highly significant. In fact, both are substantially (0.6) positively correlated. If either "highly qualified employees" or "population density" is included, estimates do not deviate qualitatively.

In contrast, the density of population within the firms' areas of supply strongly determines the firms' innovativeness. This might be a "big city effect" rather than a genuine "population-density effect", resting upon integration into innovation-enhancing networks and access to human capital, which is rather located in city centers. This finding might offer a starting-point for pushing innovativeness: Firms apparently benefit from a socio-economic environment that offers access to sources of innovations. Therefore, general investments in research and education are at least likely to have positive effects on wastewater services, too.

Finally, large firms proved to be more innovative than small ones suggesting that even a moderate restructuring within the existing legal framework that leads to larger units may help to foster innovations and improve the efficiency of the German wastewater sector. From this point of view, a process of mergers and acquisitions – which has already started in drinking water supply services – could be beneficial for the wastewater sector as well.

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Appendix 1: Organizational Arrangements

A *municipal department* (Regiebetrieb) is legally and organizationally a dependent part of the municipality. Its finances are integrated in the general community budget, and it often does not have an accounting system to call its own. All decisions are made by the municipal council.

The *semi-autonomous municipal agency* (Eigenbetrieb) is also a legally dependent part of the municipality. In contrast to municipal departments, however, it is a separate municipal entity that operates clearly defined budgetary allotments on its own (Holzwarth/Ewens 2001: 48).

The *public law incorporation* (Anstalt des öffentlichen Rechts) concerns a firm under public law with its own legal status that can be set up by a state body only on the basis of a specific law. Public law incorporation arrangements are exempted from any tax (Hansen et al. 2000: 47).

Inter-municipal agencies (Zweckverband) and *water and soil management associations* (Wasser- und Bodenverband) are mainly associations of municipalities. This way, several municipalities can accomplish their tasks jointly. Both organizational arrangements have their own legal status, making them less de-

pendent from single responsible municipalities than municipal departments are. Additionally, they can use a semi-autonomous agency for fulfilling the wastewater services (Holzwarth/Ewens 2001: 49).

In contrast to these five types of organizational forms, wastewater services can also be arranged under private law. "Private", however, does not necessarily mean that the entire firm or even shares are held by private owners (material privatization); it also labels firms that are still entirely publicly owned while operated under private law (formal privatization). Three general types of private arrangements can be distinguished:

A *municipal enterprise* (kommunale Eigengesellschaft) is usually organized as a limited liability company (GmbH) or as an incorporated company (AG). The entire shares are held by the municipality. The firm is independent of the local government in terms of its organization and its accountancy; however, the municipality has influence through the supervisory board.

In the case of *a management and services enterprise* (Betriebsführungsgesellschaft), the ownership of the assets and the corresponding responsibility for investments both remain with the municipality, whereas the private firm runs the wastewater treatment plants, etc.

Joint ventures and *co-operating enterprise* (Kooperationsgesellschaft) represent public utilities, in which a private firm holds a (typically minor) share in the firm's capital. Other types of organizational arrangements involving private firms may occasionally occur, whereas completely private wastewater firms are extremely rare in Germany.

Appendix 2: Description of Organizational Innovations

Split wastewater charges (gesplitteter Gebührenmaßstab): In principle, wastewater charges can be calculated in two different ways. The common method exclusively takes the amount of freshwater used by the consumer as the basis of the charges. In contrast, "split wastewater charges" combine two criteria. The first charge is for sewage that results from freshwater consumption. The second one is for rain run-off and depends on, among other things, the size of the sealed surface. Thus, the polluter-pays-principle is realized by using a "split wastewater charge" rather than an exclusively freshwater-based measure. Nevertheless, about three out of four German municipalities use the latter one (Rahmeyer 2002: 367).

Success-related fees (Erfolgshonorarvereinbarung) refers to fees that architects and engineers receive. These fees are traditionally calculated wholly on basis of production costs. Since 1996, a revised ordinance has allowed for the agent's fee to be partly dependent on cost-reduction effects of so-called tech-

nical-scientific solutions; i.e. a municipality that orders, for example, the renewal of a sewage plant is allowed to pay the architect an extra fee of up to 20 percent of the cost saved by an innovation. In our survey, a mere 4 percent of the firms already use this instrument, and further 14.4 percent intend to use it.

Service and operation directions (Dienst- und Betriebsanweisungen) are special legally defined bureaucratic means to systematically concretize a firm's tasks, regulate the duties of the staff, and create norms for dealing with the facilities. Their implementation is regarded as an organizational innovation. In detail, "service directions" explain what the task "wastewater disposal" is comprised of, and which single tasks have to be fulfilled. They name the legally responsible persons and assign duties. "Operation directions" describe the facilities (e.g. sewage networks or sewage plants) and list the corresponding duties to operate and maintain the facilities. Beyond these two types, more detailed instructions about specific parts of the technical facilities can also be used.

Cost and activity accounting (Kosten- und Leistungsrechnung) deals with the coverage and assignment of costs to cost units (i.e. a product) and cost centers (i.e. a department) in order to determine how cost-intensive the different parts and outputs of a firm are. While "cost and activity accounting" is part of double entry-bookkeeping and therefore standard for private enterprises, it is not mandatory for public institutions, and therefore not for public utilities, either.

Internal performance indicator systems (interne Kennzahlensysteme): Although closely related to "cost and activity accounting", "internal performance indicator systems" represent a wider approach. This instrument can deal with all kinds of performance categories, such as quality, reliability, customer service, sustainability, and economic efficiency, and can, therefore, look at monetary as well as non-monetary indicators.

Benchmarking is related to "performance indicators systems". In contrast to these, benchmarking restricts the analysis not only to indicators concerning the own firm, but also compares them with those of its peers. If done properly, benchmarking can help to reveal any hidden potential to catch up with the most efficient firm. In Germany, benchmarking is performed by utilities on a voluntary basis, and in most cases, the information remains confidential (WRc/Ecologic 2002: 112). Besides, benchmarking initiatives are often comprised of only one or a few processes. As a contrast to this, it is used for ex ante regulation of the English and Welsh water sector.

Management systems (Managementsysteme) seek to improve the quality of processes and products, as well the management of environmental and health risks of drinking water and wastewater services. Certain management systems

can be certified according to the standards defined in ISO 9000 pp. or ISO 14001; by doing so, a firm signals that its processes have reached a good and generally accepted quality.

Incentive wages (Entlohnungs- und Anreizsysteme) reward the staff for good working results, special achievements, etc. This organizational innovation is considered because traditional payment systems used in the public sector are often considered to be inflexible.