Efficiency in the Public & Private French Water industry: Prospects for Benchmarking

Aude LE LANNIER Simon PORCHER

Economics of Public-Private Partnerships Chair (EPPP),
IAE Sorbonne Business School

September, 2011
Very First Draft - Please do not quote

Résumé

This paper evaluates and gives a benchmarking of the efficiency of a hundred public and private French water services in 2009, using a mixture of data envelopment analysis and stochatic frontier analysis. Previsous empirical results mostly suggest that either private companies are more efficient or that the relative efficiency between private and public companies is ambigous. Contrary to that, our premiminary results indicate a strong advantage for publicly managed water companies in terms of technical efficiciency.

1 Introduction

In France, local authorities must provide local public service obligations in terms of water provision on behafl of their citizens. The service can be managed in-house or be outsourced to a private operator using a public-private arrangement. Whatever the management system, the local authorities set the objectives - such as an uninterrupted service and a good water quality - and have to enforce them. For the last three years, water management have been a hot political topic in France.

In 2009, a year after the municipal elections, the left-winger mayor of Paris decided not to renew the city's water provision contract with two private operators and to go back to direct public management regime. The municipality is now in charge of providing water to the 2 millions inhabitants of the city. In the beginning of 2011, after a year of direct public management, the mayor announced that good performances will lead to a decrease by 8% of the drinking water price in Paris from july 2011 on. Consequently, other French public authorities decided to directly provide water to their users without contracting out with private operators arguing that public management was more efficient for public services.

This paper addresses the relative efficiency of public and private (or mixed) managed of water services in France. To do so, we evaluate water producers in terms of their ability to minimize their revenues and debts in the provision of given outputs, relative to the performance of other producers in our comparison set. We indeed consider that efficient water services operate with low revenue and debt for a given level of outputs. The latter are divided between physical outputs such as the volume of billed water, the length of main and the number of customers and quality outputs such as customer's satisfaction, water quality, and index of the companies' knowledge about its network and the linear leakage index measured as the ratio between the average amount of daily leakages in cubic meters and the length of the distribution network. However, one may argue that efficiency depends also on the characteristics of the environment in which production is carried out, hazard such as good and bad luck and management efficiency. To take into account these effects, we include a set of environmental variables [1] and we run a three-stage Data Envelopment Analysis (DEA), a widely used linear programming technique to assess the relative producer performance. The three-stage DEA method is the following. In the first-stage, a conventional oriented DEA using only inputs and outputs is run. In the second-stage, we regress the slacks of the first-stage against the environmental variables and an error term using a Stochastic Frontier Analysis (SFA) to purge the possible managerial efficiencies and statistical noise. Finally, the third-stage is a DEA like in the first-stage with outputs corrected for the impacts of the environmental variables and statistical noise (but taking into account managerial efficiency). This allows us to benchmark the performance of water services without and to control for endogeneity in the management selection made by the municipalities. We then rank the municipalities according to their efficiency scores.

A large number of studies uses a benchmarking method to evaluate the efficiency of publicly and privately managed water services in industrialized and developing countries. For example, Bhattacharyya et al. [1995], using a translog variable cost function on 221 US water utilities, find that US publicly owned water utilities are more efficient. The same result is found by Shih et al. [2004] who apply DEA to two US datasets. No significant results are obtained by Saal et al. [2007], who apply SFA to ten British and Welsh private water and sewerage companies, neither Garcia-Sanchez [2006] who use DEA for Spanish water utilities nor Saal and Parker [2000, 2001], who apply Total Factor Productivity (TFP) analysis to a panel of ten UK private companies. In developing countries, studies find a slight positive impact of private ownership on company efficiency.

Kirkpatrick et al. [2006] use DEA and SFA to determine the impact of ownership structure on efficiency performance in African countries. Hi-

1. Water source origin, a dummy that takes 1 if the area is touristic, density of population, a dummy that takes 1 if the area is interconnected, a dummy that takes 1 if the water and sewerage services are managed by the same operator, a dummy equals to 1 if the operator is public.

gher relative efficiency is shown for privately owned utilities, when using DEA method, whereas no statistically significant results for the impact of ownership is found with SFA. Estache and Kouassi [2002] estimate a Cobb-Douglas production function for 21 African water utilities. Their results indicate that private ownership significantly decreases inefficiency. No significant differences between efficiency under public and private ownership are observed by Estache and Rossi [2002], who estimate a Cobb-Douglas variable cost function using data from 50 water utilities in developing and transition countries in the Asian and Pacific region.

In France, where there is no national regulator, water distribution is increasingly coming under scrutiny by operators, policymakers, and researchers. Benchmarking is a means that is widely used in various countries and sectors (see Lévêque [2005]) to provide information and incentives to utilities (see for instance Shleifer [1985] and Auriol [2000]). While early applications of benchmarking techniques have been practiced in the UK, most compartive studies between public and private management in the French water sector such as (Carpentier et al. [2005] and Chong et al. [2006]) use econometric methods. This is partly due to the missing data on costs, revenues and quality indicators. Since the 2007 decree and the implementation of the *French National Observatory of Water and Aquatic Environments* (ONEMA) the same year, the idea of a benchmarking of water services in France got more popular. The *Fédération Nationale des Communes Concédantes et Régies* (FNCCR), an association of municipally elected persons who manage public services, has already financed two benchmarking studies on 31 voluntary French water provision services on 2008 and 2009 datasets. By the same token, the *Professional Association for Water Companies* (FP2E for *Fèdèration Professionnelle des Entreprises de l'Eau*), a group of private firms operating in the water and sewage sector, also collect data and finance studies (Group [2007]) on the relative performances of direct and delegated management. Finding the regulating tools that will reduce the information asymmetry between local authorities and water companies and promote the performance objectives in the water industry has become a broadly shared goal. Assessing relative performances can become a valuable regulatory instrument and is beginning to gain popularity in France.

This paper contributes to the previous literature in three different ways. Firstly, in addition to traditional measures of technical efficiency, we take quality indicators into account to assess the performance of water services and debt as an input. Quality indicators are important because they usually warrant attention of the civil society, especially because water companies must comply with quality standards and public service expectations. Debt is an important input as a municipality with a low-pricing strategy may be willing to increase its water debt for political purposes. Secondly, we mix different benchmarking models. These approaches need to be robust to be accepted by stakeholders (see for instance Berg and Lin [2008] [2] and Sage

2. As argued by Berg and Lin [2008], "*If the criterion of consistency is not met, these groups [the stakeholders] cannot be confident that the relative performance indicators are meaningful.*

[1999]). Consistent results will improve the relevance of benchmarking tools, the reliability of performance rankings and finally, it will limit enforcement difficulties of . Eventually, our results indicate that publicly managed French water utilities are more efficient, in average, when applying a DEA-based benchmarking and a heterogeneity control with SFA method, even if we take into account public debt.

The outline of the paper is the following. Section 2 provides a general description of the regulatory regime and the institutional framework for the French water industry. The model specification is set out in section 3. Section 4 focuses on the input, output and environmental variables along with the arguments that support their choice. Empirical results are presented and discussed in section 5. A brief conclusion follows.

2 The Water Sector in France

2.1 The provision of water in France

In France, municipalities must provide local public services that have public good characteristics. This provision can be made by the municipality alone or by a group of municipalities that collectively engage to provide one or several public services.As there is no national regulator for these services, local public authorities define the general principles governing those services on behalf of their citizens : they monitor prices, control entry and exit of firms into the market, organize competition and ensure uninterrupted service. Regulation has thus been replaced by a contract in the case of a private operator or a decision of the municipality board in the case of public operation. In the case of a delegated management, public authorities face the classic regulatory problem : they are in an information asymmetry position and have few tools to carry out their essential tasks.

Water provision is a broad subject implying four public services. On the one hand, water provision refers to the production and the distribution of water ; on the other hand, sewerage implies wastewater collection and treatment. Due to potential scope economies, water provision and sewerage can be run by the same operator [3] but through two separated contracts.

Furthermore, rules have been defined to ensure that standards are respected during the operation to limit the potential opportunistic behavior of operators. These rules support water quality, duration of contracts and information about management and provision quality. In the case of water

However, when alternative methodologies yield broadly similar rankings, stakeholders are less likely to engage in acrimonious high-stakes disputes."

3. An official report by Dexia, a French financial intermediary, states that 63% of French medium-sized cities contract out the services of potable water treatment and distribution and 58% also contract out their sewerage services. It is however difficult to have a precise estimation of how many municipalities and communities have contracted out both services with the same operator.

quality, a precise definition of more than 60 verifiable quality parameters has been set by the 1992 water act to ensure that water services, would it be private or public, respect quality standards. Consequently, water quality is respected and is rarely below a 95% score of conformity to the standards of the microbiological analysis. Moreover, limits on duration have been implemented and management and provision information is now required to be publicly reported. To ensure that competition between operators arises, the "*Barnier Law*"(1995) gives a clear limitation to the duration of contracts and include an automatic renegotiation of the contract every five years. To struggle against information asymmetries, the executive power passed a decree in 2007 that forces municipalities and communities to provide 14 performance indicators in the *Annual Report on Prices and Service Quality* (RPQS in French) of the mayor. These performance indicators and other data about water and sewerage services are being collected for 2009 by the *French National Observatory of Water and Aquatic Environments* (ONEMA in French) to provide data in order to inform users and citizens about their water services.

2.2 The institutional framework of water industry in France

In France, each local public authority may choose a particular contractual form from the differentiated set of alternatives. Although some municipalities manage production through a *direct public management* and undertake all operations and investments needed for the provision of the service, the hiring of a private operator, independent of the local government, to manage the service and operate facilities is common.

In the latter case, the local public authority may choose to involve an outside firm in the operation of the service choosing a *gerance contract* in which it pays an external operator a fixed fee, or an *intermediary management contract*, i.e. a gerance contract but with a small part of the company's revenues depending on its performance. Such contracts provide few incentives to reduce costs and transfer few risks and decision rights to the private water company. Between *gerance contract* and privatization, there are two main *delegated management* contracts [4]. *Lease* contracts are characterized by investments to maintain the network and a financial compensation directly through customer receipts. In the *concession contract*, the external company also undertakes construction risk, as it must finance a large part of investments over the duration of the contract. *Lease* and *concession* contracts differ from the previous ones in that they give companies incentives to reduce costs, and companies share risk in exchange for greater decision rights and claims on revenues.

The institutional framework to select the private partner is the following. Since the "*Sapin law*" (1993), if the public authority chooses a lease

4. Our sample has only *delegated management contracts*.

or a concession contract, it selects its partners in two steps. First, the public authority launches a classical invitation to tender that is open to all interested private water companies. Second, there is a negotiation phase between the public authority and potential entrants that it shortlists. At the end of the negotiation, the public authority chooses its final partner for the duration of the contract. The selection of the private company follows the *intuitu personae* principle according to which the municipality or the community sets a list of criteria to select the firm that is considered as the best partner. However, the number of bidders remains low, around 1.9 for each bidding process (Guérin-Schneider and Lorrain, [2003]).

3 The model specifications

3.1 Methodology

In 1957, Farrell introduced a data envelopment methodology [5] for the measurement of economic efficiency. From an input-oriented perspective [6], technical efficiency is associated with the ability to produce on the efficiency boundary of the production possibility set given a predetermined quantity of output.

The basic DEA model described evaluates economic efficiency using traditional input and output variables but it does not consider the potential role that environmental factors may have on companies' performances. Several models have been developed in order to incorporate environmental effects into a DEA-based performance evaluation. [7] One possible approach is to include the environmental variables directly into the linear programming formulation either as non-discretionary inputs, outputs or neutral variables, according to the circumstances (Ferrier and Lovell [1990]). This requires that further linear programming constraints be included. As a consequence, only few environmental variables can simultaneously be taken into account to avoid excessive restriction of the reference set, hence reduction of the discriminatory power of DEA.

A possible approach to better evaluate the producer performance is to adopt a multi-stage DEA analysis. This ensures that the comparison is made among units which operate under similar environmental conditions, thus eliminating the environmental effects from the single company's performance assessment. As noted by Erbetta and Cave [2007], both these approaches are, however, deterministic and so they fail to take into consi-

5. For a comprehensive description of DEA models, see Charnes et al. [1978], Thanassoulis [2000a,b], Charnes et al. [1994] and Cooper et al. [2004]

6. In principle, economic efficiency may be measured using an input or an output-oriented approach. In the first case, the input use is minimized given a certain amount of output, while in the second the output is maximized for a given level of inputs. Generally, the adoption of an input-oriented framework is preferred when public utilities are considered as the demand of service the suppliers must provide may be seen as exogenous

7. See Coelli et al. [1998] for details on these models.

deration the effects of statistical noise on efficiency performance.

Another group of models is based on two-stage mixed approaches which imply a regression-based second stage. These models involve solving a DEA problem in a first stage using traditional input and output variables in order to calculate initial efficiency measures. The efficiency scores are then regressed upon a set of environmental variables in a second stage, the objective being to determine the signs, as well as the significance of the coefficients of the environmental variables and to consider the impact of noise (see for intance Bhattacharyya et al. [1997]) by adjusting the first stage efficiency scores.

For their part, Fried et al. [1999] introduced a three-stage approach where the initial DEA efficiency scores based exclusively on output and input are then regressed in the second stage using a tobit upon a vector of environmental factors. Predicted values of the impact of the environmental effects can then be computed. In the third stage, the original data are adjusted to account for the effect of environmental variables and DEA is re-run in order to obtain new DEA scores unaffected by environmental characteristics. This approach, however, is unable to account for the role of statistical noise on efficiency.

In order to embody the action of both environmental variables and statistical noise upon efficiency, we adopted, like Erbetta and Cave [2007] a three-stage approach proposed by Fried et al. [2002]. This mixed approach which combines DEA and SFA makes it possible to obtain a measure of the intrinsic managerial performance, separately both from the impacts of the environmental characteristics in which production takes place and from random noise. As SFA is regression-based, it can isolate managerial inefficiencies from environment effects and statistical noise in the second stage. In the last stage, producers' inputs are adjusted to account for the environmental effects and statistical noise identified in stage two and DEA is run again to re-evaluate producer performance.

3.2 Model set-up

TBD.

4 Data

A data collection has been launched to get the 2009 *Annual Reports on Prices and Service Quality* (*RPQS*) of the 325 bigger French water services. When we could not access the Annual *RPQS*, we used the *Delegate Annual Reports* of 2009. Like in many empirical studies, we focus only on the water service and we do not consider the sewerage one. [8] We finally managed to

8. A on sewerage activities would be constrainted by a lack of comparators.

get only 275 reports but the sample gets smaller according to the variables that we want to take into account.

4.1 Dependent variables

We use companies' revenue (***REV***) and debt (***DEBT***) as dependent variables. The total companies' revenue mainly depends on the price paid by consumers and the number of cubic meters billed, but it also includes other products and profits from works on the networks. In France, the price of water is divided between a fixed fare and a variable part depending on the consumption pattern of the user. A part of the profit coming from the water sales can be paid back to the community or to the municipality in accordance with the contractual design. The final price paid by the consumer includes also several taxes transfered to the water public agencies and to the state. As these taxes are fixed according to the regulation statutory, it does not reflect the performance of the service. We thus use as an input the revenue of the water service excluding the revenues coming from the other products, the works on the networks and the product of public taxes. The remaining part represents the revenues from the water sales that are shared between the private water company and the public authority. Most of studies in the water industry use the operating costs as the dependent variable (see for instance Cubbin and Tzanidakis [1998] and Thanassoulis [2000a,b] in the case of water companies in England and Wales, Corton [2003] for water companies in Peru, Tupper and Resende [2004] for water and sewerage companies in Brazil and Corton and Berg [2009] for Central American water utilities). However, we had not been able to collect a lot of information on this variable as it is often not written in the reports. However, using revenues is meaningful as most contracts are lease contracts which are close to cost-plus contracts : the price is decided by the municipality after having been informed of the operator costs. This is in line with the "water pays water" principle according to which the price of water must cover the production costs. By including the REV variable as an input, we first assume that lower revenues reflect lower operating costs (and therefore lead to lower final prices paid by users). Therefore, a water provision unit will be more efficient the lower the revenues for a given level of outputs.

We also used, as an input and as a control in a second test, the debt (in euros) contracted by the public authority for the specific water public service. This means that the water service budget is separated from the whole municipal budget. The debt problem is twofold. On the one hand, a water service could choose to increase its short-term debt to decrease final prices rather than improving its operating efficiency (with lower revenues). This could be especially true for directly run services. On the other hand, a long-term water service debt could mean that revenues (costs) will increase in order to pay the debt service. Therefore, according to our discussions with public and private water services, we assume that a water provision unit will be all the more efficient that it operates with relatively low revenue and debt, for a given level of outputs.

4.2 Physical outputs

In order to compare water provision units' performance, we use the three traditional physical outputs used in the literature : the volume of water billed in cubic meters (***VOL***), the number of customers (***CUST***) and the length of main in kilometers (***LENG***).

The volume of water billed is a conventional measure of the water production activity and is represented, in our database, by the total volume of water delivered and billed to households and non-households.

The number of customers is also a commonly used output (see for instance Saal and Parker [2000], Lin [2005], Berg and Lin [2008], Corton and Berg [2009], Picazo-Tadeo et al. [2008]) and includes the total number of household and non-household billed by the water company. The number of customers in our database also represents the number of properties connected for water supply. In French urban areas, a connection can represent a whole building or a part of the building. Several studies underlined the relevance of combining both the volume of water billed and the number of customers (Saal and Parker [2006], Corton and Berg [2009]). For instance, Saal and Parker [2006] justify this specification by the fact that the two tasks have different characteristics and heterogeneous marginal costs. Moreover, as noted by Saal and Reid [2004], previous researches (see for instance Antonioli and Filippini [2001] and Garcia and Thomas [2001]) have suggested that because of the cost of maintaining network connections, the number of customers is an important determinant of water industry costs and revenues. According to Erbetta and Cave [2007], this specification is a proxy for the scale of the distribution activity.

Furthermore, water companies may have different revenues depending on the length of mains (Corton and Berg [2009]). Therefore, as regard the outputs commonly used in studies (see for instance Cubbin and Tzanidakis [1998] and Thanassoulis [2000a,b]), we add the length of mains as an output. Thanassoulis [2000a,b] argued the length of mains reflects the geographical dispersion of connections. For Berg and Lin [2008], this variable is an indicator of capital.

We expect that the higher these explanatory variables, the higher the companies' revenues.

4.3 Quality outputs

In addition to traditional measures of technical efficiency, service quality is a performance indicator that warrants attention, since one important characteristic of water companies is that they must comply with quality standards. To measure performance, we use four variables that give us information about service quality, drinking water quality, environmental performance and network quality. These quality indicators are an important outcome as private operators usually justify their higher prices by higher quality standards (Group [2007]).

In the water industry, the variables representing quality might differ considerably from one country to another. In some developing countries, service coverage, service continuity or the percentage of water receiving chemical treatment are adequate variables to measure water quality (see for instance Lin [2005] and Berg and Lin [2008] in the case of Peru, Corton and Berg [2009] for the Central American water utilities). In contrast, in developed countries where water services cover nearly all the population, alternative measures of quality are required (see for instance Saal and Parker [2000, 2001], Antonioli and Filippini [2001], Estache and Rossi [2002], Tupper and Resende [2004], Lin [2005], Alegre et al. [2006], Saal and Parker [2006], Saal et al. [2007], Berg and Lin [2008], Bouscasse et al. [2008] and Picazo-Tadeo et al. [2008]).

To measure the service quality, we use a proxy reflecting the "perception by users of the quality of services provided" (see for instance Bouscasse et al. [2008]). We use the rate of customers' complaints (like Corton and Berg [2009] and Bouscasse et al. [2008], among others), measured as the ratio between the number of written customers' complaints and the number of customers during a given year. On the basis of this variable, we calculate a satisfaction index measured as the ratio between the number of customers minus the number of complaints and the number of customers (***NonComp***). A small number of complaints indicates a higher quality of service. Therefore, we expect the higher the companies' revenues, the higher the satisfaction of customers.

Concerning the drinking water quality, we retain the percentage mean zonal compliance with the microbiological standards (***Drink***) (see for instance Saal and Parker [2000]). A higher compliance with microbiological quality standards may have an ambiguous effect on the level of revenues. On the one hand, a better quality of drinking water may be due to a higher share of groundwater sources for an operator. In this case, it is an "environmental" advantage for the operator, since the drinking quality is often regarded as being closely linked to the production of drinking water from groundwater (see for instance Bouscasse et al. [2008]). To take this aspect into account, we will add an environmental variable. However, in the other hand, a higher quality of drinking water may also come from firms' efforts to achieve the qualitative criteria. In this case, a positive impact on revenues is expected. In our sample, the drinking water quality never exceeds the 5% of non-compliance. However, as users and municipalities are sensitive to the water quality, we decided to rescale the variable between 0 and 1 to be able to discriminate companies according to this indicator. 0 corresponds to the lower performance, here 95% of samples matching the quality parameters, while 1 corresponds to the best practice, i.e. a total compliance with the 100% conformity to the microbiological parameters.

Another set of variables measures the performance of the water service from the public authority's point of view. In France, water networks are the property of the municipality. The company of the water service, would it be private or public, must report every year an index of the knowledge of the network (***KNOW***). This index going from 0 to 100 depends on the level of information given to the municipality and on network management. It is divided in ten indicators, weighting 10 points each, about information (e.g. "the percentage of network maps updated"), network investments and management (e.g. "Is there a program aiming at replacing all lead connections before 2013 ?" and "Is there an information system to detect leakages ?"). This knowledge indicator is important as one could expect opportunistic operators to withhold information in order to protect themselves from competitors or to get a higher market power during renegotiations with the contractors.

To measure the network quality, we use the linear leakage index (***LOSS***) measured as the ratio between the average amount of daily losses in cubic meters and the length of the distribution network. Some studies use the water losses to take account for deficiencies in either operational or commercial practices. Indeed, as argued by Corton and Berg [2009], water losses may reflect a cost trade off between increasing water production and repairing network leaks to keep up with water demand. Hence, the idea is that, to satisfy demand, managers may find it more costly to repair leaks and to control water losses than to increase water production. For Garcia and Thomas [2001], water network losses are considered as a non-desirable output produced jointly with the service of water delivery. For their part, Coelli et al. [2003] regard water losses as an indicator of the technical quality of service. In our empirical analysis, we use the inverse of the linear leakage index to keep a growing linear relationship between the latter and the inputs.

4.4 Environmental variables

The efficiency of a firm could be affected by exogenous conditions that are not under the direct control of managers. Environmental variables have been included because they may influence the technology under which water utilities operate and may account for exogenous differences in operating environment experienced by each firm (see Bhattacharyya et al. [1995], Garcia and Thomas [2001], Tupper and Resende [2004] and Filippini et al. [2008] among others). These variables enable to take account of the impact of the different characteristics of the network and of the area where the service is provided, thus controlling for heterogeneity among firms [9].

The source of water (***SOURCE***) is commonly used in benchmarking studies including quality criteria ; The source of water is a proxy not only for the complexity of service provision, but also the level of specific investments needed to operate the service, an important variable from a transaction cost

9. The environmental variables used are consistent with many of the mentioned empirical studies. See for instance Erbetta and Cave [2007].

perspective (Williamson [1999]). Indeed, as noted before, a better quality of drinking water may be due to a higher share of groundwater sources for an operator. The source of water determine the type of treatment as the quality of underground water is generally more stable over time, reducing uncertainty about the evolution of the kind of treatment over the life of the contracts.

Furthermore, some water services can be subject to a high volatility of demand due to seasonal variations in the population that might necessitate overcapacity in order to satisfy peak-load demand. A dummy variable for the touristic nature of the service (***TOURIST***) takes the value 1 if the service area is considered to be touristic according to the *French National Bureau of Statistics* (INSEE) classification and 0 otherwise.

As noted by Saal and Reid [2004], an extensive literature has included measures of the density of operations as an important determinant of water industry costs (see for instance Bhattacharyya et al. [1995], Cubbin and Tzanidakis [1998], Antonioli and Filippini [2001], Estache and Rossi [2002]). Therefore, the water service density or, in other words, the population density (***DENS***) is included in our specification and is defined as population per kilometer of water main (i.e. the ratio between the population provided with water and the length of mains). For Erbetta and Cave [2007], providing service to a more concentrated population is, generally, cheaper than providing a dispersed population. The idea is that more dispersions of the network, more frequent maintenance and more energy are needed. However, as argued by Bottasso and Conti [2003], the population density may have ambiguous effects on cost inefficiency since, one the one hand, it may be more expensive too service dispersed customers, but in the other hand, a higher density may create congestion problems.

Moreover, small towns have fewer internal resources either to produce water themselves or to pay external experts and to monitor and control private operators. At the same time, private operators have little incentive to operate in small towns. This may explain the tendency of small towns to create pools, which then provide water directly through a joint bureau of outsource. A dummy (***POOL***) equals 1 if the municipality provides water jointly with other local authorities, 0 otherwise.

We also add a dummy variable reflecting the activity of companies (***Act***), which assumes a value of 1 if the company manages both water and sewerage activities and 0 otherwise. This dummy should pick up technology differences existing between the water and sewerage companies and the water only companies (see for instance Hunt and Lynk [1995], Saal and Parker [2001] and Bottasso and Conti [2003]). A higher level of performance is expected when the same company runs both activity in accordance with the possibility of scale economies.

Finally, as public-private partnerships in the French water industry are characterized by different types of contracts, we also include a management dummy (***MANAGE***) to check whether a given type of management can lead to a predicted level of performance. Our result could thus assess the relative performance of different organizational types. In our sample, the share of public and private managed water companies is summarized in Table 1.

Management Type	**Share**
Direct Public Management	47.22%
Delegated Management	52.78%

Table 1 – Distribution of Management Types in the 72 water services in 2009

Note that the proportion of water delivered to non-households is often used to reflect the cost savings associated with supplies to larger customers (see Cubbin and Tzanidakis [1998], Bottasso and Conti [2003] and Corton [2003]) but is not available in our database for the moment. However, we think that taking the density population into account enable to partly control for the presence of industrial customers.

Because of missing data, our benchmarking is run on 72 water provision units for the moment (collection of data still is in progress, in the end we should get a sample of 100 water services). Appendix 1 provides a list of the services involved in the benchmarking. The first test, introduced in this draft paper, includes the three physical outputs describe above, one drinking water quality indicator, with the revenue as an input. All the environmental variables described are used to capture heterogeneity between operational conditions. Table 2 provides the sample summary statistic when using these variables.

Variables	Mean	Standard deviation	Min	Max
Dependant variable				
Revenues (in thousands)	10,526.77	17,167.59	688.11	93,623.00
Debt (in thousands)	5,662.47	7,505.12	0	32,293.36
Physical outputs				
Volume billed (in thousands)	7,518.29	12,067.10	851.21	69,697
Length of mains	629.70	767.64	86	4,123
Nb of customers	35,262.31	54,238.33	3,378	299,123
Environmental variables				
Population density	192.77	95.50	31.73	502.95
Touristic Area	0.89	0.32	0	1
Water Source	0.69	0.46	0	1
Pool of authorities	0.51	0.50	0	1
Management	0.47	0.50	0	1
Activity	0.50	0.50	0	1
Quality indicators				
Drinking water quality	93	0.44	98	100
1/Linear Leakage Index	0.17	0.13	0.04	0.64

TABLE 2 – Sample summary statistics *(72 water services in 2009)*

5 Empirical Results

5.1 Test 1 : using debt as an input

A summary of the first three-stage DEA results is shown in Table 3. The mean technical efficiency score is equal to 0.800, quiet a low level (once again we miss controls that we hope to have fully collected by the end of june), which indicates that the average company could reduce revenues and debt by 20%, still producing the same amount of outputs. The minimum value is 0.413, indicating that there are substantial differences among water services. 40.27% of water services are efficient which seems to be a satisfactory indicator.

Mean	Standard dev.	Min	Max	Nb of efficient services
0.800	0.204	0.413	1	29 (40.27%)

TABLE 3 – Efficiency summary - Test 1

Table 4 summarized the differences in performances results between public and private water companies. The mean technical efficiency score is equal to 0.759 for private and mixed managed water companies while it is 0.846 for public companies, indicating that the latter are in average more efficient. This is surprising as one may argue that lower revenues in directly managed water services could be compensated by higher debt levels. Overall, 31.57% of private and mixed companies are efficient in our sample, whereas 50% of public companies determine the efficiency frontier. One may argue that this is due to an unobservable selection effect : municipalities would delegate the water services that are difficult to run while they would run in-house most efficient services. Our results however break the usual argument that private operators are more efficient and keen on sound public finances. Indeed, most of the efficiency gaps are explained by poor water quality or high linear leakage index, thus indicating subsequential high revenues for such inefficiencies in the water service management.

	Private Management	**Public Management**
	Score	Score
Mean	0.759	0.846
Standard dev.	0.204	0.203
Min	0.434	0.388
Max	1	1
Best Rank	2	1
Nb of efficient services	12 (31.57%)	17 (50.00%)
Nb of services	38	34

TABLE 4 – Private vs. Public management - Test 1

5.2 Test 2 : using debt as a control

Our second test is summarized in Table 5. The mean technical efficiency score is equal to 0.772, a bit lower than in the first test and remains at a low-level. The minimum value is 0.402, indicating that there are substantial differences among water services. The percentage of efficient water services drops from 40.27% to 29.17%. Services that are at the efficiency frontier in test 2 are the same than the ones in test 1. Those which are not anymore at the frontier remain usually close to the frontier.

Mean	**Standard dev.**	**Min**	**Max**	**Nb of efficient services**
0.772	0.206	0.402	1	21 (29.17%)

TABLE 5 – Efficiency summary - Test 2

Table 6 summarized the differences in performances results between public and private water companies when debt is used as a control. The mean technical efficiency score is equal to 0.731 for private and mixed managed water companies and to 0.819 for public companies, indicating that the direct management is still more efficient. Only 21.05% of private and mixed companies are efficient in our sample, whereas 38.23% of public companies determine the efficiency frontier. Using debt as a control may be more robust as we cannot distinguish between short-term and long-term debt neither use the stock of debt as an input (while revenues are yearly flows).

	Private Management	**Public Management**
	Score	Score
Mean	0.731	0.819
Standard dev.	0.203	0.210
Min	0.421	0.381
Max	1	1
Best Rank	2	1
Nb of efficient services	8 (21.05%)	13 (38.23%)
Nb of services	38	34

TABLE 6 – Private vs. Public management (debt as a control)

6 Conclusion

By using a mixture of DEA and SFA-based benchmarking approach, we show a higher efficiency of water companies when the management is public. Note however that this result should be interpreted with caution in the extent that some data are missing for the moment and that the benchmarking is run with limited data.

Références

Alegre, H., Baptista, J. M., Cabrera, E., Cubillo, F., Duarte, P., Hirner, W., Merkel, W., and Parena, R. (2006). *Performance Indicators for Water Supply Services.* second ed. International Water Association Publishing, London.

Antonioli, B. and Filippini, M. (2001). The Use of a Variable Cost Function in the Regulation of the Italian Water Industry. *Utilities Policy*, 10(3-4) :181–187.

Auriol, E. (2000). Concurrence par comparaison : Un point de vue normatif. *Revue Economique*, 51(3) :621–634.

Berg, S. and Lin, C. (2008). Consistency in Performance Rankings : The Peru Water Sector. *Applied Economics*, 40(6) :793–805.

Bhattacharyya, A., Harris, T. R., Narayanan, R., and Raffiee, K. (1995). Specification and estimation of the effect of ownership on the economic efficiency of the water utilities. *Regional Science and Urban Economics*, 25(6) :759–784.

Bhattacharyya, A., Lovell, C. A. K., and Sahay, P. (1997). The Impact of Liberalization on the Productive Efficiency of Indian Commercial Banks. *European Journal of Operational Research*, 98 :332–347.

Bottasso, A. and Conti, M. (2003). Cost Inefficiency in the English and Welsh Water Industry : An Heteroskedastic Stochastic Cost Frontier Approach. Economics Discussion Papers 573, University of Essex, Department of Economics.

Bouscasse, H., Destandau, F., and Garcia, S. (2008). Analyse économétrique des coûts des services d'eau potable et qualité des prestations offertes aux usagers. *Revue d'économie industrielle*, 122 :7–26.

Carpentier, A., Nauges, C., Raynaud, A., and Thomas, A. (2005). Analyse micro-economique des différentiels de tarification dans les services publics locaux de l'eau. Rapport pour le ministère de l'ecologie et du développement durable, National Economic Research Associates.

Charnes, A., Cooper, W. W., Lewin, A. Y., and Seiford, L. M. (1994). *Data Envelopment Analysis : Theory, Methodology and Application*. Kluwer Academic Publishers, Boston.

Charnes, A., Cooper, W. W., and Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operational Research*, 2 :429–444.

Chong, E., Huet, F., Saussier, S., and Steiner, F. (2006). Public-private partnerships and prices : Evidence from water distribution in france. *Review of Industrial Organization*, 29(1-2) :149–169.

Coelli, T. J., Estache, A., Perelman, S., and Trujillo, L. (2003). *A Primer on Efficiency Measurement for Utilities and Transport Regulators*. The World Bank Institute, Washington.

Coelli, T. J., Rao, D. S. P., and Battese, G. E. (1998). *An Introduction to Efficiency and Productivity Analysis*. Kluwer Academic Publishers, Dordrecht.

Cooper, W. W., Seiford, L. M., and Zhu, J. (2004). *Handbook on Data Envelopment Analysis*. Kluwer Academic Publishers, Boston.

Corton, M. L. (2003). Benchmarking in the Latin American water sector : the case of Peru. *Utilities Policy*, 11(3) :133–142.

Corton, M. L. and Berg, S. V. (2009). Benchmarking Central American water utilities. *Utilities Policy*, 17(3-4) :267–275.

Cubbin, J. and Tzanidakis, G. (1998). Regression versus Data Envelopment Analysis for Efficiency Measurement : An Application to the England and Wales Regulated Water Industry. *Utilities Policy*, 7(2) :75–85.

Erbetta, F. and Cave, M. (2007). Regulation and Efficiency Incentives : Evidence from the England and Wales Water and Sewerage Industry. *Review of Network Economics*, 6(4) :425–452.

Estache, A. and Kouassi, E. (2002). Sector organization, governance, and the inefficiency of African water utilities. Policy Research Working Paper Series 2890, The World Bank.

Estache, A. and Rossi, M. A. (2002). How Different Is the Efficiency of Public and Private Water Companies in Asia ? *World Bank Economic Review*, 16(1) :139–148.

Ferrier, G. D. and Lovell, C. A. K. (1990). Measuring Cost Efficiency in Banking : Econometric and Linear Programming Evidence. *Journal of Econometrics*, 46 :229–245.

Filippini, M., Hrovatin, N., and ZoriÄ, J. (2008). Cost efficiency of Slovenian water distribution utilities : an application of stochastic frontier methods. *Journal of Productivity Analysis*, 29(2) :169–182.

Fried, H. O., Lovell, C. A. K., Schmidt, S. S., and Yaisawarng, S. (2002). Accounting for Environmental Effects and Statistical Noise in Data Envelopment Analysis. *Journal of Productivity Analysis*, 17 :157–174.

Fried, H. O., Schmidt, S. S., and Yaisawarng, S. (1999). Incorporating the Operating Environment into a Nonparametric Measure of Technical Efficiency. *Journal of Productivity Analysis*, 12 :249–267.

Garcia, S. and Thomas, A. (2001). The Structure of Municipal Water Supply Costs : Application to a Panel of French Local Communities. *Journal of Productivity Analysis*, 16(1) :5–29.

Garcia-Sanchez, I. M. (2006). Efficiency Measurement in Spanish Local Government : The Case of Municipal Water Services. *Review of Policy Research*, 23(2) :355–371.

Group, B. C. (2007). Etude economique comparative relative aux modes de gestion des services d'eau. Confidential Report.

Hunt, L. C. and Lynk, E. L. (1995). Privatisation and Efficiency in the UK Water Industry : An Empirical Analysis. *Oxford Bulletin of Economics and Statistics*, 57(3) :371–88.

Kirkpatrick, C., Parker, D., and Zhang, Y.-F. (2006). State versus Private Sector Provision of Water Services in Africa : An Empirical Analysis. *The World Bank Economic Review*, 20(1) :143–163.

Lévêque, J. (2005). Réduire le poids des contraintes informationnelle, politique et sociale grâce á la concurrence par comparaison : Le cas des trains régionaux de la sncf. *Revue d'Economie Industrielle*, 111 :57–78.

Lin, C. (2005). Service Quality and Prospects for Benchmarking : Evidence from the Peru Water Sector. *Utilities Policy*, 13(3) :230–239.

Picazo-Tadeo, A. J., Sáez-Fernández, F. J., and González-Gómez, F. (2008). Does Service Quality Matter In Measuring Performance Of Water Utilities ? *Utilities Policy*, 16(1) :30–38.

Saal, D., Parker, D., and Weyman-Jones, T. (2007). Determining the Contribution of Technical Change, Efficiency Change and Scale Change to Productivity Growth in the Privatized English and Welsh Water and Sewerage Industry : 1985-2000. *Journal of Productivity Analysis*, 28(1) :127–139.

Saal, D. S. and Parker, D. (2000). The impact of privatization and regulation on the water and sewerage industry in England and Wales : a translog cost function model. *Managerial and Decision Economics*, 21(6) :253–268.

Saal, D. S. and Parker, D. (2001). Productivity and Price Performance in the Privatized Water and Sewerage Companies of England and Wales. *Journal of Regulatory Economics*, 20(1) :61–90.

Saal, D. S. and Parker, D. (2006). Assessing the Performance of Water Operations in the English and Welsh Water Industry : A Lesson in the Implications of Inappropriately Assuming a Common Frontier. In *In Coelli T., Lawrence D. (eds) : Performance Measurement and Regulation of Network Utilities*. Edward Elgar Publishing, Cheltenham.

Saal, D. S. and Reid, D. (2004). Estimating Opex Productivity Growth in English and Welsh Water and Sewerage Companies : 1993-2003. Aston Business School Working Paper.

Sage, E. (1999). *La concurrence par comparaison : thï¿½orie et appplications. Une proposition pour le secteur de l'eau en France*. Ph.D dissertation, Université Paris Dauphine, Paris, France.

Shih, J. S., Harrington, W., Pizer, W. A., and Gillingham, K. (2004). Economies of Scale and Technical Efficiency in Community Water Systems. Resources for the Future. *Discussion paper 04-15*.

Shleifer, A. (1985). A theory of yardstick competition. *RAND Journal of Economics*, 16(3) :319–327.

Thanassoulis, E. (2000a). DEA and its use in the Regulation of Water Companies. *European Journal of Operational Research*, 127(1) :1–13.

Thanassoulis, E. (2000b). The use of Data Envelopment Analysis in the Regulation of UK Water Utilities : Water Distribution. *European Journal of Operational Research*, 126(2) :436–453.

Tupper, H. C. and Resende, M. (2004). Efficiency and Regulatory Issues in the Brazilian Water and Sewage Sector : An Empirical Study. *Utilities Policy*, 12(1) :29–40.

Williamson, O. (1999). Strategy research : Governance and competence perspectives. *Strategic Management Journal*, 20 :1087–1108.

Appendices

	Private Management				Public Management			
Variable	Mean	Standard deviation	Min	Max	Mean	Standard deviation	Min	Max
Dependant variable								
Revenues (in thousands)	12,958.90	14,734.31	688.112	83,372	7,808.51	18,948.91	93,623	69,697
Debt (in thousands)	4,683.29	7,807.93	0	32,293.359	6,756.84	7,185.28	0	30,559.034
Physical outputs								
Volume billed (in thousands)	8,954.51	9,333.08	865.536	49,241.785	5,913.10	14,044.494	851.207	1,228.228
Length of mains	717.15	739.68	97	4,123	531.96	791.29	86	3,126
Nb of customers	40,442.82	50,985.12	3,378	299,123	29,472.32	57,168.54	3,615	275,370
Quality indicators								
Drinking water quality	99.74	0.099	99	100	99.75	0.154	98	100
1/Linear Leakage Index	0.18	0.320	0.046	0.460	0.16	0.528	0.037	0.641
Environmental variables								
Population density	198.779	98.078	94.274	502.947	187.400	94.114	31.725	424.481
Touristic Area	0.853	0.359	0	1	0.921	0.273	0	1
Water Source	0.706	0.462	0	1	0.684	0.471	0	1
Pool of authorities	0.412	0.500	0	1	0.605	0.495	0	1
Activity	0.559	0.504	0	1	0.447	0.504	0	1

Table 7 – Descriptive Statistics : Private vs. Public management

Service ID	Name of the public authority	Organizational type (1 if public)	Efficiency score
1	AGEN	0	0,657
2	ALBI	1	1
3	ANGERS LOIRE METROPOLE	1	1
4	ARLES-CRAU-CAMARGUE-MONTAGNETTE (CA)	0	0,792
5	BELFORTAINE (CA)	1	0,72
6	BLANC-MESNIL (LE)	0	0,537
7	BORDEAUX (CUB)	0	1
8	BOURGES AGGLO	1	0,744
9	BREST METROPOLE	0	0,864
10	CAEN	0	0,869
11	CERGY-PONTOISE (CA)	0	0,753
12	CHALON-SUR-SAONE	0	0,541
13	CHERBOURG (CU)	1	0,719
14	CLERMONT-FERRAND	1	1
15	CONCARNEAU	1	0,937
16	COURNON-D'AUVERGNE	1	1
17	DENAIN	1	1
18	DIGNE-LES-BAINS	0	1
19	EVREUX (CA)	1	1
20	EVRY (CA)	0	0,556
21	GAP	0	0,717
22	GRAND LYON (CU) GG	0	0,469
23	GRAND LYON (CU) LDE	0	0,653
24	GRAND LYON (CU) VEOLIA	0	1
25	HYERES	0	0,476
26	JOUARS PONCHARTRAIN MAUREPAS (SIE)	0	1
27	LA SEYNE-SUR-MER	0	0,66
28	LANNION	1	1
29	LAVAL	1	0,601
30	LE MANS (CU)	1	1
31	LILLE METROPOLE (EDN)	1	1
32	MACON	0	0,694
33	MANOSQUE	0	0,798
34	MEAUX	1	1
35	MONT-DE-MARSAN	1	1
36	MONTLUCON (CA)	1	0,838
37	MONTPELLIER	0	1
38	MOULINS	1	0,657
39	NICE-COTE-D'AZUR (CA)	0	1
40	NIMES METROPOLE (CA)	0	0,798
41	PLOEMEUR	1	1
42	POITIERS (CA)	1	0,959
43	REIMS METROPOLE	1	0,933
44	ROANNAISE DE L'EAU (SIE)	1	0,7
45	ROCHEFORT	1	0,701
46	ROCHE-SUR-YON (LA)	0	1
47	SAINT LOISE 1 (CCA)	0	0,519
48	SAINT-AMAND-LES-EAUX	1	0,388
49	SAINT-AVOLD	1	0,908
50	SAINT-BRIEUC	1	0,423
51	SAINT-DIZIER	0	0,685
52	SAINT-ETIENNE	0	1
53	SAINT-MALO	0	0,488
54	SICASIL	0	0,78
55	SIE NORD MARMANDE (REGION NM)	0	1
56	SIECL	0	0,434
57	SMGSEVESC (VERSAILLES-SAINT-CLOUD)	0	0,907
58	STRASBOURG (CUS)	1	1
59	SYNDICAT DU NORD DU LOT	0	1
60	SYNDICAT DU SUD DU LOT	0	1
61	THIONVILLE	1	0,425
62	THONON-LES-BAINS	1	1
63	VOIRONNAIS (CA PAYS)	1	1
64	ARGENTAN	0	0,471
65	COLMAR (CA)	1	1
66	SALLANCHES	1	1
67	CASTRES	0	1
68	SENART-VILLE-NOUVELLE (SAN)	0	0,669
69	BRIVE (CA)	0	0,598
70	CAHORS	1	0,473
71	CLUSES	0	0,468
72	HEROUVILLE-SAINT-CLAIR	1	0,624

TABLE 8 – Efficiency scores and ranking - Test 1

Service ID	Name of the public authority	Organizational type (=1 if public)	Efficiency score
1	AGEN	0	0.629
2	ALBI	1	1
3	ANGERS LOIRE METROPOLE	1	1
4	ARLES-CRAU-CAMARGUE-MONTAGNETTE (CA)	0	0.734
5	BELFORTAINE (CA)	1	0.718
. 6	BLANC-MESNIL (LE)	0	0.515
7	BORDEAUX (CUB)	0	1
8	BOURGES AGGLO	1	0.748
9	BREST METROPOLE	0	0.765
10	CAEN	0	0.858
11	CERGY-PONTOISE (CA)	0	0.729
12	CHALON-SUR-SAONE	0	0.517
13	CHERBOURG (CU)	1	0.714
14	CLERMONT-FERRAND	1	1
15	CONCARNEAU	1	0.936
16	COURNON-D'AUVERGNE	1	1
17	DENAIN	1	0.589
18	DIGNE-LES-BAINS	0	1
19	EVREUX (CA)	1	0.914
20	EVRY (CA)	0	0.557
21	GAP	0	0.689
22	GRAND LYON (CU) GG	0	0.421
23	GRAND LYON (CU) LDE	0	0.609
24	GRAND LYON (CU) VEOLIA	0	1
25	HYERES	0	0.463
26	JOUARS PONCHARTRAIN MAUREPAS (SIE)	0	1
27	LA SEYNE-SUR-MER	0	0.625
28	LANNION	1	0.837
29	LAVAL	1	0.494
30	LE MANS (CU du), Le Mans Métropole	1	1
31	LILLE METROPOLE (EDN)	1	1
32	MACON	0	0.654
33	MANOSQUE	0	0.756
34	MEAUX	1	1
35	MONT-DE-MARSAN	1	1
36	MONTLUCON (CA)	1	0.785
37	MONTPELLIER	0	1
38	MOULINS	1	0.634
39	NICE-COTE-D'AZUR (CA)	0	0.968
40	NIMES METROPOLE (CA)	0	0.796
41	PLOEMEUR	1	1
42	POITIERS (CA)	1	0.96
43	REIMS METROPOLE	1	0.915
44	ROANNAISE DE L'EAU (SIE)	1	0.695
45	ROCHEFORT	1	0.711
46	ROCHE-SUR-YON (LA)	0	0.916
47	SAINT LOISE 1 (CCA)	0	0.475
48	SAINT-AMAND-LES-EAUX	1	0.381
49	SAINT-AVOLD	1	0.916
50	SAINT-BRIEUC	1	0.405
51	SAINT-DIZIER	0	0.679
52	SAINT-ETIENNE	0	0.813
53	SAINT-MALO	0	0.436
54	SICASIL	0	0.718
55	SIE NORD MARMANDE (REGION NM)	0	1
56	SIECL	0	0.439
57	SMGSEVESC (VERSAILLES-SAINT-CLOUD)	0	0.901
58	STRASBOURG (C,U,S)	1	1
59	SYNDICAT DU NORD DU LOT	0	1
60	SYNDICAT DU SUD DU LOT	0	0.956
61	THIONVILLE	1	0.418
62	THONON-LES-BAINS	1	0.985
63	VOIRONNAIS (CA PAYS)	1	1
64	ARGENTAN	0	0.456
65	COLMAR (CA)	1	1
66	SALLANCHES	1	1
67	CASTRES	0	1
68	SENART-VILLE-NOUVELLE (SAN)	0	0.659
69	BRIVE (CA)	0	0.571
70	CAHORS	1	0.466
71	CLUSES	0	0.468
72	HEROUVILLE-SAINT-CLAIR	1	0.617

TABLE 9 – Efficiency scores and ranking - Test 2