How to stimulate natural monopolies? The drinking water experience (1)

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ABSTRACT

To stimulate the efficiency of utilities in the drinking water sector, different countries employ heterogeneous incentive schemes. By the use of a cross-country comparison of Dutch, Belgian, English and Welsh, Australian and Portuguese utilities, this article demonstrates the effectiveness of regulatory incentive schemes such as benchmarking and yardstick competition. It employs bias-corrected Data Envelopment Analysis efficiency estimates and it takes the physical, social and institutional environment into account.

Key words: water sector, incentives, benchmarking, non-parametric

JEL Codes: C14, L51, L95, C61

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1. The use of benchmarking

Benchmarking can be defined, in a simple way, as the process of seeking best practices through a regular comparison of performance measures. In the drinking water sector, which is endowed with several market failures such as natural monopoly, sunk costs, externalities and asymmetric information, benchmarking obtains a key role. As regional monopolists, water utilities can provide the service at a high cost and poor service level and sometimes earn unreasonable and unfair profits. The benchmarking is even pointed up as the unique tool to fight the *quiet life* of Hicks (1935) and the *X-inefficiency* of Leibenstein (1966). In this sense, it replaces the competitive incentives by competition by comparison. In Europe, there is even a view that defends a new paradigm for the water sector based on use and abuse of benchmarking (Marques and Witte, 2008).

Several kinds of benchmarking exist and are applied with diverse aims. For example, benchmarking can be classified into bottom up or top down, into metric or process and regulatory or non-regulatory. The methods to benchmark can further be divided into total or partial, parametric or non-parametric, frontier or non-frontier and stochastic and deterministic. They can also be applied by different actors, for instance operators, regulators, customers and financial entities. Benchmarking can be used by the operators as a tool to improve the performance, but it can simultaneously be employed by regulators as a tool to establish tariffs or to enforce the operators to improve the quality of service (labelled as yardstick competition). Even the '*name and shame*' strategy of the performance, known as sunshine regulation, put into practice by some regulators, leads to good outcomes (Marques, 2006). However, independently of the stakeholder, benchmarking has always common principles and goals. All benchmarking methodologies intend to assess performance, measuring the inputs consumed and the results (outputs) produced and, as such to compute the efficiency of activities, processes or organizations.

In this article, we apply benchmarking with a different aim. We assess the performance of drinking water utilities by country, intending to identify the best practices regarding the incentives provided to water utilities to be efficient and to provide the value for money. By the non-parametric frontier benchmarking technique of Data Envelopment Analysis (DEA), we carry out an international benchmarking research comparing the efficiency of drinking water utilities while taking into account the institutional framework and the operational environment of five countries, respectively, the Netherlands, England and Wales, Australia, Portugal and Belgium (Witte and Marques, 2007a). The model accounts for a-typical observations and measurement errors and investigates if the existence of incentive regulation has a positive influence on the efficiency of water utilities. In addition, we first commentate on mergers which, although undermining the effectiveness of the benchmark, are often justified on the basis of scale economies and inefficiency reductions.

The paper is organized as follows. Next to this introduction, Section 2 highlights the advantages and problems of carrying out international benchmarking studies. Section 3 displays the selection and main features of the countries and their water sector included in the research. Afterwards Section 4 briefly introduces the non-parametric methodology used to measure the efficiency of drinking water utilities and discusses the main results. Section 5 concludes the paper.

2. Benchmarking versus merger economies

In many countries, the number of comparable utilities is too low to make a valuable benchmark study. This can be attributed to the many mergers in the sector. We start this section by discussing the absence of merger economies.

2.1 Merger economies

Many drinking water utilities are invoking economies of scale and inefficiency reductions when they try to argument a merger with another utility. As it is hard to proof that mergers in the drinking water sector indeed create scale economies, regulators often give the benefit of the doubt to merging companies. However, by merging, the number of comparable utilities in the sample decreases, so that benchmarking becomes more intricate. Indeed, after the last merger, the one remaining utility is efficient by default. However, recent research proofs that mergers in the drinking water sector do not provide merger economies (De Witte and Dijkgraaf, 2007).

The literature distinguishes three possible merger economies (Roller *et al.*, 2000). Firstly, merger economies could arise from the increased market power. In a benchmarking context, this corresponds to the decrease of comparable utilities, so that the remaining companies could more easily invoke different exogenous characteristics. Secondly, merger economies could arise from an increase in scale economies, i.e. by operating at a larger scale, costs per unit decrease. Thirdly, merging companies could benefit from increased incentives to fight inefficiencies. This is particularly the case when stakeholders agreed on the merger on the basis of cost reductions.

By the use of both non-parametric and parametric techniques, De Witte and Dijkgraaf (2007) show for the Dutch drinking water sector that the large efficiency gains in the sector could be attributed to the effect of benchmarking, while the merger economies, both in the sense of scale economies and increased incentives to fight inefficiencies, are absent. Only for very small companies, merger economies are detected. Therefore, they conclude that regulators should be suspicious to mergers and do not give them the benefit of the doubt. However, if scale economies would be present, the regulator can opt for an international benchmark study to compensate for the decrease in comparable units.

2.2 International comparisons

With only few remaining utilities, companies can easily invoke exogenous characteristics. To circumvent this problem, utilities from other countries and regions could be added to the reference sample. An international benchmark study arises. As pointed out in De Witte and Marques (2007a), a cross-country comparison offers some advantages.

Firstly, it offers the possibility to escape the unsteady equilibrium between the claimed economies of scale for merging utilities and a sufficient number of remaining comparators in the sample. Secondly, also the best practices, which are usually the same for a longer period of time, can be benchmarked. This creates additional incentives for those utilities. Indeed, the possibility that a national best practice remains the reference in an enlarged data set decreases. Finally, international benchmark studies allow comparing the incentive schemes in different countries. Therefore, in an international data set, we measure the efficiency of water utilities by the use of DEA. After correcting bias in the efficiency estimates and after taking into account environmental factors, which are out of control of the firm's management, we evaluate the effect on efficiency of a benchmarking and regulation incentive scheme.

However, these advantages come at a cost as international benchmarking creates some difficulties as well. Especially the intricate comparability of the data sources should attract a lot of attention. Indeed, national regulators and utilities employ different definitions of similar concepts. For example, the definition of medium and large sized customers differs even within countries. Therefore, one should be cautious when merging these samples. Secondly, the data could also suffer from exogenous differences which influence the values. For example, exchange rate fluctuations or purchasing power differences could give rise to differences in the sample. Thirdly, in some countries a larger extent of the activities are outsourced to specialized companies, so that the total number of employees and staff costs differ. Finally, heterogeneity arising from exogenous characteristics should be taken into account to obtain a fair comparison.

In spite of these difficulties, we think it is possible to perform an international benchmark study. In particular, we account for the intricate lack of comparability of the data by making four specific assumptions. Firstly, we adopt variables in quantities (e.g., the inputs staff and mains length) that are less susceptible to the lack of comparability. Secondly, the major differences among countries are related to taxation issues. However, thanks to the quantities variables, tax heterogeneity does not significantly influence the model. Thirdly, also other heterogeneous factors which characterize the operational and institutional environment are integrated in the second stage analysis of the model. Fourthly, we removed outliers and a-typical observations from the data set. For example, the Australian water services, which may seem very different from the others, correspond only to major cities of Australia, and thus, are more comparable to the other observations.

3. Cross-country comparision

Many approaches are suggested to solve the principle-agent problem in which the monopolistic utilities (the agents) have private information about their ability to transform inputs into outputs. As society (the principal) wants a guaranteed service at the lowest price possible, the utilities can extract information rents. The objective of society is to minimize the extraction of information rents while assuring a satisfactory service. Policy makers can apply a broad range of incentive schemes in order to reach this goal (see, e.g., Laffont and Tirole, 1993). Although every government wants a secure drinking water provision at a price as low as possible, countries have different ideological views on the extent of state intervention in the economy, which creates different incentive schemes. In this article, we selected five countries which each have some specific incentive regulatory characteristics: the Netherlands, England and Wales, Australia, Portugal and Belgium. For each of these countries, the data are obtained from the sector associations and regulators for the year 2005 (except for Belgium where we have 2004 data).

After a debate on the possibilities to deregulate monopolistic markets (among which the drinking water sector), the Dutch drinking water utilities started a voluntary benchmarking in 1997. The benchmarking works on the principle of 'naming and shaming' and is closely observed by the Dutch public opinion (Van Dijk *et al.*, 2007).

In England and Wales, the Thatcher administration privatised the water sector in 1989. To avoid the exploitation of the newly established regional monopolists, three regulators were established, from which the Office of Water Services (OFWAT) is the economic regulator. It uses yardstick competition to set drinking water prices and to monitor the utilities (Bakker, 2003).

Australia benefitted from the US and UK regulatory models in that they incorporated the US ideas of transparency, enactment and accountability and the UK ideas of performance incentives. Australia possesses a strict regulatory model which aims at sustainability and corporatization.

Portugal employs regulation for its private utilities, while public utilities are not triggered by incentive regulation. Only recently, benchmarking was introduced in the sector.

In the federal country of Belgium, the Walloon area started benchmarking in 2006 (hence, not observable in our data yet) while the Flemish utilities are not influenced by incentives. In both regions, the maximum drinking water prices for a particular provision area are determined by a federal pricing commission (although drinking water is a regional competence) (Aubin *et al.*, 2007).

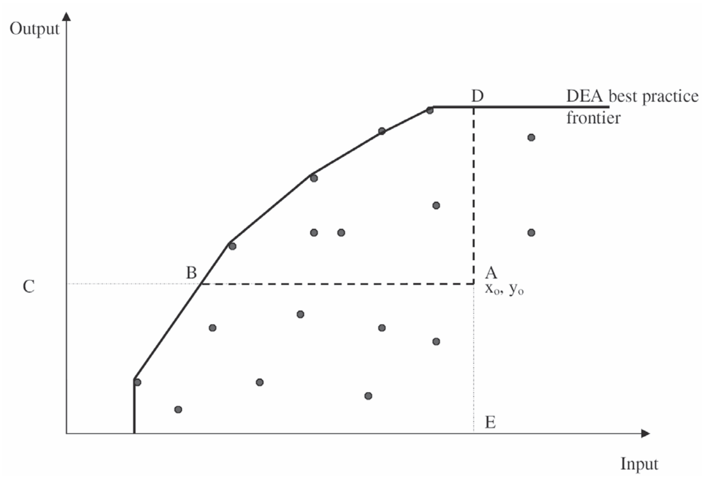
4. Measuring efficiency

Efficiency can be measured by a broad range of tools. A first branch of methodologies are the parametric cost functions. These assume a specific functional form to the data and could easily incorporate exogenous characteristics and measurement errors. In this article, we focus on a second branch of methodologies, non-parametric models which do not assume any *a priori* assumptions on the data and, therefore, let the data speak for themselves. We concentrate on the Data Envelopment Analysis (DEA) model. We briefly explain this approach.

Consider Figure 1 where the horizontal axis presents a one dimensional input and the vertical axis a one dimensional output. Observation A denotes the evaluated utility with inputs x and outputs y. In an input-oriented model, DEA detects all observations which are using less inputs to produce the same amount of outputs. In an output-oriented model, DEA considers all observations which are producing more outputs for a given amount of inputs. For observation A, this corresponds to all observations in its fourth quadrant. We label these observations as dominant observations relative to A. Some observations are not dominated by any of the reference points. These undominated observations constitute the best practice frontier. Any deviation relative to the best practice frontier is considered as inefficiency. The input-oriented inefficiency for observation A corresponds to the distance AB relative to the distance AC. Its output-oriented inefficiency corresponds to the distance AD relative to DE. Obviously, observations which constitute the frontier obtain an efficiency score of 1, while inefficient observations obtain scores larger than 1.

However, Simar and Wilson (1998, 2000) point out that not the full distance AB or AD could be attributed to inefficiency. A part of this distance is due to measurement errors, a-typical observations which influence the shape of the frontier and noise in the data. Taken together this corresponds to the bias. We account for the bias by bootstrapping (i.e., repeatedly estimating the problem with small disturbance in the input variables). Thanks to these bootstrap estimates, we can induce the properties of the DEA estimates. We refer to Simar and Wilson (1998, 2000) for an extensive introduction in the methodology.

Graph 1
Dea best practice frontier



In the assessment of efficiency, an objective and fair comparison is needed. Therefore, we have to equalize all physical, social and institutional characteristics which are beyond the scope of the firm's managers. We include three physical variables: (1) the percentage of leakage (it captures the geographical relief as a hilly landscape requires more pressure on the mains and the extent of maintenance as more leakages correspond to less expenses with maintenance), (2) groundwater use (the production cost is much lower than the counterparts that abstract superficial water or import water from other utilities) and (3) delivery to medium and large sized customers. The social variables capture the characteristics of the customers. Firstly, gross regional product (GRP) captures the relative wealth of the customers, the difference in skill distribution (see above) and approximates the average productivity of a region. Secondly, water consumption per capita reflects demand side management. By the institutional variables we try to capture (1) the scope economies (i.e., the only activity is the delivery of drinking water), (2) the corporization (i.e., the hard or soft budget constraints), (3) the scale economies (i.e., delivery to more than three municipalities) and finally, the type of incentive regulation, i.e. (4) yardstick competition or (5) benchmarking.

The literature developed several procedures to incorporate environmental characteristics in DEA efficiency scores. Initially, the literature employed truncated Tobit regressions to detect the size and direction of the exogenous influence. However, these models suffer from a separability condition in that the heterogeneity does not influence the shape of the frontier. Therefore, Simar and Wilson (1998, 2000) develop a double bootstrap procedure and Daraio and Simar (2005) introduced the conditional efficiency estimates. The latter procedures are combined in De Witte and Marques (2007a). As in De Witte and Marques (2007b), in this article we use the residuals of the truncated Tobit regression to incorporate the environmental variables. By using the residuals of the Tobit regression, we avoid the above mentioned separability condition.

We first present the results of the bias corrected double bootstrap procedure in Table 1. A positive sign denotes a negative influence to efficiency (i.e., an increase in inefficiency) while a negative sign points to a positive influence to efficiency (i.e., a decrease in inefficiency). We observe that industrial customers, high consumption per capita and corporatization decrease the efficiency of the utilities. Contrary, a higher proportion of leakage, groundwater extraction, GRP, scope economies, scale economies, regulation and benchmarking increase the efficiency of utilities. All of these variables have the expected sign, except for leakage.

By the use of the residuals of the Tobit regression, we correct the efficiency scores for these characteristics. The average results, as presented in Table 2, show the efficiency scores as would all utilities face exactly the same physical, social and institutional environment (indeed, all other influences than the incorporated are captured by the intercept). We observe that in comparison to the uncorrected efficiencies, the Belgian and private Portuguese utilities gain most. The efficiency of the Dutch companies even reduces if exogenous characteristics are taken into account. More interesting is the fourth column of Table 2 where we equalize all physical, social and institutional influences, except for the effect of regulation and benchmarking. The comparison of the latter with the equalized efficiency scores indicates the positive effect of benchmarking and regulation. Indeed, it reveals the effectiveness of the Dutch benchmarking scheme (as the Dutch companies are performing more efficient if benchmarking is taken into account) and the power of the English and Welsh, Australian and (private) Portuguese regulatory models. As there is no clear incentive structure for the Belgian and Portuguese public utilities, their average efficiency falls in comparison to the equalized situation. The Belgian and Portuguese authorities could ameliorate the performances of their drinking water sector by introducing a clear incentive scheme.

Table 1
Influence of exogenous environment

	DEA eff.	Lower bound estimate 5 %	Upper bound estimate 5 %
Intercept	4,2216 ***	1,9184	6,6944
Leakage (%)	-0,02258 ***	-0,06406	0,01550
Industry water/household delivery	0,02396 ***	0,01353	0,03404
Groundwater extraction (%)	-0,0001359	-0,007760	0,007383
Gross regional product (GRP)	-0,00006879 ***	-0,0001579	0,000007980
Consumption per capita	0,00005716 ***	-0,00006598	0,0001714
Water unique activity (=1)	-0,2644 ***	-1,0319	0,4602
Corporatization (=1)	1,2254 ***	-0,3341	2,6574
Delivery in one municipality (=1)	-1,3448 ***	-2,4574	-0,3601
Regulator (=1)	-0,9637 ***	-2,1884	0,1741
Benchmarking (=1)	-0,1198 ***	-1,3720	1,1548

*** denotes significance at a 1%-level

Source: De Witte and Marques (2007)

Table 2
Average corrected efficiency scores

Method	Uncorrected efficiencies	All influences equalized	Incentive scheme
The Netherlands	1.216	1.274	1.322
England and Wales	1.358	1.202	1.219
Australia	1.453	1.322	1.331
Portugal public	1.761	1.554	1.524
Portugal private	1.741	1.411	1.372
Belgium	1.600	1.355	1.347

Source: De Witte and Marques (2007)

5. Conclusion

The analysis provides significant evidence for the positive effects of incentive schemes on efficiency and demonstrates that in absence of clear and structural incentives the average efficiency of utilities even falls in comparison with utilities which are encouraged by incentives. The natural monopoly in the drinking water sector leads to the *quiet life* of Hicks (1935) and *X-inefficiency* of Leibenstein (1966). The presence of benchmarking (in the sense of sunshine regulation or yardstick competition) is a key element which replaces competition *in* the market or competition *for* the market by competition by comparison.

The analysis allows to deduce some policy implications. Firstly, regulators and government should be suspicious regarding mergers in the water sector. Often, mergers are invoked on a scale economies reasoning. However, mergers reduce the effectiveness of the benchmark. Secondly, as the benchmarking proofs its effectiveness as a regulatory tool, it should be extended to more variables. In addition, to prevent gaming (in which utilities spend huge resources to improve the measured variables on the cost of the unmeasured variables), government should supervise the scope of the benchmark, in particular the included variables. Thirdly, to allow for a fair comparison among utilities, the employed definitions should be harmonized within countries and among countries.

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