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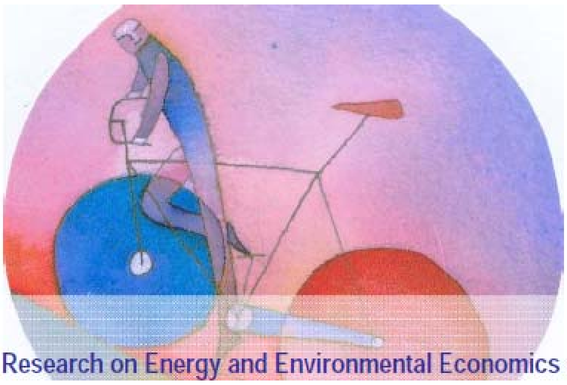

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What determines efficiency? An analysis of the Italian Water Sector

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Abstract

The Italian water sector has encompassed major changes since mid-90s when law 96/94 has entered into force. Next to private participation, integration of services and growth in production scales, the reform was intended to revolutionize the traditional financial model almost fully based on public funds. Although citizens, politicians and experts on water services have been debating for a long time on the impact of the reform on the industry, as well as on the fairness of a tariff system inspired by the concept of full cost recovery, we are still on a state of uncertainty. The final purpose of this paper is to provide regulators with guidelines that could be used to revise water tariffs in a way that may be cost-efficient, sustainable and fair to the most. According to the analyses, which rely on firm-specific *X-inefficiency* scores, despite a satisfactory mean level of performance, in the period under investigation, efficiency improvements have been limited. Moreover, the results demonstrate that both the ownership structure and politics do have an impact on the efficiency of the firms: in particular, public shareholding and centre-right local governments negatively affects firms' performances. To this respect, we think that a more effective regulation would also have the side effect of loosening the ties between politicians and managers.

KEYWORDS: Water Policy, Water Distribution, Water Pricing, Efficiency.

JEL Classification: H44, L95

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Introduction

Water supply industries around the world have been radically transformed in the last two decades due to liberalization, privatization and implementation of new regulatory design. These reforms were intended to enhance efficiency, productivity and quality of services provided. Italy has followed a similar path since 1994, when the so called Galli Law (l. 36/94) entered into force. Alongside with statutory efficiency and minimum quality standards, the law (and its subsequent amendments) set rules for delegation and private-public participation. This led to a final puzzle where fully public, mixed and listed water companies coexist. Albeit Italian water utilities distinguish from each other for other dimensions than ownership, this characteristic is the one that has been mostly debated. On the wave of rising prices for water services, some local representative started complaining that privatization was causing more damages than it was supposed to cure, due to the gambling of privates upon basic public needs (Massarutto,2009). The partial failure of the liberalization process and the growing concerns on private participation paved the way to a referendum in 2011. This latter has resulted in a break of the legislative framework, thus leaving a urge for supplementary reforms. As a consequence, there is a clear need for more information about the performance of the Italian water companies (Walter *et al*., 2009). Performance analyses do exist (Romano and Guerrini, 2011; Caliman and Nardi, 2010; Benvenuti and Gennari, 2008; Antonioli and Filippini, 2001); however, to date, there are no studies that investigate efficiency in Italy over several years nor studies on all the water services, namely distribution, sewerage and treatment. These analyses have been performed for several countries (Abbott and Cohen, 2009; Coelli and Walding, 2005). Establishing a more robust regulatory benchmark has become more and more urgent given that law 214/11 has empowered the Italian Regulatory Authority for Electricity and Gas to define, in a couple of years, tariff schemes to be implemented by water utilities.

The novelty of the study is threefold. First, we offer an original evaluation of the efficiency of the biggest sample ever gathered of Italian water companies over a period of four years. Second, we contribute to the debate on the likely impact of ownership upon the relative efficiency and the productivity of water companies. Third, we provide some guidelines for the future regulatory reform of the sector. From the methodological viewpoint we use non-parametric linear-programming technique of Data Envelopment Analysis (DEA), which has been suggested by several scholars for the water sector (Thanassoulis, 2000a&b). The orientation is to opt for an input minimization DEA, as the main objective for each water utility is to minimize costs rather than maximizing their output. Both constant and variable returns to scale are considered to test the role of both technical and allocative efficiency. We then investigate the determinants of the efficiency by performing different regression analyses.

The study shows that, despite a satisfactory mean level of efficiency, in the period under investigation, performance improvements have been limited, suggesting the need to introduce a more stringent efficiency-enhancing regulation. Moreover, the results demonstrate that both the ownership structure and politics do have an impact on the efficiency of the firms: in particular, public shareholding and center-right local governments negatively affects firms' performances.

The paper unfolds as follows: Section 2 briefly describes the Italian water distribution sector. Data and methodology used are described in Section 3, while Section 4 discusses the main findings. In Section 5, we perform some econometric estimates to explain the efficiency scores obtained with the DEA analysis. Finally, in Section 6 we draw some policy recommendations.

The Italian water distribution sector: a short description

Until the first half of the 90's, the management of water utilities was entrusted exclusively to municipalities and was performed *in-house*, i.e. performed directly from the local municipality, or thru a public grant. The result was a high number of firms, almost one for each municipality, with a subsequent low level of production efficiency together with poor quality of service provided[2].

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[2] According to ISTAT, in 1999, five years after the Galli reform, the number of firms was still very high: 7,822.

Such scenery was completely reformed in 1994 by the Galli Law (law 36/1994). Its main objective was to enhance the efficiency of water resources by applying an "industrial" regime to the sector. The founding principles of such a measure were:

1. The identification, delegated to the Regions, of hydrographic basins (*bacini idrografici*), i.e. of optimal license areas (*Ambito Territoriale Ottimale, ATO*), that could promote a corporate management of the process;
2. The separation of the control and auditing activites, through the creation of an authority for each optimal license area (Autorità d'Ambito Territoriale Ottimale), from the managerial activities, with the commitment of a single supervisor for the whole water integrated system (*Sistema Idrico Integrato, SII*, hereinafter) for each ATO;
3. A tariff regime with a full coverage of costs, both fixed and variable.

In other words, the goal was to realize both a vertical integration within the heterogeneous activities of distribution, treatment and sewage and a horizontal integration on a sufficiently big area for attaining economies of scale (Parisio, 2013).

In the end, the identification of the ATOs has been quite heterogeneous:

- 5 Regions (Val d'Aosta, Molise, Basilicata, Puglia and Sardegna) opted for unique regional ATOs;
- Calabria, Emilia Romagna, Liguria, Lombardia, and Sicilia defined the ATOs by the province boundaries, with the exception of the city of Milan, which alone constitutes an ATO;
- All other Regions (Abruzzo, Campania, Friuli-Venezia-Giulia, Marche, Piemonte, Toscana, Umbria, Veneto) opted for mixed ATOs, which can either be defined by single provinces or by the aggregation of more than one.

In the end, all Italian Regions, with the exception of Trentino-Alto-Adige (being a Region with a special statute), implemented the SII between 1994 and 2002, for a total of 91 ATOs.

The Galli law contemplated also the existence of CoNViRI (*Comitato Nazionale per la Vigilanza sull'uso delle risorse idriche*), a National Committee whose duty was to protect the interests of consumers and ensure a fair adjustment of water tariffs. Nevertheless, the whole system was centered on the AATOs. In fact, the newly defined Area authorities were required first to conduct a survey of the water system and then to set up a 20-year management and investment plan indicating the situation of the existing infrastructure, the quality of the service to attain, the expected future investments and the tariff to be applied. This plan represented the basis for the assignment procedure, defined with the financial law of 2002, which introduced three delegation procedures, namely: public tender, *in house* entrustment, direct grant to a mixed society where the private partner is chosen thru a tender.

The 2009 amendment of the Galli law (l. 166/2009) reduced the possibility for direct assignments, pushing the sector towards public tenders. In particular, all existing delegations granted through direct assignments were to be reassigned with public tenders. Moreover, the 2009 amendment introduced a safe return on investments equal at a national level (as before it was set by each AATO).

In June 2011, a referendum repealed both amendments, creating a legislative vacuum, only partially solved by the 214/11 legislative decree. As for the delegation procedure, Italy is back to the system that imposes public tenders only when the grantee is a private firm, letting again direct entrusting to public firms, under the supervision of local authorities. As for the return on investments in particular, and the tariff scheme more in general, the decree has devolved to the Regulatory Authority for electricity and gas (AEEG) the powers that had initially been exercised by AATOs and CoNViRI, which has been abolished. AEEG therefore has the function of defining and maintaining a reliable and transparent tariff system, reconciling the economic goals of operators with general social objective, and promoting environmental protection and the efficient use of energy.

The old tariff scheme

Until the referendum, the tariff system was designed as a *revenue cap*, but it was, *de facto*, a cost of service regulation. AATO had to determine the reference tariff on the basis of the 20-year investment and management plan. The basic revenue scheme was the following:

Equation 1

$$R_n = (C + A + R)_{n-1} \times (1 + RPI - X)$$

Where the revenues for year n (R_n) were equal to the sum of the allowed operative expenditures (OPEX), or variable costs, (C), the amortization (A) and the return on capital (R) for year *n-1*, multiplied by the inflation (RPI) and capped by the *X-efficiency term*. The peculiarity is that the revenues and the tariffs where not set on actual costs but on those foresaw in the plan. Every three years, if costs were higher than those modeled, operators could ask for the revision of the plan; only for differences bigger than 30%, then the AATO could ask for efficiency improvements. Till the referendum, the average tariff was about 1.2 Euros per cubic meter[3].

As we have seen, AEEG is now responsible for tariff setting. To this day, the authority has arranged the hearings of the interested parties with the aim to set the adequate standards apt to guarantee the quality of the service, intended as technical, environmental and commercial quality. We do believe that, in this context, an efficiency analysis of the sector is of extreme importance.

Efficiency in the Italian water distribution sector

Efficiency analysis: preliminary considerations

The performance of a firm is a measure of "how well" the firm converts inputs into outputs. Inputs and outputs can be measured as quantities or in monetary terms. In the first case, the focus will be on technical efficiency, that is how well a firm combines inputs to produce outputs; in the latter, instead, the focus will be on allocative efficiency, that is the ability of the firm to use the inputs according to

[3] Data from Utilitatis database, 2008

their costs. Technical and allocative efficiency combined give an overall economic efficiency measure. Finally, as performance is a relative concept, it is necessary to compare the firm under study with a peer.

As stated in Coelli et al. (2005), there are basically four major methodologies to analyze firms' efficiency:

- Total factor productivity indeces;
- Least-squares econometric production models;
- Non parametric analysis, such as data envelopment analysis (DEA);
- Stochastic frontiers.

The first two methods are generally used to compare the evolution of the efficiency of a firm over time. They are the simplest methods as they assume that all firms under study are technically efficient. On the other hand, the last two methods do not assume that all firms are efficient and they are used to compare the relative efficiency of *n* peers. The main difference between the two methods is that DEA, being non-parametric, does not assume any specific production or cost function; stochastic frontier, instead, does require a functional form.

Given its flexibility, we have opted for the DEA. DEA is a multi-factor productivity analysis model, based on a non-parametric approach that measures the relative efficiency of the so-called Decision Making Units (DMU). Charnes et al. firstly introduced this analysis in 1978, as a tool that could extensively be applied in benchmarking and performance evaluation of various public institutions such as schools, libraries, hospitals, but also of private entities such as banks and production plants. It was later extended by other authors such as Banker, Charnes, and Cooper (2000) and extensively developed in the last two decades thanks to its versatility and loose assumptions.

The basic idea underlying this methodology is to envelop observed input-output linear combinations in order to retrieve an estimate of the best practice frontier for the decision making units, by solving a linear programming model. Units achieving the highest level of efficiency within the dataset will form the *best practice frontier* and will score 1 in the efficiency index. The remaining DMUs will reach an index lying between 0 and 1, which is inversely proportional to their distance from their virtual best. This score thus measures the potential reduction in the quantity (or costs) of inputs necessary to reduce the inefficiency (or *X-inefficiency*, under the cost case) of the firm, in relation to the optimal frontier. In this framework, efficiency is defined as the ratio of a linear combination of outputs over a linear combination of inputs (or input-costs). In other words, DEA methodology aims at reducing the ratio multi-input/multi-output towards a single virtual input and a single virtual output.

Clearly there are two ways to accomplish this. One is by maximizing the numerator, i.e. the outputs, keeping inputs constant. This is the so-called *output-oriented model.* Vice versa, when we keep output constant and we minimize the denominator, i.e. the inputs, we obtain an *input oriented model*.

DEA approach has been widely extended thanks to its various advantages. First of all, being a non-parametric model, no assumptions on input or output functional forms are required, apart from a general convexity presumption. This feature also avoids in misidentifying the effect of erroneous specifications in the functional form of technology and inefficiency with those of inefficiency. Secondly, it can be applied also in small datasets, even thou its discriminatory power would be less effective in small samples. Also, by increasing sample size it is more likely to have a higher number of efficient combinations of inputs and outputs, since there can be significant gaps between observations, being the frontier determined by a piecewise linear function. It is thus important to check for robustness of results. Being n and m respectively the number of inputs and of outputs, according to Cooper et al. (2000) the minimum number of observations should be given by the maximum between $3 \times (m + n)$ and $(m \times n)$.

Moreover, firms are not compared to statistical measures, but they are put in comparison directly against a peer or a combination of peers. Consequently, DEA can be easily applied to any regulated firm and it allows for control of other exogenous variables that might affect efficiency through a two step approach or also by adding them as non-controllable inputs or outputs in the linear programming. As a drawback, when adding these non-controllable variables, it is compulsory to know their classification as inputs or outputs a priori before the analysis is computed, in order to set the correct inequality in linear programming problem.

The main drawback of DEA is the absence of a random error. Any measurement error, noise or outlier can cause significant problem, being DEA an extreme point technique, and will be automatically interpreted as inefficiencies. The choice of outputs and inputs is thus very sensible, as it influences directly the scores. Also, being DEA a non-parametric technique, it does not permit for statistical hypothesis tests. Hence, it is not possible to test neither for the significance of the main variables included in the model nor for the significance of differentials in efficiency.

Statistical properties

As already seen, DEA estimators measure the level of efficiency relative to an estimate of an unobserved true frontier, conditional on observed data resulting from an underlying data generating process (DGP). The properties of the DEA estimators depend thus on this DGP which created the data sample. Simar and Wilson (2008) list several assumptions for the DGP:

- observations on inputs (x) and outputs (y) are realizations of *i.i.d.* random variables (X,Y) with density function $f(x, y)$;
- The probability of observing and efficient unit approaches unity as the size grows;
- For all (x, y) belonging to the feasible production set, DEA estimators $\vartheta(x,y)$ are differentiable in (x, y);
- Convexity and closeness of the feasible production set;
- Free disposability of inputs and outputs;
- All outputs require the use of some inputs, that is no *free lunch hypothesis* (Bottasso et al., 2013).

Under these assumptions, the authors show that DEA efficiency estimator is consistent and has a known rate of convergence. (Simar and Wilson 2000). But still a closed form for the density function is yet to be derived. The authors propose a means for inferences about the efficiency of this estimator in a multivariate framework, through a methodology called Bootstrap DEA. The aim of this approach is to approximate the sampling distribution by simulating the DGP and to capture the sampling variation of the DEA estimator from the true estimator *[ϑDEA(x,y) -ϑ(x,y)].* Bootstrap DEA, thus, improves statistical efficiency in the second stage regression as it corrects from serial autocorrelation (Simar and Wilson, 2007).

Constant and variable return to scale

Return to scale describe what happens as the scale of production increases in the long run, when all input levels, including physical capital usage are variable i.e. chosen by the firm. Constant return to scale (CRS) apply when the change in output resulting from the change in all inputs is proportional. On the other hand, if the changes in output are not proportional, i.e. output either outperforms or underperforms in relation to inputs, then variable return to scale (VRS) apply. In other words, VRS index measures the real capability of a company to purchase, mix and consume inputs i.e the *allocative efficiency*, while CRS represents the productive efficiency of a DMU, given by the product of pure efficiency and scale, i.e. the *technical efficiency.*

Literature review

Investigations on efficiency of the Italian water sector do exist but are mostly small sampled and are limited in the time dimension. Since data collection is not entrusted to a public central administration, the lack of reliable and complete database is an issue and has limited the analysis so far. Romano and Guerrini (2011) provide an analysis of 43 Italian water mono-utilities to determine what affects their efficiency, using the DEA. They find that public owned companies are more efficient and thus better able to purchase and employ inputs when compared to mixed owned companies. Surprisingly, they also find that Southern and Central firms are more efficient compared to Northern firms, but they explain this unexpected result by proposing that it could be due to the higher rate of sanitation treatment per cubic meter shown by northern companies as well as to the size of firms, since companies in central-southern Italy are mostly large, and large companies typically have high scale efficiency.

Giolitti (2010) investigates the presence of economy of scale and density on a sample of 30 water firms in the years 2005-2007, using a translog variable cost function. She finds evidence for both economies of scale and density until a served population of 500,000 inhabitants.

Abrate *et al.* (2008) analyze the relationship between heterogeneity and inefficiency on 46 regulatory plans drafted by ATOs by means of cost frontier models on a 20-year period. Results show that part of the managerial inefficiency is due to structural nature. Operating costs are found to depend positively and significantly upon the extension of the service area and the number of municipalities. "The percentage of highlands influences costs negatively and significantly, thus indicating that higher expected costs for maintenance in highland areas are probably offset by the proximity to the water sources. Likewise, the geographical dummy shows a negative and statistically significant sign, thus denoting a structural shortfall in southern Italy, with respect to northern Italy, which might be attributed to the different status of the network and other capital facilities. This highlights the high penalization suffered by the southern area in terms of major maintenance and intervention costs" (Abrate *et al.*, 2008). Moreover, the authors assess that local authorities do not include in the regulatory long-term plans incentives to improve efficiency with respect to operative costs, which is in contrast with what suggested by the water reform. Hence, as policy implication they suggest that a benchmarking activity at a national level is necessary in order to provide the right incentives to improve efficiency.

Antonioli and Filippini in 2001 estimate a variable cost function using a sample of 32 water distribution firms operating at the provincial level over the period 1991-1995. They find that several explanatory variables such as price of labor, water loss and service area characteristics are significant in explaining efficiency. In particular the coefficient of chemical treatment is significant, confirming the relevance of geographical and morphological variables in water cost estimation.

Nevertheless, the authors find no evidence that larger areas result in any economies in water distribution, imputing that a merger between two companies with adjacent service areas does not significantly decrease average cost.

Concluding, the datasets and the time dimensions of the studies already conducted in Italy are quite limited and neglect to investigate several variables, such as the political stability of the municipality of the firm, or the quality of water delivered.

The water companies in the sample

The sample consists of 54 companies that operate as regulated monopolist in the provision of water and wastewater services (SII, hereinafter) in specific areas of Italy. These utilities have been selected among the extensive list of companies to which the Italian local regulatory authorities (AATOs) entrusted the SII no later than 2007 (CoNViRI, 2009). Due to delays in the implementation of law 36/94, most of the companies have been entrusted between 2003 and 2007. Given the time perspective of the study and the need to collect data for the same companies over a 4 year period (2007-2010), those players that were inactive in 2007 or that have become so later on - due to merges or changes in the local framework - have been excluded from the analysis. Table 2-1 describes the main features of the utilities in the sample as compared to the full list of Italian operators, as reported by CoNViRI (2009). Notwithstanding the partial coverage, the selected companies are representative of the Italian water industry as for geographical location, size, ownership structure, type of business and clients served.

Geographical location is crucial in that while in Northern and Central Italy there is abundance of rivers and lakes, in Southern regions (islands included) the water is scarcer and irregularities are more likely. Indeed, according to the most recent assessments by ISTAT (the Italian statistic Bureau), while less than 6% of clients suffers from irregularities in water distribution in the Northern regions, one out of three clients experiences severe service irregularities (with likely rationing of water especially in the summer) in the Southern regions. The sample encompasses firms located in any geographic area of the Country, with some 26% of the companies in the Northwest, 26% in the Northeast, 28% in the Centre and 20% in the South (including islands).

Regarding ownership, we have distinguished among publicly owned, mixed and privately owned companies. The former class includes utilities that are fully under the control of local entities, the latter those that are completely managed and operated by private parties, while the second group considers firms where private and public parties coexist due to the joining of private shareholders to traditional public ones. Concerning ownership, 56% of the selected companies are public, 24% are mixed and the remaining 20% is private. These figures match the Italian structure of the water sector where few less than 60% of the utilities are currently managed and operated by local authorities. Data on the shares held by the main shareholder have been collected as well to investigate, beside the effect of private participation on companies' relative efficiency, the impact of fragmentation in shareholding on cost-efficiency, an issue never taken into account in so far.

As in past assessments (Romano and Guerrini, 2011; Antonioli and Filippini, 2001), we have classified firms based on the number of residential consumers served. A water company will thus be defined as large, medium or small if it has respectively more than 250.000, between 50.000 and 250.000, or less than 50.000 customers, respectively. Large companies prevail, both in the sample (60%) and in Italy. Medium (30%) and small (10%) follow. Although one can see a bias in the sample which takes in some 76% of the large companies listed by CoNViRI (2009), while leaving aside some 80% of the small ones, the distribution of clients served confirms that the data are representative and fully consistent with national paths. In fact, according to CoNViRI (2009), while 42 large companies are responsible for the provision of SII to some 87% of customers, 32 small firms do supply water to some 1% of users.

	Sample			CoNViRI, 2009		
Geographical location	n. of firms	% of firms	% of clients	n. of firms	% of firms	% of clients
North-East	14	25.93%	17.21%	28	26.42%	23.92%
North-West	14	25.93%	14.01%	39	36.79%	19.34%
Central	15	27.78%	37.59%	19	17.92%	29.69%
South	9	16.67%	29.11%	14	13.21%	24.08%
Island	2	3.70%	2.08%	6	5.66%	2.97%
Size						
Small	6	11.11%	0.58%	32	30.19%	1.28%
Medium	16	29.63%	8.27%	32	30.19%	11.85%
Large	32	59.26%	91.15%	42	39.62%	86.88%
Ownership structure						
Public	30	55.56%	43.63%	63	59.43%	50.58%
Private	11	20.37%	19.68%	17	16.04%	16.21%
Mixed	13	24.07%	36.69%	26	24.53%	86.88%
Type of business						
Mono-utility	37	68.52%	79.69%	72	67.92%	74.71%
Multi-utility	17	31.48%	20.31%	34	32.08%	25.29%

Table 1. The main features of the companies in the sample as compared to the extensive list of Italian operators as reported by CoNViRI. Source: authors' elaborations.

Concerning the type of service to be taken into account, we have opted for the inclusion of both firms that are active in the SII sector exclusively (*mono-utility*, 69%) and utilities that are active in related sectors (*multi-utility*, 31%) such as energy and waste, to see if there are scope economies.

Designing the DEA for the efficiency analysis of the water sector

As specified before, the linear programming problem that could be run with DEA may be defined in several ways. It is possible to opt for: input or output orientation; constant or variable returns to scale; one, two or multi-stage models. Consistently with the most recent analyses (e.g. Romano and Guerrini, 2011), we decided for input orientation and run both constant and variable returns to scale in a multi-stage framework. The rationale for these choices is as follows.

Input oriented models aim at minimizing the cost of producing a fixed (predetermined) level of output. Efficiency within this context is measured as the proportional reduction in inputs to get the actual level of output. By converse, output oriented models aim at maximizing output given input availability. Here, efficiency is computed as the increase in output that could be achieved by optimally using available inputs. Depending on whether it is more suitable to consider the sector as input or output constrained, the latter or the former approach must be set. In the case of water utilities, where output - as measured by the water delivered or by the inhabitants served – is price-inelastic and inputs (labour costs, material costs, etc.) may be adjusted accordingly, input-orientation is more suitable.

Return to scale concerns the effects on output of a proportional rise in all inputs. In particular, if the rise in output is proportional to those in inputs constant return to scale holds, which means that there is no-size performing better than others. The other way round, if the rise in output outperforms (underperforms) those in inputs, increasing (decreasing) return to scale applies, thus indicating that large (small) companies do perform better. We have considered both CRS and VRS to investigate both technical and allocative efficiency, a crucial issue in the context. CRS efficiency scores rank DMUs according to their technical efficiency *id est* the suitability of the production process used. VRS efficiency scores rank DMUs with respect to their purchase, mix and usage of inputs in the production process.

Finally, the run of multi-stage DEA is intended to reduce the inefficiency caused by the likely occurrence of input/output slacks, *id est* to situations where the efficient projected points of a decision making unit belong to the perfectly elastic or inelastic portion of the frontier. Since slacks do not represent Pareto-efficient projections of DMUs, efficiency indexes relying on slacks would provide misleading information. To overcome this issue, we carry out two or multi-stage DEA as suggested by Coelli *et al.* (2005).[4]

Input and output data

Studies applying DEA on water utilities present several similarities in input and output selection to which we conform. Materials, labour, services and capital (amortization and depreciation), measured either in term of unit consumed or of cost incurred, are traditional inputs.

The water delivered and treated (or the population served, using both would be misleading given the high correlation shown by the two variables) and the length

[4] For more details on slacks and multi-stage DEA, see Coelli *et al.* (2005).

of water and sewerage mains[5] are used as traditional outputs. Since data on the water delivered provided by CoNViRI were available only for 2008 and given the regulated structure of the sector with predetermined tariffs, we opted for water revenues and water mains as outputs. We collected financial data on relevant inputs – cost of material, labour and services (OPEX) and other indirect costs - from Bureau Van Dijk's AIDA database. Depreciation, amortization and interests have been excluded because of the limited time span of the assessment and because these items are often affected by earnings management policies, such as fiscal optimization. This exclusion means that we clearly focus on operative efficiency; one could question that water services are capital intensive and measuring the efficiency without taking into account capital costs could be misleading. Although we are aware that investments are relevant, considering their extremely long expected lifetime and amortization period, CNEL (2010) shows that operative costs account for more than 75% of the tariff structure, while capital remuneration and amortization the remaining part. As for outputs, revenues have been collected from Bureau Van Dijk's AIDA database, while corporate web sites were used for data concerning assets and network length.

Finally, to reduce the heterogeneity in the sample due to the number of residential served, all variables are expressed in per-capita terms by dividing the overall figures for the number of residential served. Table 2-2 displays the correlation matrix for the variables collected.

The positive correlation between revenues and costs confirms the cost of service structure of the tariff, while the negative effect of mains over revenue suggests likely economies of density.

[5] Water mains are used as a proxy to measure economies of density (Thanassoulis, 2000a&b; Garcia-Valinas e al, 2007).

	Mains length per capita	Revenues per capita	Cost of materials per capita	Operative costs per capita	Indirect costs per capita
Mains length per capita	1				
Revenues per capita	-0.02	1			
Cost of materials per capita	0.03	0.18	1		
Operative costs per capita	-0.02	0.90	0.10	1	
Indirect costs per capita	0.03	0.21	0.00	0.06	1

Table 2. The correlation matrix of inputs and outputs.

Efficiency scores: results and discussion

Table 3 shows the minimum, mean, median and standard deviation values for technical (CRS), allocative (VRS) and cost-efficiency (S) scores for the utilities in the sample over the relevant time period (2007-2010). Following Coelli (1998), cost-efficiency (S) is the ratio between CRS and VRS: if its value is one, than the DMU is operating at its optimal scale; if the value is lower than one, than the DMU is not at its optimal scale, but the index does not say whether the DMU should increase or decrease it.

The mean and median level of CRS and VRS are close and relatively high, indicating a good level of efficiency among water utilities. Allocative efficiency is significantly higher than technical efficiency: this is not surprising since, at least in the short term, it is impossible to adjust significantly the production process, which is linked to mains and other long term assets. Therefore, notwithstanding complaints and oppositions, which have contributed in smoothing down the implementation of the water reform, the performance of the sector twenty years after the Galli law could be regarded as quite satisfactory.

	Obs.	Min.	Mean	Median	N. of frontier DMUs	Std. Dev.
CRS 2007	54	0.44	0.81	0.83	10	0.15
CRS 2008	54	0.48	0.82	0.83	10	0.14
CRS 2009	54	0.40	0.81	0.84	11	0.16
CRS 2010	54	0.42	0.80	0.81	12	0.17
VRS 2007	54	0.46	0.87	0.94	20	0.15
VRS 2008	54	0.48	0.87	0.91	19	0.14
VRS 2009	54	0.40	0.85	0.89	17	0.16
VRS 2010	54	0.42	0.83	0.86	15	0.17
S 2007	54	0.69	0.94	0.98	10	0.08
S 2008	54	0.64	0.95	0.97	10	0.07
S 2009	54	0.66	0.95	0.99	11	0.07
S 2010	54	0.65	0.96	0.99	12	0.06

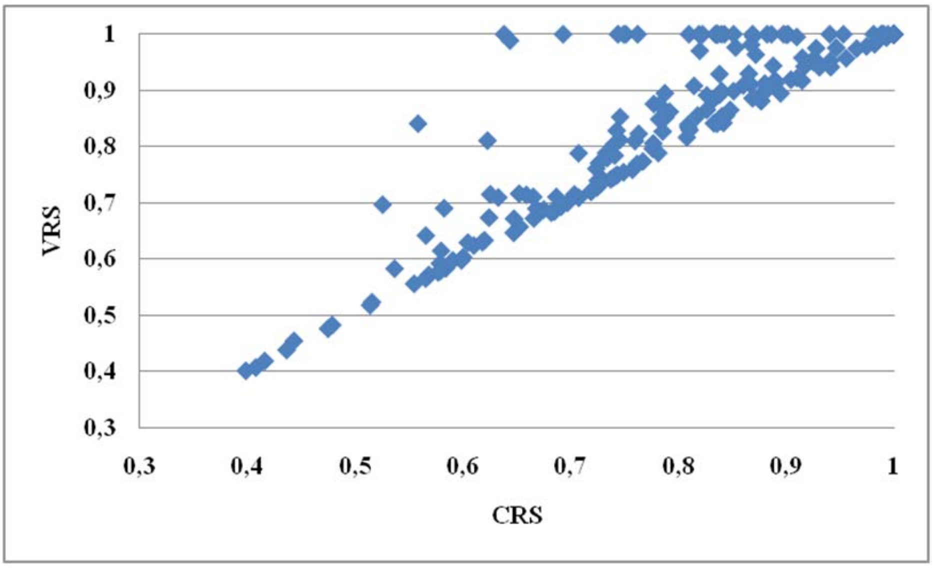
Table 3: DEA efficiency scores.

Both CRS and VRS have decreased between 2009 and 2010: this might be a symptom of the economic crisis, which has affected the efficiency of the utilities, in particular their capabilities in purchasing, mixing and using inputs in the production process.

The frontier is extremely stable, as well as the distribution of DMUs among different years. For CRS efficiency, 6 companies rank first for all four years; 3 for three years; 3 ad 4 DMUs rank first for two years and one year respectively. For VRS, there are 11 units raking first for all 4 years and 5 for three years; 4 companies rank first for two years and 4 for just one year.

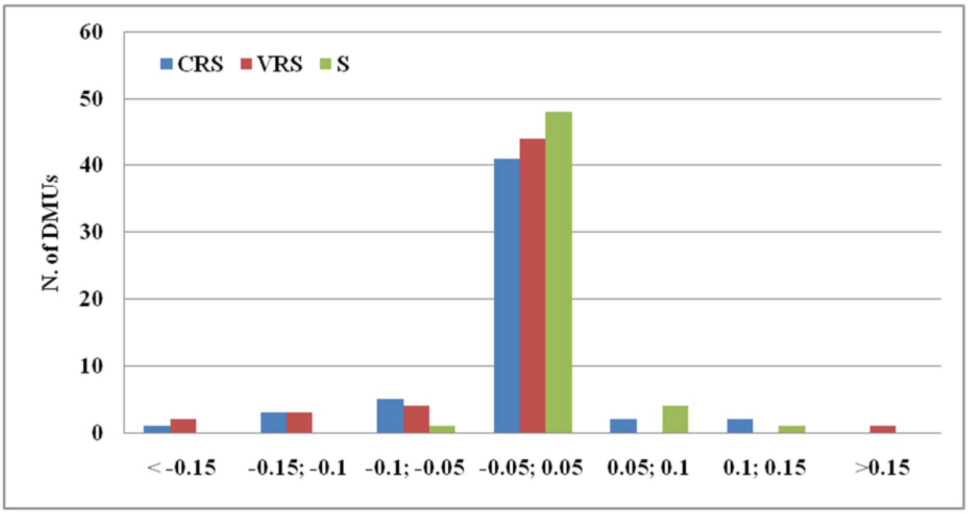
Cost-efficiency scores indicate that water utilities are operating extremely close to their efficient scale. The median operator has a value ranging from 0.97 to 0.99: this might indicate that the conceived licence areas are indeed optimal. Figure 2-1 shows a scatter plot of DMUs with respect to CRS and VRS: the relationship is linear and the correlation is high (0.90); the deviation from the linear correlation is always in favour of allocative efficiency, which of course is easier to improve than technical efficiency in the short term.

Figure 1: Correlation between VRS and CRS of Italian water utilities: 2007-2010.



Most utilities have not improved their efficiency over time either in technical or in allocative terms. At this purpose, data illustrate that several distributors – nine out of ten in global terms, three out of four in CRS and four out of five in VRS - have experienced a change in their efficiency paths in the zero range.

Figure 2: Mean efficiency score changes of Italian water utilities: 2007-2010.



Stable efficiency frontiers may have a twofold rationale. On the one hand, utilities in the sample may have just attained maximum efficiency levels (i.e. Pareto-efficiency), so that further improvements are not possible, at least in the time span under investigation in the study. On the other hand, water suppliers have not enough incentives toward better performance. Indeed in the former case, it is possible to consider that the reform initiated by the Galli Law has attained a fair efficiency objective; while in the latter, a break with the past is necessary to prompt the cost-efficient evolution of the sector.

Notwithstanding the relatively high levels of efficiency shown above, there are companies whose score is particularly low. What could explain the coexistence of such heterogeneous levels? May regulators affect the ability of water distributors to deal with risks? Is yardstick-based regulation optimal on benchmarking? To tackle these issues we econometrically explore some factors that, according to scholars (Massarutto et al. 2009), can interfere with efficiency. Both endogenous and exogenous variables are considered to effectively identify the areas for future policy interventions.

The determinants of efficiency

The second stage of the analysis aims at investigating what determines the efficiency scores calculated above. There is an ample debate on which regression technique performs better in the second stage, given a first stage based on DEA. According to several scholars (Dusansky and Wilson, 1994; Hoff, 2007), the DEA approach introduces a censoring problem in the upper tail of the distribution as most efficient units cluster at a limiting value. Consequently, the appropriate econometric treatment to avoid inconsistent estimates can be a tobit model, as it assumes that the dependent variable has a number of its values clustered at a limiting value and, as such, it can give unbiased results even if observations are clustered at that limiting value (McDonald and Moffit, 1980); however, estimates may be inconsistent if errors are not normally distributed or if they are heteroskedastic (Carson and Sun, 2007).

On the other hand, McDonald (2009) contends that DEA does not have a censoring data generating process (DGP), as its results are a kind of fractional or proportional data. Moreover, by the very nature of DEA, a second stage analysis performed with a tobit model will result in an error term being heteroskedastic, thus resulting in inconsistent estimates. As a consequence, McDonald suggests the adoption of OLS, as its estimates of β are "consistent and asymptotically normal under general conditions, and hypothesis tests can be validly carried out if allowance is made for heteroskedasticity" (McDonald, 2009, p. 794) .

Notwithstanding the regression methods used, Simar and Wilson (2007) shows that DEA scores might suffer from serial autocorrelation, which can be corrected only with a bootstrap procedure, as it improves statistical efficiency in the second-stage regression. As for the second stage of the analysis, the final option is to opt for both bootstrapped OLS and tobit models[6].

To perform such econometric analyses, first we have looked at variables that may be related with the governance: ownership (*PP*, which measures the percentage of shares owned by the public, and *SH*, which measures the percentage of shares hold by the main shareholder of the utility) and the type of business (*Mono*, which takes value 1 if the company is a *mono-utility* and 0 otherwise). Second, we have taken into account two managerial parameters: concentration (n. of clients served by the utility expressed as a share of the population in the ATO, *HHI*) and interruptions (*Inter*, measuring the frequency of interruptions in water distribution). Finally, we have considered environmental variables, related to the area where the unit is active: geographic location (two dummies *North* and *South*), incidence of metropolitan areas (daily in/outflows of people, *D flex*), incidence of touristic areas (seasonal in/outflows of people, *S flex*) and the coalition in charge in the municipality granting the concession[7] and nominating AATO's governing body (*DX*, which takes value 1 if a center-right coalition has the majority and 0 otherwise).

Indeed, the company and shareholders have (almost) direct control over the variables in the first and second classes, while in the last set are reported indexes, which are almost beyond the control of the persons in charge of managing, operating, controlling and sanctioning the activity. Summary statistics and

[6] I have also considered the possibility of a panel data analysis, but tests have rejected this possibility. This may be due to the short time span of the sample; still, I have introduced a time dimension in the analysis (discussed later).

[7] In case of multiple municipalities, I have considered the coalition governing the most important one; in case of regional ATOs, I have considered the regional government.

correlation matrices for the variables to be included in the regressions are reported in App. I (Tab. A1-A2).

Table A2 shows that the explanatory variables are not particularly correlated among each other, with the notable exception of *Inter* with the geographical dummies, with opposite signs (positive with *South* and negative with *North*). This high correlation recommends the exclusion of one of the two variables to avoid collinearity concerns. We perform four bootstrapped regressions to test what affects both CRS and VRS (one OLS and one tobit each). Preliminary results have shown the presence of heteroskedasticity, which has obliged us to opt for White's method (1980) for calculating standard errors in the OLS regressions. At the same time, we have kept also tobit results, as a comparison. We have also introduced time dummies; results are not shown, as they were never significant in any of the different regressions performed.

Variable	**Category**	**Dependent Variable CRS**		**Dependent Variable VRS**	
		OLS	tobit	OLS	tobit
Constant		0.8190 (24.94)***	0.8283 (18.32)***	0.9060 (27.59)***	0.9711 (16.43)***
PP	Governance	-0.011 (-4.55)***	-0.0014 (-4.31)***	-0.0010 (-2.89)***	-0.0017 (-4.16)***
Mono	Governance	-0.0265 (-1.38)	-0.0333 (-1.47)	-0.0537 (-3.17)***	-0.0749 (-2.70)***
SH	Governance	-0.0002 (-0.01)	-0.0028 (-0.12)	-0.0239 (-1.03)	-0.0336 (-1.00)
HHI	Governance	0.0001 (0.38)	0.0002 (0.58)	0.0004 (1.26)	0.0007 (1.39)
Inter	Managerial	0.0022 (1.20)	0.0023 (1.10)	0.0039 (2.35)**	0.0041 (1.75)*
South	Exogenous	-0.0724 (-2.74)***	-0.0825 (-4.39)***	-0.1034 (-4.12)***	-0.1300 (-3.92)***
D flex	Exogenous	2.2890 (4.97)***	3.0008 (4.70)***	1.7715 (3.71)***	3.1194 (3.59)***
S flex	Exogenous	0.07311 (0.61)	0.0971 (0.64)	-0.0711 (-0.57)	-0.1064 (-0.59)
DX	Exogenous	-0.0416 (-2.17)**	-0.0429 (-1.99)**	-0.0360 (-1.83)*	-0.0426 (-1.60)
	Summary Stats Adj R2 chi2 Prob>chi2	 0.23 121.08 0.000	 97.25 0.000	 0.24 184.03 0.000	 137.63 0.000

***z-ratios significant at 1% level; ** 5% level; * 10% level.

Table 4: Regressions results.

According to the study, the higher the share of the public, the lower the performance. This result is in contrast with the rising distrust on private participation in water services, at least in Italy (Romano and Guerrini, 2011). Moreover, it has to be highlighted that PP is a continuous variable, ranging from 0% to 100%. This means that every percentage point increase in public participation reduces, although very little, the dynamic efficiency of the firm. In the literature, there is no clear evidence that private companies perform better: very recent studies on Spain (Garcia-Sanchez, 2006) and the UK (Saal et al., 2007) cannot find any efficiency differences between private and public companies. Since the sector is extremely country specific, we think that findings for a country might not work for another. As for the results, given that the timeframe of the analysis encompasses a period of economic downturn, we can explain them by saying that private and mixed companies were able to better respond to the crisis than their public counterpart. There are two major *caveat* to this: first, as stated in Massarutto (2009), public-owned utilities tend to serve also unattractive municipalities (for instance, those with a scattered population far from big cities); second, the analysis does not take into account service quality. The latter is an issue that must be checked and that is left for future researches. Quality standards, in fact, are tying and a slowdown in the performance such as the one envisaged by public utilities may reflect a more timely accomplishment of new requests. If this would be the case, the primacy held by privates would be nothing but a worthless success.

Consistently with expectations, the possibility to purchase, mix and combine inputs for water and other services, increase the allocative efficiency of a DMU while leaving its technical counterpart unaffected, thus explaining why *Mono* is significant only when the dependent variable is *VRS*. Indeed network services are characterized by scope economies that, however, do not span to technological assets given their sector-specific value. Also this result is consistent with previous literature, in particular with Piacenza and Vannoni (2004), which show the presence of scope economies for Italian multi-utilities.

With respect to size, the findings support the existence of constant return to scale. The variable HHI is not statistically significant, thus indicating that there is not a specific firm-size performing better than others. Fabbri and Fraquelli (2000) have found weak economies of scale in the Italian water industry, suggesting that efficiency drivers have to be found somewhere else. Also SH is not statistically significant, thus indicating that breaks-up in the shareholding does not appear to reduce firm's ability to optimally allocate resources. In particular, the participation of many municipalities in the governance does not seem to influence efficiency.

From a pure managerial perspective, we find that interruptions have a positive impact on (allocative) efficiency. Indeed, interruptions are commonly used in southern region (and islands) to optimally deal with shortages. Data confirms that this strategy raises the efficiency of the system. To our knowledge, this is the first time that this result has been proved.

While seasonal in/outflows of people do not statistically contribute to efficiency, daily in/outflows do matter, indicating that urban density is one important determinant of efficiency. To this respect, the result is consistent with previous findings (Garcia-Sanchez, 2006; Renzetti and Dupont, 2008).

Finally, we find negative and statistically significant figures for the variable proxying the center-right coalition on the efficiency of water utilities. As shown in table A2, *DX* is not correlated to geographical variables nor to the public participation in the company. On the one hand, this rules out the possibility that conservatives' local governments are concentrated where there are the less efficient operators or the worst conditions; on the other hand, there is no evidence that center-right coalitions are more present in municipalities with higher stakes in water utilities. Consequently, we can imagine that conservatives are less experienced or less interested in efficient local public service provisions.

Conclusions and policy recommendations

The present paper is the first attempt to measure and explain efficiency in the Italian water distribution sector over four years. The analysis clearly adds to the existing literature on water distribution as it stresses the importance of the dynamic aspects of firm's efficiency. In particular, the dynamic analysis showed that only a third of the sample was able to improve its efficiency scores, thus suggesting the idea that a more efficiency-based regulation could prove to be beneficial. At the same time, the paper shows that the Italian water companies perform well both in relation to technical efficiency (CRS) and inputs purchase (VRS). In fact, more than 78% of the suppliers in the dataset are characterized by CRS's figures in the upper range (70-100%). Results are even stronger when VRS is taken into account since other units join the upper range.

The econometric estimates are highly significant too. In particular, they reverse some previous findings on the Italian water distribution, which were either claiming higher efficiency scores for public firms (Romano and Guerrini, 2011) or that ownership was not influencing efficiency (Caliman and Nardi, 2010). Looking at the efficiency from a dynamic perspective shows that public companies perform slightly worse than mixed and privately owned counterparts, at least in time of economic slowdowns. At the same time, the analysis confirms the importance of some exogenous variables, namely the geographical location and population density.

Therefore, we think that the new tariff structure, which will introduce some efficiency mechanisms, has to be properly designed. In particular, we think that it would be appropriate to introduce a differentiated performance-based mechanism, in order to take into account different quality levels and the geographical location of the utilities.

Finally, the new tariff structure, together with a more effective regulation, would ease the impact of both the shareholding structure and the political parties on firms' efficiency, which at present is relevant. In particular, we show how public-owned utilities tend to underperform and how conservatives' local governments have a negative impact on firms' efficiency.

Further studies are needed in order to better assess the performance of water utilities. First, it would be important to extend the timeframe taken into account, to study the dynamic efficiency over a longer period. Moreover, as already stated above, it would be interesting to consider the availability and quality of water for each company in the area where they operate.

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Appendix

Table A1. Summary stats of independent variables

Variable	Obs.	Mean	Std. Dev.	Skewness	Kurtosis
PP	216	71.99	37.37	-0.98	2.48
SH	216	41.42	29.03	0.69	2.56
HHI	216	0.77	0.40	-0.18	2.67
Inter	216	10.73	7.31	1.81	6.10
D flex	216	0.03	0.02	2.87	15.21
S flex	216	0.07	0.07	1.98	6.79

Table A2. Correlation matrix of independent variables

	PP	Mono	SH	HHI	Inter	South	North	D flex	S flex	DX
PP	1.00									
Mono	0.02	1.00								
SH	-0.40	0.05	1.00							
HHI	-0.09	0.12	0.01	1.00						
Inter	-0.27	0.28	0.16	0.23	1.00					
South	-0.11	0.24	0.13	0.19	0.77	1.00				
North	0.11	-0.24	-0.13	-0.19	-0.77	-1.00	1.00			
D flex	0.03	0.01	0.30	0.05	-0.11	-0.13	0.13	1.00		
S flex	0.17	-0.01	-0.21	0.22	-0.04	-0.15	0.15	-0.03	1.00	
DX	0.09	-0.02	-0.05	-0.06	-0.06	-0.04	0.04	0.08	0.02	1.00