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Governance, strategy and efficiency of water utilities: the Italian case

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Abstract

The determinants of the performance of water utilities are a topical issue worldwide. This paper analyzes the relationship between efficiency and corporate governance in Italian water utilities, measured through data envelopment analysis. Using an M-quantile regression model, efficiency estimations are ranked considering relevant governance (board size and composition; firm size) and strategy features (membership of a corporate group; provision of wholesale services) in order to provide decision-makers with indications regarding the best corporate governance and strategic choices to improve the efficiency. Results show that fully publicly owned firms reach lower levels of efficiency than their counterparts with an ownership structure that also includes private partners. Moreover, higher levels of efficiency are reached by utilities with more than six board members and by firms in which the presence of politically connected directors is substantial (more than two-thirds of board members being politically connected). The empirical results also show that the worst situation is where the entirety or the great majority of board members are not graduates or over a certain age and where the firm size is 'median'. Finally, being part of a group and having the opportunity to provide wholesale services to other firms contribute to improving efficiency.

Keywords: Corporate governance; Data envelopment analysis; Efficiency; M-quantile; Strategy; Water utilities

Introduction

Over the last 25 years the governance of public services, and of water services in particular, has been a major challenge in many economies (Hall, 2001; Lobina & Hall, 2007; Araral, 2008; Bel & Warner, 2008; Marques, 2008; Miralles, 2008; Furlong & Bakker, 2010). Managers, institutions, and policy-makers worldwide are looking for the best ways to improve efficiency, environmental sustainability, financial viability, and affordability of water services. Many reforms have been proposed and realized

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to meet these goals, even if a great debate about if and how different regulatory models affect a firm's performance is still ongoing (Berg, 2016) and perverse effects have been highlighted if a new regulatory model is implemented in isolation from the analysis of its influence on a firm's policy and strategies (Simões & Marques, 2012).

The Italian water industry has undergone important reforms over the last two decades with various different aims (Danesi *et al*., 2007; Guerrini *et al*., 2011), one of these being to end the direct supply of water and wastewater services through public administrations, by outsourcing these services to independent, public, mixed ownership or privately owned firms (Carrozza, 2011; Massarutto & Ermano, 2013; Guerrini & Romano, 2014). However, the Italian water supply system still represents a very complex landscape, with 75% of water industry operators being municipalities or other public bodies (such as consortia of local governments or mountain communities) that provide one or more water services (collection, water treatment and purification, transportation, distribution of water for civil use, wastewater collection and treatment) directly (Romano & Guerrini, 2014). Moreover, public, mixed and privately owned utilities coexist, operating on different scales and with different strategic and organizational status. The close connection between Italian utilities and local government leads to a dominance of politically connected directors on the boards of Italian utilities (Menozzi *et al*., 2011), fueling continuous debate about which is the best ownership structure and the best size and composition of local utilities' boards to achieve satisfactory performance. Specific legal provisions regulate the size and composition of the boards of Italian utilities owned either totally or partly by public shareholders: fully publicly owned utilities can appoint no more than five board members, according to Law 78 of 2010 and more recently Decree 175 of 2016. For both fully publicly owned and mixed ownership utilities, Law 138 (2011) banned the appointment to boards of directors of any politicians who have acted in the previous three years as administrators of the municipalities owning the utility.

Despite the relevance of this issue, which is much debated among decision-makers, scholars, and citizens, the water industry literature to date has focused mainly on the ownership–performance linkage and only a few empirical studies have investigated the relationship between the efficiency of water utilities and board size and composition (Romano & Guerrini, 2014; Romano *et al*., 2015).

Evaluation of the operational performance of firms in comparison to their rivals is a topical issue worldwide. Building on the New Public Management approach (Hood, 1990, 1991; Ferlie *et al*., 1996) and on agency theory (Jensen & Meckling, 1976; Eisenhardt, 1989), our paper aims to improve the scientific literature on water utility management by investigating how the corporate governance of water utilities (i.e. their ownership, board size and board composition), through its influence on firms' decisions, ultimately impacts their efficiency. The present study uses a dataset composed of 255 observations regarding 85 Italian water utilities from 2010 to 2012 and over 1,100 board members; to the best of our knowledge, for the first time, it includes multi-year data and applies data envelopment analysis (DEA) with an input orientation to determine the relative efficiency of utilities, and then M-quantile regression to rank their efficiency estimation considering relevant corporate governance and strategy features (board size; political connection, age, graduation, and sex of board members; firm size; membership of a corporate group; and provision of wholesale water services).

This study applies a novel methodology, for the first time used to link efficiency and corporate governance and strategy features of firms. M-quantile regression has recently been used in the water industry literature by Romano *et al*. (2014) to investigate the factors affecting water utility companies' decision to implement public information campaigns aimed at promoting sustainable water use and reducing household water consumption.

Our results contributed to the debate on how to improve the corporate governance and organizational structure of water utilities, providing useful indications for decision-makers on the best corporate governance choices to improve the efficiency of water utilities.

This article is structured as follows. The next section offers a review of the literature on the links between corporate governance and the performance of water utilities. The third and fourth sections describe the process of data collection, the research method and the analysis conducted. The fifth section outlines the key findings of our empirical research, and the final one concludes the paper and discusses the main implications.

Literature review

According to the OECD (2004), corporate governance is a key element in improving economic efficiency and growth, and in enhancing investor confidence. In recent years there has been growing interest in determining the effectiveness of corporate governance by means of different measures of firm performance (García-Sánchez, 2010), investigating both privately owned firms (e.g. Dulewicz & Herbert, 2004; Zelenyuk & Zheka, 2006; Rodríguez-Domínguez *et al*., 2012) and publicly owned ones (e.g. Bozec & Dia, 2007; Bachiller, 2009; Reddy *et al*., 2011). With reference to the water industry, some scholars have investigated the linkage between corporate governance and financial performance through the analysis of financial ratios and accounting performance (Shaoul, 1997; Guerrini *et al*., 2011; Romano *et al*., 2013). Menozzi *et al*. (2011) analyzed the effects of board composition on the performance of a sample of 114 Italian local public utilities dedicated to gas, electricity, and water production, distribution, and sale to the final customer. More recently, Romano & Guerrini (2014) investigated the linkage between the economic and financial performance (measured using accounting results) of Italian water mono-utilities and their corporate governance, using a dataset composed of 72 water utilities with data for the year 2011. Their preliminary findings show that private or mixed-ownership utilities achieve higher profitability than entirely publicly owned firms, even if the latter are less debt-dependent. Furthermore, they find that the boards of Italian water utilities are dominated by politically connected directors, who boost access to debt and thus negatively affect the firms' capital structures.

Alongside research focusing on the linkage between financial ratios and corporate governance, many studies have investigated the linkage between corporate governance and the efficiency of water utilities. Technical efficiency is considered extremely relevant, since operations, i.e. the process of transforming inputs into outputs, are the core of a business organization. Moreover, Hill & Snell (1989) argue that technical efficiency is considered a more accurate measure than financial ratios and Tobin's q, since the latter are extremely sensitive to differences in accounting methods or accounting profit manipulation (Barth *et al*., 2005).

As revealed by a review of the scientific literature (Berg & Marques, 2011), the problem of estimating the determinants of water utilities' performance trends has been investigated especially by authors adopting the performance evaluation model based on production frontiers, parametric or non-parametric. The most frequently used non-parametric method is DEA, which compares each producer with its related virtual 'best'. As Cubbin & Tzanidakis (1998) point out, regression analysis and DEA are both useful tools for comparative efficiency analysis and authors who have applied both the DEA models and parametric frontiers (Bhattacharyya *et al*., 1995; Seroa da Motta & Moreira, 2006) have found that the results were very similar.

In the water industry, many studies using DEA methods have focused on the ownership of water utilities in attempts to identify the best ownership structure. Some authors report that the ownership structure does not influence efficiency (Byrnes *et al*., 1986; García-Sánchez, 2006; Kirkpatrick *et al*., 2006; Seroa da Motta & Moreira, 2006; Peda *et al*., 2013; Barbosa *et al*., 2016). Other studies highlight the relevance of ownership to efficiency, claiming that public ownership improves it (Lambert *et al*., 1993; Shih *et al*., 2006) or, on the contrary, that private utilities outperform public companies in the management of specific production factors, mainly labor (Picazo-Tadeo *et al*., 2009a, 2009b). Therefore, no clear picture has emerged and this result has further been confirmed by recent analyses of the entire literature related to the water industry (Renzetti & Dupont, 2003; Abbott & Cohen, 2009; Pérard, 2009; Walter *et al*., 2009; Berg & Marques, 2011; Guerrini *et al*., 2011). With reference to Italy, Cruz *et al*. (2012) show that, in both Italy and Portugal, water utilities with public ownership are more efficient than mixed and private ones, demonstrating that the reforms favoring private sector participation in both countries were not necessarily successful. In contrast with previous findings, Guerrini & Romano (2014), using a wider dataset for the Italian water industry, show that the presence of a private shareholder improves the global efficiency of water utility firms. Since environmental variables have a relevant impact on the water sector, using the order-m method that allows the inclusion of environmental variables in efficiency estimation, Pinto *et al*. (2016) found a positive influence of private sector participation on the Portuguese water sector.

Studies investigating the linkage between board size and composition and the efficiency of firms are very few (see Table 1). With the exception of Gallego-Álvarez *et al*. (2010), the empirical studies have always used DEA and have mainly investigated listed firms (Lin *et al*., 2009; Gallego-Álvarez *et al*., 2010; García-Sánchez, 2010; Nanka-Bruce, 2011) and state-owned enterprises (SOE) (Bozec & Dia, 2007; Bachiller, 2009). The results are limited and quite conflicting, highlighting the need for further investigation of these issues. With reference to the water industry, Romano *et al*. (2015) recently analyzed the linkage between the board size and board composition of Italian water utilities and their efficiency, using DEA and a panel data regression model, finding that a certain board size can negatively affect the efficiency of water utilities; moreover, the presence of directors with political affiliations, or who are/were members of the local or national government, negatively affects efficiency, and the presence of directors with a university degree on the board has a slight negative effect on productivity. This two-stage approach is not without criticism (Simar & Wilson, 2004, 2007). DEA scores are expected to be correlated with each other (multicollinearity problem), as the calculation of efficiency of one firm incorporates observation of all other firms.

Data collection

The process of data collection started from the database published by the Italian Regulatory Authority for Electricity, Gas and Water Services (AEEGSI), i.e. the Italian national water authority. This database, available on the authority's website, includes information about all the 1,235 independent firms and public bodies involved in the provision of Italy's water services at the end of the year 2013. Of these 1,235 operators, 75% (N. 931) are municipalities or other public bodies (such as consortia of local governments or mountain communities) that provide one or more water services directly 'in house'. Thus, only 304 of the 1,235 operators at the end of 2013 are independent firms (water utilities).

Analyzing the financial statements and websites of these 304 Italian water utilities during the period January–March 2014, we find that 202 of them provide only water services (mono-utilities) and are not

Table 1. Literature review of studies investigating the linkage between firms' efficiency and their corporate governance (with the exception of ownership).

Authors	Year	Country	Dataset used	Years analyzed	Method	Variables studied									
						Board size	Board independence	Public (civil) servant/Political connection	Board duality	Graduate board members	Board reputation	Board diversity	Average board member age	Board activity	Corporate governance compliance
Romano *et al.*	2015	Italy	85 water firms	2010–2012	DEA	−		−		−		=	=		
Tariq & Abbas	2013	Pakistan	119 firms	2003–2010	DEA										+
Nanka-Bruce	2011	15 Western European countries (namely, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland, UK) and the USA	Listed firms	2003–2005	DEA	−	+		+						
García-Sánchez	2010	Spain	92 non-financial firms listed on the Spanish continuous market	2004–2006	DEA	=	=				−	+		+	
Gallego-Álvarez *et al.*	2010	Spain	117 listed firms from different activity sectors	2004–2006	Stochastic frontier analysis	=	=		=					=	
Bachiller	2009	Spain	5 SOE	1984–2005	DEA	=									
Lin *et al.*	2009	China	461 publicly listed manufacturing firms	1999–2002	DEA		+		=					+	
Bozec & Dia	2007	Canada	14 SOE	1976–2001	DEA	+	+	−	=						

+, −, and = indicate a positive, negative, and null effect of the variable studied on efficiency, respectively.

involved in other industries such as electricity, gas, or municipal waste management. Moreover, according to the AEEGSI database, only 100 firms are mono-utilities that provide all the various water services at the same time (collection, water treatment and purification, transportation, distribution of water for civil use, wastewater collection and treatment).

For the purpose of our study, we focused only on these 100 utilities, thus excluding companies that provide only some services and those that are multi-sector utilities (e.g. providing gas, waste management, and energy). This makes it possible to eliminate from the statistical analysis the effect of differentiated operations and strategies, which could severely affect firms' performance (Guerrini *et al*., 2013).

The AEEGSI database also provides us with information about the firms belonging to a group and whether or not they also provide a wholesale service. Both of these two facts are relevant, since economic and efficiency results could be affected by these strategic and organizational choices, along with the features of corporate governance.

The list was cross-checked against the Analisi Informatizzata delle Aziende Italiane (AIDA) database of Bureau Van Dyck. Following Romano & Guerrini (2014), the AIDA database was used to collect data on governance items: size of the board of directors (board size), percentage of women on the board (women), age of directors (age), and the distinction between 'fully publicly owned' firm and 'not fully publicly owned' firm. Moreover, the percentage of directors with university degrees (degree) and of politically connected directors (politics) were identified, examining whether or not each director on the board had a degree and held or had held political assignments, candidacies in national and local elections, and/or membership of a political party.

According to Menozzi *et al*. (2011) and Romano & Guerrini (2014), directors were considered 'politically connected' when they currently held a seat in parliament or in the municipal, provincial, or regional government, or had held one in the past, and, more generally, were affiliated to a political party or had a well-known relationship with a political party. The firms' websites, local newspaper websites, and the main web search engines were used to identify the political connections of all the directors.

Moreover, the AIDA database was used to collect economic and financial items referring to the three-year period analyzed (2010–2012): total revenues, value of production (prod. value, i.e. a relevant variable obtained from the firms' annual report that summarizes total revenues and stock variation), depreciation, amortization and interest paid, staff costs, and other operative costs (e.g. services, maintenance, materials) and number of employees (staff).

We obtained all the required information for 85 water utilities that operate only in the water and wastewater industry, providing all the water services, for which we collected information about their 1,118 board members. The final panel obtained includes 255 observations about these 85 firms. It is relevant to say that these water utilities, located in many different Italian regions, served around 30 million Italian citizens (Table 2) with around 300,000 km of mains.

In line with the literature (Guerrini & Romano, 2014) and the data available, for efficiency estimation we consider three inputs (the sum of amortization, depreciation, and interest paid; staff costs; other operating costs) and two outputs (population served, i.e. the number of inhabitants of the municipalities served by each firm and value of production, a variable obtained from the firms' annual reports that summarize total revenues and stock variation).

Tables 3 and 4 summarize some descriptive statistics regarding the governance, strategic, and economic variables used.

The majority of the dataset is composed of fully publicly owned firms, whose shareholders are municipalities or other public bodies (68%) that are not part of a broader group (74%). Around half of the

Table 2. Location and population served by the water utilities included in the dataset.

Region	Population served	%
Abruzzo	546,016	1.8%
Basilicata	591,338	2.0%
Calabria	112,683	0.4%
Campania	2,119,225	7.1%
Emilia Romagna	296,723	1.0%
Friuli Venezia Giulia	570,636	1.9%
Lazio	5,088,674	17.0%
Liguria	331,247	1.1%
Lombardia	4,493,251	15.0%
Marche	120,000	0.4%
Piemonte	2,218,516	7.4%
Puglia	4,000,000	13.4%
Sardegna	1,757,000	5.9%
Sicilia	965,000	3.2%
Toscana	3,363,174	11.2%
Umbria	500,000	1.7%
Veneto	2,863,517	9.6%
	29,937,000	

Table 3. Descriptive statistics.

	Fully publicly owned firm N. (%)	Utility is part of a group N. (%)	Utility also provides a wholesale service N. (%)
Yes	174 (68.2)	66 (25.9)	135 (52.9)
No	81 (31.8)	189 (74.1)	120 (47.1)
Total	255 (100.0)	255 (100.0)	255 (100.0)

Table 4. Descriptive statistics.

	Board size (N.)	Politics (%)	Degree (%)	Women (%)	Age (N.)	Prod. Value (€)	Staff (N.)
Mean	4.36	56	55	9	52.69	41,158,737.32	174.58
Median	5	60	60	0	53	18,853,392	83
Standard deviation	1.92	36	31	17	5.57	77,551,177.68	300.45
Minimum	1	0	0	0	39	638,013	0
Maximum	9	100	100	100	68	552,306,126	2,000

dataset comprises utilities that also provide a wholesale service, by selling potable water or treating wastewater, to other firms that are the concessionaire of water services in one or more municipalities (Table 3).

The boards are composed of an average of four members, with a minimum of a sole director and a maximum of nine members. On average, the boards are made up of 56% politically connected directors (only 18% are non-political) and of 55% graduate members. Women count, on average, for 9% of board

members, with around 70% of boards having no women at all and only one firm having 100% female presence (a sole female director). The average age of the board members is around 53 years (calculated as the mean of the average age of the members of each board), with a minimum of 39 and a maximum of 68 years (Table 4).

Method

Determining the efficiency of water utilities: DEA

In order to estimate the level of efficiency of water utilities, we applied a non-parametric frontier model known as DEA (Charnes *et al*., 1978), which is an alternative to financial ratios and parametric frontier models (Guerrini *et al*., 2011). Financial ratios make it possible to conduct benchmarking among many operating units, focusing on their financial results. However, their main weakness in measuring performance, such as operating profit to collection revenues, is the lack of technical indicators capable of estimating the effectiveness of customer service and plants, and the quality of the water. The parametric frontier method is based on a multivariate regression analysis of a specific dataset, formed of production inputs and outputs (e.g. cost of labor, cost of capital, and water delivered). Efficiency is measured by the distance between the data observed and maximum production, represented by the frontier. Compared to traditional ratio analysis (Beaver, 1968; Davis & Peles, 1993), the advantages of frontier models are their high reliability, being based on a mathematical approach, and their ability to measure efficiency considering many inputs and outputs. Their main limitation is the need to choose a cost function (for example, Cobb–Douglas, Translog), which cannot perfectly fit with the research dataset.

A non-parametric analysis such as DEA overcomes the limitations of financial ratios and parametric analysis, since it does not require the specification of any particular functional form to describe the efficient frontier, and it permits the combination of multiple inputs and outputs. DEA compares each decision-making unit (DMU) with its related virtual 'best' producer. Every virtual producer is identified through a linear programming approach, which enquires whether it is possible for a real operative unit to obtain more output with the same input, or to obtain the same output with less input (Farrell, 1957). DEA is based on an optimization algorithm that assigns a score (between 0 and 1) to each DMU, given the inputs consumed and the outputs produced, hence providing a ranking of firms based on their efficiency. The difference between 1 and the score assigned to a single DMU shows the amount of input that could be saved (input-oriented optimization problem) or the increase of output that could be obtained given a certain input (output-oriented optimization problem). Therefore, hypothesizing the adoption of DEA with an input orientation, a score of 0.77 assigned to a DMU shows a 23% margin for input saving.

The linear programming problem can be defined by choosing between two alternatives: constant return to scale (CRS) or variable return to scale (VRS) (Charnes *et al*., 1978; Banker *et al*., 1984). The use of both DEA models enables the establishment of three indexes: CRSTE (constant return to scale technical efficiency), VRSTE (variable return to scale technical efficiency), and SCALE (scale efficiency). The first represents the global efficiency of a DMU, given by pure efficiency and scale; the second measures the real capability of a company to purchase, mix, and consume inputs; while the third indicates the correctness of the choice to operate with a certain production scale.

Thanassoulis (2000) claims that firms can be evaluated for their global efficiency regardless of the true nature of the return to scale in the water industry, and adopts a CRS model in his study despite

counter-arguments such as the influence of non-controllable contextual variables on SCALE. Garcia-Valiñas & Muñiz (2007) use a similar approach. Although we use both CRS and VRS and thus calculate the three indexes (CRSTE, VRSTE, and SCALE), for the aim of the present study we focused only on global efficiency (CRSTE).

As highlighted by Berg (2010) and De Witte & Marques (2012), there are also disadvantages of applying DEA, such as that results are sensitive to the selection of inputs and outputs and to measurement error; moreover, the number of efficient firms tends to increase with the number of inputs and outputs included in the efficiency estimation. In the present paper, unlike previous studies that evaluate efficiency in a panel dataset by the use of a Malmquist index (De Witte & Marques, 2012), we do not measure the change in efficiency over time. Building on Lin *et al.* (2009), García-Sánchez (2010), and Tariq & Abbas (2013), we investigate whether and to what extent corporate governance practices affect efficiency.

We consider three inputs (the sum of amortization, depreciation, and interest paid; staff costs; other operating costs) and two outputs (population served and value of production). Data were obtained from annual reports (through the AIDA database), so they could have the traditional limitations of accounting data: accounting estimates, subsidization, accountancy rules, etc. For the DEA analysis to be meaningful, a general rule of thumb is applied: the number of DMUs analyzed should be greater than three times the number of inputs and outputs (Bozec & Dia, 2007).

Ranking water utilities' efficiency: the M-quantile approach

We applied the M-quantile regression to the scores obtained by DEA (y variable) in order to study the distribution of y given the auxiliary variables: size of the board of directors, percentage of women on the board, age of directors, ownership structure, the distinction between 'fully publicly owned' and 'not fully publicly owned' firms, the number of directors with university degrees, and of politically connected directors, firms belonging to a group or not, and whether they also provide a wholesale service, value of production, and staff costs. For each qualitative variable we have used a dummy variable that takes the value 0 or 1 to indicate the absence or presence of some categorical effect that may be expected to shift the outcome.

We evaluated the performance of each company by identifying a unique quantile, q_j, for every one (see Kokic *et al.*, 1997). These coefficients were then averaged from observations based on the group (three years observed), in order to define a group-level M-quantile coefficient.

Regression analysis is a standard tool for modeling the relationship between a response variable y and some covariates x. It summarizes the average behavior of y given x, and has been one of the most important statistical methods in applied research for many decades. However, in some circumstances, the mean does not give a complete picture of a distribution. It does not consider, for example, the extreme behavior of y conditional on x. Quantile regression summarizes the behavior of different parts (e.g. quantiles) of the conditional distribution of y at each point in the set of the x values. In the linear case, quantile regression leads to a family of hyper-planes indexed by a real number $q \in (0, 1)$. Given a set of covariates, x, and a response variable, y, for each value of q, the corresponding model $Q_y(q|x) = x\beta_q$ shows how the q-th quantile of the conditional distribution of y given x varies with x. The set of quantile regression parameter estimates satisfies the criterion of the minimum sum of asymmetrically weighted absolute residuals, and estimates of β_q are obtained using linear programming methods.

M-quantile regression further extends this idea by providing a 'quantile-like' generalization of regression based on influence functions. The relationship between sample M-quantiles and standard M-estimates of a regression function is shown by sample quantiles and the sample median. In fact, the M-quantile regression line of order q is defined as the solution $Q_y(q|x, \psi_q) = x\beta_{\psi q}$,

$$\int \psi_q\big(y - Q_y(q|x, \psi_q)\big)dF(y|x) = 0 \tag{1}$$

where F denotes the distribution of y given x underlying the data, and ψ_q denotes the influence function associated with the q-th M-quantile (see, for details, Breckling & Chambers (1988)). Being a robust regression model, it can be fitted using an iteratively reweighted least squares algorithm, which guarantees the convergence to a unique solution. M-quantiles are somehow less intuitively interpretable than quantiles. However, M-quantile regression also shares other advantages of robust regression related to the great flexibility in modeling that derives from using different influence functions, such as those of Huber or Hampel (Huber, 1981).

The M-quantile regression can be used to construct a performance measure of the Italian water utility companies following the proposal by Kokic *et al.* (1997). A key concept in the application of M-quantile methods to data is the identification of a unique 'M-quantile coefficient' associated with each datum observed. For most values in the x range, the fitted M-quantile surface $\hat{Q}_{y_j}(q|x_j, \psi_q)$ will increase monotonically with q, starting below all the y-data values when $q = 0$ and finishing above all y-data values when $q = 1$. If the q-th M-quantile surface passes through y_j, then we set the performance measure for the j-th company to $q_j = q$. In the continuous y case the M-quantile coefficient for observation j is simply defined as the unique solution q_j to the equation $y_j = \hat{Q}_{y_j}(q|x_j, \psi_q)$. Thus, the performance of each company is defined by q_j, which solves the previous equation.

Empirical results

Table 5 presents the descriptive statistics of the DEA scores. In comparison to previous studies applying DEA to Italian water utilities (Romano & Guerrini, 2011; Guerrini *et al.*, 2013), the current scores are higher. The reason for this difference may be due to many factors: first of all, the different choice of the input/output set; moreover, it may depend on the fact that Guerrini *et al.* (2013) analyzed both mono- and multi-utilities, and the data in the previous papers were older, being based on 2007 and 2008 figures.

Then, we applied the M-quantile regression to the scores obtained by DEA (CRSTE – y variable) in order to study the distribution of y given the auxiliary variables: size of the board of directors, percentage of women on the board, age of directors, ownership structure, the distinction between 'fully publicly owned' and 'not fully publicly owned' firms, the number of directors with university degrees,

Table 5. Descriptive statistics of DEA scores (255 observations).

	CRSTE	VRSTE	SCALE
Mean	0.871	0.899	0.968
Maximum	1	1	1
Minimum	0.306	0.364	0.755
Standard deviation	0.086	0.079	0.041

and of politically connected directors, firms belonging to a group or not, and whether they also provide a wholesale service, value of production, and staff costs. We evaluated the performance of each company by identifying a unique quantile, q_j, for every one (mean q individual); these coefficients were then averaged from observations based on the group (three years observed), in order to define a group-level M-quantile coefficient (mean q group).

We have fitted the M-quantile regression model at different quantiles from 0.006 to 0.996 for identifying a unique 'M-quantile coefficient' associated with each datum observed with the aim to construct a performance measure of the Italian water utility companies following the proposal by Kokic *et al.* (1997). For reporting all the results, we need a table for each quantile, because there are covariates that are significant at low quantiles, but which are not significant at high quantiles, and vice versa. For this reason, we have decided to retain all the covariates in the model because our target is the identification of unique 'M-quantile coefficient' associated with each datum observed. We can report, as an example shown in the Appendix (available with the online version of this paper), the results for the median regression ($q = 0.5$).

Table 6 reports the empirical findings considering the global efficiency. The scores are obtained as average of the M-quantiles coefficient and the estimate of their variability is a topic under research. We cannot use a traditional variance of the mean to measure the variability, but an iterative method (like bootstrap or jackknife method), the development of which is not the aim of this study.

Confirming the results of many scholars (see, for references, Abbott & Cohen (2009) and Berg & Marques (2011); for Italy, see Guerrini & Romano (2014)), the present study shows that not fully publicly owned firms are more efficient than fully publicly owned firms. This result supports the consideration that the political dimension of public enterprises cannot be ignored (Florio & Fecher, 2011). Hence, publicly owned firms are thought to prefer social and political objectives over profit and efficiency maximization (Romano *et al.*, 2017).

Moreover, board size seems to be relevant in influencing the utilities' efficiency: the greatest efficiency is obtained by firms with a 'bigger' board size (more than six members), followed by firms with four to six members; firms with boards composed of only a few members (one, two, or three) have the lowest efficiency. These results therefore confirm the findings of researchers who argue that larger boards are positively associated with better corporate performance (Pearce & Zahra, 1992) and are more effective in monitoring, as the directors appointed might be able to draw on a broader range of knowledge and experience (Van den Berghe & Levrau, 2004), even though the composition of such boards partially conflicts with the current regulation of Italian water utilities, which requires fully publicly owned utilities to appoint no more than five board members (Law 175/2016).

The results concerning the presence of politics highlight that the efficiency of water utilities is greater when the presence of politically connected directors is substantial (more than two-thirds of board members being politically connected). The worst scenario occurs when few politics are involved in the board (i.e. maximum one-third of board members being politically connected), probably due to the greater difficulties in communicating, discussing, and defining clear strategies. Thus, a higher presence of politicians (principally in fully publicly owned firms) could play a significant role in utility management, also by helping the firm gain access to financial capital from banks (Khwaja & Mian, 2005; Claessens *et al.*, 2008; Romano & Guerrini, 2014).

With reference to the percentage of graduate directors on the board, the empirical results show that, as expected, the worst scenario arises when the entirety or the great majority of board members are not university graduates. According to the literature (Forbes & Milliken, 1999), boards, as strategic-issue-processing

Table 6. Empirical results.

	N.	%	Mean q individual	Mean q group
Ownership				
not fully publicly owned firm	81	32%	0.523	0.523
Fully publicly owned firm	174	68%	0.506	0.506
Board size				
1,2,3 members	118	46%	0.499	0.498
4,5,6 members	101	40%	0.51	0.514
7,8,9 members	36	14%	0.556	0.548
Politics				
0–33%	81	32%	0.486	0.488
34–66%	94	37%	0.511	0.505
67–100%	80	31%	0.537	0.542
Degree				
0–33%	76	30%	0.446	0.445
34–66%	104	41%	0.577	0.578
67–100%	75	29%	0.488	0.486
Women				
0–33%	233	91%	0.519	0.518
34–66%	19	7%	0.395	0.407
67–100%	3	1%	0.661	0.661
Average age				
39–48	58	23%	0.452	0.461
49–58	160	63%	0.558	0.554
59–68	37	15%	0.402	0.407
Prod. value				
I tertile	85	33%	0.567	0.575
II tertile	85	33%	0.437	0.436
III tertile	85	33%	0.53	0.524
Staff				
I tertile	85	33%	0.59	0.595
II tertile	85	33%	0.455	0.443
III tertile	85	33%	0.489	0.497
Group				
Yes	66	26%	0.522	0.522
No	189	74%	0.508	0.508
Gross sale				
Yes	135	53%	0.532	0.532
No	120	47%	0.488	0.488

groups, must have members who possess knowledge and skills that cover business, accounting, finance, marketing, and law. Board members must also have firm-specific knowledge and skills that allow an intimate understanding of their firm's operations and internal management issues. However, efficiency is highest in firms whose boards have more than one-third but less than two-thirds of graduate directors. This result could be explained by the idea that having a degree is relevant but not, in itself, sufficient to make a significant contribution to a firm's decision-making and thus performance (Romano & Guerrini, 2014). As a matter of fact, in our dataset some graduate board members (around 3.5% of the dataset) have degrees that do not provide them with knowledge and skills in economics or law, nor in engineering or

geology (e.g. they have degrees in veterinary science, medicine, teaching, etc.); lastly, we were not able to identify the degree subject area for 7% of the graduate directors.

Considering the female presence on boards, our empirical findings (excluding the only case of a sole female director) show that efficiency is higher if the female presence is higher than two-thirds of board members or lower than one-third. In our dataset, there are never more than two females on a single board: therefore, as in Romano & Guerrini (2014), this result could be explained by the fact that the female board members in our dataset do not reach the critical mass of three or more women per board (Erkut *et al*., 2008). Consequently, as a 'token presence' (Kanter, 1977), these women may not feel comfortable on homogeneously male-dominated boards, and their contributions may not be as exploited as they could be, given broader representation.

With reference to the average age of directors on the board, a proxy for business experience (Anderson *et al*., 2004), the empirical results confirm that demographic variables, such as the age of board members, can help explain the values and cognitive bases that ultimately affect a firm's performance (Hambrick & Mason, 1984; Erhardt *et al*., 2003). As a matter of fact, the data show that the worst situation for efficiency is the one in which board members are more than 59 years of age (i.e. they are in the oldest tertile). In contrast, the highest efficiency is found in firms whose boards are, on average, over 49 but below 58 years of age. Hence, it seems that the directors' business experience, seen in the average age of all board members, contributes to improving efficiency. However, when a certain threshold is reached, a higher average age (over 58) becomes a limitation, and the positive effect of experience is cancelled out by the negative effect of being older, such as resistance to new ideas and more passivity in controlling management decision-making (Zajac & Westphal, 1996).

Considering strategic and organizational choices, the empirical results show that efficiency is higher in smaller water utilities (in terms of both value of production and staff numbers). Moreover, the data show that the worst size is that of the 'median tertile', thus confirming the findings of a previous study on Italy (Guerrini & Romano, 2014): water utilities are better able to achieve efficiency if they remain small local firms or if they become big players. This result confirms that in the water industry 'one size does not fit all' (Berg & Marques, 2011) and that economies of scale could be mediated by other positive effects of the smaller size, such as higher labor efficiency, higher commitment with investments' realization, and better control of expenses.

Finally, the other two strategic and organizational choices observed (being part of a broader corporate group and providing a wholesale service) seem to have a positive impact on efficiency, since the water utilities with these characteristics achieve, on average, higher efficiency than the others. In this regard, the presence of economies of scope in the water industry is confirmed (Berg & Marques, 2011; Guerrini *et al*., 2013), thus highlighting the need to further improve the provision simultaneously of 'wholesale' and 'retail' services. Moreover, the creation of broader groups also improves efficiency, thanks to economies of scope and synergies that could be exploited from the joint provision of drinking water supply with other activities such as piped gas, electricity, or urban waste (Carvalho & Marques, 2014). The impact of group membership on efficiency has been investigated by Destefanis & Sena (2007) and Keramidou *et al*. (2011), who also found a positive impact on technical efficiency of firms belonging to a group.

Conclusion and policy implication

This paper investigates the corporate governance and efficiency of Italian water utilities and analyzes how the former affects firms' decisions and ultimately impacts the level of efficiency reached. The

empirical study uses a dataset comprising 255 observations regarding 85 Italian water utilities and over 1,100 board members from 2010 to 2012. The novel method applied is composed of DEA to determine the relative efficiency of utilities, and M-quantile regression to rank the efficiency estimation considering relevant corporate governance and strategy features (board size; political connection, age, graduation, and sex of board members; firm size; membership of a corporate group and provision of wholesale water services).

In terms of policy implications, the obtained results could provide useful recommendations for the water utilities, water regulators, and policy-makers. As a matter of fact, the results provide a picture of the best practices that the above-mentioned decision-makers could consider when defining the corporate governance of water utilities and their organizational and strategic choices and when legal and regulatory obligations are issued. In particular, they confirm that fully publicly owned firms reach lower levels of efficiency than their counterparts with an ownership structure that also includes private partners. Moreover, higher levels of efficiency are reached by utilities with more than six board members, while lower levels are reached by those with very few board members (one to three). This result contrasts with the legal provisions in Italy, which set a threshold for the number of board members in fully publicly owned utilities (no more than five), which are still the majority of the Italian water industry. Similarly, the empirical results show that higher levels of efficiency are reached by firms in which the presence of politically connected directors is substantial (more than two-thirds of board members being politically connected). Again, these results partially conflict with the legal provisions in force, since Italian law currently bans the appointment to boards of directors of any politicians who have operated in the previous years as administrators of a local authority that owns the utility (fully public or mixed ownership).

The empirical results also show that the worst situation is where the entirety or the great majority of board members are not graduates or are over a certain age (59 years, on average). These results, along with the previous ones, suggest that corporate governance could affect in a relevant way the efficiency of water utilities; thus, the results might suggest best practices for the choice of the directors of water utilities board for water regulators and policy-makers.

Moreover, decision-makers could obtain from this study useful suggestions about the water industry structure in terms of number of operators: the worst situation is found where the firm size, measured by value of production and staff numbers, is 'median'. This latter aspect confirms that in the water industry, although there exist the economies of scale, 'one size does not fit all' (Berg & Marques, 2011). Finally, as expected and according to the existing literature, being part of a group and having the opportunity to sell water wholesale or provide wastewater services to other firms impact efficiency and contribute to improving efficiency. These findings might induce regulators and policy-makers, along with water utilities' shareholders and managers, to pursue strategies that encompass the creation of groups and diversification policies.

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