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RESEARCH ARTICLE

Evaluation of the influence of economic groups on the efficiency and quality of service of water companies: an empirical approach for Chile

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Abstract

The privatization of water and sewerage services (WSS) has led to the foundation of water economic groups, which integrate several water companies and have gained notable importance at the global level. In the framework of benchmarking studies, there are no prior studies exploring the impact that economic groups have on the efficiency and quality of service provided by water companies. This study investigates, for the first time, whether the membership of water companies in an economic group influences their performance. Quantity- and quality-adjusted efficiency scores were computed using data envelopment analysis models. An empirical application was developed for the Chilean water industry since most of their water companies are private and belong to an economic group. The results show that independent water companies provide WSS with better quality than do water companies that belong to an economic group. From a statistical point of view, it was evident that membership in an economic group impacts both the quantity- and quality-adjusted efficiency scores of water companies. The results of this study illustrate that applying the model-firm regulation to the Chilean water industry has significant drawbacks that should be addressed by the water regulator to promote the long-term sustainability of the water industry.

Keywords Privatization · Water companies · Urban water · Quality of service · Performance

Introduction

Sustainable urban water management involves the efficient technical and economic use of resources (García-Rubio et al. 2010). Thus, evaluating the efficiency of water companies is a useful tool for policy makers and regulators to improve the service quality and reduce their operational costs (Guerrini et al. 2013). A comparison of the performance of water companies can be used to develop and implement water management policies (Berg 2013). In this context, a major issue that has been investigated over the past 20 years is private vs. public ownership and/or management of water companies and its impact on efficiency (Berg and Marques 2011). Despite the large number of studies, it is unclear if the involvement of a private body influences the efficiency of water companies (see for example Lannier and Porcher (2014) and Araral (2009)).

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Although it has not been proven that private water companies provide water and sewerage services (WSS) more efficiently than public companies, world institutions such as the World Bank and International Monetary Fund have promoted the privatization of WSS (Baer 2014). Thus, in 2015, more than 1 billion people were served by private operators (GWI 2016). In several countries, such as England and Wales, Senegal and Chile, WSS are provided by private water companies in most of the urban areas. There are other countries, such as the USA, France, Spain, and Italy, where the presence of private water companies is not negligible (Pérard 2007).

The role of the private sector in the provision of WSS has led to the foundation of economic or business groups that integrate several water companies operating worldwide. According to Water and Waste Digests (2015), the world's 50 largest private water economic groups (WEG) served drinking water to more than 280 million people in 24 countries. This trend of agglutinating water companies under a common economic group that serves as a management umbrella occurs at both the international and national levels.

From the performance point of view, grouping water companies into economic groups might have positive and negative effects on efficiency. The provision of WSS through WEG could reduce competition between water companies, thus accentuating the monopoly problems that characterize the water industry. Thus, operators do not have incentives to improve their efficiency, innovation, or quality of service (Marques and Simões 2008). However, water companies that belong to the same economic group could share know-how, innovations, and procedures contributing to efficiency improvement. In this context, regulation might have an important role in protecting the public interest from an economic point of view, i.e., tariffs and quality of service (Romano et al. 2017).

Given the importance that private water companies have acquired in the provision of WSS, efficiency studies have focused only on comparing the performance of public vs. private water companies. In spite of the several empirical studies focused on the efficiency assessment of private water companies, to the best of our knowledge, there are no prior studies investigating the influence that the membership of water companies in economic groups has on efficiency. In other words, there are no prior studies comparing the efficiency of water companies belonging to economic groups with those that do not.

Including quality issues in the measurement of efficiency warrants attention, given their relevance to citizens, regulators, and the environment (Dobbie et al. 2016). The total value of WSS cannot be adequately evaluated only in terms of quantitative outputs since quality of service is an important attribute of the final product (De Witte and Marques 2010). Some water regulators are incentivizing improved service quality by means of penalties or awards when setting prices (Molinos-Senante et al. 2016). Given the importance of this topic, several previous empirical studies estimating the efficiency scores of water companies have integrated quality of service variables (e.g., Tupper and Resende 2004; Hernández-Sancho et al. 2012). In doing so, several previous studies considered the lack of service quality variables to be the most common undesirable output (Molinos-Senante et al. 2015). This approach obtains a quality-adjusted efficiency score for each water company analyzed.

Against this background, the objectives of this paper are twofold. First, the main objective is to investigate the influence of WEG on the economic efficiency and quality of service of water companies. Second, whether the introduction of quality variables into an assessment affects the efficiency scores of water companies is explored. The Chilean water industry was selected as a case study, given the importance of the WEG in the provision of WSS in this country. Chile is a paradigmatic case since 16 of the 22 main water companies that provide WSS to more than 90% of the total urban population belong to 1 of 5 WEG (SISS 2015). In the Chilean context, a WEG involves a private owner of a portfolio of water companies.

Efficiency was assessed for the 22 main Chilean water companies, of which 16 belong to 1 of 5 WEG. In the framework of this study, Chile is an interesting case study because WEG have become increasingly important in the provision of WSS since the privatization of the water industry. Thus, water regulators in other countries can learn important lessons from the Chilean case.

This manuscript contributes to the current literature by exploring for the first time the influence that WEG have on the quantity- and quality-adjusted efficiency scores of water companies. Despite the large number of previous papers analyzing the impact of ownership on the performance of water companies, none of them have focused on participation in economic groups, which represents a relevant aspect in "model-firm regulation," the type of regulation used for the Chilean water industry. This study provides insights into the impact of quality of service on the efficiency of water companies. We consider these topics relevant and deserving of investigation.

The water industry in Chile

Chile is widely known as a country with a highly liberalized economy, even as a kind of extreme free market economy. In fact, proof of this can be found in the privatized Chilean utilities, including telecommunications, water, electricity, education, health system, and highways. Privatization started in 1982 with the electric utility, even before the privatization process in the UK, which started with the telecommunication utility in 1984 (Fuentes and Saavedra 2007). The water industry privatization process began in 1988, when a new regulatory framework was established (Bitrán et al. 1999). Then, it continued through several laws, which privatized by using two bidding methods: first, the government sold their shares

Table 1 Membership of Chilean water companies to economic groups

Water company	Customers in the total national (%) by water company	Water economic group	Customers in the total national (%) by water economic group
1	35.85	1	43.53
2	4.31		
3	3.12		
4	0.25		
5	15.09	2	35.88[a]
6	11.92		
7	4.60		
8	4.26		
9	3.97	3	8.93
10	3.07		
11	1.00		
12	0.89		
13	1.78	4	2.32
14	0.54		
15	0.43	5	0.57
16	0.14		
17	0.07	Independent water company	0.07
18	3.83	Independent water company	3.83
19	3.32	Independent water company	3.32
20	0.35	Independent water company	0.35
21	0.28	Independent water company	0.28
22	0.10	Independent water company	0.10

Source: Own elaboration from SISS (2015) data

[a] Although one company appears as the controller group of the Water Company 7, we consider WEG 2 as owner because they are the principal shareholder with 90.10% of the shares, that means they have 90.10% of Water Company 7's property.

in water and sewerage utilities through public sales, including the property of their companies. Second, the government transferred the operation of their companies for 30 years but kept the property (Alegría and Celedón 2006), even though these companies are part of a public-private partnership, in practice they are considered by the water regulator as part of private sector since they behave, share the same legal framework, and are treated as private companies.

Despite these massive privatizations, the Chilean water industry ended up in a different position with respect to the rest of privatized utilities because of a new sort of regulation for water industry: "model-firm regulation," which consists of a theoretical efficient-firm. Among other issues, this regulation approach involves setting water tariffs assuming that the water company is technically and economically efficient. An unpublished kind of regulation was created to solve the main problem of other kinds of regulation (such as the return rate and price cap): information asymmetry (Bustos and Galetovic 2002). However, after 20 years, the results have shown that model-firm regulation has the same problem with information asymmetry (Gómez-Lobo and Vargas 2001). This occurs because even although the calculations should be independent of a real firm, in practice, a model firm is built from a real firm that is later optimized; accordingly, every company tries to state costs as high as can be justified (Galetovic and Sanhueza 1999).

The results of this liberalization process show that private water companies increased from 2.7% in 1998 to 95.8% in 2015 and that public companies decreased from 97.3% in 1998 to 4.2% in 2015 (SISS 2015). One of the conditions required for private companies to buy public companies and for making concessions to WWS was to have experience in the water industry. Thus, the Chilean water industry was attractive for economic groups providing WSS worldwide. This trend continued over time, and these WEG bought other water and sewerage companies in subsequent years to reach the current situation: a strongly concentrated industry, with market shares similar to an oligopoly and characterized by a few WEG owning the larger companies (see Table 1).

Methodology

To investigate whether the membership of water companies in economic groups influences performance, the first step was to compute their quantity- and quality-adjusted efficiency scores. In doing so, data envelopment analysis (DEA) method was used. It applies mathematical programing techniques to develop frontier-relating inputs and outputs (Cooper et al. 2007). DEA models can assume constant returns to scale (CRS) or variable returns to scale (VRS) technology. In the context of the Chilean water industry, Molinos-Senante et al. (2015) showed that water companies in Chile exhibit CRS. DEA models can be either input- or output-oriented. In the framework of the water companies' efficiency assessment, an input orientation was adopted in most empirical applications since the main objective of water companies is to meet the water demand while minimizing operational costs (Marques et al. 2014). In this study, the two DEA models applied assume CRS technology and input orientation.

Calculation of quantity efficiency scores

First, the methodological approach followed to compute quantity efficiency scores of water companies is described, i.e., excluding undesirable outputs. Assuming a production process where from an input vector $x\in\mathfrak{R}_{+}^{N}$, a vector of desirable outputs $y\in\mathfrak{R}_{+}^{M}$ is obtained using the technology T. The production possibility set is defined as follows:

$$P(x) = \{(x,y) : x \text{ can produce } y\} \tag{1}$$

The input distance function is defined as

$$D(x,y) = min_{\theta}\{\theta > 0 : x\theta\in P(x)\} \tag{2}$$

The input distance function indicates the maximum reduction of inputs that a unit (water company in this study) can obtain and still produce the same vector of desirable outputs (Morales and Heaney 2016). The input-oriented distance function is interpreted as follows: if $D(x, y) > 1$, then the input vector, x, belongs to the interior of $P(x)$; therefore, the unit is inefficient since it can reduce the use of inputs to generate the same output vector. By contrast, if $D(x, y) = 1$, then x is located on the production frontier, and the unit is efficient.

To compute efficiency scores while assuming CRS technology and input orientation, the following linear programming model was solved for each water company (Charnes et al. 1978):

$$\begin{array}{ll} Min\ \ \theta & \\ s.t. & \\ \sum_{j=1}^{N}\lambda_j x_{ij}\leq\theta x_{i0} & 1\leq i\leq M \\ \sum_{j=1}^{N}\lambda_j y_{rj}\geq y_{r0} & 1\leq r\leq S \\ \lambda_j\geq 0 & 1\leq k\leq N \end{array} \tag{3}$$

where θ indicates the efficiency of the water company evaluated, M is the number of inputs used; S is the number of outputs generated, N is the number of units analyzed, and λ_j is a set of intensity variables which represent the weighting of each analyzed water company j in the composition of the efficient frontier $\theta \in (0, 1]$;a unit (water company) is efficient if its efficiency score (θ) equals unity, whereas it is inefficient if $0 \leq \theta < 1$.

Calculation of quality-adjusted efficiency scores

A DEA model to compute quality-adjusted efficiency scores, i.e., DEA research on the introduction of service quality variables as undesirable outputs, is presented subsequently. Assuming a production process where from an input vector $x\in\mathfrak{R}_{+}^{N}$, a vector of desirable outputs $y\in\mathfrak{R}_{+}^{M}$ and another vector of undesirable outputs $b\in\mathfrak{R}_{+}^{H}$ are obtained using the technology T. The production possibility set of desirable and undesirable outputs is defined as follows:

$$P^{*}(x) = \{(y,b) : x \text{ can produce } (y,b)\} \tag{4}$$

The input distance function including undesirable outputs is defined as follows:

$$D(x,y,b) = min_{\theta}\{\theta > 0 : x\theta\in P^{*}(x)\} \tag{5}$$

Following Färe et al. (1994), for each water company j, the linear programing (Eq. 6) was solved to compute efficiency scores including quality of service variables:

$$\begin{array}{ll} Min\ \ \theta^{*} & \\ s.t. & \\ \sum_{j=1}^{N}\lambda_j x_{ij}\leq\theta^{*} x_{i0} & 1\leq i\leq M \\ \sum_{j=1}^{N}\lambda_j y_{rj}\geq y_{r0} & 1\leq r\leq S \\ \sum_{j=1}^{N}\lambda_j b_{zj} = b_{z0} & 1\leq z\leq H \\ \lambda_j\geq 0 & 1\leq k\leq N \end{array} \tag{6}$$

where θ^{*} indicates the quality-adjusted efficiency score of the water company evaluated, M is the number of inputs used, S is the number of desirable outputs generated, H is the number of undesirable outputs involved in the assessment; N is the number of water companies analyzed, and λ_j is a set of intensity variables which represent the weighting of each analyzed water company j in the composition of the efficient frontier. As in model 3, $\theta^{*} \in (0, 1]$ and a water company is efficient if θ^{*}equals unity, whereas it is inefficient if $0 \leq \theta^{*} < 1$.

Analysis of the influence of economic groups on water company efficiency

The similarity of the ranking of water companies regarding their efficiency scores was tested while both excluding and including quality of service variables. The Spearman's rho and Kendall's tau correlation coefficients were computed.[1]

[1] Note that we did not compute the Pearson correlation coefficient since it assumes that both variables (quantity- and quality-adjusted efficiency scores) are normally distributed.

They are non-parametric coefficients that measure how well the relationship between two variables can be described by using a monotonic function. Both coefficients are large when the observations have similar (identical for a correlation of 1) rank between the two variables (quantity and quality efficiency scores in this study). By contrast, the coefficients are low when the observations have a dissimilar rank between the variables.

To test whether the membership of a water company influences its performance and quantity- and quality-adjusted efficiency scores, two statistical tests were conducted: Kruskal-Wallis and Kolmogorov-Smirnov *Z*. The first is a non-parametric test similar to the traditional one-way analysis of variance (ANOVA), but unlike it, the Kruskal-Wallis test does not assume a normal distribution. This test is a method for testing whether samples originate from the same distribution (Kruskal and Wallis 1952). The null hypothesis is that the medians of all groups (economic groups in this study) are equal, and the alternative hypothesis is that at least one population median of one group is different from the population median of at least one other group. The Kolmogorov-Smirnov *Z* is also a non-parametric test. It quantifies the distance between the empirical distribution functions of two samples. It is very useful for comparing samples (Smirnov 1948). For both tests, the null hypothesis cannot be rejected with the usual level of confidence of 95% if the *p* value is larger than 0.05.

Sample description

The sample assessed in this study includes the 22 main Chilean water companies, which provide WSS to 99.16% of the urban customers, i.e., to 16,195,334 people (SISS 2015). The 22 water companies evaluated provide WSS in all 15 regions of the country. Hence, our study is at the country level. This issue is especially relevant from a policy and regulatory perspective, given that the national urban water regulator could use the conclusions of this paper to develop national policies.

The membership of water companies in economic groups is shown in Table 1. It illustrates that 16 of the 22 water companies evaluated belong to 5 economic groups, whereas the remaining 6 water companies are "independent" in the sense that they do not belong to any economic group. Most of the Chilean water companies belong to an economic group that finances and manages more than one water company. This feature is even more noticeable when the percentage of customers of each water company of the total national population is considered. Table 1 shows that the water companies comprising economic groups 1 and 2 provide WSS to 43.5 and 35.8% of Chilean customers. This issue is relevant from a regulatory point of view because it might aggravate the monopoly problems that characterize the water industry.

A limitation in any DEA model is the number of water companies analyzed in relation to the number of inputs and outputs. To avoid relative efficiency discrimination problems, "Cooper's rule" must be taken into account. Accordingly, the number of units (water companies) to be evaluated must be larger than or equal to $\max\{m \times s; 3(m+s)\}$ where m is the number of inputs and s is the number of outputs involved in the assessment (Molinos-Senante et al. 2016). In this study, 22 water companies were evaluated while the number of inputs was two and the number of outputs (desirable and undesirable) was four. Hence, "Cooper's rule" is met.

Following previous studies assessing the efficiency of Chilean water companies (e.g., Molinos-Senante et al. 2015, 2016, 2018; Ferro and Mercadier 2016), several variables were involved in the analysis carried out in this study. The selection of input and output variables to estimate efficiency scores of water companies was also influenced by sample size (i.e., number of water companies analyzed) and the availability of data. The variables used as inputs and desirable and undesirable outputs are as follows:

- Input 1: operating costs expressed in Chilean pesos (CLP) per year, which are the water and sewerage industry's total operating expenditure. They involve energy costs, resource and treatment costs incurred in water and sewerage services, and business activity costs.
- Input 2: number of employees working in water companies. This variable includes direct workers and external employees who develop tasks for water companies but do not belong to them.
- Desirable output 1: volume of billed water expressed as cubic meters per year. According to IWA (2015), it is the difference between extracted water and non-revenue water. Given the large percentage of non-revenue water for the Chilean water companies (average in 2015 was 33.6%); the volume of billed water was considered a better desirable output than the volume of water abstracted.
- Desirable output 2: number of customers who have access to wastewater treatment services. As Chilean water companies provide both WSS, at least one of the desirable outputs should reflect the latter service.
- Undesirable output 1: total number of written complaints. As measure of the perception by customers of the offered service quality (Molinos-Senante et al. 2015), a small number of complaints indicates a better quality of service (Corton and Berg 2009).
- Undesirable output 2: total number of unplanned interruptions in water supply and in wastewater collection networks. This variables provides information about the reliability of the water supply and wastewater collection services and, therefore, about the service quality to customers.

Table 2 Sample description

	Inputs		Desirable outputs		Undesirable outputs	
	Operational costs (10^3CLP/year)	Employees (number)	Billed water (10^3 m^3/year)	People with wastewater treatment	Written complaints (number)	Total unplanned interruptions (number)
Average	31,955,643	637	50,934	735,839	27,417	6420
SD	42,922,016	777	95,370	1,371,144	44,459	10,289
Maximum	183,757,940	3026	445,871	6,306,998	195,091	37,009
Minimum	647,224	40	1663	6516	53	14

Source: own elaboration from SISS (2015) data

It should be noted that in the assessment of the efficiency of water companies, several variables representing service quality have been used as undesirable outputs (see Hernández-Sancho et al. 2012; Mbuvi et al. 2012; Molinos-Senante et al. 2015). Their selection depends on the objectives of the study and the features of the water industry assessed. Because this study focused on Chilean water companies, the number of complaints and the unplanned interruptions in WSS reflect the quality of service provided by the water companies to customers.

The source of data used in this study is the management report about WSS for 2015 published by the Chilean water regulator (SISS). Table 2 shows the main statistical features of the data used.

Results and discussion

Quantity- and quality-adjusted efficiency scores of the 22 Chilean water companies evaluated were computed by solving Eqs. (3) and (6). Figure 1 illustrates in a graph the efficiency scores at water company level based on both quantity- and quality-adjusted variables. To ease the exploration of whether the membership of a water company in a WEG influences efficiency, the six water companies that do not belong to any economic group (WC17–WC22) were underlined. Figure 1 shows notable differences between water companies belonging to WEG and those that do not when quality of service variables are integrated in the assessment of efficiency. Only 2 of the 16 water companies that belong to economic groups change their efficiency score when quality of service is considered in the assessment. In both cases, their efficiency scores improved. Conversely, the six water companies that do not belong to any WEG improved efficiency notably when the assessment integrated quality of service. This finding suggests that in general, these water companies provide WSS with better quality than do water companies that are members of WEG.

Table 3 shows the main statistical results for the Chilean water industry for three cases: (i) total sample of water companies, (ii) sub-sample of water companies that belong to a WEG, and (iii) sub-sample of water companies that do not belong to any WEG. The whole sample of water companies, i.e., the Chilean water industry, illustrated that when efficiency assessment excludes quality of service, the mean score was 0.639. This means that on average, the water companies evaluated could reduce their inputs by 36% if they were operated

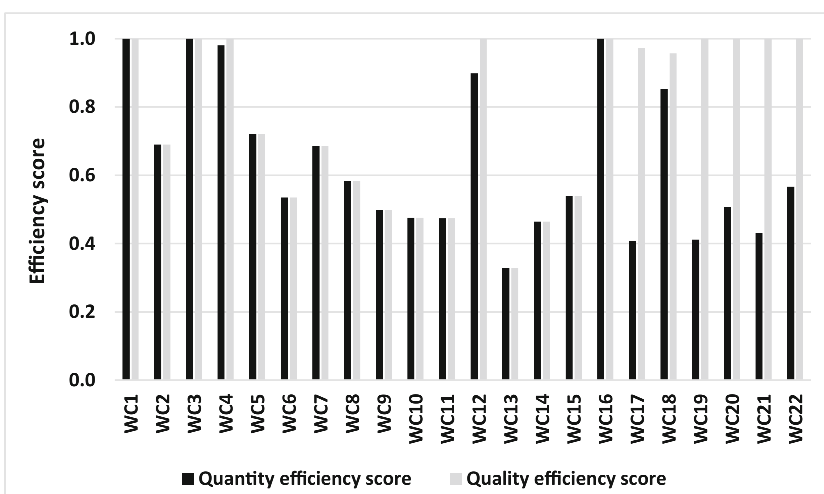

Fig. 1 Quantity- and quality-adjusted efficiency scores for the 22 Chilean water companies evaluated

Table 3 Main statistics of the efficiency scores of water companies evaluated

	Total sample		Sub-sample water companies membership to water economic groups		Sub-sample water companies do not membership to water economic groups	
	Quantity efficiency scores (θ)	Quality efficiency scores (θ^*)	Quantity efficiency scores (θ)	Quality efficiency scores (θ^*)	Quantity efficiency scores (θ)	Quality efficiency scores (θ^*)
Average	0.639	0.769	0.680	0.687	0.530	0.988
SD	0.221	0.244	0.229	0.238	0.170	0.019
Maximum	1.000	1.000	1.000	1.000	0.853	1.000
Minimum	0.329	0.329	0.329	0.329	0.409	0.957
Percentage of efficient water companies	13.6	40.9	18.8	31.3	0.0	66.7

as efficient companies. It should be noted that in this scenario, only 3 of the 22 water companies (13.6%) were efficient, i.e., they could be considered as reference companies. In contrast, when quality issues are integrated into the assessment, the number of efficient water companies doubles (6 of 22), and the mean efficiency score increases to 0.769. This finding means that in general, Chilean water companies are penalized when the quality of service is not integrated into the efficiency assessment.

Focusing on water companies belonging to a WEG, the results show that the average efficiency score barely changes when the quality of service is integrated into the assessment. However, the number of efficient water companies increases from three to five. In contrast, the average efficiency score of the water companies that are not members of any economic group improved from 0.530 to 0.988 when the efficiency assessment includes quality of service variables. In this case, four of the six water companies are efficient. The results show the importance of considering quality of service variables in the evaluation of efficiency to avoid favoring low-cost but low-quality water companies. In this sense, the Spearman's rho and Kendall's tau correlation coefficients between the quantity- and quality-adjusted efficiency scores were 0.485 and 0.498. This finding verifies that the ranking of water companies regarding their efficiency scores changes markedly when quality of service is considered in the evaluation.

To deepen the discussion of the influence on water companies' efficiency of membership in a WEG, Table 4 shows the average and standard deviation of the efficiency scores for each WEG analyzed and for independent water companies, i.e., water companies that do not belong to any economic group. The results illustrate that the four water companies integrated in water economic group 1 have the best performance based on both quantity and quality variables. As shown in Fig. 1, two of the four water companies comprising water economic group 1 are efficient based on quantity variables, and three are efficient when quality of service is integrated into the assessment. This water economic group provides water and sewerage services to 43.5% of the Chilean people (see Table 1). However, water economic group 1 integrates large water companies as well as small ones whose market share is lower than 5%, but they are efficient. Although previous studies have verified the presence of economies of scale in the water industry in some cases (Guerrini et al. 2013), the results of this study suggest that the efficiency of water companies is influenced by their membership in a certain WEG. In this sense, the efficiency scores of water economic group 5 also support this hypothesis. This economic group exhibits the second best average efficiency scores. However, its market share is only 0.57% of the total nation. In contrast, none of the water companies comprising water economic group 2 are efficient, in spite of their market share of 35.9% of the total nation; one of the water companies of this group provides WSS to more than 15% of the Chilean people. To test whether the efficiency scores of water companies from different WEG and from independent water companies are different from a statistical perspective, the non-parametric test of Kruskal-Wallis and Kolmogorov-Smirnov Z were conducted. The null hypothesis is that the efficiency scores for the different WEG exhibited no significant differences. For the quantity efficiency scores, the p values for both tests were 0.032 and 0.010, and for quality-adjusted efficiency scores, the p values were 0.023 and 0.010. Hence, the null hypothesis is rejected, which means that the distribution of efficiency scores among water companies comprising WEG is significantly different for quantity- and quality-adjustment assessments.

The results show that efficiency, which is closely related to costs, depends on the decisions of the WEG owner of a set of firms. This finding suggests that managerial decisions are made for all company members of the same WEG and suggests that they follow a short-term economical criterion rather than a technical one. This idea is supported by several figures. First, Chilean water companies present a high turnover rate of chief executive officers (CEOs). They have been changed every 17 months on average during last 10 years period 2005–2014). Second, the infrastructure replacement is very low: 0.5 and 0.2% for water and sewerage network, respectively. However, according to the model firm, both rates must be 2%.

Table 4 Average efficiency scores of Chilean water companies grouped according to their water economic groups

		Water economic group 1	Water economic group 2	Water economic group 3	Water economic group 4	Water economic group 5	Independent water companies
Quantity efficiency score	Average	0.918	0.631	0.587	0.396	0.770	0.530
	SD	0.152	0.087	0.208	0.096	0.325	0.170
Quality efficiency score	Average	0.922	0.631	0.612	0.396	0.770	0.988
	SD	0.155	0.087	0.259	0.096	0.325	0.019

Finally, according to the model firm, the water losses must be below 15%. However, the average value for the 22 water companies for 2014 was 34%. For more details, see Supplemental Information.

Both points remain in evidence when the decisions made by the owner are analyzed. However, by paying special attention to determine if they impact short- or long-term objectives, it is clear that every WEG in this industry has a short-term vision because they decide to gain efficiency very quickly by making massive decisions at the same time for all owned companies. The owner chooses to invest resources in favor of decreasing some costs simultaneously in the companies. This means that the owner is not considering the cost structure of every firm separately, which would be part of a long-term vision and would be slower but profitable because every company would increase its efficiency by improving its cost structure, which can be completely different or even nearly opposite among companies of the same WEG.

Considering that Chile is one of the longest countries in the world—the driest worldwide desert is located in its northernmost area and the biggest territory in Antarctica (belonging of a country) is located in its southernmost area—a relationship between geography and efficiency is expected because costs are strictly related to geography in model-firm regulation. Contrary to expectations, the results show that every WEG determines the efficiency of its own companies, leaving aside the cost structure of those companies.

This point can be stressed with the most representative counterexample: water economic group 3, which owns water company 10, which is located in the northernmost region of the country, as well as water company 11, which is located in the southernmost region. This means that the technical difficulties and challenges are completely different for this pair of companies because the variables to build a real firm come from completely opposite realities and technical conditions, which suggests that the efficiency presents dissimilar processes and concerns for those company managers and, consequently, for those respective WEG managers. Nevertheless, the results indicate that efficiency depends strictly on the WEG management, leaving the infrastructure, geography, and operational systems in the background, all of which are variables that strongly impact efficient performance because of the difficulties that must be solved by the local managers.

During the tariff process, every company searches for increased costs to obtain a higher tariff (Galetovic and Sanhueza 1999). Therefore, considering the model-firm regulation tariff, the results are completely surprising because the calculation is based on a real firm in a specific geographic area. Thus, costs are highly dependent on the characteristics of the concession's zone, which determines the kind of sanitary infrastructure that must be constructed to implement proper operation. This requires assessing water availability, temperature, humidity, relief, altitude, latitude, and soil, as a set of variables that every company establishes as reasons to increase its tariffs, even though they are not considered by company or WEG managers. Consequently, a negative effect of WEG arises: they tend towards a monopoly behavior, with no need to improve efficiency by lowering the most significant costs, as the losses in doing so would maximize their profits. Instead of obtaining the maximum benefit according to the aim of regulation, companies skip this incentive to increase their profitability and thus fall into a large self-contradiction, preferring to gain less profit by taking as much as possible from the information asymmetry, which means easier management with a short-term approach instead of gaining more profit by properly investing, which means more complex management with a long-term approach.

From a policy perspective, the results and conclusions of this study are of great interest to water regulators and policy makers. They will serve as a basis for developing both short- and long-term policies. This study identifies the water companies with the best performance, including quality of service issues. This information is relevant for introducing measures to unify and improve the quality of service of water companies and contributing to equity in the provision of WSS. The study also provides conclusions about the influence of WEG on the performance of water companies, which is an outstanding aspect for assessing the tariff fixing process in model-firm regulation. It is essential to support policies to regulate the process of mergers and purchase of water companies by economic groups.

Conclusions

WEG, which serve as a management umbrella for several water companies, are acquiring growing importance in the provision of WSS. However, there are no prior studies comparing the performance of water companies belonging to WEG and those that do not. As a pioneering study, we investigated, for the first time, whether the membership of water companies in an economic group influences their quantity- and quality-adjusted efficiency scores. An empirical application was developed for the Chilean water industry since it is an extreme example of a massively privatized water industry and of diverse geography.

The results of this study are summarized as follows. First, quantity- and quality-adjusted efficiency scores are very similar for water companies belonging to a WEG. By contrast, the efficiency of the independent water companies improves markedly when the quality of service is included in the assessment. Second, from a statistical point of view, it is evident that the efficiency of water companies is influenced by membership in a certain WEG. Thus, water companies belonging to the same WEG have similar efficiency, independent of their size and the geographic conditions of the concessionary area.

From a policy perspective, the results of this study provide very relevant conclusions. First, unlike water companies belonging to WEG, independent water companies are severely penalized when quality of service is not integrated in efficiency assessment. This issue is very relevant for the Chilean water industry since water tariffs are based on WSS costs and quality of service is ignored. Hence, water companies belonging to a WEG can be considered "low-cost and low-quality" companies, but this status does not impact their tariffs. Second, the model-firm regulation applied in the Chilean water industry assumes that WSS costs are influenced by the geographical conditions of the concessionary areas and operating systems of the water companies, among other factors. However, this study shows that efficiency, which is directly related to the costs of water companies (according to model-firm regulation and its legal framework), depends primarily on the WEG management. It illustrates that the decisions made by water companies are focused on short-term rather than long-term objectives. The low replacement rate of the water and sewerage networks, the high level of water losses, and the high turnover rate of CEOs are clear examples of this policy. This short-term vision of the water companies puts the sustainability of the water companies in serious risk. Under this context, it is imperative that the Chilean water regulator implement notable changes in the model-firm regulation to internalize the quality of the service in water tariffs and promote the long-term sustainability of the water companies.

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