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# Technical Efficiency in Water and Sanitation Providers in Chile.

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# Technical Efficiency in Water and Sanitation Providers in Chile

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**Abstract:** Chile has achieved universal levels of coverage in water, sewerage and sewerage treatment in urban areas. Also, the providers exhibit complete cost recovering, universal metering and diminishing consumption. On the other hand, the regulatory model in use is criticized because it does not solve the asymmetric information among regulator and providers. Based on a sample of 18 providers, we computed an input distance function through stochastic frontier analysis. We explore comparative technical efficiency in the sector, concentrating our attention in the recent years, looking for responses to new challenges related with loss reduction, maintenance expenditures, and lower tariffs.

**Resumen:** Chile ha logrado niveles de cobertura universal en agua potable, alcantarillado y tratamiento de aguas residuales en áreas urbanas. Sus prestadores exhiben completa recuperación de costos, micromedición universal y un consumo unitario en descenso. En contraste, su modelo regulatorio es criticado por no resolver la asimetría informativa entre regulador y regulados. Sobre una muestra de 18 prestadores, estimamos una función de distancia de insumos a través de análisis de frontera estocástica. Exploramos eficiencia técnica comparativa en el sector, concentrándonos en años recientes, buscando respuestas a nuevos desafíos relacionados con reducción de pérdidas en red, gastos de mantenimiento y menores tarifas.

**JEL: C22, L51**

**Key Words:** Efficiency, Water and Sanitation, Regulation, Chile

## 1. Introduction

The water and sanitation sector in Chile has made a significant effort in both investments and institutionalization in the last four decades, achieving universal levels of coverage of water and sewerage to urban population, and nearly universal wastewater treatment levels. The sector reached levels of full cost recovery, universal micro-metering and progressive control of volumes consumed. It represents a very interesting case study, for a consequent pursue of the objectives of service universalization, cost recovery, rationalization of consumption and environmental improvement, even with very important changes in the political regime in the middle. A critical view of the regulatory mechanism used (model or referential company), characterize it as one that does not solve the asymmetry of information in favor of the regulated company. Also it is highlighted the relatively low investments in network maintenance, the stagnation in water loss control, and the concentration of company ownership in a few groups, who have achieved cost synergies and economies of scale, which have not seem transferred to consumers in the form of lower rates.

In this paper our objectives are:

1) To determine comparative technical efficiency of the providers and its drivers.
2) To analyze the evolution of technical efficiency over time, exploring the possibility to trespass efficiency gains to consumers (X-Factor).

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3) To determine a possible path to increase maintenance investments with the aim to reduce losses in the years to come (K-Factor).

Based on a sample of 18 Chilean providers of water and sewerage for the period 2005-2013, we computed an input distance function through stochastic frontier analysis (SFA). We performed a True Random Effects model to control for possible unobserved heterogeneity between providers.

In doing so, we organize the paper in seven sections. After this Introduction, in Section 2 we review the literature and establish some facts on the sector history and evolution. In Section 3 we discuss the method of analysis and the model to be estimated. In section 4 we present our database. Section 5 is for Results discussion, Section 6 is for some policy considerations, and Section 7 is for concluding remarks.

## 2. Literature Review on Chilean W&S Sector

In 1931 was created the General Directorate of Drinking Water and Sewerage in the Ministry of the Interior, to begin the institutional development of the country's sanitation sector (Salazar, 2000). In 1953 the Directorate of Waterworks (DOS) was created to carry out the study, planning, construction, repair, administration and provision of facilities for potable water and sewerage, implying a partial unification of the supervision of the sector (Ebensperger, 2012). The DOS joined the Department of Hydraulic of the Ministry of Public Works and the Directorate General of Drinking Water of the Ministry of the Interior (Salazar, 2000). The two bodies did not possess own assets and their revenue were part of the national budget. In 1973, 74% of the financing came from fiscal resources, a 16% was external and only the remaining 10% came from own resources (rates). Most of the spending was aimed at investment in expanding coverage, whereas expenditure on maintenance was below 15 percent. Between 1968 and 1973, the staff increased from 3800 to 13500 (Fischer & Serra, 2007).

In 1977 was created SENDOS as the single state agency (rural and urban) for the operation and maintenance of sanitation systems, performing also the regulatory and supervisory role, and depending on the Ministry of Public Works. The State funded investments and there was a system of tariffs on the basis of cross-subsidization between regions without considering costs of providing the service. This system operated centrally in the area of investment planning, resource allocation and pricing, being the regional SENDOS only operational services (SEP, 2006). They had its headquarters in eleven of the thirteen regions and there were two autonomous state owned companies in the remaining regions: EMOS (today Aguas Andinas, in the Metropolitan Region) and Esval (in Valparaiso Region), all under the Ministry of Public Works (Ebensperger, 2012, SEP, 2006, Alfaro, 2009). By 1979 the SENDOS staff had been reduced to approximately 3000 employees (Fischer & Serra, 2007).

In 1988 a law for Sanitation Services (Decree with the force of Law 382) was passed, giving a momentum to the autonomy of providers. With this, the two regional companies became subsidiaries of CORFO, which is the governmental agency for economic and industrial development acting as a holding company of public enterprises (Fischer & Serra, 2007). They also began to implement efficient rates and self-financing criteria. The Law which sets the rules for the operation of the sanitation providers, the conditions in which they must provide the service and the regime of concessions on which they operate Supreme Decree 121, of 1992 (Joy Calvo & Celedón Cariola, 2006).

In 1989 the new institutional framework for the sector was established, with the separation of the roles of producer (in charge of the companies) and regulator (in charge of the SISS). The SISS was created by Law 18902 of 1990 (Gómez-Lobo, 2001) and was constituted as an essentially technical, regulatory and supervisory body (Joy Calvo &

Celedón Cariola, 2006). The SISS was strengthened in 1998 with greater authority and budget (Espinosa Sarria, 2014). The SISS is responsible for setting rates, make studies and oversee the sector. Superintendent of Sanitation is directly appointed by the President and can be removed at any time by the same. Hierarchically depends on the Ministry of Public Works. Its funding comes from the national budget entirely (Gómez-Lobo, 2001). In the Decree with the force of Law No. 70 of the Ministry of Public Works (General Law on Rates), are established the procedures and standards for the tariffs determination (Joy Calvo & Celedón Cariola, 2006). Until January 1990, the Ministry of Economy set tariffs, moving from there onwards to be the responsibility of the SISS. The Law 18778 of 1989 establishes a direct subsidy to consumption, awarded by the State through the municipalities, allowing the tariffs reflect the private supply costs. The subsidy covers in practice, with discounts in the invoice, to a 15 percent of the users.

Already in the 1990s were privatized the companies EMOS (today Aguas Andinas), Essbio, Essal and Esval, while reserving for the state a minority stake in the property. In the mid-1990s was finished the transformation of the former SENDOS regionals in eleven corporations, all subsidiaries of CORFO (SEP, 2006). Since 1998 began a new phase of privatizations by granting concessions for 30 years (and no longer in perpetuity, as was the case of the former), and in 2011 the State sold the shares that retained in all of the privatized enterprises, reserving to CORFO equity participations of the 5% that allow to choose a director and have the right to veto (Golden Share). The Law 19,549 of 1998 amended the legislation and regulatory framework of the sector, introducing limits on the ownership structure to prevent excessive concentration in the sector, both at the horizontal as well as sectoral level (Gómez-Lobo, 2001).

The motivation for the privatization was counting with private financing for investment projects in wastewater treatment. In 1995, and due to the country's decision to open to the world economy through free trade agreements, which demanded health and environmental obligations that Chile did not meet in export products, a policy priority was given to wastewater treatment (Joy Calvo & Celedón Cariola, 2006). For its part, the change of the privatization model (of concessions in perpetuity to thirty years of duration, opening 10% of capital on the stock market, and up to 10% of the shares to purchases by employees), was in part influenced by the perception that the regulatory framework was still precarious to regulate these companies successfully (Gómez-Lobo & Vargas, 2002). The privatizations implied a collection of US$ 2500 million and between 2000 and 2012 the industry has invested US$ 3561 million in various infrastructure works, mainly for wastewater treatment (Espinosa Sarria, 2014 and Ebensperger, 2012).

The water and sanitation services sector in Chile covers the provision of rural areas with a 11 percent of the population, organized into cooperatives and that do not require concessions delivered by the SISS, and urban areas granted by the SISS (plus the single municipal service remaining state owned provider SMAPA), which comprise 89 percent of the population.

Before the reform, tariffs permit to recover less than 50 percent on average of the operation costs and in some regions with a shortage of source (north of the country), the cost coverage was lower than 20 percent (Serra, 2000 cited by Gómez-Lobo, 2001). The tariff increase recorded during the 1990s made it possible to reverse the financial deficit of the providers. At the same time, it was reduced the average consumption per customer and production by the companies. The losses, however, have increased in the time, which indicates probably lack of investments in the maintenance of the networks (Joy Calvo and Celedón Cariola, 2006). A form of indicative measure of the intensity of investment in infrastructure maintenance, is expressing them in terms of years necessary to renew the entire network. On the other hand, the sector currently operates with half of the staff that existed at the beginning of the process of reforms, part of them are outsourced staff in service activities (Joy Calvo & Celedón Cariola, 2006)

Also before the reform process, price discrimination between regions was common (10 percent of the income of each region were redistributed by two poor regions) and by volumes consumed, in growing blocks of less than 15 cubic meters per month, 15-45 and more than 45 (Sjöden, 2006). The current pricing system does not provide for the socio-economic situation of the customers: the tariffs are fixed per cubic meter consumed according to "efficient production costs" and apply to all customers equally. There is no distinction between residential, commercial or industrial customers (but there are seasonal and "overconsumption" rates). It is anticipated the possibility of cut-off services for non-payment. There are subsidies from 1990 to the demand for poor families, who must apply to the former and receive a percent discount in their invoices from the municipalities according to the grade obtained in the means testing Social Protection Survey (Espinosa Sarria, 2014).

Tariffs are set for a period of five years (time within which they are indexed automatically if the variations of a cost index exceeds 3 percent accumulated), although if both the authority and the company deemed it necessary in an extraordinary review in the middle of the review period, it can be done. Tariffs are maximum prices: companies may charge values below. The technical support for its determination takes a regulator's report, one of the company and the differences are settled by a committee of experts who must decide on behalf of one of the two studies for each of the points where there are discrepancies. The cost studies are based on a model or referential or model company (fictitious), designed to provide the efficient services (Gómez-Lobo, 2001). Tariffs are differentiated by stage and between fixed and variable charges, including a component for the months of peak demand (summer). Pricing is done on the basis of incremental costs of development (marginal long-term costs). Efficiency tariffs are adjusted by the percentage needed to reach the revenue required. Charging is calculated by system and not by company. The mechanism of model company has been criticized by unlink totally costs and rates of the real enterprise, while at the same time not being an actual incentive regime. Tariffs unrelated to costs could force the regulator to micromanage the company, prevents the use of incentives and yield practical problems that can distort the rates process (Gómez-Lobo & Vargas, 2002).

## 3. Method and the model

The model used in this paper is drawn from Coelli et al (2005) and follows Saal et al (2007) research strategy. Given that we have no price information, we use distance functions to estimate the characteristics of multiple-output production technology.

The production technology can be fully described by the input distance function, which yields the deflation factor which must be applied to an observed input bundle *x* (a vector of *N* dimensions) in order to project it onto the efficient frontier of the input requirements set ($I^t(y)$). Thus, for the output vector *y* (a vector of *M* dimensions) at time *t*:

$$D_I(y, x, t) = \max\left\{\delta : \frac{x}{\delta} \in I^t(y), \delta > 0\right\} \quad (1)$$

The inverse of the input distance function is a measure of *Farrell input based efficiency* of the firm, being $\ln D_I \geq 0$ therefore the technical inefficiency of the firm.

The choice of an input distance function rather than an output distance function is driven by the nature of production and regulation in the water and sewerage industry in Chile. Measuring efficiency with an alternative output distance function implies the adoption of an output oriented approach in which efficiency is improved by increasing outputs given an exogenous input allocation. In contrast, measuring efficiency with an input distance function implies the adoption of an input oriented approach in which efficiency is improved by reducing input usage for a given exogenous output level. Considering that the providers have a statutory obligation to meet demand, it is appropriate to assume that outputs are exogenous and inputs are endogenous, rather than the converse. Coelli et al. (2005) argues that, in general, input distance functions are appropriate when firms have more control over inputs than outputs.

Important properties of the function $D_I(y,x,t)$ are that it is non-decreasing, linearly homogeneous and concave in inputs, and non-increasing and quasi-concave in outputs.

We choose a functional form that expresses the log-distance as a linear function of (transformations of) inputs and outputs. Although the Translogarithmic is more flexible to accommodate for an unknown technology, we choose the Cobb-Douglas functional form because the sample is very small and the former option would consume many degrees of freedom.

The function then becomes:

$$\ln D_{it}(y,x,t) = \alpha + \sum_{n=1}^{N} \beta_n \ln x_{nt} + \sum_{m=1}^{M} \gamma_m \ln y_{mt} + \delta t + v_{it} \quad (2)$$

Where $v_{it} \sim N(0, \sigma_{vi}^2)$ is a random error, introduced to account for approximation errors and other sources of statistical noise, and $\delta$ is the periodic contraction (or expansion) in the input vector.

This function is non-decreasing, linearly homogeneous and concave in inputs if $\beta_n \geq 0$ for all *n* and if:

$$\sum_{n=1}^{N} \beta_n = 1 \quad (3)$$

We impose the property of homogeneity of degree 1 in inputs, by deflating all but one of the inputs by the remaining input, and then re-arranging, so that the negative of that input is the dependent variable in the regression.

$$-\ln x_{Nit} = (\alpha + w_i) + \sum_{n \neq N} \beta_n \ln \tilde{x}_{nit} + \sum_{m=1}^{M} \gamma_m \ln y_{mt} + \sum_{m=1}^{M} \theta_k \ln z_{kit} + \delta t + v_{it} - u_{it} \quad (4)$$

where $\tilde{x}_{nit} \equiv (x_{nit}/x_{Nit})$, $u_{it}$ is a non-negative variable associated with technical inefficiency, and $u_{it} \sim N^+(0, \sigma_{ui}^2)$. In addition, $u_i$ and $v_{it}$ are independently distributed from each other and from the model's covariates.

The modeled function differs from the standard Cobb-Douglas approximation to the input distance in three important aspects.

First of all, it is enhanced by the addition of *k* exogenous operating characteristics, whose impact on input requirements is captured in the term $\theta_k$.

Secondly, in order to account for possible unobserved heterogeneity we introduce $w_i$ which is a firm specific effect obtained through the True Random Effect (TRE) method developed in Greene (2005). These random effects allow us to control for further factors influencing input requirements that have not been specifically controlled for in the model.

Thirdly, following Caudill & Ford (1993), Caudill et al. (1995) and Hadri (1999), we parametrize the variance of the pre-truncated inefficiency distribution in the following way:

$$u_i \sim N^+(0, \sigma_{u_i}^2) \quad (5)$$

$$\sigma_{u_i}^2 = \exp(h_i' \varphi) \quad (6)$$

Where $h_i$ is a variables vector related to the firm (including the intercept) and $\varphi$ is a vector of unknown parameters. Caudill & Ford (1993) finds that heteroscedasticity leads to overestimation of the intercept and underestimation of the slope coefficients.

We also extend the model by allowing the variance of the idiosyncratic error to be heteroscedastic. If the idiosyncratic error was heteroscedastic and we assumed the contrary, it would bias the efficiency estimates:

$$v_i \sim N^+(0, \sigma_{v_i}^2) \quad (9)$$

$$\sigma_{v_i}^2 = \exp(g_i' \rho) \quad (8)$$

Although our TRE model may appear to be the most flexible and parsimonious choice among the several existing time varying specifications, it can be argued that a portion of the time-invariant unobserved heterogeneity does belong to inefficiency or that these two components should not be disentangled at all. We employ a balanced panel of 18 providers with 9 years of data (2005-2013). Therefore, given our long panel data, it is difficult to argue that the random effects capture an estimated time invariant level of inefficiency. If this were the case, then our study would constitute a lower bound of inefficiency.

We acknowledge that using TRE we are not allowing for correlation between $w_i$ and the regressors. This problem could be solved estimating True Fixed Effects (TFE) or through Mundlak's (1978) correction. However, if some of the explanatory variables have a very low degree of within-group variability, the parameter vector is not estimated at all precisely: this is exactly what happens in our model, where the network related variables have minor variability. For this reason we have decided to discard TFE and estimated a TRE model, which is less reliant on the within variability of the regressors, and assumes zero correlation between $w_i$ and the regressors. Due to our small sample, Mundlak's (1978) correction was very difficult to implement because it consumed many degrees of freedom.

We therefore follow Greene (2005) and employ simulated maximum likelihood techniques to allow for firm specific random effects, while also allowing for a time varying inefficiency specification. The unknown parameters to be estimated are the $\alpha$, $\beta_n$, $\gamma_m$, $\theta_k$, $\delta$, as well as the variance terms of the composed error idiosyncratic and inefficiency components: $\sigma_v^2$, $\sigma_{ui}^2$ and $\varphi$. For estimation purposes, the last three parameters are not directly estimated, but instead the model is estimated using the re-parameterization $\sigma = \left(\sigma_v^2 + \sigma_{ui}^2\right)^{1/2}$, which is the standard deviation of the overall error variance, and $\lambda = \sigma_{ui}^2 / \sigma_v^2$ which has the advantage of being a useful indicator of the relative importance of inefficiency in the overall error variance.

## 4. Data

We built a database departing from SISS information. The Annual Reports are very complete and more information is disposable in the SISS webpage. In our database we have Non-Monetary and Monetary Variables. To the first set we did not apply any transformation, while to the second group we opted to express them in real terms, translating into “Unidades de Fomento” (UF), which is a widely used Chilean CPI indexed unit. In Table 1 we present the definition of each variable and its acronym, and in the Appendix we show the value of the UF at the end of each year.

**Table 1: Definition of the Variables**

| **Name** | **Non-Monetary Variables** | **Name** | **Monetary Variables** |
|---|---|---|---|
| FIRM | Abridged name of the firm | ROE | Return on equity |
| DMU | Firm-Year | ROA | Return on Assets |
| YEAR | Year | UF | "Unidad de Fomento" indexed unit of account |
| WATE | Water production in 000 m3 per month | OREV | Operational revenue in UF |
| CLIE | Clients | OCOS | Operational cost in UF |
| PERS | Personnel | EXPL | Exploitation result in UF |
| PERP | Personnel of the firm | NEXP | Non exploitation result in UF |
| PERO | Outsourced personnel | PROF | Profits in UF |
| NETT | Total network in km | INVE | Investments in UF |
| NETW | Water network in km | ASSE | Fixed Assets in UF |
| NETS | Sewerage network in km | INVO | Average invoice of 20 m3 per month in UF |
| UFWA | Unaccounted For Water | IASS | Investments on fixed assets |
| CONS | Average consumption per client in m3 | | |
| DENS | Density of clients on network km | | |
| OROC | Operational revenue/operational costs | | |

**Source: Author’s Own Elaboration**

In Table 2 we display the descriptive statistics of the variables used in the estimates. Our sample is a balanced panel with 162 observations along 9 years for 18 companies. There are other minor providers which started activities in very recent years. We decided not to include the latter for the sake of the balancing of the sample, taking into account also of the low importance of the new providers with respect to the size of the market.

**Table 2: Descriptive Statistics of the variables in the estimates**

| **Variable** | **Definition** | **Unit** | **Obs** | **Mean** | **Std. Dev.** | **Min** | **Max** |
|---|---|---|---|---|---|---|---|
| NETT | Total network | Km | 162 | 3,723 | 4,965 | 89 | 21,356 |
| PERS | Total personnel | number | 162 | 647 | 723 | 50 | 3,014 |
| CLIE | Clients | Number | 162 | 240,949 | 362,909 | 3,059 | 1,725,516 |
| WATE | Water production | 000 m3 per month | 162 | 84,238 | 135,290 | 1,565 | 626,589 |
| UFWA | Unaccounted for water | % | 162 | 0.323 | 0.116 | 0.064 | 0.554 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ROA | Return on Assets | % | 162 | 0.093 | 0.046 | (0.037) | 0.224 |
| INVE | Investments | UF | 162 | 432 | 732 | (1,267) | 5,637 |
| CONS | Average consumption | m3 per client | 162 | 26.9 | 28.9 | 13.1 | 156.0 |

**Source: Author's Own Elaboration**

In Table 3 we present the correlation of the variables used in the estimates. Outputs and inputs have positive and high correlation, as expected. Unaccounted For Water is positively correlated to inputs and outputs, but the level of the correlations is low.

**Table 3: Correlation matrix of the variables in the estimates**

| | NETT | PERS | CLIE | WATE | UFWA | ROA | INVE | CONS |
|---|---|---|---|---|---|---|---|---|
| NETT | 1.000 | | | | | | | |
| PERS | 0.975 | 1.000 | | | | | | |
| CLIE | 0.993 | 0.963 | 1.000 | | | | | |
| WATE | 0.974 | 0.929 | 0.990 | 1.000 | | | | |
| UFWA | 0.195 | 0.261 | 0.171 | 0.135 | 1.000 | | | |
| ROA | -0.032 | -0.036 | -0.014 | 0.004 | -0.073 | 1.000 | | |
| INVE | 0.718 | 0.702 | 0.727 | 0.699 | 0.163 | -0.080 | 1.000 | |
| CONS | -0.174 | -0.209 | -0.159 | -0.098 | -0.406 | -0.239 | -0.100 | 1.000 |

**Source: Author's Own Elaboration**

## 5. Empirical results and discussion

Based on a sample of 18 Chilean providers of water and sewerage for the period 2005-2013, we computed an input distance function through stochastic frontier analysis (SFA). We performed a True Random Effects to control for possible unobserved heterogeneity between providers. The estimated model is presented in Table 4.

**Table 4: Results**

| VARIABLES | LABELS | Coefficient | Standard Error |
|---|---|---|---|
| **Frontier** | | | |
| ln_PERS_r | Personnel | 0.043*** | (0.014) |
| ln_CLIE | Clients | -0.801*** | (0.021) |
| ln_WATE | Water production in 000 m3 per month | -0.124*** | (0.022) |
| T | group(YEAR) | 0.000 | (0.002) |
| UFWA | Agua No Fact | 0.257*** | (0.059) |
| ROA | ROA | 0.198** | (0.086) |
| ln_INVE | Investments | 0.008** | (0.004) |
| Constant | Constant | -0.212*** | (0.024) |
| **Usigma** | | | |
| T | group(YEAR) | -0.696** | (0.349) |
| Constant | Constant | -8.118*** | (1.243) |
| **Vsigma** | | | |
| ln_CONS | ln_CONS | 1.737*** | (0.298) |
| T | group(YEAR) | 0.075 | (0.215) |
| Constant | Constant | -6.965*** | (0.267) |
| **Theta** | | | |
| Constant | Constant | 0.165*** | (0.005) |
| | | | |

| | | | |
|---|---|---|---|
| Observations | | 157 | |
| Number of Firm | | 18 | |
| Standard errors in parentheses | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | |

**Source: Author's Own Elaboration**

We first consider $\beta_{PERS}$,and $\beta_{NETT}$ (coefficients for our proxies to labor and capital, respectively). The parameters reveal that the providers distance function input elasticities for personnel and network are respectively 0.043 and 0.957,[3] thereby accurately reflecting the relative input contribution shares of a capital intensive industry.

Focusing then on the output elasticities, Table 4 indicates that $\gamma_{CLIE}$ and $\gamma_{WATE}$ are negative and significantly different from zero, implying that the estimated distance function is decreasing in outputs. Thus, the model is well specified: increases in output vector shorten the distance function. The estimated returns to scale for the sample are 1.081 = 1 / (0.825+0.074), statistically different from one, thereby suggesting that the industry is characterized by increasing returns of scale. We acknowledge that Cobb-Douglas specification assumes that returns to scale are the same for the whole sample but even if it varied, the results show that on average there are scale opportunities to be exploited.

The coefficient associated to the time trend $\delta$ is statistically not significant and suggests that along the sample there were no technical change in the period under analysis.

Unaccounted For Water coefficient $\theta_{UFWA}$ is positive and statistically significant: increases in unaccounted for water leads to decreased input requirements. Its value suggests that costs associated with water loss detections, repairs and controls are more substantial than the costs of producing and distributing additional cubic meters of water. Reduction in 10 percent of unaccounted for water implies an increase of 2.6 percent in the input vector. This result is consistent with Garcia & Thomas (2001).

Return on assets coefficient $\theta_{ROA}$ is positive and statistically significant: increases in ROA decreases input requirements.

Although investments coefficient $\theta_{INVE}$ has a very low value, it is positive and statistically significant, meaning that increases in the level of investments would lead to decreasing input requirements. Specifically, if the investments were doubled, input requirement would shrink in 1 percent. This result suggests that there is a trade-off between investment and input requirement.

With regards to the idiosyncratic error, we used two arguments to explain it: the first one was the time trend (*t*) and the second one was the average consumption per client (ln_CONS). A negative coefficient $\rho_t$ would imply that along the years firms have become alike, but the time trend resulted statistically not significant so we cannot assess that providers became more alike. Average consumption attempts to capture the effect of bigger clients. Assuming that all residential clients consume more or less the same, having greater average consumptions implies ceteris paribus a greater share of industrial customers. The positive sign and statistically significance implies that increases in average consumption per client make providers less alike because they may require different input mixes. To provide water to industrial clients has to affect input usage and both go in opposite directions. On the one hand, it reduces input requirement because for the same output delivered less commercial effort (metering, billing, claims). This result is also found in Mizutani & Urakami (2001). On the other hand a bigger share of industrial clients might have a significant influence on sewerage treatment input requirements. Saal et al (2007) find that relatively greater industrial effluent treatment results in higher input requirements. Given that the idiosyncratic error was heteroscedastic, if we had assumed homoscedasticity, then the

[3] Since NETT has been used as a numeraire, the NETT elasticity can be recovered as $\beta_{NETT} = 1\text{-}\beta_{PERS.}$

inefficiency estimate would have been biased in favor of those providers with less industrial clients.

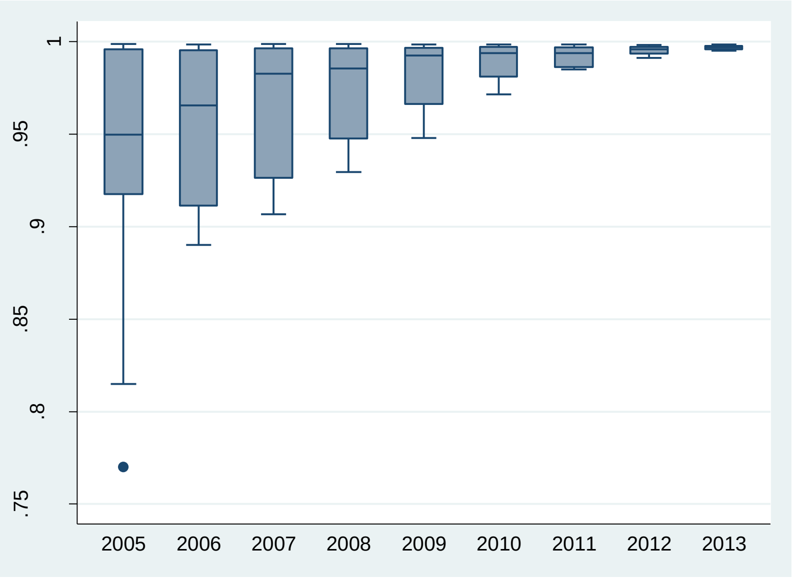
Although the time trend did not explain the idiosyncratic error, it is a very important argument to explain the inefficiency dispersion. As times goes by there has been a process of catch up. In order to make this point clearer, Table 5 provides Technical Efficiency Scores of each company in every year. The outer rows and columns account for average and standard deviations for years and providers, respectively. From the last rows it can be seen that in 2005 technical efficiency was 94.1 percent with a standard deviation of 6.5 percent and a minimum of 77 percent while in 2013 those numbers were 99..7 percent, 0.01 percent and 99.5 percent, respectively. This means that providers with lower efficiency rates improved their technical efficiency at a greater pace. Figure 1 graphically shows the catch up process.

**Table 5: Technical Efficiency Scores of each company in every year**

| Firm | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Mean | Std Dev |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Altiplano | 0.997 | 0.997 | 0.997 | 0.997 | 0.998 | 0.998 | 0.998 | 0.998 | 0.998 | **0.998** | **0.001** |
| Andinas | 0.994 | 0.994 | 0.995 | 0.995 | 0.995 | 0.996 | 0.997 | 0.997 | 0.998 | **0.996** | **0.001** |
| Antofagasta | 0.996 | 0.995 | 0.996 | 0.996 | 0.996 | 0.996 | 0.997 | 0.997 | 0.998 | **0.996** | **0.001** |
| Araucania | 0.942 | 0.952 | 0.960 | 0.979 | 0.988 | 0.993 | 0.994 | 0.996 | 0.997 | **0.978** | **0.021** |
| Aysen | 0.770 | 0.903 | 0.916 | 0.929 | | | 0.985 | | | **0.901** | **0.079** |
| Chacabuco | 0.999 | 0.999 | 0.999 | 0.999 | 0.998 | 0.998 | 0.998 | 0.998 | 0.998 | **0.998** | **0.001** |
| Chanar | 0.931 | 0.962 | 0.997 | 0.997 | 0.997 | 0.997 | 0.994 | 0.996 | 0.997 | **0.985** | **0.023** |
| Coopagua | 0.927 | 0.932 | 0.926 | 0.948 | 0.966 | 0.981 | 0.989 | 0.993 | 0.996 | **0.962** | **0.029** |
| Cordillera | 0.958 | 0.969 | 0.977 | 0.992 | 0.994 | 0.995 | 0.996 | 0.997 | 0.997 | **0.986** | **0.014** |
| Decima | 0.993 | 0.993 | 0.991 | 0.991 | 0.992 | 0.991 | 0.994 | 0.996 | 0.997 | **0.993** | **0.002** |
| DelValle | 0.929 | 0.893 | 0.907 | 0.930 | 0.948 | 0.971 | 0.986 | 0.993 | 0.996 | **0.950** | **0.038** |
| Essal | 0.900 | 0.911 | 0.918 | 0.945 | 0.948 | 0.971 | 0.986 | 0.991 | 0.995 | **0.952** | **0.036** |
| Essbio | 0.917 | 0.935 | 0.949 | 0.949 | 0.966 | | 0.986 | 0.993 | 0.996 | **0.961** | **0.029** |
| Esval | 0.998 | 0.997 | 0.996 | 0.996 | 0.997 | 0.997 | 0.997 | 0.997 | 0.998 | **0.997** | **0.001** |
| Magallanes | 0.914 | 0.902 | 0.920 | 0.935 | 0.954 | 0.973 | 0.986 | 0.993 | 0.995 | **0.953** | **0.036** |
| Manquehue | 0.815 | 0.890 | 0.943 | 0.967 | 0.981 | 0.988 | 0.992 | 0.995 | 0.996 | **0.952** | **0.062** |
| NuevoSur | 0.960 | 0.980 | 0.988 | 0.960 | 0.981 | 0.982 | 0.988 | 0.994 | 0.996 | **0.981** | **0.013** |
| Smapa | 0.998 | 0.998 | 0.998 | 0.998 | 0.998 | 0.998 | 0.998 | 0.998 | 0.998 | **0.998** | **0.000** |
| **Mean** | **0.941** | **0.956** | **0.965** | **0.972** | **0.982** | **0.989** | **0.992** | **0.995** | **0.997** | | |
| **Std Dev** | **0.065** | **0.041** | **0.035** | **0.027** | **0.018** | **0.010** | **0.005** | **0.002** | **0.001** | | |
| **Min** | **0.770** | **0.890** | **0.907** | **0.929** | **0.948** | **0.971** | **0.985** | **0.991** | **0.995** | | |
| **Max** | **0.999** | **0.999** | **0.999** | **0.999** | **0.998** | **0.998** | **0.998** | **0.998** | **0.998** | | |

**Source: Author's Own Elaboration**

**Figure 1: Technical Efficiency Catch Up Process**




## 6. Policy considerations

Table 6 shows the evolution of the coverage that 50 years ago was just half of the population in water and a quarter of it in sewerage, being currently universal in both services. In addition it have been achieved from 1990 onwards the universalization in wastewater treatment.

**Table 6: Evolution of coverage**

| Year | Drinking Water | Sewerage | Wastewater Treatment |
|---|---|---|---|
| 1965 | 53,5 | 25,4 | 0 |
| 1970 | 66,5 | 31,1 | 0 |
| 1975 | 77,4 | 43,5 | 0 |
| 1980 | 91,4 | 67,4 | 0 |
| 1985 | 95,2 | 75,1 | 0 |
| 1990 | 97,4 | 81,8 | 8,0 |
| 1995 | 98,6 | 89,4 | 14,0 |
| 2000 | 99,6 | 93,1 | 20,9 |
| 2013 | 99,8 | 96,1 | 100,0 |

**Source: Alé Yarad, 2013.**

With the “reference” or “model Company” in Chile, “efficient costs” are first determined and on that basis price caps are set. These are indexed automatically if the cost of an input bundle reaches a ceiling of 3 percent. If comparing with traditional Price Cap scheme (i.e. RPI-X), the differences are as follow:

Under RPI-X: P1 = P0 (as determined in the periodical tariff review)*(IPC-X)

In Chile: P1’ = P0' (as determined in basis of the “model Company”) * (Cost Index if > 3 percent accumulated)

The model has reached important goals in coverage (both drinking water and sewerage) and sewerage treatment. It has been criticized because tariffs had not decreased sufficiently over time and maintenance investments have not been enough to reduce water losses. Both assertions need more precision.

First, let us explain on tariffs. We prepare an index which could inform of the tariff variations. First we collect data on the 20 cubic meters a month invoice (that is more or less the average consumption per client, starting from 23 at the beginning of the period to almost 19 nowadays). Since in every operator there are different prices for two or more places, we selected the biggest city of each operator as representative (See in the Appendix the localities we choose). Then, we calculated the mean 20 cubic meters invoice in UF. Its cost was 0.93 in 2005, on average, and went to 0.84 in 2013. There are two additional considerations to make: first, there is a strong standard deviation (See the Appendix for details), since in some parts of the country water is very expensive because of the scarcity of the source (especially in the north which is a desert, but also in some places in the south). Second, we do not weight per number of clients, since the Metropolitan region accounts for one third of total population. Looking at the data, we took 2005 as the basis year and then in the last three years of the series a decreasing of the index in real terms can be appreciated. Comparing 2005 to 2013, our index of tariffs decreases 10 per cent in real terms.

Second, we calculate the mean of Unaccounted For Water. The average was 33 percent in 2005, decreasing to 31 percent in 2013. Again, there is high dispersion between operators and years, as it can be seen in Table 8. The average, since it is a simple arithmetic mean, is highly influenced by two observations of small companies (Coopagua and Manquehue) which reports very low losses. Also, we developed an index to express investments in a meaningful way to compare between periods (for the raw numbers, see the Appendix). On average, the number of 20 cubic meters invoices invested in each period by the companies in water was 30 thousand in 2005, and 33 thousand in 2013, but in the rest of the period was smaller than in both observations.

**Table 7: Evolution of Investments in Water, Unaccounted For Water and Tariffs at sector level**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|
| Mean Investment in Water / Fixed Assets | 16.12 % | 12.66 % | 7.98% | 6.97% | 6.29% | 18.23 % | 3.13% | 3.19% | 4.15% |
| Mean Unaccounted For Water | 32.95 % | 32.31 % | 33.11 % | 32.50 % | 32.75 % | 32.80 % | 32.27 % | 30.92 % | 31.00 % |
| Mean 20 cubic meter Invoices in UF | 0.93 | 0.91 | 0.87 | 0.90 | 0.90 | 0.95 | 0.86 | 0.86 | 0.84 |
| Standard Deviation 20 cubic meter Invoices in UF | 0.30 | 0.28 | 0.24 | 0.30 | 0.29 | 0.28 | 0.26 | 0.27 | 0.27 |
| Index 2005 = 100 Mean 20 cubic meter Invoice | 100.00 | 98.30 | 94.06 | 96.29 | 96.71 | 102.39 | 92.69 | 92.88 | 90.10 |
| Mean Number of 20 cubic meters Invoices Invested in Water | 30444 | 28292 | 11800 | 12161 | 17449 | 10705 | 20169 | 22981 | 33440 |

**Source: Author's Own Elaboration on SISS data**

In Table 8 we present the information in a slightly different way, by operator and splitting the mean into two periods: 2005-2013 and 2011-2013. The investment in water divided into fixed assets fell on average in the second period compared with the first. Recall that at the year 2000 complete coverage in water has been achieved (Table 6). If we conservatively suppose an average 50 year life length of the infrastructure, a 1 percent investment per year implies that we are replacing just half of the capital we lose. Unaccounted For Water is constant in many important operators, such as Andinas (Metropolitan Region). We also can see in Table 8 the evolution of the 20 cubic ceters Invoice. The more critical place is Antofagasta, where the invoice costs the same in both periods and is the most expensive in the country.

**Table 8: Evolution of Investment in Water/Fixed Assets, Unaccounted For Water and Average 20 cubic meters invoice**

| Operator | Mean Investment in Water / Fixed Assets 2005-13 | Mean Investment in Water / Fixed Assets 2011-13 | Mean Unaccounted For Water 2005-13 | Mean Unaccounted For Water 2011-13 | Average 20 cubic meters Invoice in UF 2005-2013 | Average 20 cubic meters Invoice in UF 2011-13 |
|---|---|---|---|---|---|---|
| Altiplano | 0.22 | 0.04 | 0.43 | 0.39 | 1.11 | 1.09 |
| Andinas | 0.01 | 0.02 | 0.31 | 0.31 | 0.59 | 0.56 |
| Antofagasta | 0.16 | 0.09 | 0.26 | 0.25 | 1.41 | 1.41 |
| Araucania | 0.06 | 0.03 | 0.45 | 0.44 | 0.83 | 0.75 |
| Aysen | 0.01 | 0.01 | 0.40 | 0.40 | 1.42 | 1.33 |
| Chanar | 0.15 | 0.11 | 0.39 | 0.34 | 0.94 | 0.81 |
| Coopagua | 0.04 | 0.01 | 0.13 | 0.13 | 0.98 | 1.04 |
| Cordillera | 0.04 | 0.01 | 0.26 | 0.20 | 0.60 | 0.56 |
| Decima | 0.03 | 0.03 | 0.21 | 0.20 | 0.93 | 0.91 |
| DelValle | 0.34 | 0.05 | 0.31 | 0.31 | 0.87 | 0.82 |
| Essal | 0.03 | 0.03 | 0.38 | 0.40 | 1.06 | 1.03 |
| Essbio | 0.03 | 0.04 | 0.37 | 0.36 | 0.72 | 0.69 |
| Esval | 0.03 | 0.02 | 0.42 | 0.42 | 0.95 | 0.91 |
| Magallanes | 0.05 | 0.01 | 0.15 | 0.16 | 1.12 | 1.07 |
| Manquehue | 0.10 | 0.05 | 0.10 | 0.11 | 0.73 | 0.71 |
| NuevoSur | 0.07 | 0.01 | 0.44 | 0.43 | 0.77 | 0.69 |
| Chacabuco | 0.07 | 0.02 | 0.36 | 0.35 | 0.54 | 0.50 |
| Smapa | 0.14 | 0.04 | 0.43 | 0.45 | 0.50 | 0.49 |

**Source: Author's Own Elaboration on SISS data**

What priorities could be assigned to the sector in the near future? Which regulatory options could we explore? One can think many of the former related with quality, environment, and the like. Maintenance of infrastructure is a priority and loss control a very important goal, after the remarkably results in coverage. Our econometric results shed some light: it will not be easy, since loss control is expensive in terms of investments. Then, we can imagine some responses to the second question: regulations could establish priority for the maintenance expenditures and water loss control goal, and to add some resources and duties to that aim. For example, we can take advantage of the results in terms of efficiency gains to establish an X-Factor which shares with the clients' part of those gains in form of lower prices. On the other hand, the obligation to meet certain maintenance expenditures and loss control achievements by means of a K factor which recognizes that increased costs, after determined the latter with a horizon to reduce losses at a reasonable pace.

In our view the tariff formula could adopt a form as:

P1' = P0' (as determined in basis of the "model Company") * [(Cost Index if > 3 percent accumulated) – X Factor (calculated as differences in efficiency scores from the best practice of the sample) + K Factor (to recognize the increased investments in maintenance and loss control).

## 7. Conclusions

Our objectives in n this paper studying technical efficiency of Chilean water and sanitation sector, are:

1) To determine comparative technical efficiency of the providers and its drivers.

2) To analyze the evolution of technical efficiency over time, exploring the possibility to trespass efficiency gains to consumers (X-Factor).

3) To determine a possible path to increase maintenance investments with the aim to reduce losses in the years to come (K-Factor).

Based on a sample of 18 Chilean providers of water and sewerage for the period 2005-2013, we computed an input distance function through stochastic frontier analysis (SFA). We performed a True Random Effects model to control for possible unobserved heterogeneity between providers.

We modeled the distribution of the efficiency and find that its dispersion is reducing over time. It seems a catch up process took place over the years. While there was no technical change at the sector as the whole level, the firms which achieved better results were the more lagged at the beginning.

We also modeled the error term and find that time was not important, implying that the firms did not became more similar, instead they depend on the type of clients they have. The higher the average consumption, more different are the operators, thus, to some of them not having a lot of non-residential clients could be detrimental.

High levels of Unaccounted For Water reduce the input requirements. This probably indicates the apparent lack of priority of control losses. Its coefficient suggests that costs associated with water loss detections, repairs and controls are more substantial than the costs of producing and distributing additional cubic meters of water. Reduction in 10 percent of unaccounted for water implies an increase of 2.6 percent in the input vector. Although investments coefficient has a very low value, it is positive and statistically significant, meaning that if the investments were doubled, input requirement would shrink in 1 percent.

The sector is highly intensive in capital, since labor contributes only in 4 percent. We find increasing returns to scale, although the functional form we employ does not allow us to explore its evolution along the time. Time trend is not significant, implying no technical change in the period, but we can observe a reduction in the technical inefficiency over the years.

What priorities could be assigned to the sector in the near future? Which regulatory options could we explore? We suggest that maintenance of infrastructure is a priority and water loss control a very important goal, after the remarkably results achieved in coverage. One regulatory response could be to establish priority for the former, and to add some resources and duties to that aim. For example, we can take advantage of the results in terms of efficiency gains to establish an X-Factor which shares with clients part of those gains in form of lower prices. On the other hand, the obligation to meet certain maintenance expenditures and loss control achievements by means of a K factor which recognizes that increased costs, after determined the latter with a horizon to reduce losses at a reasonable pace.

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## Appendix

**Table A1: Descriptive Statistics of Non-Monetary Variables**

| Statistic | YEAR | WATE | CLIE | PERS | PERP | PERO | NETT | NETW | NETS | UFWA | CONS | DENS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sum | 2005 | 1391316 | 3880195 | 9557 | 4323 | 5234 | 62941 | 34933 | 28008 | | | |
| Sum | 2006 | 1450357 | 3995456 | 10565 | 4552 | 6013 | 64172 | 35755 | 28417 | | | |
| Sum | 2007 | 1471692 | 4111945 | 11352 | 4797 | 6555 | 64876 | 36026 | 28850 | | | |
| Sum | 2008 | 1479457 | 4234530 | 11551 | 4920 | 6631 | 66528 | 36861 | 29667 | | | |
| Sum | 2009 | 1512272 | 4337183 | 11940 | 4936 | 7004 | 67028 | 37123 | 29905 | | | |
| Sum | 2010 | 1541580 | 4436177 | 12098 | 4924 | 7174 | 67944 | 37573 | 30371 | | | |
| Sum | 2011 | 1582610 | 4562372 | 12183 | 5016 | 7167 | 69139 | 38378 | 30760 | | | |
| Sum | 2012 | 1594149 | 4673005 | 12608 | 5198 | 7410 | 69865 | 38719 | 31146 | | | |
| Sum | 2013 | 1623091 | 4802945 | 13013 | 5472 | 7541 | 70673 | 39168 | 31504 | | | |
| Std Dev | 2005 | 128283 | 332115 | 668 | 266 | 405 | 4819 | 2684 | 2137 | 0.13 | 38 | 33 |
| Mean | 2005 | 77295 | 215566 | 531 | 240 | 291 | 3497 | 1941 | 1556 | 0.33 | 32 | 122 |
| Mean | 2006 | 80575 | 221970 | 587 | 253 | 334 | 3565 | 1986 | 1579 | 0.32 | 32 | 124 |
| Mean | 2007 | 81761 | 228441 | 631 | 267 | 364 | 3604 | 2001 | 1603 | 0.33 | 32 | 125 |
| Mean | 2008 | 82192 | 235252 | 642 | 273 | 368 | 3696 | 2048 | 1648 | 0.33 | 25 | 125 |
| Mean | 2009 | 84015 | 240955 | 663 | 274 | 389 | 3724 | 2062 | 1661 | 0.33 | 25 | 127 |
| Mean | 2010 | 85643 | 246454 | 672 | 274 | 399 | 3775 | 2087 | 1687 | 0.33 | 25 | 128 |
| Mean | 2011 | 87923 | 253465 | 677 | 279 | 398 | 3841 | 2132 | 1709 | 0.32 | 24 | 130 |
| Mean | 2012 | 88564 | 259611 | 700 | 289 | 412 | 3881 | 2151 | 1730 | 0.31 | 24 | 130 |
| Mean | 2013 | 90172 | 266830 | 723 | 304 | 419 | 3926 | 2176 | 1750 | 0.31 | 24 | 132 |
| Std Dev | 2006 | 135693 | 342010 | 667 | 282 | 402 | 4952 | 2781 | 2172 | 0.12 | 40 | 31 |
| Std Dev | 2007 | 136430 | 352355 | 735 | 288 | 463 | 5012 | 2814 | 2200 | 0.12 | 39 | 32 |
| Std Dev | 2008 | 135246 | 362141 | 739 | 296 | 468 | 5085 | 2851 | 2235 | 0.12 | 25 | 33 |
| Std Dev | 2009 | 137985 | 370485 | 752 | 298 | 486 | 5093 | 2850 | 2245 | 0.12 | 24 | 33 |
| Std Dev | 2010 | 140994 | 377430 | 762 | 291 | 502 | 5138 | 2871 | 2268 | 0.12 | 24 | 34 |
| Std Dev | 2011 | 144665 | 391211 | 757 | 287 | 500 | 5189 | 2901 | 2289 | 0.12 | 22 | 35 |
| Std Dev | 2012 | 142863 | 399787 | 775 | 294 | 512 | 5238 | 2926 | 2312 | 0.11 | 20 | 34 |
| Std Dev | 2013 | 145478 | 411835 | 792 | 306 | 518 | 5279 | 2949 | 2331 | 0.11 | 21 | 33 |

**Source: Author's Own Elaboration on SISS data**

**Table A2: Descriptive Statistics of Non-Monetary Variables**

| Statistic | YEAR | OROC | ROE | ROA | OREV | OCOS | EXPL | NEXP | PROF | INVE | ASSE | INVO | IASS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sum | 2005 | | | | 28808 | 16467 | 12337 | -627 | 10307 | 8241 | 82164 | | |
| Sum | 2006 | | | | 30248 | 17135 | 13051 | -678 | 10493 | 9467 | 88849 | | |
| Sum | 2007 | | | | 31279 | 17884 | 13386 | 186 | 11386 | 5977 | 91741 | | |
| Sum | 2008 | | | | 32745 | 19124 | 13615 | -515 | 10883 | 6270 | 95593 | | |
| Sum | 2009 | | | | 34456 | 20016 | 14432 | 42 | 12474 | 7339 | 130990 | | |
| Sum | 2010 | | | | 34039 | 20364 | 13717 | -1954 | 10109 | 5199 | 118573 | | |
| Sum | 2011 | | | | 34466 | 20587 | 13935 | -2221 | 9825 | 9771 | 149647 | | |
| Sum | 2012 | | | | 37982 | 22437 | 15533 | -2292 | 12116 | 7880 | 163357 | | |
| Sum | 2013 | | | | 39159 | 24138 | 15083 | -1651 | 11312 | 9818 | 163629 | | |
| Mean | 2005 | 1.67 | 0.16 | 0.10 | 1600 | 915 | 685 | -35 | 573 | 458 | 4565 | 0.84 | 0.27 |
| Mean | 2006 | 1.68 | 0.16 | 0.10 | 1680 | 952 | 725 | -38 | 583 | 526 | 4936 | 0.86 | 0.26 |
| Mean | 2007 | 1.68 | 0.15 | 0.10 | 1738 | 994 | 744 | 10 | 633 | 332 | 5097 | 0.86 | 0.16 |
| Mean | 2008 | 1.61 | 0.12 | 0.09 | 1819 | 1062 | 756 | -29 | 605 | 348 | 5311 | 0.95 | 0.14 |
| Mean | 2009 | 1.62 | 0.15 | 0.09 | 1914 | 1112 | 802 | 2 | 693 | 408 | 7277 | 0.90 | 0.08 |
| Mean | 2010 | 1.55 | 0.12 | 0.09 | 1891 | 1131 | 762 | -109 | 562 | 289 | 6587 | 0.90 | 0.36 |
| Mean | 2011 | 1.57 | 0.12 | 0.09 | 1915 | 1144 | 774 | -123 | 546 | 543 | 8314 | 0.87 | 0.05 |
| Mean | 2012 | 1.56 | 0.12 | 0.09 | 2110 | 1247 | 863 | -127 | 673 | 438 | 9075 | 0.91 | 0.04 |
| Mean | 2013 | 1.53 | 0.11 | 0.08 | 2175 | 1341 | 838 | -92 | 628 | 545 | 9090 | 0.93 | 0.06 |
| Std Dev | 2005 | 0.26 | 0.08 | 0.04 | 2371 | 1258 | 1122 | 102 | 1003 | 679 | 8225 | 0.30 | 0.26 |
| Std Dev | 2006 | 0.27 | 0.08 | 0.04 | 2482 | 1289 | 1204 | 125 | 1062 | 679 | 8333 | 0.28 | 0.24 |
| Std Dev | 2007 | 0.24 | 0.07 | 0.05 | 2490 | 1310 | 1191 | 195 | 1131 | 348 | 8364 | 0.24 | 0.11 |
| Std Dev | 2008 | 0.30 | 0.07 | 0.05 | 2603 | 1339 | 1288 | 171 | 1167 | 402 | 8543 | 0.30 | 0.13 |
| Std Dev | 2009 | 0.37 | 0.09 | 0.05 | 2721 | 1363 | 1388 | 249 | 1349 | 671 | 13189 | 0.29 | 0.15 |
| Std Dev | 2010 | 0.29 | 0.07 | 0.05 | 2703 | 1374 | 1356 | 181 | 1109 | 747 | 12905 | 0.28 | 0.86 |
| Std Dev | 2011 | 0.29 | 0.09 | 0.05 | 2747 | 1380 | 1415 | 210 | 1107 | 1314 | 13204 | 0.26 | 0.04 |
| Std Dev | 2012 | 0.28 | 0.07 | 0.04 | 2942 | 1453 | 1540 | 238 | 1210 | 750 | 13481 | 0.27 | 0.07 |
| Std Dev | 2013 | 0.31 | 0.07 | 0.05 | 3003 | 1610 | 1433 | 172 | 1140 | 700 | 13529 | 0.27 | 0.06 |

**Source: Author’s Own Elaboration on SISS data**

**Table A3: Decomposition of Investments**

| Year | Investment in Water (UF) | Investment in Sewerage (UF) | Investment in Treatment (UF) | Other Investments (UF) | Fixed Assets (UF) | Total Investments (UF) |
|---|---|---|---|---|---|---|
| 2013 | 6099 | 1103 | 1403 | 1213 | 163629 | 9818 |
| 2012 | 3916 | 2847 | 769 | 348 | 163357 | 7880 |
| 2011 | 3377 | 1322 | 5287 | 317 | 149647 | 9771 |
| 2010 | 1851 | 885 | 2364 | 102 | 118573 | 5199 |
| 2009 | 2856 | 3063 | 1186 | 234 | 130990 | 7339 |
| 2008 | 2348 | 2357 | 949 | 565 | 95593 | 6270 |
| 2007 | 2114 | 929 | 881 | 1133 | 91741 | 5977 |
| 2006 | 4492 | 4513 | 461 | 0 | 88849 | 9467 |
| 2005 | 4242 | 2841 | 1158 | 0 | 82164 | 8241 |
| TOTAL | 31296 | 19859 | 14458 | 3912 | | 69962 |
| **Year** | **Investment in Water as a Percentage of Fixed Assets** | **Investment in Sewerage as a Percentage of Fixed Assets** | **Investment in Treatment as a Percentage of Fixed Assets** | **Other Investments as a Percentage of Fixed Assets** | **Fixed Assets as a Percentage of Fixed Assets** | **Total Investments as a Percentage of Fixed Assets** |
| 2013 | 3.73% | 0.67% | 0.86% | 0.74% | 100.00% | 6.00% |
| 2012 | 2.40% | 1.74% | 0.47% | 0.21% | 100.00% | 4.82% |
| 2011 | 2.26% | 0.88% | 3.53% | 0.21% | 100.00% | 6.53% |
| 2010 | 1.56% | 0.75% | 1.99% | 0.09% | 100.00% | 4.38% |
| 2009 | 2.18% | 2.34% | 0.91% | 0.18% | 100.00% | 5.60% |
| 2008 | 2.46% | 2.47% | 0.99% | 0.59% | 100.00% | 6.56% |
| 2007 | 2.30% | 1.01% | 0.96% | 1.23% | 100.00% | 6.51% |
| 2006 | 5.06% | 5.08% | 0.52% | 0.00% | 100.00% | 10.66% |
| 2005 | 5.16% | 3.46% | 1.41% | 0.00% | 100.00% | 10.03% |
| | **Investment in Water as a Percentage of Total Investments** | **Investment in Sewerage as a Percentage of Total Investments** | **Investment in Treatment as a Percentage of Total Investments** | **Other Investments as a Percentage of Total Investments** | **Total Investments** | |
| 2013 | 62.12% | 11.23% | 14.29% | 12.35% | 100.00% | |
| 2012 | 49.70% | 36.12% | 9.76% | 4.42% | 100.00% | |
| 2011 | 34.56% | 13.53% | 54.11% | 3.25% | 100.00% | |
| 2010 | 35.60% | 17.02% | 45.46% | 1.96% | 100.00% | |
| 2009 | 38.92% | 41.73% | 16.17% | 3.19% | 100.00% | |
| 2008 | 37.45% | 37.60% | 15.14% | 9.01% | 100.00% | |
| 2007 | 35.38% | 15.55% | 14.73% | 18.95% | 100.00% | |
| 2006 | 47.45% | 47.67% | 4.87% | 0.00% | 100.00% | |
| 2005 | 51.47% | 34.47% | 14.05% | 0.00% | 100.00% | |

**Source: Author's Own Elaboration on SISS data**

| Firm | Locality |
|---|---|
| Altiplano | Iquique |
| Andinas | Gran Santiago |
| Antofagasta | Antofagasta |
| Araucania | Temuco |
| Aysen | Coyhaique |
| Chanar | Copiapo |
| Coopagua | Santo Domingo |
| Cordillera | Aguas Cordillera |
| Decima | Valdivia |
| DelValle | La Serena |
| Essal | Puerto Montt |
| Essbio | Concepcion |
| Esval | Valparaiso |
| Magallanes | Punta Arenas |
| Manquehue | Santa Maria de Manquehue |
| NuevoSur | Curico |
| Chacabuco | Colina Esmeralda |
| Smapa | Maipú |

| Year | 1 UF = $ |
|---|---|
| 2005 | 17975.97 |
| 2006 | 18336.38 |
| 2007 | 19622.66 |
| 2008 | 21453.00 |
| 2009 | 20943.00 |
| 2010 | 21455.55 |
| 2011 | 22994.00 |
| 2012 | 22841.00 |
| 2013 | 22841.00 |