



## **CENTRUM Católica's Working Paper Series**

**No. 2015-11-0021 / November 2015**

### **Benchmarking the Efficiency of Public Water Companies in Peru: A Conditional DEA Approach**

Guillermo Díaz

**CENTRUM Católica Graduate Business School  
Pontificia Universidad Católica del Perú**

Working papers are in draft form. This working paper is distributed for purposes of comment and discussion only. It may not be reproduced without permission of the author(s).

# Benchmarking the Efficiency of Public Water Companies in Peru: A Conditional DEA Approach

Guillermo Díaz\*<sup>1</sup>

<sup>1</sup>CENTRUM Católica Graduate Business School, PUCP, Lima, Perú

## Abstract

Benchmarking has been suggested as a useful regulatory tool for water companies in both developed and developing countries, specially due to the predominance of public firms in these sectors. However, in order to be effective, the comparisons should reflect differences in the firms' performances, rather than capture differences in their operating contexts. In this paper I apply a conditional data envelopment analysis (DEA) benchmarking technique that specifically controls for this, i.e., the conditional DEA approach. As a result, I find that conditioning on the population density in each firm's area of operation affect the estimated efficiencies in a significant way. The results are consistent with previous findings in other countries (which use different methodologies), and are new in the case of Peru.

## 1 Introduction

Providing incentives for the efficient performance of water companies in developing countries is a complex issue, not least because of the prevalence of state-owned companies in these sectors. While the theoretical incentive regulation literature has largely focused on profit-maximizing firms, empirical studies have simultaneously shown evidence that would contradict this behavioral paradigm in the case of government-owned firms.<sup>1</sup>

The empirical evidence in the water sector, however, points to a slow productivity growth in most instances, irrespectively of the ownership configuration. For example, Saal et al. (2007) found increased technical change in the UK in the years following the privatization, but, also, equally significant efficiency losses in the newly-privatized water and sewerage companies, summing up to a non-existent net effect.<sup>2</sup> In the case of Peru, where the companies have not been

---

\*Jr. Daniel Alomía Robles 125, Santiago de Surco, Lima, Perú. T: +(51 1) 626-7100, Ext. 7185. E-mail: jgdiazg@pucp.pe

<sup>1</sup>For example, Dewenter and Malatesta (2001), studying a very heterogeneous sample of firms in several sectors, find that government-owned firms are significantly less profitable than private firms, and tend to be more labor intensive. On the other hand, Seim and Waldfogel (2013), in study about of liquor retail stores, conclude that the behaviour of the public monopoly is best rationalized as "profit maximization with profit sharing".

<sup>2</sup>Portela et al. (2011) extended the analysis for the period 1993-2007, and even finds a *decline* in productivity starting in 2005.

privatized, Lin and Berg (2008) did find some productivity growth in the period 1998-2002 (mostly from technical change, no efficiency gains), but very modest.<sup>3</sup>

Therefore, the question of how to provide incentives for efficient performance to public companies remains open. One common approach taken by the regulatory agencies, as in Peru, has been the use of publicly benchmarking the companies in the sector, with the hope that the public pressure from stakeholders provide the incentives for efficient performance. In fact, in the case of Netherlands, De Witte and Saal (2010) found a positive effects on prices and efficiency from this simple approach, named as “sunshine regulation” by the authors.

The objective of this study is to contribute to this literature by proposing a method, within the DEA framework, to benchmark the productive efficiency of the firms in the Peruvian water sector, but taking into account the heterogeneity in the operating context that the companies face. As suggested by Berg and Lin (2008), “to be of use to regulators (...), and to be accepted by other stakeholders, performance comparisons must be robust to promote confidence that the performance rankings do indeed reflect managerial skill rather than accidents of geography or history” (p. 794). Although DEA as a benchmarking technique has been proposed and implemented in previous studies (Berg and Lin, 2008; Lin, 2005), these studies did not take into account the heterogeneity in the firms’ operating contexts.

In the context of input-oriented efficiency analysis, this means that input usage requirements can be different in different operating contexts. For example, in cities with low population density, the amount of inputs (i.e., length of water network) required to reach a certain output level can be higher than in more highly densely populated areas. In this sense, the ideal would be to perform the comparison conditional on having relatively similar levels of population density. This is precisely the objective of the conditional DEA method, proposed in Daraio and Simar (2005). In order to keep the practical applicability at a simple level, this method is applied within a deterministic DEA approach.<sup>4</sup>

The previous literature in the Peruvian case suggest the importance of the contextual (also called “environmental”) heterogeneity, beyond the control of the firms, to partially explain differences in performance. Corton (2003), for example, shows that the number of districts in the area of operation and the natural region where the firm is located are statistically significant to explain the variation in operating costs (controlling for length of mains).

The concern in controlling for the heterogeneity of the operating context is shared with studies about other countries. For example, Tupper and Resende (2004) proposed a regression-based method to clean the effect of contextual variables on the estimated efficiencies (they take away the variation explained by the contextual variables, using a Tobit regression model), and applied it to the water sector in Brazil. The main difference between their methods and the ones applied here is that the conditional DEA methodology does not impose parametric constraints on the relation between the contextual variable and the unconditional DEA estimated efficiencies.

In regards to the empirical evidence in developed countries, De Witte and Saal (2010) applied the method proposed in this study for the Dutch case, but under an stochastic DEA framework. They also found important to condition the DEA estimates on the population density. Similarly, Vidoli (2011) applied a novel nonparametric method to evaluate the dependency of the efficiency estimates on contextual variables in the Italian case, and finds a predominant role to the population density.

---

<sup>3</sup>Also, Estache et al. (2005) concludes that there is scant evidence of any differential overall performance between public and private operators in the water sector, after surveying productivity studies in developing countries.

<sup>4</sup>Berg and Lin (2008) show that deterministic DEA can be considered a robust benchmarking technique in the Peruvian case, by showing that the performance rankings produced with this technique are not too dissimilar to those produced with stochastic DEA techniques, theoretically more robust to outlier observations.

The remaining of the paper is organized as follow: Section 2 briefly describes the main institutional features of the water industry in Peru, Section 3 describes the benchmarking methodologies applied, Section 5 describes the details of the model specification, as well as the main features of the data at hand, Section 5 presents the main results, and Section 6 concludes.

## 2 The Water Sector in Peru

The water and sewage sectors in Peru are a decentralized system, formed by the municipality-owned companies that are under the supervision of SUNASS (Superintendencia Nacional de Servicios de Saneamiento), the agency in charge of regulating the operation of the firms in the sector.

Starting in 1999, SUNASS established a benchmark system to evaluate the performance of the companies under its supervision. This system was based, originally, on nine indicators, grouped into four areas:<sup>5</sup> quality, coverage, management efficiency, and managerial finance efficiency. The indicators are expressed as a percentage, and averaged (with equal weight). Finally, the firms are ranked according to the score obtained within four groups, determined by the number of connections (small, with less than 10,000 connections; medium, with between 10,000 and 40,000 connections; and big, with more than 40,000 connections). See the results of the benchmarking for 2013 in Table 3, in Appendix A.

Berg and Lin (2008) evaluate the consistency of SUNASS's benchmarking method, in comparison to other frequently-used methodologies, such as regression, DEA (deterministic and stochastic), and stochastic frontier. The advantage of the alternative methodologies is that, generally, they consider the role of each indicator as either input, output, or "contextual" variable - that is, variables that characterize the operating environment of the firm, i.e., (1) they are outside the control of the firm, and (2) affect either input usage, or output production.<sup>6</sup>

Given the above discussion, unsurprisingly, the study found that the DEA and SFA-based methods generally produce consistent rankings, differently to those of the SUNASS and regression methods. In particular, the authors trace the major differences between methodologies that acknowledge input-output causality relations and SUNASS's simple benchmarking methodology in units that, although show low output levels, also show low input usage. These units would obtain low scores by definition under the simple average of SUNASS's indicators. The optimization-based techniques, on the other hand, would recognize that some of this output performance might be explained by the low availability of inputs.

I extend the deterministic DEA methodology used in the previous study, by incorporating the influence of the firms' context of operation. In particular, I consider the influence of the population density, given the extensively documented economies of density present in the sector - see De Witte and Saal (2010), Vidoli (2011).

## 3 Methodology

Consider a vector of inputs,  $X \in \mathbb{R}^p$ , used to produce a vector of outputs,  $Y \in \mathbb{R}^q$ . Then, the production set is defined as:  $\Psi = \{(x, y) | x \text{ can produce } y\}$ . In this context, the Farrell's radial input efficiency measure for a DMU using input vector  $x$  to produce output  $y$  can be defined

---

<sup>5</sup>The number of indicators has risen in recent years, so that, for example, thirteen indicators were used in the 2013 benchmarking exercise.

<sup>6</sup>Besides the previously referenced studies, see also Thanassoulis (2000), for a review of the use of DEA techniques in the regulation of water companies in the UK.

as:

$$\theta(x, y) \equiv \inf\{\theta | (\theta x, y) \in \Psi\}$$

This is an input-oriented efficiency measure: it calculates the maximum proportional (i.e., radial) decrease in input usage,  $\theta$ , that is technically feasible while keeping the production vector  $y$  constant.

DEA is an empirical way to assess the Farrell input efficiency of a firm, relative to the observed performance of a group of comparable firms, or peers. That is, DEA takes all the units' input and output combinations and use them to form an empirical set of production possibilities,  $\hat{\Psi}$ . This set reveals what combinations of inputs and outputs are possible, *given the observed input-output combinations of the real units* (plus additional assumptions specified below). Given that it assess the unit's efficiency based on the observed performance the firm's peers, DEA can be seen as a benchmarking tool.

To be more concrete, consider the following typical assumptions for the empirical production possibilities set,  $\hat{\Psi}$ , under the DEA approach:

- Convexity: given two observed input-output configurations, any linear combination of them also belongs to  $\hat{\Psi}$ .
- Free disposal: given an input-output configuration in  $\hat{\Psi}$ , any other configuration with either lower output or higher input also belongs to  $\hat{\Psi}$ .
- Constant (CRS) or variable (VRS) returns to scale: under CRS any input-output configuration in  $\hat{\Psi}$  is scalable, that is, it can be implemented any number of times. Under VRS, this is not the case.

Now consider a group of decision-making units (DMUs),  $j = 1, \dots, J$ . Under the previous assumptions, the CRS and VRS empirical production possibilities can be determined in reference to the observed performance of all the units in the group, as follows:

$$\hat{\Psi}^{CRS} = \{(x, y) \in \mathbb{R}_+^{M+P} \mid x \leq \sum_{j \in J} \lambda_j x_j, y \geq \sum_{j \in J} \lambda_j y_j, \lambda_j \geq 0, \forall j \in J\}$$

$$\hat{\Psi}^{VRS} = \{(x, y) \in \mathbb{R}_+^{M+P} \mid x \leq \sum_{j \in J} \lambda_j x_j, y \geq \sum_{j \in J} \lambda_j y_j, \sum_{j \in J} \lambda_j = 1, \lambda_j \geq 0, \forall j \in J\}$$

Then, the DEA input usage efficiency can be calculated by applying Farrell's efficiency definition to any of these production possibilities sets (under the CRS or VRS assumption, respectively). For example, under the VRS assumption, a firm  $i$  with observed input-output configuration  $(x_i, y_i)$  has an input usage efficiency of:

$$\theta_i^{VRS} \equiv \theta^{VRS}(x_i, y_i) = \inf\{\theta | (\theta x_i, y_i) \in \hat{\Psi}^{VRS}\}$$

For example, if  $\theta_i^{VRS} = 0.7$ , it would mean that DMU  $i$  could reduce its inputs usage by up to 30% (in every input dimension), and still be able to produce the same output vector  $y_i$ . A fully input efficient unit would have  $\theta^{VRS} = 1$  (no proportional input reduction is possible). This would mean that there is no other unit in the sample (or linear combination of them) that produces the same level of output, with a lower amount of inputs. As can be seen, this is a *relative* measure of efficiency because it defines efficient performance based on the observed performance of other units, not up to an ideal or absolute standard of efficiency.

Notice that the previous definition considers all the units as comparable. However, what if the contexts in which the units operate are *too* different? In the case of water distribution, it could be very different to provide the service in cities with different population densities.

Arguably, it could be much less input-demanding to increase the coverage of the service in cities with higher population density. More generally, consider a *contextual* variable  $Z$ , that captures this diversity. One would want to compare cities with relatively similar values of this variable. Consider a firm  $i$ , with input-output configuration  $(x_i, y_i)$  and contextual variable  $z_i$ . We can define a production possibilities set, conditional on the value of its contextual variable  $z_i$  (I only present the CRS case for brevity):

$$\hat{\Psi}^{CRS}(z_i) = \{(x, y) \mid x \leq \sum_{j \in J} \lambda_j x_j, y \geq \sum_{j \in J} \lambda_j y_j, \lambda_j \geq 0, \\ \forall j \in J \text{ such that } z_i - h \leq z_j \leq z_i + h\}$$

In this definition, the comparison set for unit  $i$  is formed following a similar procedure as before, but now considering only the units (indexed as  $j$ ) that have a value  $z_j$  within a distance  $h$  of  $z_i$ . That is, the comparison group here considers units with a relatively similar value of  $z$  (the similarity is controlled by appropriately choosing the bandwidth parameter,  $h$ ). Following Daraio and Simar (2005), we denote this as a *conditional* DEA efficiency index.

## 4 Model Specification and Data

I study the performance of 43 firms from 2006 to 2013, which is the full set of firms operating in the sector with the exception of the firm operating in the capital city, SEDAPAL, and a few small companies (due to missing data). This firm is excluded because its operating environment is radically different from the rest of the country: it serves almost 1.4 million active connections, compared to an average of 38 thousand for the firms in other cities. Given that having such a different observation in the sample may distort the performance comparisons, it is therefore excluded.

In order to deal with the panel data structure, I pool the information for all the years and calculate a single efficient frontier. In this way, the observed performance of every unit is compared to a single benchmark, which is intended to be formed by the best observed performances along all the years in the sample. With this practice I follow Estache et al. (2004) in their study of electric utilities in South America, as well as previous studies about the Peruvian water sector specifically, such as Berg and Lin (2008).

I also follow the last study, as well as the applied literature in the sector and in this industry in particular (Corton, 2003; Lin, 2005), to specify the inputs and outputs of the production model. The list of inputs includes the operating costs, the number of employees and the total length of the distribution network. The operating costs are used as a proxy for the use of intermediate inputs in the production and delivery process, while the number of employees measure the amount of labor (given the absence of more precise measures of labor input usage), and the length of the distribution network proxies the amount of the capital input utilized (given the usual problems in measuring capital).

Regarding the outputs, the list include the total amount of water billed, the coverage ratio, and the degree of continuity of the service. This intends to capture not only output, but also quality dimensions (Lin, 2005; Picazo-Tadeo et al., 2008). For example, the amount of water billed indirectly measures a (negative) dimension of quality, such as the amount of water losses in the network. This problem is regarded as highly relevant in the Peruvian case (Berg and Lin, 2008) - e.g., by 2013 only around 65% of the water produced was actually billed, in average for all operators.

The other two variables included as outputs, the coverage and continuity of the service provision, can be seen as fully quality indicators. As shown in Lin (2005) (a benchmarking study, in the stochastic frontier analysis framework), these variables seem to have a significant

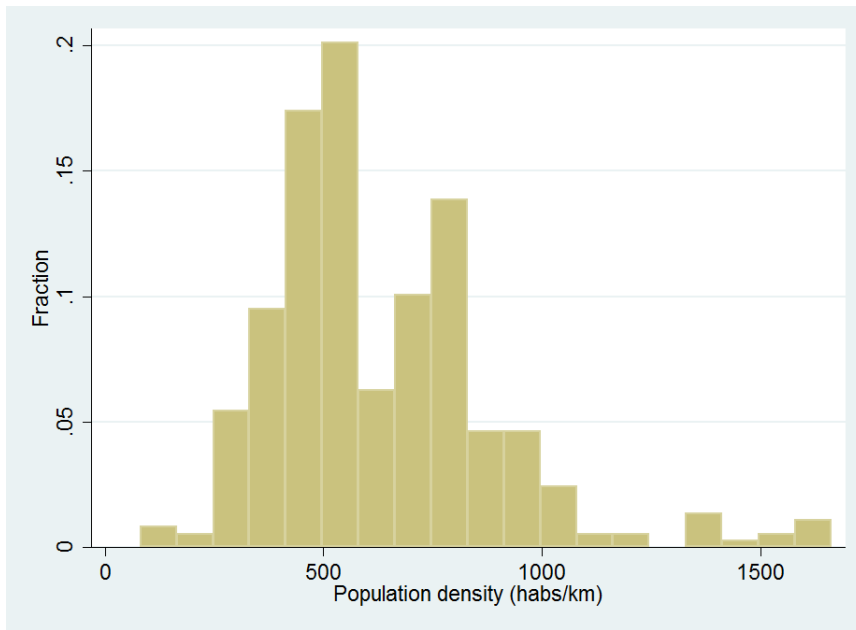


Figure 1: Histogram of Population Density

incidence on the firms' operating cost efficiencies in this sector. I consider, therefore, fruitful to include them also as determinants of productive efficiency. The coverage is calculated as the ratio between the estimated population served by the operator, and the total amount of population within the area of service. Continuity is measured as the average number of hours that the service is operating on a daily basis.

Table 1: Summary Statistics

|                                  | Mean     | St. Dev. | Min    | Max      |
|----------------------------------|----------|----------|--------|----------|
| <b>Outputs</b>                   |          |          |        |          |
| Water Billed (m3)                | 7766287  | 9067781  | 348231 | 44531840 |
| Coverage (%)                     | 83       | 12       | 29     | 100      |
| Continuity (hs/day)              | 15       | 6        | 0      | 24       |
| <b>Inputs</b>                    |          |          |        |          |
| Operating costs (S/.)            | 11275086 | 16503797 | 260677 | 92253000 |
| Workers                          | 132      | 144      | 2      | 740      |
| Total water network length (kms) | 336      | 388      | 28     | 2044     |
| <b>Context</b>                   |          |          |        |          |
| Population density (habs/km)     | 627      | 255      | 82     | 1662     |

Table 1 shows the summary statistics of the aforementioned variables. Notice that there is still a considerable degree of heterogeneity left in the sample, in spite of having excluded the operator in Lima and those with a high degree of missing information (mostly very small networks). In particular, the population density (our proposed determinant of the operating context) has a big range of variation, from 82 to 1662 inhabitants by kilometer of water network. Figure 1 shows an histogram for this variable, which illustrates the high heterogeneity present in the sample. This suggests that the differing contexts could be relevant to explain part of the observed operating performance.

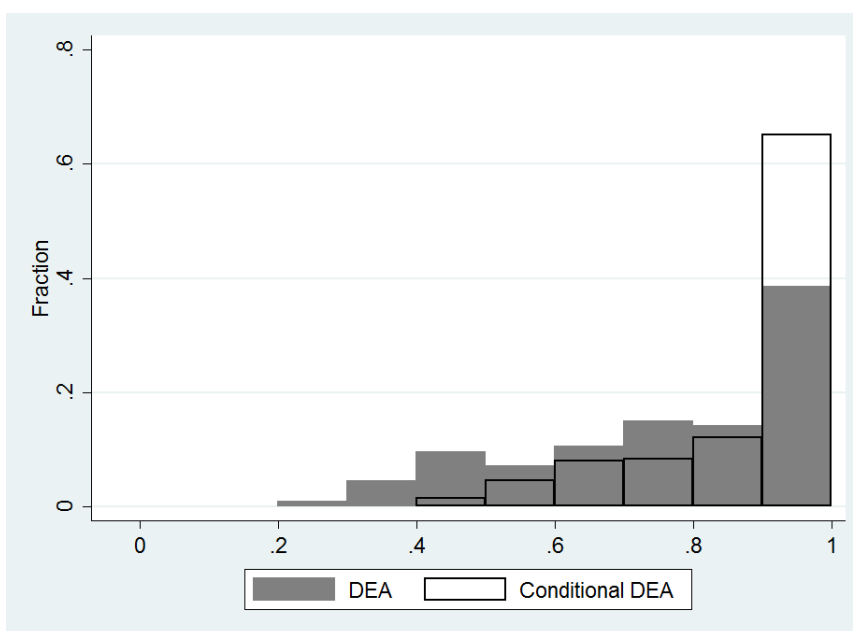


Figure 2: Histogram of DEA Efficiency Scores (VRS)

## 5 Results

The Table 2, and Figures 2 and 3, show the statistics and histograms, respectively, of the DEA efficiency scores calculated under the VRS and CRS assumptions - the detailed results for every firm in every year are shown in Tables 4 and 6 in Appendix A. It is important to remember at this point that the efficiency assessments are *relative*: a fully efficient firm under this approach (i.e., with an efficiency score of 1) does not necessarily mean that the firm is technically fully efficient, but only than its performance is the best of the pool of firms under evaluation.

The distribution of the unconditional efficiency scores in both, the VRS and CRS cases, show an ample variability (particularly in the CRS case, as expected). Taken at face value, the VRS results imply that at the average observed performance (0.788), input usage could have been decreased by 21.2% in every dimension without affecting the output and quality produced, only taking as a reference the observed performance in the sample chosen. In the CRS case, given the more ample distribution, the average performance is of only 0.588.

Table 2: Efficiency Scores Statistics

|                      | Mean  | St. Dev. | Min   | p25   | p50   | p75   | Max   |
|----------------------|-------|----------|-------|-------|-------|-------|-------|
| <b>Unconditional</b> |       |          |       |       |       |       |       |
| CRS                  | 0.588 | 0.221    | 0.234 | 0.416 | 0.507 | 0.767 | 1.000 |
| VRS                  | 0.788 | 0.206    | 0.262 | 0.658 | 0.830 | 1.000 | 1.000 |
| <b>Conditional</b>   |       |          |       |       |       |       |       |
| CRS                  | 0.797 | 0.193    | 0.387 | 0.639 | 0.830 | 1.000 | 1.000 |
| VRS                  | 0.901 | 0.145    | 0.441 | 0.837 | 0.994 | 1.000 | 1.000 |

The distribution of the conditional DEA estimates are, naturally, less disperse - this is expected because with conditional DEA each performance is compared only to a subset of the sample, those observations with similar levels of population density. In both the CRS and VRS cases, the average efficiency increases substantially. In the CRS case it reaches 0.797 (up from 0.588 in the unconditional DEA), while in the VRS case is now 0.901 (up from 0.788). That is, the distance between the observed best and worst performances could be explained in



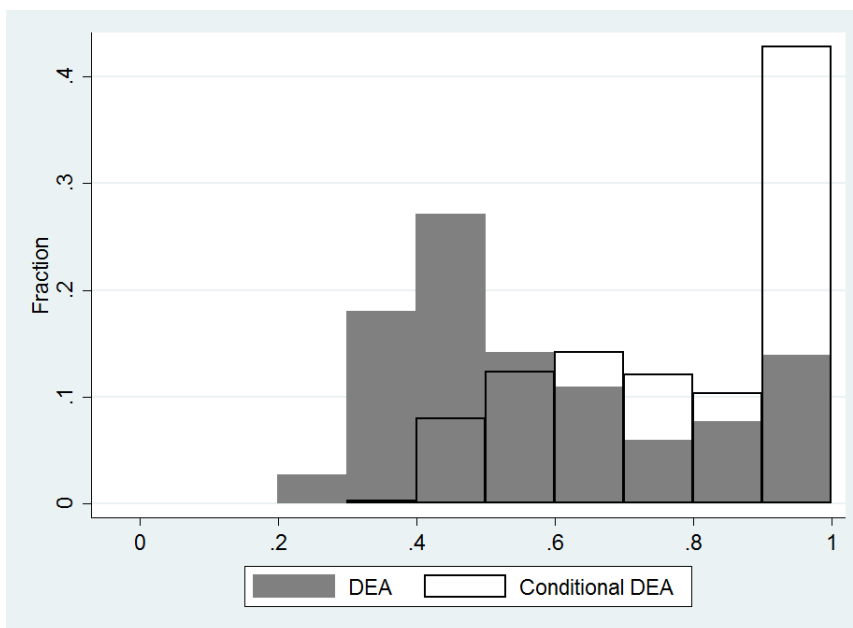


Figure 3: Histogram of DEA Efficiency Scores (CRS)

a significant degree by different contexts in which the firms perform. The detailed calculated scores are presented in Tables 5 and 7 in the Appendix A.

To get a sense of how much the context of operation could be affecting the production possibilities of the firms, I compare the ratio of the unconditional over the conditional DEA scores with the population density. Figures 4 and 5 plots these observations (denominated as  $R$  in the figures), along with a non-parametric (lowess) regression estimate. The ratio of the DEA efficiency scores measures the distance between the unconditional and conditional production possibilities ( $\hat{\Psi}$  and  $\hat{\Psi}(z)$  in the methodological section). When the ratio is closer to one it means that the both estimates are exactly equal, so conditioning on the context would not affect the production possibilities of the firms. The farther the measure deviates from one, on the contrary, would mean that there is a significant effect. We can see that in both the CRS and VRS cases there seems to be positive relation between the ratios and population density, stronger in the CRS case. We can interpret this as saying that low population densities seem to affect the production possibilities of the firms.

## 6 Conclusions

In this study I applied production performance benchmarking techniques, within the DEA framework, to compare the input usage efficiency of the water companies in Peru. The advantage of the DEA approach is that it does not only compares output and quality performance across companies, but also takes into consideration the input usage level. As noticed by Berg and Lin (2008), simple performance measures, like those used by SUNASS, mostly omit the input side of the production process.

On the other hand, in the DEA approach it could be complicated to account for the different contexts in which the companies operate, in comparison to regression methods, for example. At the same time, there is also the concern that the perceived differential performance could actually be explained in some degree by these differing contexts (Tupper and Resende, 2004). In this study I apply an extension of the usual input-oriented DEA benchmarking methodology to account for the possibly differential contexts. The conditional DEA method (Daraio and Simar, 2005) relies on comparing units with approximately similar contexts of operation, where

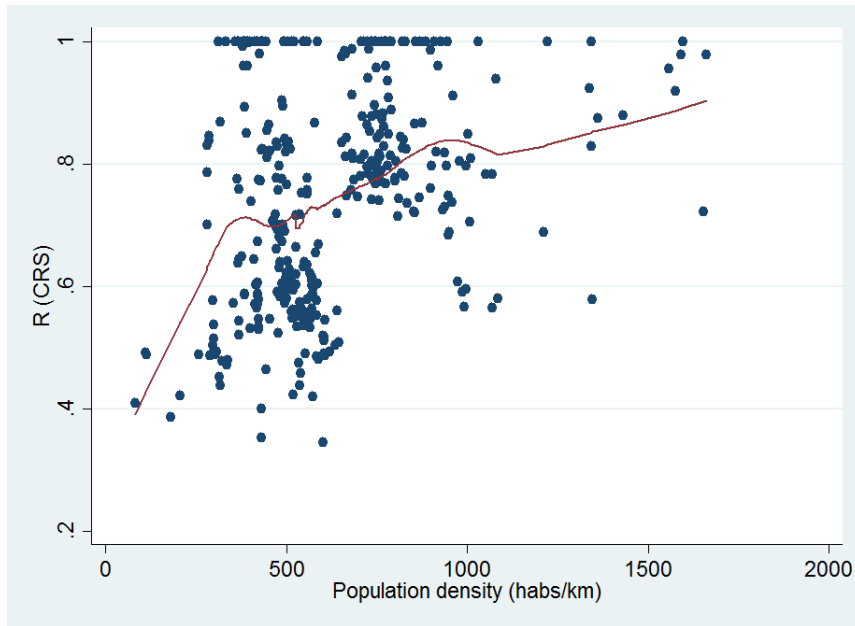


Figure 4: Ratio of Unconditional over Conditional DEA versus Population Density (CRS)

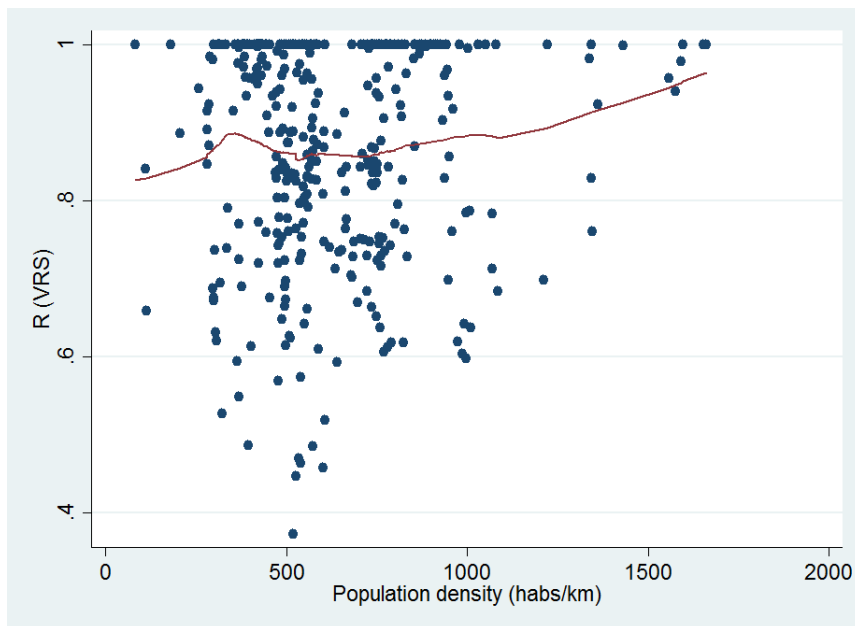


Figure 5: Ratio of Unconditional over Conditional DEA versus Population Density (VRS)

this is quantified by a so-called “contextual variable”.

I calculated conditional DEA scores by conditioning on the population density in the area of operation of each company. I find that controlling for the context of operation in this way affects in an economically significant amount the calculated efficiencies, and therefore can affect the performance benchmarking of water companies in Peru.

## References

- Berg, S. and Lin, C. (2008). Consistency in performance rankings: the Peru water sector. *Applied Economics*, 40:793–805.
- Corton, M. L. (2003). Benchmarking in the Latin American water sector: the case of Peru. *Utilities Policy*, 11:133–142.
- Daraio, C. and Simar, L. (2005). Introducing environmental variables in nonparametric frontier models: a probabilistic approach. *Journal of Productivity Analysis*, 24:93–121.
- De Witte, K. and Saal, D. (2010). Is a little sunshine all we need? On the impact of sunshine regulation on profits, productivity, and prices in the Dutch drinking water sector. *Journal of Regulatory Economics*, 37:219–242.
- Dewenter, K. and Malatesta, P. (2001). State-owned and privately owned firms: An empirical analysis of profitability, leverage, and labor intensity. *American Economic Review*, 91:320–334.
- Estache, A., Perelman, S., and Trujillo, L. (2005). Infrastructure performance and reform in developing and transition economies: Evidence from a survey of productivity measures. World Bank Policy Research Working Paper 3514.
- Estache, A., Rossi, M. A., and Ruzzier, C. A. (2004). The Case for International Coordination of Electricity Regulation: Evidence from the Measurement of Efficiency in South America. *Journal of Regulatory Economics*, 25:271–295.
- Lin, C. (2005). Service quality and prospects for benchmarking: Evidence from the Peru water sector. *Utilities Policy*, 13:230–239.
- Lin, C. and Berg, S. (2008). Incorporating Service Quality into Yardstick Regulation: An Application to the Peru Water Sector. *Review of Industrial Organization*, 32:53–75.
- Picazo-Tadeo, A., Saez-Fernandez, F., and Gonzalez-Gomez, F. (2008). Does service quality matter in measuring the performance of water utilities? *Utilities Policy*, 16:30–38.
- Portela, M., Thanassoulis, E., Horncastle, A., and Maugg, T. (2011). Productivity change in the water industry in england and wales: application of the meta-malmquist index. *Journal of the Operational Research Society*, 62:2173–2188.
- Saal, D., Parker, D., and Weyman-Jones, T. (2007). Determining the contribution of technical change, efficiency change and scale change to productivity growth in the privatized English and Welsh water and sewerage industry: 1985-2000. *Journal of Productivity Analysis*, 28:127–139.
- Seim, K. and Waldfogel, J. (2013). Public Monopoly and Economic Efficiency: Evidence from the Pennsylvania Liquor Control Board’s Entry Decisions. *The American Economic Review*, 103:831–862.

- SUNASS (2013). Benchmarking Regulatorio de las EPS 2013. Report Nr. 314 -2014/SUNASS-120-F.
- Thanassoulis, E. (2000). The use of data envelopment analysis in the regulation of UK water utilities: water distribution. *European Journal of Operational Research*, 126:436–453.
- Tupper, H. C. and Resende, M. (2004). Efficiency and regulatory issues in the Brazilian water and sewage sector: an empirical study. *Utilities Policy*, 12:29–40.
- Vidoli, F. (2011). Evaluating the water sector in Italy through a two stage method using the conditional robust nonparametric frontier and multivariate adaptive regression splines. *European Journal of Operational Research*, 212:583–595.

## A Efficiency Scores

In this section I present the efficiency scores calculated by SUNASS, as well as those calculated with the DEA methodologies proposed in this study - under the CRS and VRS assumptions.

Table 3: SUNASS's Efficiency Scores

| Rank | Firm                        | Connections | Score | Grade 2013 | Grade 2012 |
|------|-----------------------------|-------------|-------|------------|------------|
| 1    | EPS MOQUEGUA                | 20225       | 74.03 | B+         | B-         |
| 2    | SEDAPAL                     | 1412305     | 73.16 | B+         | B+         |
| 3    | EPS ILO S                   | 24247       | 73.03 | B+         | C+         |
| 4    | EMUSAP SRL (Amazonas)       | 6733        | 68.7  | B-         | B-         |
| 5    | EPS TACNA SA                | 88836       | 68.15 | B-         | B-         |
| 6    | SEDACUSCO SA                | 73850       | 66.49 | B-         | B-         |
| 7    | SEDAPAR S                   | 265264      | 65.16 | B-         | B-         |
| 8    | EPSASA                      | 52066       | 64.68 | B-         | B-         |
| 9    | SEDACAJ SA                  | 38854       | 60.46 | B-         | C+         |
| 10   | SEDA HUÁNUCO SA             | 41353       | 60.19 | B-         | C+         |
| 11   | EPS NOR PUNO SA             | 8653        | 58.56 | C+         | C+         |
| 12   | SEDACHIMBOTE SA             | 84995       | 56.91 | C+         | C+         |
| 13   | EMUSAP ABANCAY SA           | 12957       | 56.62 | C+         | B-         |
| 14   | EMAPA Y SRL                 | 4768        | 56.31 | C+         | D+         |
| 15   | SEMAPACH SA                 | 44702       | 56    | C+         | C+         |
| 16   | EPS CHAVIN SA               | 26280       | 55.99 | C+         | C+         |
| 17   | EMAPA HUANCVELICA SA        | 8024        | 55.88 | C+         | C+         |
| 18   | EPS MARAÑÓN SRL             | 16494       | 55.83 | C+         | C-         |
| 19   | SEDAPAR SRL (Rioja)         | 5733        | 55.74 | C+         | C-         |
| 20   | SEDALIB SA                  | 165558      | 55.66 | C+         | C+         |
| 21   | EPS SIERRA CENTRAL SRL      | 9796        | 55.41 | C+         | C+         |
| 22   | EPS GRAU SA                 | 185947      | 54.89 | C+         | C+         |
| 23   | EMAPISCO SA                 | 24898       | 54.04 | C+         | C+         |
| 24   | EMAPA HUARAL SA             | 15510       | 53.7  | C+         | C+         |
| 25   | EMAPICA SA                  | 50305       | 53.66 | C+         | C+         |
| 26   | EMAPA MOYOBAMBA SRL         | 11689       | 53.15 | C+         | B-         |
| 27   | EPS MANTARO SA              | 17565       | 52.9  | C+         | C+         |
| 28   | EMSAP CHANKA SRL            | 4436        | 52.81 | C+         | C+         |
| 29   | EMAPAT SRL                  | 15046       | 52.75 | C+         | C-         |
| 30   | EMAPA SAN MARTÍN SA         | 39974       | 52.55 | C+         | C+         |
| 31   | EPSEL SA                    | 154748      | 52.42 | C+         | C+         |
| 32   | SEDAJULIACA SA              | 48278       | 52.34 | C+         | C+         |
| 33   | EPS AGUAS DEL ALTIPLANO SRL | 6304        | 51.7  | C+         | C-         |
| 34   | EMAPA HUACHO SA             | 25755       | 51.68 | C+         | C+         |
| 35   | AGUAS DE TUMBES SA          | 41392       | 51.58 | C+         | C-         |
| 36   | EMAQ SRL                    | 6692        | 51.15 | C+         | C-         |
| 37   | EMPSSAPAL SA                | 13558       | 50.97 | C+         | C+         |
| 38   | EMSA PUNO SA                | 42371       | 50.96 | C+         | C-         |
| 39   | SEDAM HUANCAYO SAC          | 67892       | 50.89 | C+         | C-         |
| 40   | SEMAPA BARRANCA SA          | 16297       | 48.74 | C-         | C-         |
| 41   | EMSAPA CALCA SRL            | 3150        | 47.25 | C-         | C-         |
| 42   | EPSSMU SRL                  | 7578        | 46.51 | C-         | C-         |
| 43   | EMAPA CAÑETE SA             | 31884       | 45.83 | C-         | C-         |
| 44   | EMAPAVIGS SAC               | 8504        | 45.58 | C-         | C-         |
| 45   | EPS SEDALORETO SA           | 88418       | 44.02 | C-         | C-         |
| 46   | EMSAPA YAULI SRL (La Oroya) | 3215        | 41.6  | C-         | D+         |
| 47   | EMAPACOP SA                 | 24515       | 40.03 | C-         | C-         |
| 48   | EMAPA PASCÓ SA              | 11343       | 39.93 | D+         | D+         |
| 49   | EPS SELVA CENTRAL SA        | 22088       | 39.48 | D+         | D+         |
| 50   | EMAPAB SRL                  | 4759        | 39.32 | D+         | D+         |

Source: SUNASS (2013).

Table 4: Efficiency Scores: Unconditional DEA (CRS)

| Firm                      | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| EMUSAP AMAZONAS           | 1.000 | 1.000 | 1.000 | 0.961 | 1.000 | 1.000 | 0.981 | 0.893 | 0.824 |
| SEDA HUANUCO S.A.         |       |       | 0.442 | 0.453 | 0.461 | 0.474 | 0.465 | 0.536 | 0.548 |
| EMAPACOP S.A.             | 0.416 | 0.358 | 0.405 | 0.396 | 0.372 | 0.353 |       | 0.442 | 0.416 |
| EPS SEDALORETO S.A.       | 0.722 | 0.690 | 0.378 | 0.373 | 0.419 | 0.465 | 0.478 |       | 0.319 |
| EMAPA CAÑETE S.A.         | 0.575 | 0.548 | 0.591 | 0.595 | 0.563 | 0.688 | 0.529 | 0.581 | 0.641 |
| EMSA PUNO S.A.            | 0.392 | 0.752 | 0.356 | 0.358 | 0.366 | 0.369 | 0.501 | 0.445 | 0.356 |
| EPSSMU S.R.LTDA           | 0.821 | 0.824 | 0.884 | 0.903 | 0.683 | 0.695 | 0.733 | 0.794 | 0.832 |
| AGUAS DE TUMBES           | 0.321 | 0.251 | 0.390 | 0.435 | 0.407 | 0.368 | 0.366 | 0.251 |       |
| EMAPA PASCO S.A.          |       | 0.719 |       |       | 1.000 | 0.650 |       | 0.914 | 1.000 |
| EMAPISCO S.A.             |       | 0.323 | 0.281 | 0.234 | 0.278 | 0.297 | 0.319 | 0.303 | 0.346 |
| SEDACAJ S.A.              | 0.350 | 0.843 | 0.377 | 0.378 | 0.331 | 0.312 | 0.301 | 0.320 | 0.344 |
| EPS TACNA S.A.            | 0.396 | 0.397 | 0.403 | 0.425 | 0.412 | 0.441 | 0.435 | 0.481 | 0.466 |
| EMAPAVIGSSA               | 0.741 | 0.812 | 0.854 |       | 0.950 | 1.000 | 0.798 | 0.836 | 0.936 |
| SEDACHIMBOTE S.A.         | 0.444 | 0.467 | 0.431 | 0.491 | 0.453 | 0.423 | 0.386 | 0.367 |       |
| EPSASA                    | 0.511 | 0.489 | 0.452 | 0.455 | 0.448 | 0.412 | 0.414 | 0.436 | 0.473 |
| EMAPA SAN MARTIN S.A.     | 0.375 | 0.410 | 0.868 | 0.413 | 0.396 | 0.387 | 0.539 | 0.373 | 0.367 |
| EMAPAT S.R.LTDA.          | 0.434 | 0.457 | 0.376 | 0.358 | 0.356 | 0.246 | 0.330 | 0.353 | 0.400 |
| SEMAPACH S.A.             | 0.365 | 0.362 | 0.398 |       | 0.353 | 0.436 | 0.456 | 0.474 | 0.492 |
| EPS SELVA CENTRAL S.A.    | 0.705 | 0.503 | 0.724 | 0.740 |       | 0.783 | 0.940 | 0.848 | 1.000 |
| EMAPA MOYOBAMBA S.R.LTDA. | 0.761 |       | 0.774 | 1.000 | 0.985 | 0.783 | 1.000 | 0.805 | 0.812 |
| EMAPA HUANCVELICA S.A.C   | 0.960 | 1.000 | 0.848 | 0.614 | 0.668 | 0.763 | 1.000 | 0.611 | 0.620 |
| EPS MOQUEGUA S.R.LTDA.    | 0.559 | 0.599 | 0.594 | 0.603 | 0.529 | 0.471 | 0.479 | 0.421 | 0.409 |
| EMAPA HUARAL S.A.         | 0.919 | 1.000 | 0.979 | 0.956 | 0.879 | 0.875 | 0.829 | 1.000 | 0.924 |
| EMAPA HUACHO S.A.         | 0.471 | 0.433 |       | 0.440 | 0.433 | 0.425 | 0.432 | 0.451 | 0.488 |
| EPS ILO S.R.LTDA.         | 0.268 | 0.274 | 0.275 | 0.280 | 0.278 | 0.292 | 1.000 | 0.294 | 0.298 |
| SEDALIB S.A.              | 0.385 | 0.393 | 0.421 | 0.414 | 0.440 | 0.420 | 0.473 | 0.493 | 0.464 |
| EPSEL S.A.                | 0.684 | 0.610 | 0.687 |       |       | 0.539 |       | 0.546 | 0.868 |
| SEDAPAR S.A.              | 0.416 | 0.413 | 0.434 | 0.913 | 0.377 | 0.363 | 0.359 | 0.423 | 0.438 |
| EPS - SEDACUSCO S.A.      | 0.412 | 1.000 | 1.000 | 0.901 | 0.418 | 0.405 | 0.495 | 0.412 | 0.734 |
| EPS GRAU S.A.             | 0.597 | 0.371 | 0.460 | 0.470 | 0.496 | 0.591 | 0.628 | 0.768 | 0.714 |
| EPS CHAVIN S.A.           | 0.480 | 0.476 | 0.497 | 0.503 | 0.499 | 0.525 |       | 0.805 |       |
| EMAQ S.R.LTDA.            |       | 1.000 | 1.000 | 1.000 |       | 1.000 | 0.957 | 1.000 | 1.000 |
| EMAPAB S.R.LTDA.          | 0.712 | 0.751 | 0.787 | 0.801 | 0.644 | 0.677 | 0.777 | 0.742 | 0.758 |
| SEMAPA BARRANCA S.A.      | 0.554 | 0.562 | 0.570 | 0.526 | 0.540 | 0.487 | 0.399 | 0.418 | 0.436 |
| EMAPICA S.A.              |       |       |       |       | 0.456 | 0.503 |       | 0.539 | 0.489 |
| EMPSSAPAL S.A.            | 0.846 | 0.783 | 0.705 | 1.000 | 0.535 | 0.548 | 0.533 | 0.864 | 1.000 |
| EPS SIERRA CENTRAL S.A.   | 0.695 | 0.658 |       | 0.767 | 0.668 | 0.660 | 0.699 | 0.821 | 0.803 |
| NOR PUNO S.A.             | 1.000 | 1.000 | 1.000 | 0.903 | 1.000 | 1.000 | 1.000 | 0.998 | 0.869 |
| SEDAJULIACA S.A.          | 0.502 | 0.479 | 0.516 | 0.533 | 0.522 | 0.558 | 0.500 | 0.607 | 0.525 |
| EPS MANTARO S.A.          | 1.000 | 0.406 | 0.538 | 0.550 | 0.472 | 0.513 | 0.489 | 0.491 | 0.489 |
| EMUSAP ABANCAY            | 0.604 | 0.544 | 0.571 | 0.539 | 0.477 |       | 0.468 | 0.469 | 0.468 |
| EPS MARAÑON               | 0.579 | 0.565 | 0.579 | 0.567 | 0.818 |       | 0.912 |       | 0.504 |
| SEDAM HUANCAYO S.A.C      |       | 0.614 | 0.678 |       |       | 0.441 | 0.450 | 0.439 | 0.387 |

Table 5: Efficiency Scores: Conditional DEA (CRS)

| Firm                      | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| EMUSAP AMAZONAS           | 1.000 | 1.000 | 1.000 | 1.000 |       | 1.000 | 0.988 | 1.000 | 0.969 |
| SEDA HUANO S.A.           |       |       | 0.543 | 0.563 | 0.588 | 0.561 | 0.523 | 0.690 | 0.738 |
| EMAPACOP S.A.             | 0.523 | 0.408 | 0.459 | 0.466 | 0.448 | 0.443 | 0.471 | 0.646 | 0.742 |
| EPS SEDALORETO S.A.       | 1.000 | 0.705 | 0.468 | 0.514 | 0.525 | 0.622 | 0.656 | 0.581 | 0.391 |
| EMAPA CAÑETE S.A.         | 0.779 | 0.901 | 1.000 | 1.000 | 0.712 | 1.000 | 0.699 | 0.750 | 0.822 |
| EMSA PUNO S.A.            | 0.465 | 1.000 | 0.688 | 0.692 | 0.662 | 0.654 | 0.766 | 0.666 | 0.537 |
| EPSSMU S.R.LTDA           | 0.982 | 1.000 | 0.988 | 1.000 |       | 0.826 | 0.894 | 0.954 | 0.995 |
| AGUAS DE TUMBES           | 0.448 | 0.447 | 0.609 | 0.685 | 0.538 | 0.474 | 0.482 | 0.387 | 0.702 |
| EMAPA PASCO S.A.          |       | 1.000 |       |       | 1.000 | 0.650 |       | 0.914 | 1.000 |
| EMAPISCO S.A.             |       | 0.511 | 0.464 | 0.427 | 0.471 | 0.567 | 0.613 | 0.556 | 0.605 |
| SEDACAJ S.A.              | 0.420 | 1.000 | 0.461 | 0.466 | 0.670 | 0.639 | 0.717 | 0.664 | 1.000 |
| EPS TACNA S.A.            | 0.615 | 0.657 | 0.714 | 0.723 | 0.722 | 0.772 | 0.682 | 0.820 | 0.792 |
| EMAPAVIGSSA               | 1.000 | 1.000 | 0.978 | 1.000 | 0.989 | 1.000 | 0.878 | 0.970 | 1.000 |
| SEDACHIMBOTE S.A.         | 0.799 | 0.767 | 0.717 | 0.797 | 0.748 | 0.706 | 0.657 | 0.625 | 0.669 |
| EPSASA                    | 1.000 | 0.892 | 0.804 | 0.830 | 0.812 | 0.747 | 0.751 | 0.755 | 0.864 |
| EMAPA SAN MARTIN S.A.     | 0.581 | 0.693 | 1.000 | 0.844 | 0.690 | 0.723 | 0.842 | 0.636 | 0.629 |
| EMAPAT S.R.LTDA.          | 0.701 | 1.000 | 0.791 | 0.849 | 0.603 | 0.516 | 0.710 | 1.000 | 1.000 |
| SEMAPACH S.A.             | 0.458 | 0.467 | 0.576 | 0.502 | 0.454 | 0.608 | 0.658 | 0.697 | 0.731 |
| EPS SELVA CENTRAL S.A.    | 1.000 | 0.599 | 0.984 | 0.928 |       | 1.000 | 1.000 | 1.000 | 1.000 |
| EMAPA MOYOBAMBA S.R.LTDA. | 0.879 | 1.000 | 0.972 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| EMAPA HUANCVELICA S.A.C   | 1.000 | 1.000 | 1.000 | 1.000 | 0.954 | 0.914 | 1.000 | 1.000 | 0.967 |
| EPS MOQUEGUA S.R.LTDA.    | 0.965 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| EMAPA HUARAL S.A.         | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |       | 1.000 |
| EMAPA HUACHO S.A.         | 0.536 |       | 0.519 | 0.499 |       | 0.498 | 0.501 | 0.605 | 0.603 |
| EPS ILO S.R.LTDA.         | 0.521 | 0.544 | 0.560 | 0.573 | 0.566 | 0.593 | 1.000 | 0.650 | 0.679 |
| SEDALIB S.A.              | 0.477 | 0.493 | 0.530 | 0.537 | 0.573 | 0.535 |       | 0.664 |       |
| EPSEL S.A.                | 0.948 | 0.845 | 0.922 | 0.885 | 1.000 | 0.657 | 0.701 | 0.719 | 1.000 |
| SEDAPAR S.A.              | 0.658 | 0.666 | 0.796 | 1.000 | 0.777 | 0.681 | 0.663 | 0.862 | 1.000 |
| EPS - SEDACUSCO S.A.      | 0.526 | 1.000 | 1.000 | 0.912 | 0.538 | 0.520 | 0.641 | 0.577 |       |
| EPS GRAU S.A.             | 0.731 | 0.477 | 0.572 | 0.585 | 0.638 | 0.767 | 0.811 | 1.000 | 0.904 |
| EPS CHAVIN S.A.           | 0.951 | 0.936 | 0.509 | 0.513 | 0.507 | 0.532 |       | 1.000 | 0.575 |
| EMAQ S.R.LTDA.            |       | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| EMAPAB S.R.LTDA.          | 0.842 | 0.896 | 1.000 | 0.966 | 0.919 | 0.816 | 1.000 | 0.988 | 1.000 |
| SEMAPA BARRANCA S.A.      | 0.711 | 0.681 | 0.692 | 0.586 | 0.574 |       | 0.697 | 0.673 | 0.754 |
| EMAPICA S.A.              |       |       |       |       | 0.848 | 0.937 |       | 1.000 | 0.920 |
| EMPSSAPAL S.A.            | 0.979 | 0.915 | 0.868 | 1.000 | 0.649 | 0.666 | 0.690 | 0.881 | 1.000 |
| EPS SIERRA CENTRAL S.A.   | 0.967 | 0.991 | 1.000 | 1.000 | 0.952 | 0.947 | 0.989 | 1.000 | 0.979 |
| NOR PUNO S.A.             | 1.000 | 0.999 | 1.000 | 0.941 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| SEDAJULIACA S.A.          | 0.906 | 0.852 |       | 0.995 | 0.976 | 1.000 | 0.906 | 0.882 | 0.909 |
| EPS MANTARO S.A.          | 1.000 | 0.726 | 0.858 | 0.895 | 0.610 | 0.693 | 1.000 | 1.000 | 1.000 |
| EMUSAP ABANCAY            | 1.000 | 0.902 | 0.942 | 0.801 | 0.815 | 0.805 | 0.808 | 0.858 | 0.876 |
| EPS MARAÑON               | 1.000 | 1.000 | 1.000 | 1.000 | 0.999 |       | 1.000 |       | 0.675 |
| SEDAM HUANCAYO S.A.C      |       | 0.547 | 0.628 |       |       | 0.764 | 0.838 | 0.902 | 1.000 |

Table 6: Efficiency Scores: Unconditional DEA (VRS)

| Firm                      | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| EMUSAP AMAZONAS           | 1.000 | 1.000 | 1.000 | 1.000 | 0.958 | 1.000 | 1.000 | 1.000 | 0.933 |
| SEDA HUANO S.A.           |       |       | 0.748 | 0.805 | 0.796 | 0.809 | 1.000 | 1.000 | 1.000 |
| EMAPACOP S.A.             | 0.417 | 0.363 | 0.413 | 0.421 | 0.378 | 0.356 | 0.372 | 0.461 | 0.434 |
| EPS SEDALORETO S.A.       | 1.000 | 1.000 | 0.572 | 0.598 | 0.677 | 0.706 | 0.732 | 0.731 | 0.585 |
| EMAPA CAÑETE S.A.         | 0.728 | 0.552 | 0.596 | 0.598 | 0.605 | 0.699 | 0.537 | 0.596 | 0.670 |
| EMSA PUNO S.A.            | 0.457 | 0.753 | 0.514 | 0.559 | 0.572 | 0.555 | 0.727 | 0.649 | 0.667 |
| EPSSMU S.R.LTDA           | 0.875 | 0.888 | 0.892 | 1.000 | 0.807 | 0.801 | 0.755 | 0.801 | 0.874 |
| AGUAS DE TUMBES           |       | 0.262 | 0.391 | 0.460 | 0.427 | 0.424 | 0.407 | 0.349 | 0.486 |
| EMAPA PASCO S.A.          |       | 0.885 |       |       |       |       |       | 0.924 | 1.000 |
| EMAPISCO S.A.             |       | 0.434 | 0.457 | 0.298 | 0.382 | 0.431 | 0.580 | 0.519 | 0.915 |
| SEDACAJ S.A.              | 0.471 | 0.843 | 0.486 | 0.547 | 0.500 | 0.519 | 0.376 | 0.405 | 0.458 |
| EPS TACNA S.A.            | 0.916 | 0.921 | 0.909 | 1.000 | 0.967 | 0.983 | 0.940 | 0.985 | 1.000 |
| EMAPAVIGSSA               | 0.947 | 0.930 | 1.000 | 1.000 | 1.000 | 1.000 | 0.795 | 0.905 | 1.000 |
| SEDACHIMBOTE S.A.         | 0.956 | 1.000 | 0.806 | 0.893 | 0.828 | 0.783 | 0.711 | 0.758 | 0.693 |
| EPSASA                    | 0.889 | 0.889 | 0.792 | 0.834 | 0.820 | 0.775 | 0.778 | 0.823 | 1.000 |
| EMAPA SAN MARTIN S.A.     | 1.000 | 0.641 | 1.000 | 0.770 | 0.864 | 0.964 | 1.000 | 0.921 | 0.780 |
| EMAPAT S.R.LTDA.          | 0.447 | 0.463 | 0.381 | 0.372 | 0.416 | 0.275 | 0.435 | 1.000 |       |
| SEMAPACH S.A.             | 0.377 | 0.377 | 0.408 | 0.387 | 0.520 | 0.677 | 0.681 | 0.744 | 0.648 |
| EPS SELVA CENTRAL S.A.    | 0.786 | 0.510 | 0.728 | 0.741 |       | 0.783 | 1.000 | 0.995 | 1.000 |
| EMAPA MOYOBAMBA S.R.LTDA. | 0.869 | 0.994 | 1.000 | 1.000 | 1.000 |       | 1.000 | 0.822 | 0.933 |
| EMAPA HUANCVELICA S.A.C   | 1.000 | 1.000 | 0.871 | 0.624 | 0.689 | 0.769 | 1.000 | 0.673 | 0.751 |
| EPS MOQUEGUA S.R.LTDA.    | 1.000 | 1.000 | 1.000 | 0.825 | 0.720 | 0.739 | 0.790 | 0.886 | 1.000 |
| EMAPA HUARAL S.A.         | 0.940 | 1.000 | 0.979 | 0.957 | 0.999 | 0.923 | 0.829 | 1.000 | 0.982 |
| EMAPA HUACHO S.A.         | 0.469 | 0.454 | 0.480 | 0.504 |       | 0.554 | 0.590 | 0.670 | 0.729 |
| EPS ILO S.R.LTDA.         | 0.396 | 0.441 | 0.450 | 0.432 | 0.423 | 0.426 | 1.000 | 1.000 | 0.695 |
| SEDALIB S.A.              | 0.612 | 0.642 | 0.658 | 0.671 | 0.708 | 0.703 | 0.714 | 0.742 | 0.720 |
| EPSEL S.A.                | 1.000 | 0.921 | 0.950 | 0.996 | 1.000 | 1.000 | 1.000 | 0.987 | 1.000 |
| SEDAPAR S.A.              |       | 0.948 | 1.000 | 1.000 | 1.000 | 0.964 |       | 0.958 | 1.000 |
| EPS - SEDACUSCO S.A.      | 0.757 | 1.000 | 1.000 | 0.914 | 0.867 | 1.000 | 0.753 | 0.721 | 1.000 |
| EPS GRAU S.A.             | 0.753 | 0.661 | 0.701 | 0.714 | 0.744 | 0.859 | 0.897 | 1.000 | 1.000 |
| EPS CHAVIN S.A.           | 0.679 | 0.688 | 0.750 | 0.749 | 0.853 | 1.000 |       | 1.000 | 1.000 |
| EMAQ S.R.LTDA.            |       | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.956 | 1.000 | 1.000 |
| EMAPAB S.R.LTDA.          | 0.871 | 0.906 | 0.914 | 0.846 | 0.856 | 0.992 | 1.000 | 0.958 | 0.963 |
| SEMAPA BARRANCA S.A.      | 0.734 | 0.789 | 0.963 | 0.867 | 0.947 | 0.863 | 0.511 | 0.585 | 0.536 |
| EMAPICA S.A.              |       |       |       |       | 0.726 | 0.814 | 0.881 | 0.955 | 0.957 |
| EMPSAPAL S.A.             | 0.888 | 0.870 | 0.882 | 1.000 | 0.661 | 0.708 | 0.883 | 1.000 | 1.000 |
| EPS SIERRA CENTRAL S.A.   | 0.724 | 0.759 | 0.919 | 1.000 | 0.809 | 0.811 | 0.930 | 1.000 | 1.000 |
| NOR PUNO S.A.             | 1.000 | 0.960 | 1.000 | 0.938 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| SEDAJULIACA S.A.          | 0.599 | 0.632 | 0.776 | 0.771 | 0.804 | 0.843 | 0.754 | 0.856 | 0.803 |
| EPS MANTARO S.A.          | 1.000 | 0.418 | 0.539 | 0.551 | 0.477 | 0.526 | 0.658 | 0.841 | 0.943 |
| EMUSAP ABANCAY            | 1.000 | 0.943 | 1.000 | 0.840 | 0.830 | 0.859 | 1.000 | 0.993 | 1.000 |
| EPS MARAÑON               | 0.760 | 0.712 | 0.684 | 0.642 | 0.828 |       | 0.918 |       | 0.523 |
| SEDAM HUANCAYO S.A.C      |       | 1.000 | 1.000 |       |       | 0.981 | 1.000 | 0.984 | 1.000 |



Table 7: Efficiency Scores: Conditional DEA (VRS)

| Firm                      | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| EMUSAP AMAZONAS           |       | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.999 |
| SEDA HUANUCO S.A.         |       |       |       | 0.854 | 0.878 | 0.878 | 1.000 | 1.000 | 1.000 |
| EMAPACOP S.A.             | 0.610 | 0.547 | 0.633 | 0.662 | 0.624 | 0.581 | 0.603 | 0.660 | 0.731 |
| EPS SEDALORETO S.A.       | 1.000 | 1.000 | 0.899 | 0.662 |       | 0.756 | 0.762 | 0.755 | 0.781 |
| EMAPA CAÑETE S.A.         | 0.957 | 0.893 | 0.987 | 1.000 | 0.830 | 1.000 | 0.763 | 0.798 | 0.891 |
| EMSA PUNO S.A.            | 0.632 | 1.000 | 0.688 | 0.692 | 0.693 | 0.670 | 0.787 | 0.692 | 0.725 |
| EPSSMU S.R.LTDA           | 1.000 | 1.000 | 1.000 | 1.000 | 0.818 | 0.826 | 0.896 | 0.958 | 1.000 |
| AGUAS DE TUMBES           | 0.456 | 0.457 | 0.609 | 0.695 | 0.751 | 0.713 | 0.741 | 0.506 | 1.000 |
| EMAPA PASCO S.A.          |       | 1.000 |       |       | 1.000 | 0.670 |       | 0.928 | 1.000 |
| EMAPISCO S.A.             |       | 0.517 | 0.476 | 0.441 | 0.476 | 0.581 | 0.753 | 0.716 | 1.000 |
| SEDACAJ S.A.              | 0.640 | 1.000 | 0.692 | 0.716 | 0.676 | 1.000 | 0.775 | 0.664 | 1.000 |
| EPS TACNA S.A.            | 0.959 | 0.959 | 0.948 | 1.000 | 0.960 | 0.972 | 0.963 | 1.000 | 1.000 |
| EMAPAVIGSSA               | 0.772 | 0.856 | 0.927 | 1.000 | 0.968 | 1.000 | 0.943 | 1.000 | 1.000 |
| SEDACHIMBOTE S.A.         | 1.000 | 1.000 | 0.935 | 1.000 | 0.959 | 0.892 | 0.837 | 0.837 | 0.857 |
| EPSASA                    | 1.000 | 1.000 | 0.955 | 1.000 | 0.984 | 0.972 | 0.951 | 0.992 | 1.000 |
| EMAPA SAN MARTIN S.A.     | 1.000 | 0.799 | 1.000 | 0.887 | 0.887 | 1.000 | 1.000 | 0.977 | 0.878 |
| EMAPAT S.R.LTDA.          | 1.000 | 1.000 | 0.812 | 1.000 | 0.603 | 0.521 | 0.573 | 1.000 |       |
| SEMAPACH S.A.             | 0.484 | 0.500 | 0.614 | 0.508 | 0.554 | 0.811 | 0.898 | 1.000 | 1.000 |
| EPS SELVA CENTRAL S.A.    | 1.000 | 0.825 | 1.000 | 0.944 |       | 1.000 | 1.000 | 1.000 |       |
| EMAPA MOYOBAMBA S.R.LTDA. | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| EMAPA HUANCAMELICA S.A.C  | 1.000 | 1.000 | 0.897 | 1.000 | 0.956 | 0.928 | 1.000 | 1.000 | 0.966 |
| EPS MOQUEGUA S.R.LTDA.    | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| EMAPA HUARAL S.A.         | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| EMAPA HUACHO S.A.         | 0.545 | 0.611 | 0.654 | 0.670 | 0.736 | 0.742 | 0.810 | 1.000 | 1.000 |
| EPS ILO S.R.LTDA.         | 0.587 | 0.642 | 0.670 | 0.586 | 0.669 | 0.686 | 1.000 | 1.000 | 1.000 |
| SEDALIB S.A.              | 0.726 | 0.783 | 0.788 | 0.938 |       | 0.832 | 0.839 | 0.855 | 0.854 |
| EPSEL S.A.                | 1.000 | 0.938 | 0.961 | 0.999 | 1.000 | 1.000 | 1.000 | 0.971 | 1.000 |
| SEDAPAR S.A.              | 0.957 | 0.952 | 1.000 |       | 1.000 | 0.975 | 0.946 |       | 1.000 |
| EPS - SEDACUSCO S.A.      | 0.920 | 1.000 | 1.000 | 0.919 |       | 1.000 | 0.978 | 0.906 | 1.000 |
| EPS GRAU S.A.             | 1.000 | 0.791 | 0.825 | 0.844 | 1.000 | 0.981 | 0.957 | 1.000 | 1.000 |
| EPS CHAVIN S.A.           | 0.954 | 0.938 | 0.896 | 0.923 | 0.935 | 1.000 |       | 1.000 | 1.000 |
| EMAQ S.R.LTDA.            |       | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| EMAPAB S.R.LTDA.          | 1.000 | 0.981 | 1.000 | 1.000 | 0.960 | 1.000 | 1.000 | 1.000 | 1.000 |
| SEMAPA BARRANCA S.A.      | 0.962 | 0.954 | 1.000 | 1.000 | 1.000 | 0.990 | 0.707 | 0.709 | 0.770 |
| EMAPICA S.A.              |       |       |       |       | 0.917 | 0.948 | 1.000 | 1.000 | 1.000 |
| EMPSSAPAL S.A.            | 1.000 | 0.957 | 0.907 | 1.000 | 0.671 | 0.721 | 0.883 | 1.000 | 1.000 |
| EPS SIERRA CENTRAL S.A.   | 1.000 | 0.994 | 1.000 | 1.000 | 0.954 | 0.947 | 0.996 | 1.000 | 1.000 |
| NOR PUNO S.A.             | 1.000 | 1.000 | 1.000 | 0.966 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| SEDAJULIACA S.A.          |       | 0.864 | 0.973 | 1.000 | 1.000 | 1.000 | 0.907 | 1.000 | 0.944 |
| EPS MANTARO S.A.          | 1.000 |       | 0.860 | 0.898 | 0.618 | 0.859 | 1.000 | 1.000 | 1.000 |
| EMUSAP ABANCAY            | 1.000 | 0.973 | 1.000 | 0.841 | 0.873 | 0.885 |       | 0.993 | 1.000 |
| EPS MARAÑON               | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |       | 1.000 |       | 0.675 |
| SEDAM HUANCAYO S.A.C      |       | 1.000 | 1.000 |       |       | 1.000 | 1.000 | 1.000 | 1.000 |