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Measuring the efficiency of water utilities:

A cross-national comparison between Portugal and Italy

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Abstract:

All over the world, governments are compelling water utilities to improve their efficiency and productivity through reforms and tougher regulatory tools. Despite the different strategies and approaches, the goals remain the same: to make the whole sector more efficient, to curb the profits and the 'quiet life' of water utilities and to pass the productivity gains to customers through reduced prices or better environmental protection and quality of service. The water sector in Portugal and Italy underwent deep reforms in the 1990s, in pursuit of higher levels of performance. Therefore, there is added interest to measure the performance of water utilities in these two Mediterranean countries. We assess their performance using composite (global) indicators on a sample of 88 water utilities for the year 2007. While we compare the performance of the two countries in this sector we also try to identify the impact of the ownership structure on efficiency. Finally, this paper discusses the benchmarking results of our research and draws some policy implications.

Keywords: benchmarking indicators; Italy; performance; Portugal; water utilities.

1. Introduction

Cross-national comparisons have several appealing features. First of all, the possibility of having a larger database to identify the international best practices and provide added incentives to utility managers is noteworthy. In addition, to infer on the national panorama and have a notion of the maturity level of each country might provide better guidance for national politicians and regulators.

On the other hand, these complex international comparisons involve several problems. Different legislation as well as concepts and definitions may be used in each country which reduces the comparability of the data (Araral, 2010). Moreover, fluctuations in the purchasing power parity, the different levels of outsourcing, specific differences on explanatory factors and other contrasts like wages, taxes and tariff rules often hinder the validity of the findings (De Witte and Marques, 2010). Bearing this in mind, we compare two Mediterranean countries, Portugal and Italy, which have similar characteristics such as climate, legislation and institutional framework, increasing the comparability of the water utilities. Nevertheless, one should note that there are also some differences such as the scale and the model of the management, the actual role of the local governments and the different degree of vertical integration. Moreover, these two countries experienced different reforms (although they obviously had the same main objective, the actual strategies adopted were quite dissimilar) in the water sector in the 1990s.[1]

In this study we compute the efficiency scores of 33 Italian utilities and 55 Portuguese utilities providing drinking water and wastewater services, using the benchmarking non-parametric technique of data envelopment analysis (DEA) with two different model specifications. Hence, we are able to suggest which country may be performing better (in overall terms) in this sector, regarding the strategies adopted. Furthermore, since we have information on the organizational model of each utility, we also offer some insights concerning the efficiency of different governance structures.

[1] These differences and similarities are carefully addressed in the ensuing section.

This paper is organized as follows. In the next section we describe concisely the Portuguese and Italian water sectors. Then, in the third section, we provide a brief literature review regarding performance measurement issues and present some interesting findings in this context. In the fourth section, the data, the models and the results are presented. The discussion and concluding remarks are given in the fifth and final section.

2. Water sector

2.1 The Portuguese case

As in other Mediterranean countries, the availability of water resources in Portugal (and Italy) is seasonal. Usually, the abundance of water in the winter contrasts with its shortage in the summer. In the Portuguese case there are also some geographical differences: while the north and coastline have abundant water resources, the south and countryside suffer from water shortage problems. All water services (drinking water supply and wastewater collection and treatment) are a responsibility of local governments. In comparison to other countries, one major difference is the fact that both water and wastewater sectors, as a rule, are not vertically integrated. Indeed, the ‘wholesale’ (water intake, treatment and transportation and wastewater treatment) and ‘retail’ (water distribution and wastewater collection) markets are managed by distinct entities. This was the result of a major reform which happened in the 1990s. It was only during this decade that private sector participation (by means of concession arrangements) was allowed in the water sector. Another crucial difference is the presence of a sector-specific regulator (in the EU15 these authorities only exist in Portugal, Italy and the UK). However, in the ‘retail’ sector, The Water and Waste Services Regulation Authority (ERSAR in the Portuguese acronym) until recently has only had regulatory power over concessionary companies (contractual public-private and public-public partnership arrangements) mainly regarding quality issues (sunshine regulation using a ‘name and shame’ policy).

Currently, 21 utilities operate in the ‘wholesale’ market: three providing just drinking water, six providing just wastewater services and 12 providing drinking water and wastewater services together. One of these entities is a private concessionaire while the other 20 are public concessionaires (entities simultaneously owned by the central state and covered municipalities, see Marques, 2008).

In the ‘retail’ market there are 279 utilities. The most common governance model in this segment is the municipal department (207 units – 43% of the population). The other models observed are municipal services with autonomy (still direct public management but the entities have separate accounts), municipal companies (100% public or mixed companies – institutionalized PPPs or iPPPs), concessionary companies (cPPPs), public-public partnerships (between the central state and the municipalities) and one state-owned company (EPAL that operates in Lisbon, the capital).

Despite the legal responsibilities of local governments regarding the water and wastewater services, the significant presence of the central state in the sector is remarkable. On the other hand, private sector participation has been increasing lately. Nowadays, 21% of the Portuguese population is supplied via PPP agreements (mixed companies and concessions). Indeed, Portuguese local governments have been turning to municipal companies and to cPPP arrangements to a greater extent (Cruz and Marques, 2011). The effects of this strategy are not clear. On the one hand, publicly-owned utilities seem to depict higher efficiencies (a static measure); on the other hand, private utilities appear to show higher productivity (a dynamic measure) and quality of service (Marques, 2008). A possible explanation for this is the fact that, for ideological reasons, local governments may be contracting out the services just as a measure of last resort. In other words, concessionary companies may be endowed with the water systems that have higher infrastructural problems (for which local governments have no direct solution), and this situation might be penalizing the efficiency scores of private utilities. Moreover, the private companies pay generous upfront rents to the municipalities to enter the market.

2.2 The Italian case

In the north of Italy there is an abundance of rivers and lakes contrary to what happens in the central-southern regions where water is scarce. In the latter regions water utilities are less efficient with reference to the use of labor and also apply the highest tariffs (Guerrini et al. 2011). In addition, the coverage of sewage treatment is also inferior. In this country, a comprehensive reform of the water sector began in January 1994 (Galli law). The reform had the purpose of integrating water services (drinking water supply and wastewater collection and treatment) and merge utilities in order to exploit economies of scale and scope. Moreover, it aimed at replacing the in-house supply of services by municipalities, entrusting water services to corporatized firms, and to ensure tariffs that cover both current costs and future investments. Each region defined its ATO (*Ambiti Territoriali Ottimali* or optimal territorial areas) depending on the natural water basins and avoiding an excessive fragmentation of services (more than 7,800 utilities existed before the reform, Canitano *et al*., 2008).

A total of 91 ATOs were defined in Italy (COVIRI, 2009). The population and areas of each ATO can be quite different; there are ATOs that serve an entire region and ATOs that only serve a specific urban aggregate (e.g. Milan). Currently, the water and wastewater services (called SII) can either be delegated to a private company or a mixed-owned company (iPPP) where the private partners should be selected through a public tender. They can also be delegated to a publicly-owned company. Nevertheless, in both situations each one of them is still a natural monopoly in their specific geographical area.

Water utilities are regulated and audited by local regulatory authorities (*Autorità d'Ambito Territoriale Ottimale* – AATOs). The relationship between the AATOs and regulated utilities is characterized by information asymmetry which has to be managed through a transparent reporting system based on the companies' performance and on yardstick competition (Marques, 2006). Every AATO must determine an appropriate tariff and make sure that regulated utilities comply with it.

After more than 15 years, the reform's objectives have not been completely achieved yet (although some steps forward have been taken). In 2008 only 69 out of 91 AATOs entrusted the SII to 114 firms, encompassing 66% of the Italian population. Half of these 114 firms are government-owned companies. Many firms integrate drinking water supply and wastewater collection and treatment while some firms also provide gas, electricity and solid waste services.

The Galli law also created a national committee for water resources (the *Commissione Nazionale di Vigilanza sulle Risorse Idriche* – COVIRI) to support the Ministry for the Environment in monitoring the application of the regulatory rules (Carrozza, 2011). COVIRI has responsibilities regarding the definition and fine-tuning of the water service tariffs and consumer protection. One of the main goals of this entity is to ensure the effectiveness, efficiency and economic sustainability of the utilities. The committee can propose sanctions against the operators who fail to adhere to the principles prescribed by the Galli law. However, thus far, COVIRI has never had the resources to operate as an effective national regulator, as supposed in the Galli reform.

Today the water industry in Italy is the focus of a vast political debate. The Italian government enacted a new law (no. 133/2008 art. 23-bis modified in November 2009) that encouraged private or mixed management of the SII. The aim of this reform was to improve SII's performance through the inclusion of private investors, since the Italian government considered these models to be more effective and efficiency-oriented than the ones involving public ownership. However, in June 2011 a highly debated and participated referendum was held on these issues. As an outcome, the AATOs are now not required to delegate the SII to mixed or privately owned firms.

2.3 A brief comparison

The current state of affairs in the water sectors of both countries is unstable. In addition to being essential for the wellbeing of the populations, water services have a latent economic interest. Local governments try to retain control and discretion over the services but the pressures for removing the barriers to entry in the market are increasing. Moreover, the use of PPP arrangements is often seen by local decision-makers as the only feasible way to cope with the constraints on public debt (Carrozza, 2011).

The reforms undertaken had several positive outcomes, especially in terms of quality of service (see Danesi *et al*., 2007, and Guerrini et al., 2011 about the Italian reform, and Carvalho and Marques, 2011, and Marques, 2008 about the Portuguese reform). Table 1 provides an overview of the water sectors in both countries as they were in 2007 (the year for which we compute the efficiencies of the utilities, *vide* section 4).

[Insert Table 1 here]

Although the statistics shown in Table 1 for drinking water and wastewater are in line with other developed countries (Marques, 2010), nowadays both countries still face several important challenges. In Portugal there is an urgent need to improve the overall productivity of the sector (several utilities struggle to break even) and to clarify the role of the central state as an operator/regulator (Marques, 2006). In Italy, the main problems have to do with the very long time that the Galli reform is taking to be carried out and to the absence of open tender procedures for the selection of private partners in several occasions, especially as the minority shareholders of the mixed companies (Asquer, 2011). In addition, the outcome of the 2011 referendum has defined a framework that is still hazy and unstable regarding both the governance choices and the process of tariff setting.

3. Performance of water utilities and cross-national comparisons

Since the 1970s the performance evaluation of water utilities has been carried out mainly through several key performance indicators (KPI) organized in a report (e.g. scorecards, Tynan and Kingdom, 2002; Yepes and Dianderas, 1996) or through overall performance scores which synthesize in a single value the trend of a group of measures (e.g. financial ratios, Guerrini *et al.*, 2011, non-parametric methods like DEA, Thanassoulis, 2000, and parametric methods like regression analysis, Corton, 2003).

Partial measures (single dimension indicators) are intuitive and easy to compute. However, if used to compare the performance of a multitude of firms, they can lead to some misinterpretations and do not allow for the definition of an overall performance ranking (Marques, 2008). Indeed, the weakness of these measures is the failure to cover all inputs, outputs and explanatory factors that are relevant to the performance of the decision-making units (DMUs).

Both parametric and non-parametric methods have been used to study the influence of ownership, company size, diversification and geographical location on performance (for an overview on the strengths and limitations of both methods see Fried *et al*., 2008). The aim is to determine which would be the best ownership and regulatory structure, investigate the existence of economies of scale and scope and the different performance levels achieved in distinct regions or countries (Berg and Marques, 2011).

Regarding the ownership structure, some researchers reported that this variable does not influence performance (e.g. García-Sánchez, 2006; Seroa da Motta and Moreira, 2006; Saal *et al.*, 2007). The same happens with the market structure. Some authors defend the existence of economies of scale and of economies of scope (between different activities, such as water and wastewater or levels of integration between the 'wholesale' and 'retail' segments) while others prove the opposite (the existence of diseconomies of scale and scope). This lack of clear convergence can be analyzed in meta-analysis surveys of Abbott and Cohen (2009) and Berg and Marques (2011).

Several papers published in the past few years studied the different levels of efficiency achieved in distinct regions within the same country (e.g. see Garcia-Valiñas and Muñiz 2007; and Alsharif *et al.* 2008). However, cross-national benchmark studies are rare. Some recent exceptions can be found in the literature, like Corton and Berg (2009) and Clarke *et al.* (2004) for Latin America countries, Nauges and Berg (2008) for transition economies, Estache and Kouassi (2002) for African utilities, Estache, and Rossi (2002) for Asian and Pacific regional water companies, and De Witte and

Marques (2010) for the Netherlands, England and Wales, Australia, Portugal and Belgium, All these studies struggle with the comparability of data that depend on numerous factors. Nevertheless, the cases of Portugal and Italy are especially suitable for this kind of comparison since many important features, such as the institutional environment and the climate, are similar for both countries (Carvalho and Marques, 2011).

Research on the consequences of reforms in the water sector is also scarce. However, there is a growing notion that the privatization of water utilities, as a strategic solution for the sector, lacks empirical confirmation (Anwandter and Ozuna, 2002). Besides considering the effects of different ownership and governance structures on performance, academics and practitioners should also focus on the regulatory framework of the sector (Bel *et al*., 2010). Privatization by itself will not be an optimal answer if not accompanied by the adequate level of competition for the market and mechanisms to reduce information asymmetries. Moreover, “any reform intending to increase coverage (either through commercialization, private sector participation, additional investment or increasing efficiency) should be accompanied by the appropriate social policies” (Prasad, 2007: 21). Nevertheless, one can find some encouraging reports of reforms in developing countries (Brocklehurst and Janssens, 2004 and Brunner *et al*., 2010). We believe that this type of “reality check” is also crucial for developed countries that carried out massive reforms in the water sector.

4. Efficiency of the water utilities

4.1 Methodological approach: Data Envelopment Analysis

To compute the efficiency scores of the DMUs, we used the non-parametric technique of DEA. This type of methodologies let the data “speak by itself” without imposing *a priori* any assumptions regarding production conditions (about frontier techniques see Fried *et al*., 2008). Thus, non-parametric techniques demand fewer requirements from the data than the parametric ones (since the latter techniques assume an aprioristic production or cost function that has the technology embedded). The DEA methodology was developed by Charnes *et al.* (1978) and, using an input orientation and assuming constant returns to scale (CRS) technology and strong disposability of inputs, the efficiency estimates can be computed by solving the following linear programming problem, where $x \in \Re_{+}^{p}$ are the inputs used to produce the outputs $y \in \Re_{+}^{q}$ and θ the DEA CRS efficiency scores for a given DMU:

$$\hat{\theta}_{CRS}(x, y) = \min\left\{\theta > 0 \mid y \leq \sum_{i=1}^{n} \gamma_i y_i ; \theta x \geq \sum_{i=1}^{n} \gamma_i x_i ; \gamma_i \geq 0, i = 1,..., n\right\} \tag{1}$$

This technique allows for the determination of the best practice frontier (and thus the comparison of each DMU with this frontier). It is assumed that the technology of an observation $i \; (i = 1,..., n)$ is characterized by the production set Ψ : $\Psi = \{(x, y) \in \Re_{+}^{p+q} \mid x \text{ can produce } y\}$ and that there is free disposability of inputs and outputs and the convexity of production in set Ψ . The best DMUs will show an efficiency estimate equal to one, while inefficient DMUs will be below this value.

The best practice frontier can be determined considering CRS or variable returns to scale (VRS) technologies. While in CRS estimation assumes that every DMU operates at an optimal scale, VRS estimation only compares similar DMUs (i.e. DMUs operating at the same scale, Banker *et al.*, 1984). VRS estimates (θ) are obtained from the previous expression by adding the constraint $\sum_{i=1}^{n} \gamma_i = 1$.

If a water utility has a CRS efficiency score equal to its VRS efficiency score (i.e. if $\theta^{CRS} = \theta^{VRS}$), this means that the DMU operates in a setting with constant returns to scale, having a scale efficiency (SE) equal to one ($SE = \theta^{CRS} / \theta^{VRS}$). On the contrary, if a DMU presents a $SE < 1$ it means that that utility operates in a setting with increasing returns to scale (IRS) technology or decreasing returns to scale (DRS) technology. In our case, if a utility operates at IRS, it means that its scale efficiency would improve (i.e. its CRS efficiency score would be higher) if it could increase the output level. In other words, to increase the output level, a utility operating at IRS would also have to increase its input level, but at a lower rate. The opposite happens for utilities operating at DRS (whereas for efficient utilities operating at CRS, the inputs and outputs vary at the same rate).

To find if each utility is operating with IRS or DRS it is necessary to solve an additional DEA program imposing non-increasing returns to scale (NIRS). This is accomplished by adding the constraint $\sum_{i=1}^{n}\gamma_i \leq 1$ to equation (1). The obtained efficiencies (θ^{NIRS}) along with the θ^{VRS} estimates allow us to determine if the DMU operates with DRS ($\theta^{NIRS} = \theta^{VRS}$) or with IRS ($\theta^{NIRS} \neq \theta^{VRS}$) technologies.

4.2 Data and model specification

We have collected data from 88 utilities (33 from Italy and 55 from Portugal) for the year 2007 (see Table 2). The data were retrieved directly by the authors (from the annual account reports published by the water utilities) and by the sector-specific regulators. In particular, Italian data were obtained from COVIRI and collected directly from companies. Portuguese data were mainly obtained from the annual account reports requested to the water utilities and complemented with the information in the 2007 annual sector report of ERSAR.

[Insert Table 2 here]

All utilities in our sample (Portuguese and Italian) provide water and wastewater services and a number of Portuguese utilities are also responsible for other services (e.g. urban waste); in these cases, we removed the costs relative to other services for the computation of the efficiency estimates. As expected, in both countries the most common ownership structure is the one related to publicly-owned utilities. One interesting difference is the private sector participation model.

According to our sample, while in Italy most PPPs are of the institutional type (mixed companies or iPPPs), in Portugal contractual PPPs (concessions or cPPPs) are the most common models.[2]

Table 3 shows the statistics of the selected variables for Italy, Portugal and for both countries as a whole. Italian utilities have higher values in every variable (especially regarding unitary or per utility values). Concerning the population served by the utilities, the Italian sample encompasses about 22% of the country's population and the Portuguese sample covers 47% of the country's population (according to EUROSTAT estimates for 2007).

[Insert Table 3 here]

Since the DEA method accounts for the necessary inputs to produce a certain level of outputs (input orientation), it is necessary to specify a model including them at an adequate aggregation level. We use an input orientation because the aim of water utilities is to reduce resource consumption and not increase the market share (Berg and Marques, 2011). For this study we specified two models. The inputs and outputs adopted for each model are presented in Table 4. While in model 1 we only use costs as inputs (staff cost, capital cost – CAPEX, and other operation and maintenance costs – OOPEX), in model 2 we use quantities (although we also use OOPEX). The two selected outputs allow us to control for fixed revenues (population served) and variable revenues (revenue water volume).

[Insert Table 4 here]

[2] See the Green Paper on Public-Private Partnerships and Community Law on Public Contracts and Concessions for the definition of cPPP and iPPP (European Commission, 2004). For detail regarding iPPP arrangements see European Commission (2008).

4.3 Results

Table 5 shows the global efficiency estimates for Italian and Portuguese water utilities, for both models and using CRS and VRS approaches. It also shows the average efficiencies of public, mixed and private utilities. If the CRS and VRS efficiency estimates of a given DMU are not equal, it means that that DMU is not operating at an optimal scale. Moreover, using an input orientation, the difference between an efficiency score and the unity represents the potential (percentage) to reduce the mix of inputs consumed to produce the same quantity of outputs. This reduction could be achieved with the improvement of both scale efficiency and pure technical efficiency.

[Insert Table 5 here]

In international comparisons, it is important to take into account the purchasing power parity of each country. Hence, we also computed the efficiency scores with the adjusted costs using OECD indicators for 2007 (see Table 6). As it can easily be seen, Italian utilities appear to be slightly more efficient than their Portuguese counterparts (except for CRS estimates using model 1). Concerning the ownership structure, public utilities seem to be the most efficient ones while private (concessionary) companies depict the worst efficiency scores. However, one should bear in mind that almost all concessionary companies in our sample are Portuguese utilities; therefore we are unable to provide a verdict on the performance of this specific governance model in Italy. Furthermore, for the reasons already stated, the true effects of private ownership should also be tested using a productivity analysis (and perhaps an analysis regarding the quality of service) over a representative period of time.

[Insert Table 6 here]

The best practice frontier for the CRS-Model 1 specification is shaped by nine utilities (three Italian and six Portuguese that have efficiency scores equal to one). For the CRS-Model 2, 12 utilities are considered efficient (five Italian and seven Portuguese).

There is no statistical evidence of a significant difference between the efficiencies of Portugal and Italy. In fact, the results of non-parametric tests (Mann-Whitney U, Kolmogorov-Smirnov and Kruskal-Wallis) show that the distributions of the efficiencies are similar for both countries. One exception is the difference between the average scale efficiencies (SE) for Portuguese and Italian utilities; the difference of approximately 6% between the averages (see Figure 1) is statistically significant (at the 5% level) employing a simple T-Test on the estimates of model 1. This is an unexpected result. Indeed, one would expect that the Italian reform of the water sector would have improved the overall scale efficiency of the utilities. Nevertheless, two phenomena may be occurring: (1) the smaller scale of the Portuguese utilities may be better suited regarding the vertical disintegration carried out in this country; (2) some Italian utilities are too big (furthermore, the Italian utilities in our sample only provide water and wastewater services and might be losing the opportunity to exploit potential economies of scope, e.g. regarding urban waste services).

[Insert Figure 1 here]

5. Concluding remarks

In practical terms, the reforms undertaken by Portugal and Italy in the water sector had similar trends (trying to remove the barriers to entry) but also crucial differences (vertical disintegration in Portugal and definition of “optimal areas” for the integrated systems in Italy). The performance results obtained for both countries highlight significant levels of inefficiency. In Portugal, water (and wastewater) utilities show an average potential for improvement of around 36% (considering model 1), where 12% correspond to SE gains. In Italy, water services show an average potential for improvement of around 38% (considering model 1), where 18% correspond to SE gains. This means that, on average, each utility could reduce the consumption of inputs (mainly OPEX and CAPEX) by these percentages and produce the same quantity of outputs. When we compare the purchasing power parity adjusted results with the unadjusted results, we conclude that this amendment does matter and that Italian water utilities are penalized if this is not taken into account. Indeed, the costs in Italy are higher and most of them are explained by the higher cost of living in this country when compared to Portugal.

Concerning the outcomes of the two models, some interesting conclusions can be taken. The first one, concerning model 1, is that Italian water utilities are more efficient than Portuguese utilities with the VRS model (where scale effects are accounted for) in opposition to the current state of affairs of CRS model (where scale is irrelevant). However, when we remove the effect of scale, the opposite happens, that is, the Portuguese utilities are more efficient. This means that, unlike what was expected, it is not clear that the reform undertaken in Italy allowed for the effective exploitation of economies of scale in all cases.

Note that both countries reformed the market structure of their water sectors in the 1990s with the objective of becoming more efficient. Nevertheless, it seems that the outcomes of Italy are more evident (the pure technical efficiency is higher for Italian utilities). When we compare the results of model 2, this effect is not observable as we are dealing with two inputs in quantity units and the input mains length is only a proxy of the CAPEX. The mains length cannot be reduced (in an input orientation model) and as such it should be considered as non-discretionary (Banker and Morey, 1986).

Another interesting result is that water utilities with public ownership seem more efficient than the private ones. Although this is not an atypical result in the literature, it means that the reforms in both countries, which favored (and continue to favor) the entrance of the private sector, were not necessarily successful. Of course, the ‘scissors effect’ and high rents can partially justify the performance scores. However, these scores point out to some failures in the reforms and in the regulation of the private sector participation. Surprisingly, the mixed companies are more efficient than the private (concessionary) companies. This outcome contradicts the literature where mixed companies are often seen as the “worst of two worlds” (see Eckel and Vining, 1985 and, more recently, Cruz and Marques, 2012). A productivity analysis over a few years period would be relevant to test these results.

Finally, we should highlight that unequivocally there is room for improvement in the efficiency of Portuguese and Italian water industry and that this kind of studies might contribute to ameliorate the current situation. However, to effectively evaluate the reforms that took place in these two countries in the water sector one should consider panel data with information from before and after the reforms. Despite not being able to do it yet, the cross-section analysis carried out in this paper provides strong evidence on how important it is to account for the real impacts of the reforms.

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Figure Captions

Figure 1 – Constant returns to scale (CRS), variable returns to scale (VRS) and scale efficiency (SE) scores for model 1

Table Captions

Table 1 – Differences in the water sectors of Portugal and Italy

Table 2 – Sampled utilities and respective management models

Table 3 – Data from Portuguese and Italian water utilities

Table 4 – Inputs and outputs adopted for the data envelopment analysis models (CAPEX means capital expenditure; OOPEX means other operational expenditure)

Table 5 – Constant returns to scale (CRS), variable returns to scale (VRS) and scale efficiency (SE) scores by group

Table 6 – Adjusted constant returns to scale (CRS), variable returns to scale (VRS) and scale efficiency (SE) scores by group (minimum and average values)

Table 1 – Differences in the water sectors of Portugal and Italy

Year 2007	**Portugal**	**Italy**
Drinking water services coverage (%)	91.1	96.0
Wastewater services coverage (%)	75.1	83.6
Wastewater treatment coverage (%)	66.3	74.8
Abstracted water volume (million m^3)	862	7,600
Drinking water volume (million m^3)	560	4,500
Water losses (%)	35	40
Consumption per capita (liters/person/day)	153	230
Turnover (million €)	1,650	4,231
Drinking water average tariff (€/m^3)	0.87	1.23
Average annual invoice per customer (€)	130	250

Source: Marques (2010).

Table 2 – Sampled utilities and respective management models

Management model	Italy	Portugal	Total
Public	20	37	57
Mixed	12	4	16
Private	1	14	15
Total	33	55	88

Source: the authors.

Table 3 – Data from Portuguese and Italian water utilities

Year 2007	Italy (33 utilities)		Portugal (55 utilities)		Aggregate (88 utilities)	
	Total	per utility (average)	Total	per utility (average)	Total	per utility (average)
Cost of capital (10^6 €)	254	7	159	2	413	4
Staff cost (10^6 €)	388	11	173	3	562	6
Other cost (10^6 €)	1,359	41	332	6	1,691	19
Mains length (km)	92,961	2,817	37,649	685	130,610	1,484
No. Employees (n.)	6,966	211	5,575	101	12,541	143
Revenue water (10^6 m3)	1,138	34	320	5	1,458	16
Population served (n.)	13,161,492	398,833	4,934,955	89,726	18,096,447	205,641
Population served (% of total)	22%	–	47%	–	–	–

Source: the authors.

Table 4 – Inputs and outputs adopted for the data envelopment analysis models (CAPEX means capital expenditure; OOPEX means other operational expenditure)

	Inputs	Outputs
Model 1	Staff cost (€) CAPEX (€) OOPEX (€)	Revenue water volume (m^3) Population served (no.)
Model 2	Number of employees (no.) Mains length (km) OOPEX (€)	Revenue water volume (m^3) Population served (no.)

Table 5 – Constant returns to scale (CRS), variable returns to scale (VRS) and scale efficiency (SE) scores by group

Year 2007	Model 1			Model 2		
	CRS	VRS	SE	CRS	VRS	SE
Global	0.64	0.76	0.84	0.71	0.77	0.92
Italian utilities	0.58	0.74	0.79	0.70	0.76	0.92
Portuguese utilities	0.68	0.77	0.88	0.72	0.77	0.93
Public	0.67	0.77	0.87	0.75	0.80	0.93
Mixed	0.57	0.74	0.79	0.64	0.70	0.92
Private	0.58	0.74	0.80	0.64	0.72	0.90

Table 6 – Adjusted constant returns to scale (CRS), variable returns to scale (VRS) and scale efficiency (SE) scores by group (minimum and average values)

Year 2007 ***(purchasing power parity adjusted)***	**Model 1**					**Model 2**				
	CRS		**VRS**		**SE**	**CRS**		**VRS**		**SE**
	min	**avg**	**min**	**avg**	**avg**	**min**	**avg**	**min**	**avg**	**avg**
Global	0.31	0.63	0.33	0.74	0.86	0.32	0.71	0.36	0.76	0.94
Italian utilities	0.31	0.62	0.37	0.76	0.82	0.32	0.72	0.36	0.77	0.93
Portuguese utilities	0.33	0.64	0.33	0.73	0.88	0.38	0.71	0.40	0.75	0.95
Public	0.31	0.67	0.37	0.76	0.89	0.32	0.75	0.36	0.79	0.95
Mixed	0.33	0.60	0.33	0.74	0.82	0.42	0.66	0.43	0.71	0.93
Private	0.33	0.54	0.37	0.69	0.80	0.39	0.63	0.42	0.69	0.92
Public (Italian)	0.31	0.63	0.37	0.74	0.86	0.32	0.74	0.36	0.78	0.94
Mixed (Italian)	0.42	0.61	0.44	0.78	0.79	0.42	0.66	0.43	0.73	0.91
Private (Italian)	0.43	0.43	0.98	0.98	0.44	0.97	0.97	0.97	0.97	0.99
Public (Portuguese)	0.40	0.69	0.41	0.77	0.90	0.40	0.76	0.40	0.80	0.95
Mixed (Portuguese)	0.33	0.55	0.33	0.61	0.94	0.47	0.64	0.48	0.64	0.99
Private (Portuguese)	0.33	0.54	0.37	0.67	0.83	0.38	0.60	0.42	0.67	0.91

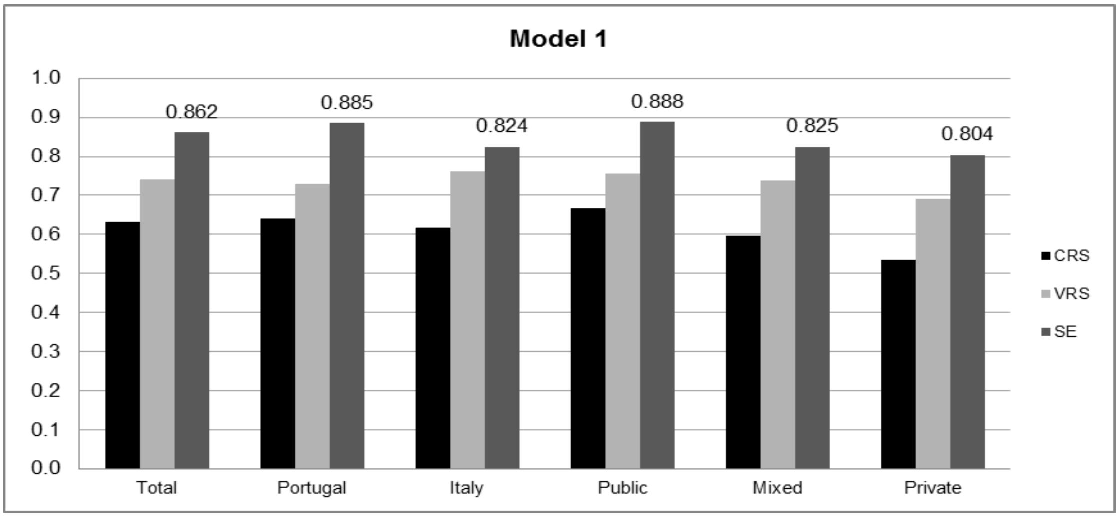

Figure 1 – Constant returns to scale (CRS), variable returns to scale (VRS) and scale efficiency (SE) scores for model 1