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Measuring and comparing the efficiency of water utility companies: A data envelopment analysis approach☆

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ABSTRACT

This study provides an analysis of Italian water utilities to determine the effects on their efficiency of certain relevant variables that have been broadly discussed in the existing literature. We reviewed the annual financial statements of 43 Italian water utility companies and obtained other technical data from Co.n.vi.r.i., the Italian national authority for water. Using data envelopment analysis we assessed their cost efficiencies and, using non-parametric statistic methods, we discuss the significant differences among clusters.

We found that ownership structure, size and geographical location had an impact on the performance of water utilities, although with different degrees of significance.

1. Introduction

Today in Italy, as well as in other countries, there is an intense debate over the water industry. Both researchers and policy makers are looking for the most effective strategies for the efficient use of water, with particular focus on governance, organizational and location choices.

The aim of this article is to determine whether the efficiency of water utility companies differs among firms with dissimilar characteristics, which have already been broadly studied in the existing scientific literature, although with contrasting results. As a matter of fact, many scholars, using different methods and models, have tried to estimate the actual determinants of performance trends, linking the specific features of each firm (such as ownership, size, geographical location and degree of diversification) to the trend of its efficiency (for references see Abbott and Cohen, 2009; Renzetti and Dupont, 2003).

This specific problem was investigated particularly by those authors who adopted the performance evaluation model based on production frontiers. Frontier models can be parametric or non-parametric. In reference to studies that analyzed performance of the water industry (Berg and Marques, 2011), the most used non-parametric method was data envelopment analysis (DEA) (Banker et al., 1984; Charnes et al., 1978), which compare each producer with the virtual "best". Every virtual producer is identified through a linear programming approach which determines whether it is possible for an operative unit to obtain more outputs with the same inputs or to obtain the same outputs using fewer inputs.

Using the DEA method and further statistical analysis, we found how efficiency differs among various clusters of Italian water utilities and which factors accounted for these differences.

Based on the New Public Management approach (Hood, 1991; Clark, 2000), our paper improves the scientific literature on the performance of water utility companies by providing an analysis of the Italian water industry using a data envelopment approach.

Italy provides a potentially valuable environment for comparing performance of water utilities because of the current co-existence of companies with different features. In particular, the Italian water industry is composed of public and private utilities, small, medium and large companies as well as mono- and multi-utilities. In addition, the Italian territory is characterized by areas, such as southern Italy, where water scarcity is more significant than elsewhere.

The results of the present research study led to an improvement in the debate on governance choices and the organizational structure of water utilities by offering useful indications to decision makers for the implementation of future strategies.

2. A review of the literature

Performance assessments of water, wastewater and sewerage utility companies have been carried out all over the world using

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different methods and models. In particular, scholars have distinguished between models based on key performance indicators (KPI), organized in a report using scorecards (Hassanein and Khalifa, 2006; Marques and Monteiro, 2001; Tynan and Kingdom, 2002; Yepes and Dianderas, 1996), and models applying mathematical methods that define an overall performance indicator that synthesizes a group of measures in a single score.

Among the latter, we can further distinguish methods that aggregate the scores of every measure by pondering them with their specific weight in order to obtain a single measure of performance (Kulshrestha, 2006); methods based on financial ratios, such as return on investment (ROI) and return on equity (ROE), which can be broken down into a wide number of indexes in order to measure profits, efficiency and liquidity (Guerrini et al., 2011; Klase, 1995; Shaoul, 1997); and methods for assessing the productive efficiencies of operating units based on linear programming, such as data envelopment analysis (García-Sánchez, 2006; Thanassoulis, 2000a, 2000b; Tupper and Resende, 2004; Woodbury and Dollery, 2004) or on regression analysis (cost function) (Antonioli and Filippini, 2001; Corton, 2003).

Except for scorecards, each method applied to the water industry allows the researcher to create benchmarking among utilities, and each has its relative strengths and weaknesses (Burns et al., 2005; Guerrini et al., 2011).

As a review of the scientific literature revealed (Berg and Marques, 2011), the problem of estimating the actual determinants of performance trends - linking the specific features of each firm (such as ownership, size and degree of diversification) to the trend of its efficiency – was investigated particularly by those authors who adopted the performance evaluation model based on production frontiers. Frontier models can be parametric or non-parametric. The former estimates a cost function by adopting a multivariate regression analysis of a set of specific data, including production inputs and outputs (for instance, labor costs, capital costs and water delivered). Efficiency is measured by the gap between observed data and maximum production represented by the frontier. Non-parametric analysis, instead, does not require specification of any particular functional form to describe the efficiency frontier.

The most used non-parametric method is DEA, which compares each producer with its related virtual "best". Every virtual producer is identified through a linear programming approach. As Cubbin and Tzanidakis (1998) pointed out, there are major differences between regression analysis (RA) and (DEA), but they are both potentially useful tools for comparative efficiency analysis. Moreover, authors who applied both the DEA models and parametric frontiers (Bhattacharyya et al., 1995 and Seroa da Motta and Moreira, 2006) found that the results were very similar.

DEA is particularly helpful in evaluating performance of water utility companies since there is scarce knowledge of the production function in the water sector (De Witte and Marques, 2010) and DEA requires no assumptions regarding the functional relationship between costs and outputs. As a matter of fact, Bogetoft (1994) pointed out certain incentive-efficient properties of DEA since it uses data on multiple inputs and outputs (Cubbin and Tzanidakis, 1998; Stolp, 1990) that are reliable, available and well-defined (Byrnes et al., 1986).

For these reasons, following the pioneering work of Byrnes et al. in 1986, over the past 25 years several studies have used DEA to analyze the performance of companies operating in the water industry.

These studies concern different countries- from the USA (Byrnes et al., 1986; Lambert et al., 1993; Shih et al., 2006) to Brazil (Seroa da Motta and Moreira, 2006; Tupper and Resende, 2004), from Japan (Aida et al., 1998) to Mexico (Anwandter and Ozuna, 2002), from Palestine (Alsharif et al., 2008) to Australia (Byrnes et al., 2010; Coelli and Walding, 2005; Woodbury and Dollery, 2004). With reference to Europe, existing studies have analyzed England and Wales (Cubbin and Tzanidakis, 1998; Thanassoulis, 2000a,b, 2002) and, more recently, Spain (García-Sánchez, 2006; Garcia-Valiñas and Muñiz, 2007; Picazo-Tadeo et al., 2008, 2009a, 2009b). In addition, De Witte and Marques (2010) recently compared the water sector of certain European countries (Netherlands, England and Wales, Portugal and Belgium) with the water industry in Australia. Performance of the water industry in other European countries has been analyzed using other methods, such as the translog cost function (Fabbri and Fraquelli, 2000), the cost function (Fraquelli and Giandrone, 2003) or the stochastic frontier and translog cost function for Italy (Fraquelli and Moiso, 2005) and the cost function for Germany (Sauer, 2005) and Portugal (Martins et al., 2006).

Due to the lack of available and reliable data, the authors that used DEA mainly considered data referring to a single year, or at the most a two-year period. Only a few papers used longer periods of time (Byrnes et al., 2010; Seroa da Motta and Moreira, 2006; Tupper and Resende, 2004); in particular, Garcia-Valiñas and Muñiz (2007) used a sixteen-year period with reference to Spain, but used only a three-unit sample. The sample periods were between 1976 and 2005, which includes the most recent data analyzed by scholars (Corton and Berg, 2009 referring to several Central America countries and De Witte and Marques, 2010 for the Netherlands, England & Wales, Australia, Portugal and Belgium).

The sample number of units varied considerably, from 3 units (Garcia-Valiñas and Muñiz, 2007) to 271 (Lambert et al., 1993). The majority of the studies used less than 40 units. Only few papers used more than 100 units for a single country and none of these regarded European countries; they referred to the USA (Byrnes et al., 1986; Lambert et al., 1993; Shih et al., 2006), Japan (Aida et al., 1998), Brazil (Seroa da Motta and Moreira, 2006) and Mexico (Anwandter and Ozuna, 2002).

Some of the studies using DEA methods focused on ownership, company size and geographical location, looking respectively for the best ownership structure, the existence of economies of scale and the different performance levels achieved in distinct regions or countries.

Looking at the findings of the studies that analyzed ownership structure, we noted that some authors reported that the ownership structure did not influence performance (Byrnes et al., 1986; García-Sánchez, 2006; Kirkpatrick et al., 2006; Seroa da Motta and Moreira, 2006). Other studies highlighted the relevance of ownership on performance, claiming that public ownership improved efficiency (Lambert et al., 1993; Shih et al., 2006) or, on the contrary, that private utilities outperformed public companies in the management of specific production factors, mainly labor (Picazo-Tadeo et al., 2009a, 2009b).

Therefore, from the literature review on DEA studies, no clear picture emerged and this result was confirmed by recent analysis of the entire literature related to the water industry (Abbott and Cohen, 2009; Berg and Marques, 2011; Guerrini et al., 2011; Pérard, 2009; Renzetti and Dupont, 2003; Walter et al., 2009).

Also, the papers that analyzed the dimension issue using a DEA approach found contradictory results. Aida et al. (1998), with reference to Japan, observed that smaller-sized firms were more efficient. On the contrary, Shih et al. (2006), studying the US water industry, found that smaller companies tended to face higher unit production costs. Accordingly, Byrnes et al. (2010), in their study on Australia, observed that larger Victoria water utilities were characterized by a higher degree of managerial efficiency.

Contrasting findings were found by Seroa da Motta and Moreira (2006) relating to the Brazilian context; they found that suppliers serving several municipalities actually benefited from larger scale economies and that scale effects enjoyed by regional operators did not improve their efficiency and lowered their tariff levels.