Efficiency of Water Utilities: Does Local Public Ownership Matter? Evidence from Italy

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Abstract

In the last decades the governance of local public services has been the focus of administrative reforms to pursue an improvement in the efficiency and productivity levels coping with increasing constrains in financial resources. In this scenario, changes in governance and ownership of local public services shave occurred with a shift from public to private ownership (Pollitt and Bouckaert, 2011). Our paper focuses on the efficiency analysis of Italian water utilities. The attention toward this type of utilities is motivated by two reasons: firstly, in recent years the Italian water industry has been at the centre of debate about the possibility of privatization; secondly in 2011 the change in the regulation conferred powers to the Italian regions to decide on which administrative body should be the provider of local water services. In addition, the law does not exclude that regions themselves could exercise this power. Thus, the evaluation of the efficiency and productivity analysis could have an important policy implication for regions and other water industry regulators. Moreover, the debate about the determinants of the performance of public service organization is a long lasting one, especially with regard to the dichotomy between public and private ownership (Andrews et al. 2011). On the bases of this background, the paper addresses the following research questions: Is the ownership (public, mixed, or private) a significant determinant of the efficiency level of water utilities? Can size and geographical location be regarded as moderators of the relationship between ownership and efficiency? The method applied in the paper combines Data Envelopment Analysis (DEA) with cluster analysis. This method has the advantage to rank water utilities on bases of their efficiency score without requiring any assumption on the distribution function of the data and to work well with small samples (Coelli et al 2005). The cluster analysis allows classifying the utilities ex-post instead of ex-ante, thus it provides more rigours results (O'Donnell et al. 2008, Balaguer-Coll et al. 2013). The results show that the ownership has not a significant effect on efficiency per se, however the combination of size and geographical location provides interesting insights on the difference observed in the performance.

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1 Introduction

In previous decades the governance of local public services has been the focus of administrative reforms in order to improve the efficiency and productivity levels and cope with increasing constrains in financial resources. In this scenario, changes in governance and ownership of local public services shave occurred with a shift from public to private ownership (Pollitt and Bouckaert, 2011). Theories and evidence show puzzling results about the relationship between ownership and performance. Yet, this issue brings questions about the publicness and applications of private management practices in public organization. Moreover, Andrews et al. (2011) argues that the understanding of the link between ownership and performance is further complicated by the effects of moderators, such as size, geographical location and governance. However, a lack of research about the influence of moderators is claimed. The paper focuses on the efficiency analysis of Italian water utilities, in order to evaluate the effect of ownership on efficiency and the influence of moderators. The attention toward this type of Italian utilities is motivated by three reasons. Firstly, in recent years the Italian water industry has been at the centre of debate about the possibility of liberalization. Secondly in 2011 the change in the regulation modified the multilevel governance of the industry. Thirdly, in Italy it is claimed that the price of the water is one the cheapest in Europe, but research results claim that is not sustainable in the future (Utilitatis 2011). In this context efficiency is not only a sufficient condition but it is a necessary condition to continue to guarantee these vital service in a fair and equal manner. Studies of efficiency of water share the same concern about other European countries, such as Spain and Portugal (Gonzlez-Gmez et al. 2013). This paper addresses the following research questions: Is the ownership (public, mixed, or private) a significant determinant of the efficiency level of water utilities? Can size and geographical location be regarded as moderators of the relationship between ownership and efficiency? The method applied in this paper combines Data Envelopment Analysis (DEA) with cluster analysis as suggested by ODonnell et al. (2008) and Balaguer-Coll et al. (2013). DEA is a non parametric technique that has the advantage to rank water utilities on bases of their efficiency score without requiring any assumption on the distribution function of the data (Coelli et al 2005). This method is widely used in the study of the effect of ownership on efficiency since the 1980s of the last century Byrnes et al. (1986). However, so far in the Italian context only one study has been found applying this technique (Romano and Guerrini 2011). Moreover, the cluster analysis allows the classification of the utilities expost instead of ex-ante, thus it is a more robust method, although improvement to the method applied in this study are needed since it is a less robust version of the technique suggested by ODonnell et al. (2008). The results show that the ownership does not have a significant effect on efficiency per se, however the combination of size and geographical location provides interesting insights on the differences observed in the performance. Thus this paper contributes to the literature in two directions. First, it brings evidence in the context of the puzzling relationship between type of ownership and performance. Second, it adopts an innovative method combining DEA with cluster analysis. Moreover, this study could have policy implications that water industry authorities can take into account. The plan of the paper is as follows. Section 2 reviews the relevant literature and provides the regulatory framework of the Italian Water

Service. Section 3 gives an account of the methodology adopted and how the study is carried out. The empirical results are reported in Section 4. Finally, Section 5 concludes the paper emphasising some recommendations for future research.

2 Literature Review

The current section provides an overview of the literature on the relationship between ownership and performance. It starts with the definitions of the elements that distinguish a public organization from a private one then briefly reports the evolution of the role of the governments that blurs the boundaries between the two sectors. After that, the section focuses on the Water Supply Services and provides an account of the Italian regulation, since it can affect the delivery mode of the service. A brief review of the methodologies used to assess the performance and the research about the relationship between ownership and efficiency is given.

2.1 The dimensions of "publicness"

The dichotomy between the public and private sector has been studied for a long time and in different areas of Economics. Scholars have tried to understand whether and how the publicness of an organization can affect its performance in order to find the most efficient, effective and fair mode to delivery public services. In order to identify the aspects that distinguish a public from a private organization, Bozeman (1997) suggests three dimensions of publicness: (1) ownership (public, private, or non profit, mixed), (2) funding (government funds and transfer or consumers payments) and (3) control (by political or market forces). In Bozemams model all the three aspects contribute to characterise an organization and thus they can affect its performance. However, a recent review of the literature reveals that most studies focus only on one aspect, which is the ownership (Andrews et al. 2011). The persistence of attention to this dimension could be firstly motivated by the purpose of finding more conclusive results. Indeed, Andrews et al. (2011) states that most studies reveal contrasting results, with some finding positive, negative and no effect of ownership on performance. Therefore, Andrews et al. (2011) suggests considering moderator of the relationship between the three dimensions of publicness and performance, such as size, geographical location, regulation and governance. A second motivation for focusing on ownership could be found in the increasing range of structural modes of delivering public services that combine public and private ownership, such as mixed companies and public-private partnership. Consequently this element increases the complexity of the relationship and justifies new studies. Moreover, the debate around the impact of ownership on performance has been trigged by the evolution of the role of government and by different theoretical perspectives that have also shaped the administrative reforms that have occurred around the world. Over the centuries, the role of the government has changed. Musgrave (1959) identifies three branches of the government: allocative, distribution and stabilisation. Through each branch the government intervene in the economy. With particular regard to the allocative branch the government aims to correct market failure through regulation, taxation and providing public goods. There-

fore, a first theoretical motivation of the public ownership of enterprises that provides public goods and services could be found in the correction of market failure. However, beside market failure there are also government failures. The latter are emphasized by the Public Choice school. The scholars belonging to this school criticize government intervention and public ownership. In particular, in the field of Public Choice (Demsetz 1967; De Alessi 1983) there is a theoretical expectation that the private sector can outperform the public sector. This assumption is based on two main arguments. Firstly, the economic theory of property rights suggests that public ownership leads to lower efficiency. In private organizations, owners and shareholders have a direct financial incentive to monitor and control the behaviour of managers. Similarly, managers of private firms themselves are likely to benefit from better performance either because company shares are part of their remuneration package or because their salary is linked directly to financial success. In contrast, property rights in the public sector are widespread. Individual voters have little to gain form expending effort on monitoring managerial behaviour. Moreover, public managers do not usually obtain direct financial benefits from higher organizational performance. A second theoretical argument is that ownership is associated with inherent differences in management practices. In particular, private organizations are widely believed to have management styles that are more innovative, productive and cutting edge. The belief of the superiority of private management practice on public practice led to wide spread reforms under the theoretical paradigm of the New Public Management (Hood 1991; Pollitt and Bouckaert 2011). In the 70s and the 80s of the last centuries, the reforms adopted by the governments all over the world has led to change in the ownership of the provision of public goods and services towards public to private sectors. Moreover, changes has also occurred in financial management and in management practices, although the debate about the difference between public and private management is still open (Boyne 2002; Meir and OToole, 2011). In the early years of the new century, the increase of hybrid modes of delivery public services and provision of public goods brought about a new role of the government: brokerage (Jackson 2001). Indeed, in this context the state is a regulator in a network of contractual relations, bringing together public and private sector organization (Jackson, 2001). This view is consistent with the literature about the network governance that emphases the role of both public and private sector in service provisions (Kickert et al. 1997; Osborne 2009). Moreover, in this framework the shadow of the recent financial crisis seems to reopen the question about the ownership of the enterprises since the government had to intervene in order to bailout many industries from financial sectors to public services. It can be concluded that the evolution of the role of governments and the mode of delivering public services can make the relationship between ownership and performance even more challenging.

2.2 Water Supply Services in Italy

The Water Supply Services (WSS) are generally considered public services provided though a network and regulated by public authorities. Therefore any speculation on the organization, the governance and the performance of this services is strongly affected by the regulatory framework of each country analysed. The Italian Water Supply Services (WSS) is regulated by four hierarchical juridical

levels: the European Union, since Italy is one of the country members, the central government, regional government and finally local governments. According to European legislation WS is classified as a service of general economic interest (European Community Treaty, Article 86(2); Commission of the European Communities Com 2003 270 final) . Therefore WSS is an economic service that has to be provided to every citizen on a regular basis and at affordable prices, regardless of the ownership of the service provider. Moreover the Commission specifies that these types of services are not subject to a comprehensive regulatory regime at Community level however the provision and organisation of these services are subject to internal market, competition (,) State aid rules and other certain aspects of the provision, such as environmental legislation (Commission of the European Communities Com 2003 270 final, p. 10). Answering to a long lasting European citizens request for protecting water resource, in 2000 the European Commission issued the Water Framework Directive (WFD) addressing all the challenges faced by the management of this crucial resource. One of the innovation introduced by WFD were both the cost recovery for water services and the polluter-pays principles. Indeed, the aim of these principles is to create an incentive for the sustainable and efficient use of the water. As highlighted in the previous section, the last decades have witnessed changes in the ownership of public services providers. The European Commission lets each Member State decide the organization of the provision of the service of general economic interest, as long as the rules on the internal market and on competition are observed. As a result, among EU Member States, different approaches to the organization of WSS can be found. For instance, in Netherlands and Germany, municipal public enterprises provide water services. Conversly, in England and Wales a complete privatization of the service has been developed beside the establishment of an Authority for its regulation (Bauby 2012). Traditionally, in Italy the WSS was provided directly by the municipalities. In this context, the service was financed by public budget and the tariff was usually not able to cover the costs (Massarutto et al. 2008). In order to improve the efficiency of the industry, a comprehensive reform of the WSS was issued in 1994 (Legge Galli, Law 196/94) introducing three crucial innovations in the Italian scenario. Firstly, the reform recognized the network features of the WSS and introduced the concept of integrated water service considering the whole water supply and sewage system. Secondly, the reform reorganized the WSS introducing an intermediate authority of the governance of the service in each area called Autorit dAmbito Ottimale (ATOs) with the aim to exploit economies of scale. The ATOs were identified by the regions according to both political-administrative and hydrographical features of the regional area. Therefore some small regions identified just one ATO while bigger ones divided their territory in different ATOs. Further, the ATOs are owned by the municipalities of the area. The main function assigned to the ATOs was to draw a plan of the management of the WSS and entrust the provider of the WSS. Indeed, from the nineties of last century to early 2000, as other services of economic general interest, the WSS was at a center of an extensive series of reforms introducing new modes of provision of services. For brevity purpose, here only the last step of the reform path is recalled: the art. 23-bis of the Law 113/2008. It provides for three forms of service management: 1) private enterprises entrusted by competition; 2) mixed enterprises where the private partner should own 40%, 3) in house providing, only in exceptional cases in derogation from the first two alternatives. However,

as for network services, such as WSS, the law has established the public ownership of networks and assets. In the early 2000s, the Law 196/94 was replaced by the Environmental Code (Decree 152/2006) keeping the two main innovations of the previous law and introducing the European principle of the cost recovery for the WSS. Among other norms, the article 154 of the Environmental Code stated that WSS price had to guarantee a remuneration for the capital invested. In the last three years new events concerned the WSS have arisen. Firstly, in 2010 the financial crises imposed governments to reduce and cut their budget. Indeed, in this context the Italian legislator decided to eliminate the ATOs by the end of 2011. However, this regulation did not suggest which authority should replace the ATOs and nowadays the question is still open. Secondly, in 2011 a referendum repealed the art. 23-bis of the Law 113/2008 and the article 154 of the Environmental Code. Subsequently, the entrusting of the WSS is based only on the European legislation, thus the service can be provided alternatively directly by the municipalities, in house or by mixed enterprises without the specification of the percentage owned by the private partners. Finally, the Italian WSS has been at a center of reforms and counter-reforms leaving two main consequences. Firstly, a multilevel governance structure of the industry, although the levels of this structure are still uncertain with regards to replacement of the ATOs. Secondly, in the absence of an intermediate authorities, like ATOs, it can be argued that municipalities could be gain once again be free to choose the delivery mode and entrust the service provider as they did in the past.

2.3 Measuring Water Supply Services Performance

Since 1970s, studies have been conducted to assess and compare the performance of and of Water Supply Service (WSS) using both (1) accounting methods and (2) econometric and operational research methods. Among the former ones, researchers have applied key performance indicators and financial ratio (e.g. Guerrini et al 2011; Hassanein and Khalifa 2007; Reynaud and Thomas 2013; Shaoul 1996; Tsagarakis 2013; Tynan and Kingdom 2002; Yepes and Dianderas 1996). Econometric and operational research techniques include the use of regression analysis for the estimation of the cost function or operational research techniques based on frontier models, such as SFA and DEA. Although there are difference between methods based on regression analysis and DEA, Cubbin and Tzanidakis (1998) highlighted that both techniques are potentially useful tools for comparative efficiency analysis in the regulated water industry. Moreover, the application of both the DEA models and parametric frontiers (SFA) seems to provide very similar results (Bhattacharyya et al. 1995; Seroa da Motta and Moreira 2006). Recently an interesting research which have focused on Italian ATOs argued that the application of SFA instead of DEA allow a better control for heterogeneity of exogenous variables affecting the performance (e.g. Abrate et al. 2011). However, as it will be explained later an innovative manner to control for heterogeneity might be to combine the flexibility of DEA assumption with cluster analysis (ODonnell et al. 2008, Balaguer-Coll et al. 2013). The current study applies DEA to estimate the WSS utilities efficiency. As pointed out by Bogetoft and Otto (2011), the selection of a benchmarking approach should reflect and respect the characteristics of the industry (p. 19). With particular reference to the WSS industry, De Witte and Marques (2010) argue that the lack of knowledge on the production function in this industry

can justify the application of DEA. Indeed, this method is considered more flexible, than parametric approaches, and is able to adapt its mean structure (shape) to data. DEA does not require any assumption regarding the functional relationship between costs and outputs. Moreover, Bogetoft (1994) highlighted the incentive-efficient properties of DEA that may be useful in the regulatory implication of the analysis (Thanassoulis 2000a; 2000b). However, a well-known limitation of this methodology is its sensitivity to outlier (Coelli et al. 2005). Further justifications for the application of this method are provided in Section 3. The following subsection provides an overview of the research that have analysed the effect of ownership on WSS efficiency applying DEA. As regards to he puzzling effect of the ownership on the WSS utilities efficiency, the first paper to apply the concept of Farrell efficiency was Byrnes et al. (1986)in the USA context. According to this definition of efficiency, the paper contributed to the literature in three different ways: 1) measuring the efficiency directly in terms of the production relationship, instead of estimating a cost function first; 2) using linear programming techniques, that have the advantage of not imposing any restrictions concerning the distribution of the data; 3) focusing on technical and scale efficiency on the basis of Farrell (1957). The theoretical perspective on which the paper was grounded provided arguments that private firms were more efficient than publicly owned firms. However, the non parametric tests used revealed no evidence that the latter utilities were more wasteful or operated with more slack than privately owned utilities (Byrnes et al. 1986 p. 341). Following and adjusting Byrnes et al. (1986) method, several studies have applied Farrell efficiency and DEA (Charner et al. 1978) to analyse the relationship between ownership and WSS utilities efficiency around the world. According to purpose of this paper, the following review provides an overview of the research on the effect of ownership on WSS utilities efficiency classifying the studies in three groups with reference to their results: 1) studies that reported no influence of ownership on efficiency; 2) research that argue that public ownership improve the efficiency and finally 3) analysis claiming to find better efficiency score for private owned utilities. In the first group of studies can be included Byrnes et al. (1986) beside other more recent research. Firstly, Garca-Snchez (2006) estimates the technical and the scale efficiency of the Spanish municipalities and distinguishes between those who externalized the WSS to private owned utilities and those who provide the service through public business corporations. The paper does not reject the null hypothesis of the non parametric Mann Whitneys test that the type of ownership discriminates efficiency level. Therefore, it claims that in the specific context analysed the creation of quasi-market does not seem to affect efficiency. The author suggest that this result can be justified by the fact that the creation of public business corporations relieves the management of the business from the traditional public sector bureaucratic procedures. Secondly, in 2013 a study about Estonian WSS utilities did not reject the hypothesis of no difference in efficiency between water utilities with different types of ownership grounded on transaction cost and industrial organization theory (Peda et al. 2013). Moreover, the research studies the influence of size on efficiency. In this case, the paper found a positive relationship between the size of the population served and the efficiency levels corroborating the assumption of scale economy gains. However, the study did not combine the influence of both size and ownership on efficiency score. Finally, in the same year another study focused on Spain rural area have been published (Gonzlez-Gmez et al. 2013).

It found that both private owned utilities and public-private partnerships are significant more efficient than public owned. However the differences in the association between the type of ownership and external variables such as, economies of density, water source and seasonality of demand, are found not significant. The authors argue that these result indicate that whether environmental factor are taken into account the differences in the efficiency scores disappears. Among others, in the second group of studies can be found a research published in 2011 about comparing the efficiency of 43 Italian water utilities in 2007 (Romano and Guerrini 2011). From the literature review conducted for the current paper, it seems that Romano and Guerrini (2011) is the first research about Italian water utilities applying DEA. The paper finds that publicly owned utilities obtain a higher efficiency score compared with mixed enterprises . The authors interpret these results suggesting that public owned utilities are better able to acquire and use their inputs. In the third group of studies the superiority of privately owned utilities is found. In Gonzlez-Gmez et al. 2013 is reported that this group is constituted by a smaller number of research compared with the other two groups. In particular, Picazo-Tadeo et al. 2009 found that privately owned utilities have better efficiency score than publicly owned utilities. The authors claim that this result is due to efficiency in the employment of labour. Indeed, they argue that the influence of union trade makes adjustment to the number of employees difficult. In conclusion, from the literature review emerges that puzzle arose in the 1980s is still unsolved, therefore more evidence are needed. Moreover, although some of the studies cited (Peda et al. 2013; Romano and Guerrini 2011) consider the effect of size and geographical location, none of them have taken into account the possible moderator influence of these variables on the relationship between ownership and efficiency. Therefore, the current research contributes to literature investigating firstly the effect of three variables separately and subsequently combining their effect on efficiency.

3 Method

Different methodologies are used to appraisal the performance of private and non profit organizations. The appropriateness of each methodology is subjected to the assumption on which it is based on and to the purpose of the study. Firstly, the study aims to investigate the effect of the ownership and the moderator (size and geographical location) on the efficiency level of the Italian water utilities. Thus, the methodology follows 3 steps: (i) estimation on the relative cost efficiency using a non parametric approach, namely the Data Envelopment Analysis (DEA) that does not require any assumption on the distribution function of the efficiency scores; (ii) cluster analysis on the bases of the ownership, the size and the geographical location of the organizations; (iii) test for differences in the efficiency level of each cluster. This approach differs to prior studies on water utilities (Peda et al. 2013; Romano and Guerrini 2011) that apply mainly a priori classification of the organizations, without considering the combine effect of different classification on the performance. Therefore, the procedure carries on in this study allows to define the clusters ex-post instead of ex-ante, thus to identify the combination of factors that can influence the efficiency level. However, this procedure could be further improved by following a more rigours approach suggested by ODonnell et al. (2008) that combine the

estimation of a metafrontier and a cluster analysis. This method was applied to Spanish municipalities in Balaguer-Coll et al. (2013). The advantage of this method is to control for heterogeneity, through a process following three stages: the estimation of efficiency of all the organization, the clustering of organization on the bases on variables that can influence the efficiency , finally the assessment of the conditional efficiency of each cluster. Before providing a description of method use (DEA), the following subsection explains the characteristics of the sample and time frame of the analysis.

3.1 The Italian Water Utilities from 2008 to 2011

The study of efficiency is carried on at organization level. Thus, a preliminary step in the analysis is to identify a list of mono-services Italian water utilities operating from 2008 to 2011. The source of information is the database Aida provided by Bureau van Dijk. Aida contains comprehensive data about financial statement, activity, location and ownership of medium and large Italian companies. The study focus on a time span of four years, from 2008 to 2011. This period is the longest that can be considered according to data available and the stability in regulation framework. Indeed, until the year 2011 the ATOs were in charge to entrust organizations to delivery water service, but after the ATOs abolition changes in the organizations entrusted might be occurred. In addition, it is worthy noticing that previous study on Italian water utilities (Romano and Guerrini 2011a; Romano and Guerrini 2011b) focus only on year, thus the current research provides a contribution to shed light of the evolution the efficiency with an arguably increase in the implications for the policy makers. Moreover, Italy is characterized by the coexistence of different organizations that provide water services. Therefore a caution selection of them is particular important for guaranteeing comparison among them and achieving the purpose of the study. A preliminary group of organizations was selected from the database Aida matching two selecting criteria: the activity base on the NACE code (E 36. Water collection, treatment and supply) and the availability of financial statement data for the time frame desiderate, since the data used to compute the efficiency and the productivity are derived from the organizations financial statements. A detailed analysis of the organization extracted from the database shows a huge heterogeneity among the organizations, for instance multi-utilities organizations were included. On one hand, the inclusion of multi-utilities in the sample would be worthy of the analysis, to have a larger and maybe more significant sample, since most of the utilities that provide water services are multi-utilities and to study the effect of economy of scope on the efficiency. On the other hand, the impossibility to acquire data on each specific activity (for instance from a segment report), separating water services from others, lead to exclude them from the analysis and focus on the mono-activity water utilities. In addition, the consideration of only mono-activity utilities increases the level of comparability among them. In conclusion, the panel dataset is balanced and constituted by 68 Italian water utilities and operating from 2008 to 2011.

3.2 Data Envelopment Analysis

The origin of the Data Envelopment Analysis (DEA) is back in Farrell (1957)approach to frontier estimation, however only in Charnes et al. (1978) the term

DEA was first used. After that, this methods has became one most popular technique for benchmarking applied from financial firms to public service organizations, including water utilities . DEA is a mathematical programming technique for the estimation of the best production frontier (or envelopment) and the measurement of the relative efficiency of different organizations (Bogetoft and Otto, 2011). This approach assigns a score between 0 and 1 to each decision making unit, allowing to rank the organizations on the bases of an increasing efficiency order. According to the DEA taxonomy, the Decision-Making units (DMUs) are the organizations object of the study, however in the remaining of the paper the word organization or firms will be continued to use. The term frontier indicated the most efficient organization that satisfies either the input-based Farrell efficiency condition, namely the organization that has a minimum quantity of input given a certain amount of output, or the output-based Farrell efficiency condition, that is the organization that has the maximum feasible quantity of output given a certain amount of inputs. Furthermore, for the purpose of the current study, it is worthy noticing the difference between technical efficiency and cost efficiency. The former is measured with regards the quantity of the inputs and outputs, whereas the latter can be estimated when price data for inputs and outputs are available. In detail, the current study refers to cost efficiency, since the data derived from the financial statements. In addition, the efficiency can be estimated under two approach: input-oriented or outp-oriented. As Coelli et al. (2005) explain the input-oriented efficiency addresses the question: By how much can input quantities be proportionally reduced without changing the output quantities produced? (p.137). Whereas the output-oriented answers the following question: By how much can output quantities be proportionally expanded without altering the input quantities used? (p. 137). Moreover the implementation of the DEA can be provided by either constant returns to the scale assumption (CRS) or variable returns to scale assumption (VRS). As Coelli et al. (2005) states the first assumption is suitable when all firms are operating at an optimal scale, thus every firm is benchmarked against all the other firms and the efficiency scores might be influenced by scale effects. By contrary, the second assumption allows to compare a specific firms against similar, thus it better control for heterogeneity among the firms. Based on these differences between the assumptions, the CRS model provides efficiency score that smaller or equal that the ones obtained under VRS, but the ranking order of the efficiency score is kept the same between the two models. In the current research, an input-oriented approach is applied beside a VRS assumption. The choice of an input-oriented approach is suggested by previous research about the same industry (Abbot and Cohen 2009; Coelli 2005; Romano and Guerrini 2011) that point out the major ability to control for input instead of output by the water utilities, since the water delivered is observed by quite steady through the time. Although previous research based the estimation of the efficiency scores both under CRS and VRS, the current research shows only the results for VRS because it allows to control for heterogeneity and at the same time it keeps the ranking order. Formally, the input-oriented VRS DEA is based on the solution of the following linear programming problem (Coelli et al. 2005, Coelli and Walding 2011):

$$\min_{\theta\lambda} \theta$$
$$st - y_i + Y\lambda \geq 0,$$

$$\theta x_i - X\lambda \geq 0,$$
$$N1'\lambda = 1$$
$$\lambda \geq 0$$

- y_i is an Mx1 vector of outputs produced by the i^{th} firm
- Y is the MxN matrix of outputs of the N firms in the sample
- X is the KxN matrix of inputs of the N firms
- is an Nx1 vector of weights (which relate to the peer firms) and is a scalar measure of efficiency, which takes a value between 0 and 1 inclusive

The computation of the efficiency level has been done by using both the package Benchmarking (Bogetoft and Otto 2011)and running in R.

3.3 Data collection on input-output

One of the most challenge in the application of DEA is the selection of the input-output variables. As regard to the inputs, previous studies used both quantity of production factors consumed and cost deriving from financial statements (Smith 1990; Thore et al. 1994). Arguably the availability of financial data lead the majority of the scholars chose cost measurement. According to this approach and following a previous research (Romano and Guerrini 2011) the current research considers data from the financial statements, in detail: cost of materials, cost of services, cost of leases and cost of labour. Although, previous studies included the depreciation , as proxy of the use of the asset (Coelli and Walding 2005) the present research excludes this variable because it could be affect by accounting policies, thus mislead its function as proxy of the consumption of the assets. As for the output, the most popular measures are: the amount of water delivered, the population served and the length of water main to measure economics of density. By contrary only in few studies the total revenue is used (Aida e al. 1998; Alsharif et al. 2008). Although it is not most sharable approach, the current studies used the total revenue as output since the only source of data are the financial statements. Since the analysis is longitudinal and input-outputs are expressed by revenues and costs, it is required to correct for inflation as suggested by Coelli and Walding (2005). Moreover, this correction is important because the period of time analysis is characterized by a quite increase in prices. The deflator chosen is the Italian CPI, that reflects the price movements in food, housing and so on. A main critique to the use of this index come from Coelli and Walding (2005) that claim the inadequacy of this indicator to measure the price of water industry inputs. However, in absence of a specific deflator for the industry, the current research must apply the Italian CPI to both revenues and costs.

3.4 Cluster analysis and Hypothesis Testing

The cluster analysis is a multivariate technique that aims to create group of objects with the attempt to maximize the homogeneity of objects within the clusters while maximize the heterogeneity between the clusters with respect to

some predetermined criteria (Hair et al. 1998). The application of the cluster analysis in combination with the DEA allows to classify the organizations ex-post and not a priory by the researchers. However, this method can further improved following ODonnell et al. (2008) and Balaguer-Coll et al. (2013). For the purpose of this research, the criteria used to characterize each water utilities are: ownership (public, mixed or private), size (small, medium or large) and geographical location (north, center, south). The source of these data is Aida. The cluster analysis is applied only for the latest year in the data base (2011). Ownership and geographical location are easy information to detect from Aida, while the size of organizations is more critique. So far, previous studies have considered the size of the population served (Peda et al. 2013; Romano and Guerrini 2011), but this information is not available in the database used. Therefore, the variable size is defined according an accounting convention. Indeed, Aida allow to know the type of financial statements provided by the firms and the type required by the law changes according to volume of revenue, total asset and employees. Therefore the type of financial statement drawn up by an organization is used as a proxy of the size. In particular, organizations that provides the short format, the detailed and the consolidated financial statements, are classify respectively as small, medium and large. Moreover, from the data can be noted that size is only variable that change over time and thus its variation can determine a modification of the numbers of the organizations in the clusters. Table 1 shows the frequency of each variable.

Table 1: Frequency Table of Ownership, Size and Geographical Location

Ownership	**No.**	**%**
Public	32	47.1%
Mixed	19	27.9%
Private	17	25%
Total	68	100%
Size	**No.**	**%**
Small	32	47.1%
Medium	33	48.5%
Large	3	4.4%
Total	68	100%
Geographical Location	**No.**	**%**
North	39	57.4%
Centre	10	14.7%
South	19	27.9%
Total	68	100%

The cluster analysis has been applied to the variables ownership, size and geographical location. The cluster analysis has been performed with Wards Method and observing both the dendogram and the coefficients reported in the agglomeration schedule, three clusters can be identified in 2011. Then a Chi-square test is applied to verify the significance level of the cluster with regard to the variables. This step allows to identify the characteristics of each cluster and label them. As can be seen from the Table 2 the cluster analysis discriminate mainly between the public ownership and the private ownership, while the mixed ownership is grouped together with publicly owned utilities. Indeed, in cluster 1 and 3 utilities are mainly public or mixed owned but the two clusters differ for the location and the size of the utilities. Only in cluster 2 private utilities can be found and they are mainly small and located both in Northern and Southern Italy.

Table 2: Clusters

Variables		Cluster 1 2011		Cluster 2 2011		Cluster 3 2011	
Cluster Label		*Mainly small, public-mixed utilities located both in Northern and Southern Italy*		*Mainly small, only private utilities located both in Northern and Southern Italy*		*Only medium, public-mixed utilities located both in Northern and Centre Italy*	
No. of utilities in the cluster		**26**	**100%**	**17**	**100%**	**25**	**100%**
Ownership	Public	19	73%	0	0%	13	52%
	Mixed	7	27%	0	0%	12	48%
	Private	0	0%	17	100%	0	0%
Size	Small	20	77%	12	71%	0	0%
	Medium	3	12%	5	29%	25	100%
	Large	3	12%	0	0%	0	0%
Geographical Location	Northern Italy	14	54%	8	47%	17	68%
	Centre Italy	1	4%	1	6%	8	32%
	Southern Italy	11	42%	8	47%	0	0%

In order to test if the efficiency scores differ between the clusters a Kruskal-Wallis test is conducted. This test is non parametric thus it does not assume that the data are normally distributed. Therefore the application of this test seems consistence with the characteristic of the data derived from the DEA that neither assume any particular distributional function for the data. The test statistic of Kruskal-Wallis is distributed as a chi-square. The null hypothesis tested is that the efficiency scores come from the same sample, so no differences are observed among utilities. The result of test helps to interpret if a difference among the group exists, however this test does not provide information about the source of the difference. Therefore, a Median test is provided in order to evaluate if the number of utilities that gain an efficiency score above the medium is significant different among the group.

4 Results

This section reports and analysis the efficiency score of the Italian water utilities and provides the result for both two tests. Table 3 shows the relative efficiency scores computed with the variable return of scale model and under input-oriented assumption. It can be noted that the efficiency score is quite high, since more than 50% of the utilities obtain a score equal to 1. With the regard to the trend, two main results seem to appear. On one hand, the utilities who get a maximum level of efficiency increase from 2008 to 2011. On the other hand, the number of utilities with a score level under 0.5 increase in the same period. It means that the utilities can improve its efficiency reducing 50% of its input and still obtain the same level of output. From this scenario a conclusive picture cannot be draw because difference in the efficiency can be due to different characteristics of the utilities.

Table 3: Efficiency Scores

Range of Efficiency Score (VRS DEA)			2008		2009		2010		2011	
			No. Of Utilities	% of Utilities	No. Of Utilities	% of Utilities	No. Of Utilities	% of Utilities	No. Of Utilities	% of Utilities
0<=	**E**	**<0.1**	2	2.9	10	14.7	8	11.8	6	8.8
0.1<=	**E**	**<0.2**	4	5.9	9	13.2	9	13.2	9	13.2
0.2<=	**E**	**<0.3**	9	13.2	2	2.9	5	7.4	4	5.9
0.3<=	**E**	**<0.4**	0	0	3	4.4	0	0	1	1.5
0.4<=	**E**	**<0.5**	2	2.9	3	4.4	3	4.4	4	5.9
0.5<=	**E**	**<0.6**	7	10.3	4	5.9	2	2.9	3	4.4
0.6<=	**E**	**<0.7**	9	13.2	6	8.8	5	7.4	0	0
0.7<=	**E**	**<0.8**	4	5.9	7	10.3	7	10.3	7	10.3
0.8<=	**E**	**<0.9**	6	8.8	5	7.4	3	4.4	4	5.9
0.9<=	**E**	**<1**	4	5.9	5	7.4	6	8.8	7	10.3
	E	**==1**	21	30.9	14	20.6	20	29.4	23	33.8
Mean Score			*0.681*		*0.575*		*0.622*		*0.663*	
Median Score			*1*		*0.9306*		*1*		*1*	

Table 4 reports the results of Kruskal-Wallis test and Median Test on the significance of the differences in the efficiency scores in the ownership type, size and geographical location. From the two tests appear that only the size is a significant driver of the efficiency, while ownership and geographical location do not affect the efficiency.

Table 4: Kruskal-Wallis test and Median Test

Kruskal-Wallis Test								
Ownership	***N***	***Mean Rank***	***Size***	***N***	***Mean Rank***	***Location***	***N***	***Mean Rank***
Public	32	36.78	Small	32	27.53	North	39	34.79
Mixed	19	36.92	Medium	33	39.39	Centre	10	34.1
Private	17	27.5	Large	3	55	South	19	34.10
Total	68		Total	68		Total	68	
p-value	0.22		***p-value***	***0.00***		p-value	0.99	

Median Test								
Ownership	***Efficiency score (VRS) 2011***		***Size***	***Efficiency score (VRS) 2011***		***Geo. location***	***Efficiency score (VRS) 2011***	
	> Median	<= Median		> Median	<= Median		> Median	<= Median
Public	17	15	Small	11	21	North	19	20
Mixed	10	9	Medium	18	15	Centre	5	5
Private	5	12	Large	3	0	South	8	11
p-value	0.24		**p-value**	**0.05**		p-value	0.88	

If the p-value is above 0.05 it is not possible to reject the null hypothesis, namely the efficiency scores come from the same sample.

Table 5 reports the result of Kruskal-Wallis test and Median Test on the significance of the differences in the efficiency observed in the three clusters. From both two tests appears that it possible to reject the null hypothesis. In particular, from Kruskal-Wallis test significant differences in the efficiency level of the three clusters emerge. Moreover, the Median Test is significant at 10% level and it shows that the greater number of utilities obtaining an efficiency score above the median belongs to the third cluster where there are medium size, public and mixed utilities located in North-Centre Italy.

Table 5: Kruskal-Wallis test and Median Test

Kruskal-Wallis Test		
Clusters 2011 (3 groups)	N	Mean Rank
Mainly small, public-mixed utilities located both in Northern and Southern Italy	26	32.211538 46
Mainly small, only private utilities located both in Northern and Southern Italy	17	27.5
Only medium, public-mixed utilities located both in Northern and Centre Italy	25	41.64
p-value	**0.05**	
Median Test	> Median	<= Median
Mainly small, public-mixed utilities located both in Northern and Southern Italy	11	15
Mainly small, only private utilities located both in Northern and Southern Italy	5	12
Only medium, public-mixed utilities located both in Northern and Centre Italy	16	9
p-value	**0.07**	

If the p-value is under 0.05 it is possible to reject the null hypothesis at 5% level of significant. If the p-value is under 0.1 it is possible to reject the null hypothesis at 10%.

5 Conclusion

The purpose of the paper was to analyze the influence of the local public ownership on the efficiency of Italian water utilities. The estimation of the efficiency scores was conducted applying the Data Envelopment Analysis. Furthermore, the differences in the efficiency of clusters were tested using Kruskal-Wallis. The motivation of this study was due to the puzzling relationship between the different types of ownership and efficiency. Moreover the literature emphasized that there is gap in understanding the effect of moderators on the performance of WSS. This paper focused on a relevant public service, the water supply services. In Italy, the WSS were traditionally provided by the local governments, however the evolution of the regulation and the acceptance of paradigms, such as New Public Management have resulted in these services being provided by different organizations the local governments directly, local owned utilities, mixed owned utilities and completely private utilities. In context, the relationship between types of ownership and efficiency is complicated by different size and location of the utilities. The previous studies do not consider the combined effect of ownership, size and location, thus this study tries to fill this gap. The results show that the ownership and geographical location does not have a significant effect on efficiency per se. This result is consistent with a previous research on Italian water utilities (Romano and Guerrini 2011). The size seems to be significant corroborating both previous results and the existence of economy of scale in the industry. However, completely different results emerge whether the cluster analysis is applied. In this case significant differences exist among public and private utilities. From the results, it can be argued that both public and mixed utilities are more efficient than small private utilities. Thus the results seem consistent with the finding of a recent research on rural areas of Spain (Gonzlez-Gmez et al. 2013). Indeed, it purports that benefits are gained by mixed utilities over private ones. It is suggested that these results can be useful both for the literature, since so far, no study combine the effect of ownership with possible moderator, and the policy implications. Indeed, it seems that a medium dimension combined with public or mixed ownership can provide better

results in terms of efficiency. Finally, the limitations of this study can be used in order to foster new research on the topic. The shortcoming of this study can be identified in different directions. In particular, non-financial data needed to be collected on WSS outputs on both ownership, size and location. Moreover, the data collection should be able to focus on different years in order to have a complete panel dataset. Furthermore, the DEA can be improved including the estimation of metafrontier in order to follow ODonnell (2008)method. Other DEA models can also be estimated, such as Free disposal Hull in order to relax the convexity assumption and Orderm model for the correct the effect of outliers.

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