Hacienda Pública Española / Revista de Economía Pública, 185-(2/2008): 39-67

Efficiency in the management of urban water services. What have we learned after four decades of research?*

FRANCISCO GONZÁLEZ-GÓMEZ
Dpto. de Economía Aplicada. Universidad de Granada
MIGUEL Á. GARCÍA-RUBIO
Dpto. de Economía Aplicada. Universidad de Granada

Recibido: Octubre, 2007
Aceptado: Febrero, 2008

Abstract

The analysis of efficiency in the management of urban water services offers valuable information both for the managers of this service and for public bodies in order to introduce improvements in business practices and in the design of public policies. Since the pioneering study carried out by Ford and Wardford (1969), there have been many attempts to follow this line of research. Due to the importance of the subject and the volume of publications in this field, we believe it is necessary to provide a balance of the work carried out over the last four decades. In this overview, we look at the main questions which have arisen over this period, we provide a synthesis of the results obtained and, finally, we point out some challenges for future research.

Keywords: Water utilities; Efficiency; Firm behaviour; Water

JEL classification: L95, L20, D21, Q25

1. Introduction

Analysis of efficiency in the management of urban water services is a practice which offers valuable information both to the managers themselves and to the regulatory bodies. The conclusions which can be drawn from this type of research can be used to introduce improvements in business practice and modifications in the design of public policies. They can offer orientation to managers in terms of the strategy to follow in order to obtain improvements in terms of

* Acknowledgements: The authors wish to express their thanks for the useful comments of the two reviewers and editors, and the suggestions on a previous draft of this paper have been received from Andrés J. Picazo Tadeo. The authors are evidently responsible for all the possible errors.

efficiency and guidance to public administrators in their dual role of regulation and control of the activity so that management units can make better use of resources, improve the quality of the service provided and introduce techniques which are more environmentally friendly.

Since the pioneering study carried out by Ford and Warford (1969), which estimated cost functions for the water industry in England and Wales, there have been many attempts to study efficiency in the management of urban water services from different perspectives. The main achievements in this field of applied research have been closely linked to advances in analysis techniques, among which we may place particular emphasis on frontier estimation along with the developed systematization in some countries of the processing of data bases. Furthermore, it should be noted that with regard to the evolution and the current status of research in this field there has been an important influence exerted by those social demands which condition political and research sensibilities at a given moment. With the passing of time, particular emphasis has been placed on the need to ensure the universalization of the different services of the urban water cycle at the same time as there has been a demand for a greater efficiency in the use of resources. In research terms, this demand has meant a concerted attempt to solve questions such as the importance of ownership (whether public or private) on efficiency in management or the valuation of scale and scope economies in this sector.

Due to the importance of this subject and the sheer volume of research already produced in this field, we have opted for a balanced summary of the aforementioned research. In this proposed overview we look at the some of the main questions which have arisen in this field over the years, we offer a synthesis of the results obtained and, finally, we highlight certain challenges facing researchers in the forthcoming years. In terms of efficiency in the management of urban water services, the question we must inevitably ask is: what have we learned after four decades of research and what remains to be learned?

2. What questions do researchers try to answer?

In this section, we try to offer a synthesis of the main features which characterize this sector. This review has been undertaken with the express aim of introducing the main questions which have historically been researched in terms of efficiency in the management of urban water services.

The first outstanding feature of the activity carried out by water utilities concerns the task which is most clearly recognised by clients which takes the form of domestic water supply. The overall services of the urban water cycle include the following tasks: water capture, water treatment to guarantee a healthy supply, distribution to homes, industry and other organisms, collection of sewage through the sewage system and sewage disposal. After this last phase, the water can be returned into the environment without negative repercussions and, if subjected to a more specific treatment, part of the water can even be reused for different purposes. Moreover, from the sewage water it is possible to generate mud as a by-product which can be used for agricultural purposes (figure 1).

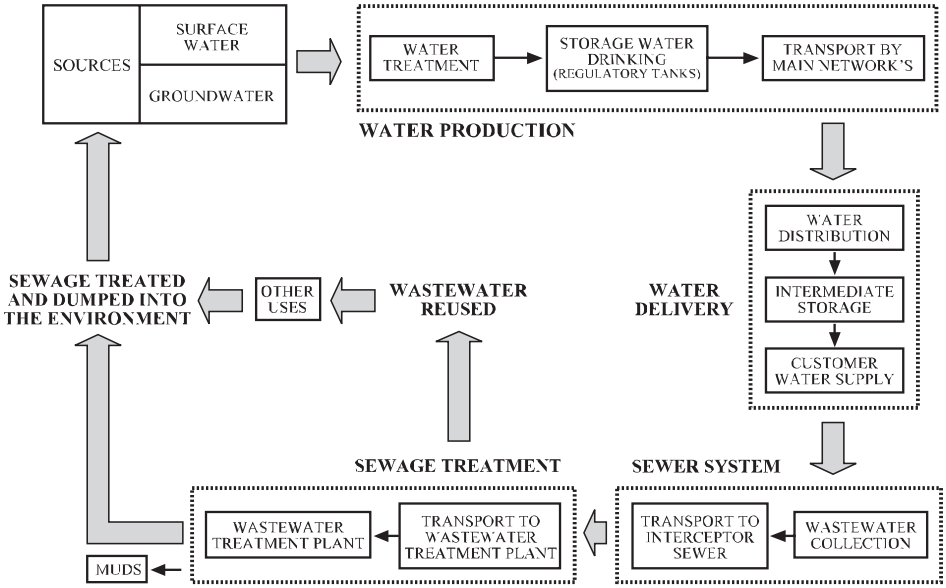

Figure 1. The urban water cycle

We must highlight the fact that the companies in this industry are multiproduct entities. This does not imply that all of the management units assume the responsibility for the totality of the tasks involved in the urban water cycle. In the industry there are both companies that manage all of the phases in the cycle and companies that only manage certain phases. ***Is it more efficient to have a single company that manages all of the phases in the urban water cycle or to have several companies specialized in each of the phases in the cycle?***

Another noteworthy question involves the structure of the industry. Like other activities based on network infrastructures, the water industry is a natural monopoly (Knapp, 1978; Hayes, 1987; Bishop, *et al.*, 1994). Furthermore, it is a sector which is very intensive in terms of the capital factor and has high fixed costs, and one in which it is inefficient to duplicate the networks of supply and sewerage. This specific nature of the sector explains why there is just one company that provides water services in each locality. In some cases and due to the scale of the fixed costs, there have been strategic proposals to create consortiums and alliances among between localities with the express aim of providing a single management unit which would provide unified water services to various localities. This strategy seeks to obtain an advantage in terms of costs. ***Are economies of scale well utilized in this industry? Is there any limit to the possibility of current economies of scale?***

One evident consequence of the nature of the sector is the tendency to create a situation close to the virtual absence of any competition.[1] According to Sepälä, *et al.* (2001), water services represent perhaps the most monopolistic industry of all those traditionally regarded to be

monopolies. In addition to the practical absence of competition, the existence of positive externalities associated with the provision of this service, demands in terms of the fulfilment of certain quality criteria in order to guarantee hygiene and environmental concerns are reasons which explain the dominance of public ownership in the management of urban water services. As profit is not the main objective of this type of company, many countries have opted for this type of management system in order to prevent possible abuse arising from a monopoly, guarantee the universal provision of the service, fulfil health requirements and protect the environment.

However, although there are evidently perfect natural conditions for a monopoly, and although public ownership is the most widespread form of management, the water industry has not remained untouched by the liberalizing tendency of the last few decades. Nevertheless, it is evident that not all countries have followed this tendency and that the intensity of the privatizing process has been quite different among those countries whose legislation has allowed the entry of private capital into this sector (OECD, 2003). ***Is there any relation between ownership and efficiency? Is privatization a way to achieve improvements in business practice?***

Finally, it is necessary to take into account the importance of the environment in which companies have to operate. The complexity of the scenario is a key factor in order to explain possible differences in terms of efficiency. The performance and the results of the different management units will vary depending on the scenario in which they conduct their business since there are factors which cannot be controlled by managers and which influence business activity. ***What are the environmental factors which must be taken into account in the water industry and what is their importance in terms of explaining differences in efficiency?***

3. Results of the research

In this section, we offer an overview of the results obtained in research undertaken with different perspectives and intentions but with the common objective of the analysis of efficiency management in urban water services. We have applied the following structure: in the first section we review the methodology used; in sections 2 and 4 we show the main conclusions related to economies of scope, economies of scale and the superiority of one form of ownership over another –public ownership versus private–; and, finally, we examine the importance of the environmental factors in terms of the analysis of efficiency in the industry.

3.1. Methodological Notes

Before commenting upon the main results found in studies in this field, we believe that it is necessary to examine the way in which research has been carried out. Although we do not aim to deal in depth with profoundly methodological questions, we offer a summary of the variables used in the literature reviewed on this subject and of the different techniques used to analyse efficiency. In table 1, we show the studies consulted and we offer a synthesis of the information discussed in this section.

Table 1
MAIN CHARACTERISTICS OF THE STUDIES ANALYZED

Authors	Country/ Region	Years of the sample	Units number of the sample	Stages in the urban water cicle [a]	Performance measure [b]	Methodological approach [c]	Model specification [d]	Economies of scale, scope and density [e]
Ford & Warford (1969)	UK	1965/1966	162 (142 publ. & 20 priv.)	B	–	CSC	Cost function	SLE
Mann & Mikesell (1976)	USA	1970	214 (188 publ. & 26 priv.)	B	–	CSC	Cost function	SLE
Morgan (1977)	USA	1970	143 (99 publ. & 44 priv.)	B	–	CSC	Cost function	–
Crain & Zardkoohi (1978)	USA	1970	112 (88 publ. & 24 priv.)	A	–	CSC	Dual function costs	SLE
Clark & Stevie (1981)	USA	2 years	12	B	–	CSC	Cost function	SLE
Feigenbaum & Teeples (1983)	USA	1970	319 (262 publ. & 57 priv.)	B	–	CSC	Hedonic cost function	SLE
Byrnes, *et al.* (1986)	USA	1976	127 (68 publ. & 59 priv.)	B	TE	DEA	Production frontier	SLE
Fox & Hofler (1986)	USA	1981	176 (156 publ. & 20 priv.)	A, B	TE, AE, CE	SFA	Production and cost frontiers, M	SLE
Teeples, *et al.* (1986)	USA	1976, 1980	719	B	–	CSC	Cost function, M	–
Hayes (1987)	USA	1960, 1970, 1976	475	B	–	CSC	Cost function , M	SLE, SPE
Kim (1987)	USA	1973	60	B	–	CSC	Dual function costs, M	SLE, SPE
Teeples & Glyer (1987a)	USA	1980	119 (57 publ. & 52 priv.)	B	–	MRS	Dual function costs	–
Kim & Clark (1988)	USA	1973	60	B	–	MRS	Cost function, M	SLE, SPE
Lambert, *et al.* (1994)	USA	1989	271 (238 publ. & 33 priv.)	B	TE	DEA	Input oriented, M	SLE
Lynk (1993)	UK	1980-1988	32 (10 RWA [f] & 22 SWC [g])	B, C, D	CE, TC	SFA	Cost frontier , M	SPE

Table 1
MAIN CHARACTERISTICS OF THE STUDIES ANALYZED
(Cont.)

Authors	Country/ Region	Years of the sample	Units number of the sample	Stages in the urban water cicle [a]	Performance measure [b]	Methodological approach [c]	Model specification [d]	Economies of scale, scope and density [e]
Raffiee *et al.* (1993)	USA	1989	271 (238 publ. & 33 priv.)	A	–	CSC	Cost function	–
Bhattacharyya *et al.* (1994)	USA	1992	257 (225 publ. & 32 priv.)	B	–	MRS	Cost function	SLE
Bhattacharyya *et al.* (1995a)	USA	1992	221 (190 publ. & 31 priv.)	B	CE	SFA	Cost frontier	SLE, DE
Bhattacharyya *et al.* (1995b)	USA	1992	26 (24 publ. & 2 priv.)	B	TE	SFA	Production frontier	–
Bhattacharyya *et al.* (1995c)	USA	1992	26 (24 publ. & 2 priv.)	B	AE	MRS	Hedonic cost function	–
Hunt & Lynk (1995)	UK	1979/80-1987/88	10 RWA	B, C, D	TC	CSC	Cost function with time trend, M	SPE
Shaoul (1997)	UK	1985-1995	10	B, C	output/cost ratio	Fynancial analysis	–	–
Cubbin & Tzanidakis (1998)	UK	1994	29	B	CE	SFA, DEA	Cost frontier	SLE
Kim & Lee (1998)	South Korea	1989-1994	42	B	-	MRS	Cost function	SLE
Ashton (2000a)	UK	1989-1997	10	B	TFP, TC	MRS	Cost function with time trend	SLE
Ashton (2000b)	UK	1987-1997	10	B	CE	FEPDM	Cost function	SLE
Fabbri & Fraquelli (2000)	Italy	1991	150	B	-	MRS	Hedonic cost function	SLE
Saal & Parker (2000)	UK	1985-1999	10 WaSCs [h]	B, C, D	-	MRS	Cost function with time trend, M	SLE, SPE
Thanassoulis (2000a)	UK	1992/93	32	B	TE	DEA	Input-oriented, CRS, VRS, M	–
Thanassoulis (2000b)	UK	1992/93	32	B	TE	DEA	Input-oriented, CRS, VRS, M	–

Table 1
MAIN CHARACTERISTICS OF THE STUDIES ANALYZED
(Cont.)

Authors	Country/ Region	Years of the sample	Units number of the sample	Stages in the urban water cicle [a]	Performance measure [b]	Methodological approach [c]	Model specification [d]	Economies of scale, scope and density [e]
Antonioli & Filippini (2001)	Italy	1991-1995	32	B	CE, TC	SFA	Cost frontier with time trend	SLE, DE
Garcia & Thomas (2001)	France	1995-1997	55 (2 publ. & 53 priv.)	B	–	FEPDM	Dual function cost, M	SLE, SPE, DE
Mizutani & Urakami (2001)	Japan	1994	112	B	–	MRS	Cost function	SLE, DE
Saal & Parker (2001)	UK	1985-1999	10 WaSCs	B, C, D	TFP	PIN	Tornqvist index	–
Anwandter & Ozuna (2002)	Mexico	1995	110	B, D	TE	DEA & second stage analysis	Input-oriented, VRS, M	–
Estache & Kouassi (2002)	Several African countries	1995-1997	21 (17 publ. & 4 priv.)	B	TE, TC	SFA	Production frontier with time trend	SLE
Estache & Rossi (2002)	Asia-Pacific	1995	50 (28 publ. & 22 priv.)	A, B	CE	SFA	Cost frontier, M	–
Ashton (2003)	UK	1991-1996	20 WoC [i]	B	-	MRS	Dual function cost with time trend	SLE
Bottasso & Conti (2003)	UK	1995-2001	28 (10 WaSC & 18 WoC)-21 (10 WaSC & 11 WoC)	B	CE	SFA	Cost frontier with time trend	SLE, DE
Corton (2003)	Peru	1998	44	B	CE	SFA	Cost frontier	SLE
Estache & Trujillo (2003)	Argentina	1992-2001	4	B, C	TFP	PIN	Tornqvist index, M	–
Garcia & Thomas (2003)	France	1995-1998	48	A, B	-	FEPDM	Cost function, M	-
Saal & Parker (2004)	UK	1985-2000	10 WaSCs	B, C, D	TFP	Malmquist index	Input distance function, M	SLE
Shih *et al.* (2004)	USA	1995, 2000	132	B	TE	DEA	Input-oriented	SLE
Tupper & Resende (2004)	Brazil	1996-2000	20	B, C, D	TE	DEA & second stage analysis	Input-oriented, VRS, M	–

Table 1
MAIN CHARACTERISTICS OF THE STUDIES ANALYZED
(Cont.)

Authors	Country/ Region	Years of the sample	Units number of the sample	Stages in the urban water cicle [a]	Performance measure [b]	Methodological approach [c]	Model specification [d]	Economies of scale, scope and density [e]
Woodbury & Dollery (2004)	Australia	1999-2000	73	B	TE, TFP	DEA & second stage analysis	Input-oriented, CRS, VRS, M	–
Aubert & Reynaud (2005)	USA	1998-2000	211	B	CE	SFA	Cost frontier , M	SLE, DE
Faria *et al.* (2005)	Brazil	2002	148 (135 publ. & 13 priv.)	B	TE	SFA	Production frontier	-
Fraquelli & Moiso (2005)	Italy	20-30 years	18 ATOs [j]	B	CE, TC	SFA	Cost frontier with time trend	SLE, DE
Lin (2005)	Peru	1996-2001	36	B	CE, TC	SFA	Cost frontier with time trend, M	–
Sabbioni (2005)	Brazil	2002	280	B, C	CE	SFA	Cost frontier , M	–
Coelli & Walding (2006)	Australia	1996-2003	18	B	TFP, TC	DEA	Input-oriented, CRS, VRS, M	–
García Sánchez (2006)	Spain	1999	24	B	TE	DEA	Input-oriented, CRS, VRS, M	SLE
Kirkpatrick *et al.* (2006)	Several African countries	2000	110	B	CE	SFA/DEA	Cost frontier/ Input-oriented, VRS	–
Mosheim (2006)	USA	1996	184 (169 publ. & 15 priv.)	B	TE, AE	SFA	Shadow cost function, M	SLE, DE
Saal & Parker (2006)	UK	1993-2003	30/22 (reduced by mergers and acquisitions)	B	TE, TFP	Malmquist index	Input distance function , M	SLE
Seroa da Motta & Moreira (2006)	Brazil	1998-2002	104 (93 publ. & 11 priv.)	A, B, C, D	TPF	DEA/SFA	Input-oriented/ Cost frontier, M	SLE
Torres & Morrison Paul (2006)	USA	1996	255	B	–	MRS	Cost function, M	SLE, SPE, DE
Garcia *et al.* (2007)	USA	1997-2000	211	B	–	REPDM	Cost function , M	SLE, SPE

Table 1
MAIN CHARACTERISTICS OF THE STUDIES ANALYZED
(Cont.)

Authors	Country/ Region	Years of the sample	Units number of the sample	Stages in the urban water cicle[1]	Performance measure[2]	Methodological approach[3]	Model specification[4]	Economies of scale, scope and density[5]
Garcia-Valiñas & Muñiz (2007)	Spain	1985-2000	3	B	CE	DEA	Input-oriented, CRS, M	–
Mugisha (2007)	Uganda	2000-2006	12 (2000-01) & 15 (2002-06)	B	TE	SFA	Input distance function, M	–
Nauges & van den Berg (2007)	Brazil Colombia Moldova Vietnam	1996-2004 2003-2004 1996-2004 1997-2003	26 48 38 49	B, D	–	MRS	Cost function, M	SLE, DE
Picazo-Tadeo *et al.* (2007)	Spain	2001	34	B, C, D	TE	DEA	Input-oriented, VRS, M	–
Picazo-Tadeo *et al.* (2008)	Spain	2001	38	B, D	TE	DEA	Output-oriented, M	-
Saal *et al.* (2007)	UK	1985-2000	10 WaSCs	B, C, D	TFP	Malmquist index	Input distance function, M	SLE
Sauer & Frohberg (2007)	Germany	2000/01	47	B	AE	SFA	Cost frontier	-
Sabbioni (2008)	Brazil	2000-2004	180/340	B	CE	FEPDM	Cost function, M	SLE
Picazo-Tadeo *et al.* (2009)	Spain	2001	34	B, C, D	TE	DEA-SFA	Input-oriented, M	-

Source: Own elaboration based on literature reviewed.
Notes:
a. According to the output variables of the model: A: water production; B: water delivery; C: sewer system; D: sewage treatment.
b. AE: allocative efficiency; CE: cost efficiency; TC: technical change; TE: technical efficiency; TFP: total factor productivity.
c. CSC: costs structure comparisons; DEA: data envelopment analysis; FEPDM: fixed-effects panel data model; MRS; multivariate regression system; PIN: prices index numbers; RPDM: random-effects panel data model; SFA: stochastic frontier analysis.
d. M: multi-output; CRS: constant return to scale; VRS: variable return to scale.
e. DE: density economies; SLE: scale economies; SPE: scope economies.
f. RWA: regional water authorities.
g. SWC: statutory water companies.
h. WaSC: water and sewerage companies.
i. WoC: water only companies.
j. ATO: ambiti territoriali ottimali (optimum size of territorial areas).

In order to measure efficiency in water utilities different specifications have been made for the problem to be solved depending on the variables used. The output which can be found in most of the research consulted is the volume of water supplied to consumers. Recently, there has been a tendency to introduce simultaneously the physical volume of water services and the number of connections (Garcia and Thomas, 2001; Saal and Parker, 2006; Coelli and Walding, 2006; Mugisha, 2007) or, instead of this, the population (Tupper and Resende, 2004; García-Valiñas and Muñiz, 2007). Only very recently has there been a greater interest in trying to include the multiproduct nature of companies and we also include sewage disposal and even water collected from sewage systems (see table 1).

In addition, it should be noted that over the last few years there has been a greater interest in introducing variables which are representative of quality. This option seeks to include the existence of a trade-off between efficiency and quality: greater quality will mean using more resources and incurring more costs. Quality can be considered as one more output of the company and has been included in studies in different ways: unaccounted for water (Antonioli and Filippini, 2001; Garcia and Thomas, 2001; Tupper and Resende, 2004; Lin, 2005; Kirkpatrick *et al.,* 2006; Picazo-Tadeo *et al.,* 2008 and Picazo-Tadeo *et al.*, 2009), test of water quality and test for organic contamination (Fox and Hofler, 1986), number of hours of water availability per day or service continuity (Estache and Rossi, 2000; Lin, 2005), percentage of metered connections (Estache and Rossi, 2000), the number of distribution system breakdowns for the water utility per unit of output per year (Bhattacharyya *et al.*, 1994) and water and service quality index (Saal and Parker, 2000 and 2001; Woodbury and Dollery, 2004; Saal *et al.*, 2007).

The inputs normally introduced in the studies reviewed are the number of workers, energy consumption in kilowatts and, more or less generally, the operation costs and some capital proxy, such as the length of the distribution network. Those studies which measure efficiency in terms of costs also introduce variables which are representative of the price of the inputs used in the production process. In this case, the most widely used variable is some proxy of the cost of the labour factor and, to a lesser extent, energy price, chemical prices and some variable which is representative of the capital cost.

In addition to the variables which specifically reflect the technical process of water utilities, most of the studies include variables which are representative of the environment in which the company operates and which cannot be controlled by the manager. They are variables which can explain differences in efficiency which cannot be attributed to bad management.[2]

In table 1, we offer a synthetic presentation of the main features of the analysis techniques used to measure efficiency.[3] Most of the studies carried out until the 1990s estimated cost functions through regression techniques i.e. adjusting a line to the data. We thus obtain a measure of average performance in the industry, but not a measure of efficiency for each one of the companies in the sample. In table 1, we use the expression ‘cost structure comparisons’ for those studies which estimate uniequational models for each type of ownership, each type of management and even for different periods. In other cases,

the high number of regressors to be estimated makes it advisable to jointly estimate the cost functions in the partial factor demand equations through models which we have called multivariate regression systems.

Since the 1990s, most of the studies carried out make use of frontier techniques.[4] These techniques allow us to compare the relative performance of a company or service in relation to those which define the efficient frontier and, therefore, represent the best practice observed. This approach to the study of efficiency is the best option possible given that researchers do not have a perfect knowledge of the scenario in which companies have to work nor do they know exactly the technology or restrictions which may affect the performance of companies.

At the same time, for the estimation of such frontiers there are two main approaches: the parametric approach and the non-parametric approach. The parametric approach specifies a concrete functional form for the frontier and estimates its parameters through econometric techniques. The non-parametric approach constructs a frontier through data envelopment analysis and once they are defined the efficiency indexes are estimated through mathematical programming techniques. Both methodologies must be seen as possible alternatives and neither one is superior to the other as they both have advantages and disadvantages.

In the parametric approach, normally stochastic frontier analysis, faced with the possibility of making use of production functions, the most common option is the estimation of cost functions. An initial reason to explain this choice is that the manager of water services has the obligation to supply water, and, therefore, the level of output will not be determined by the company itself but will determined by the demand made by the users of the service.[5] Therefore, this is not the most appropriate scenario to introduce a production function. Secondly, with a cost function we avoid the problem of possible endogeneity in the input quantities which, although not insoluble when using a function production, does complicate the estimation procedure. Thirdly, the cost functions allow us to deal more easily with the case of multiple products. Within the context of the specific models of the panel data, table 1 also indicates those studies which make use of fixed effects models (the individual effects are specific fixed parameters for each company) and random effects (the individual effects are random variables).

Regarding the non-parametric approach, Gattoufi *et al.*, (2004) have shown the rapid expansion of the use of Data Envelopment Analysis since the 1990s, a phenomenon which has also been observed in the water industry. Among the advantages of the non-parametric approach we can include the fact that there is no *a priori* imposition of strong restrictions on technology (the efficiency indexes obtained in the parametric approach are sensitive to the specification of the functional form) and the fact that this approach facilitates the treatment of multiproduct technologies. Among the disadvantages of this approach we can highlight its greater sensitivity to measurement errors, since there is no error term which controls the effect of the non-observed factors, and it is not possible to carry out traditional hypothesis tests, although recent bootstrap techniques would allow us to make statistical inferences in the non-parametric estimation of efficiency.

Finally, it is necessary to point out the growing importance that distance functions have acquired over the last few years in terms of the representation of technology in the industry (Saal and Parker, 2004, 2006; Mugisha, 2007; Saal *et al.* 2007). Both with parametric and non-parametric approaches, this technique allows us to include multiple outputs, and, therefore, specific measurements of efficiency in multiproduct contexts (measurements which are not possible using traditional production functions). This possibility leads us to believe that over the course of the next few years there will be a greater use of distance functions in studies devoted to the urban water industry, as has been the case in other network industries.

3.2. Economies of scope

There are economies of scope when it is more efficient for a single company to carry out various activities, rather than each of the production processes being performed by a different company. This is especially relevant in the management of the urban water cycle since, as has been explained in the second section, this has various phases.

There has been relatively little research considering the existence of economies of scope in this sector and, in at most, references to this circumstance are made in a partial manner. Although in the literature reviewed there are studies with a multi-output approach, there are few studies which explicitly introduce representative variables for the different phases of water.

In Lynk (1993) and Hunt and Lynk (1995), the authors contemplate as outputs water distribution services, sewerage and environmental services.[6] The authors conclude that there are benefits when we simultaneously find water distribution and sewerage services, and water distribution and environmental services, but not when we simultaneously consider sewerage and environmental services. In Battacharyya *et al.* (1995), Saal and Parker (2000) and Sauer and Frohberg (2007) economies of scale are analysed considering the phases of water distribution and sewage. While in the first of the studies we find that the companies that simultaneously carry out both activities are more technically efficient than those who are only devoted to distribution, in the other two there is no conclusive evidence for cost saving when the tasks of supply and sewerage are taken up by the same company. A different approach is provided by Garcia *et al.* (2007) who find economies of vertical integration in the phases of production and distribution of water only in smaller sized companies. They conclude that the advantages of specialization are fewer in smaller units and that the defragmentation of both phases could mean high transaction costs and disadvantages in the use of technology. Finally, Picazo-Tadeo *et al.* (2007) analyse differences in technical efficiency between companies which simultaneously offer water distribution, sewerage and sewage disposal services and those one or two of the phases considered in the study. The results show that there are no statistically significant differences between the average indicators of radical efficiency of both samples.

Economies of scope are undoubtedly the subject which has received least attention from researchers. References are scarce and the results obtained do not coincide. It is not possible to reach conclusions as to whether or not it is advisable for a single company to have all of the responsibility for the urban water cycle, or whether it is preferable to divide these tasks among more than one management unit.[7] It is to be hoped that over the next few years this subject will become the object of further research. Nevertheless, it is necessary to be cautious in terms of the methodology used. Saal and Parker (2006) recently concluded that in the context of a stochastic frontier model it cannot be assumed that companies which only offer water supply and companies which offer water supply and treatment will share a common frontier.

3.3. Economies of scale

Economies of scale take place when, as a consequence of an increase in the use of inputs, there is a decrease in average costs. In the case of water services, it would be necessary to analyse how costs evolve when production varies in relation to the size of the network and the number of consumers who are connected, but the quantity demanded by the consumer and the density of customers remain constant. This situation could occur when various municipalities agree to contract their water services with one company or when a company has to extend its services in order to give coverage to a new residential area. The existence of important economies of scale suggests that it would be more favourable to have few companies in the industry; when economies of scale are less significant this means that industry is more fragmented.

In the light of the review, it is concluded that although there are important economies of scale in this sector, they are not unlimited. They are much more in evidence in small companies and tend to decrease in relation to the size of the operation (Kim, 1987; Kim and Clark, 1988; Fabbri and Fraquelli, 2000; Antoniolli and Filippini, 2001; Kingdom, 2005; Tynan and Kingdom, 2005; Nauges and Van den Berg, 2007; Sauer and Frohberg, 2007). The need for mergers or fragmentation in the sector depends to a great extent on the degree of fragmentation present in the industry in each nation, and is determined by the institutional framework in force in each country and by the degree of dispersion of the population. For example, recently Saal and Parker (2004, 2006) and Saal *et al.* (2007) concluded that the excessive size of the water service companies created in England and Wales after industry reforms in 1989 has had a negative effect on the growth of productivity over the subsequent years. The strategy of concentration in a few large scale companies has had a negative impact on the growth of productivity in the industry.[8] Using a sample of municipalities in the south of France, Garcia and Thomas (2001) found important economies of scale and suggested the need for mergers and takeovers in this sector. In the case of Italy, Fabbri and Fraquelli (2000) concluded that the existence of economies of scale depends on the size of the operation and that, as the sector is highly fragmented in that country, most companies are on the downward slope the long term cost curve. Tynan and Kingdom (2005), in a study containing information on 270 water and sewerage providers from 33 countries, mostly developing nations, concluded that costs per user could decrease if there were a merger between service providers

in neighbouring localities, mainly those of a smaller size. Furthermore, Sauer (2005) found that, in the case of a sample of water companies in rural areas in Germany, the management units should have on average three times their current size. Finally, Torres and Morrison Paul (2006) concluded that, in the case of a sample of US water companies, a merger of small companies, in terms of the size and density of their networks, could mean savings in terms of costs, whilst a merger of large companies would probably not be profitable without a simultaneous increase in customer density.

The end of the economies of scale can be explained by the inflection in the average cost curve in some of the phases of the water cycle which involves a trade off between the different activities of the company. It is reasonable to expect that in some of the phases in the urban water cycle the maximum levels of efficiency are reached in terms of the size of the operation before this occurs in others. For example, when growth involves a greater dispersion of the population, at the same time as there is an increase in the scale, the advantages obtained in the phase of water treatment in the same water treatment plant may be compensated for by greater transport costs in the distribution phase (Clark and Stevie, 1981; Torres and Morrison Paul, 2006; Garcia *et al.* 2007). The importance of different scenarios for companies requires the use of case studies to determine the optimum size of a management unit for each geographical area.[9] There is no universally ideal size for business activity. Factors such as customer density and the dispersion of urban nuclei are decisive to be able to take a decision regarding the need for mergers or fragmentation in the industry.

3.4. Public management vs. private management

A question which economists have tried to solve is whether efficiency in management is conditioned by ownership. As a consequence of the seminal studies of Mann and Mikesell (1976), Morgan (1977) and Crain and Zardkoohi (1978) there has been a considerable amount research which have tried to demonstrate the greater efficiency of private management from the by examining a hypothesis such as the theory of public choice (Leibenstein, 1966) and the theory of property rights (Alchian and Demsetz, 1972).[10] Comparison of the efficiency of both types of ownership has been carried out in both ways, depending on the circumstances and the legal framework of each country. There are studies which have analysed the superiority of one kind of ownership over another in scenarios in which regulation allows for the coexistence of both forms of ownership in management; there also studies which have tried to estimate the benefits in terms of efficiency after the privatization of the industry.

In the light of this review we can conclude that there is no hard evidence which points to a causal relation between management ownership and efficiency. In any case, in relation to the first group of studies, and although the results are far from conclusive, it should be pointed out that since over a decade ago no study has proven the superiority of public ownership and, on the other hand, there have been studies that suggest that private

ownership is more efficient.[11] Recently Picazo-Tadeo *et al.* (2009) suggest that public ownership has more difficulty in adapting staff to the real needs of the company, partly due to the greater degree of unionization in the public sector and partly because local governments tend to avoid confrontations which could have political and social consequences. Nonetheless, the methodological problem which still needs to be faced in this type of studies concerns the possibility of determining if the greater efficiency estimated in some cases for private companies is due to the ownership factor itself or is related to the framework of regulation and control which exists in this sector. Furthermore, it would also be interesting to analyse to what extent the results in terms of levels of efficiency are not predetermined by the decisions regarding privatization made by local government. For example, in the case of urban waste disposal, Ohlsson (2003) concluded that private companies do not randomly decide to take over responsibility for the service previously provided by the local administration, but only take over services in those scenarios which are conducive to making profits.[12] Additionally, it should be noted that quality may be a determining factor in order to explain the differences in terms of efficiency between companies in this sector. However, quality has rarely been considered in the analyses of performance in the industry. Some recent research which has stressed the importance of this question includes Lin (2005), Saal *et al.* (2007) and Picazo-Tadeo *et al.* (2008).

Within the second group of studies the most extensively studied area is England and Wales, where since 1989 there were significant changes which, among other aspects, lead to the complete privatization of the industry and the creation of OFWAT (the Water Services Regulation Authority). OFWAT is the body responsible for economic regulation of the privatised water and sewerage industry in England and Wales. Its functions include guaranteeing the efficient performance of companies in this sector, for which they use benchmarking techniques. In line with the proposal made by Shleifer (1985), the price of water is fixed by companies in the industry taking into account the performance of the most efficient management units.

The most noteworthy research into the impact of privatization in England and Wales has been continuously provided since 2000 by Saal and Parker.[13] Judging from the research currently produced, it is not possible to state categorically that privatization has meant significant improvements in the level of efficiency. In their most recent publication, Saal *et al.* (2007) suggest that, although privatization may have provided a stimulus in terms of technical change, there is no evidence of improvement in levels of efficiency.[14] It seems that the regulatory and institutional framework which has accompanied the privatization of water services has allowed companies to offer more quality and to be more careful with regard to environmental issues, a question which has in turned slowed down the evolution of the total productivity of the factors.

In the context of broader framework of reforms, it is undoubtedly in developing countries where the debate concerning the participation of the private sector in the industry is at its most intense in the political sphere. Since the end of the 1980s, some countries

started reform processes in which it was believed that the participation of the private sector could be a good alternative in order to solve many of the problems in the industry (Estache *et al.* 2000; OECD 2000). The objective was to make it easier to obtain capital to invest in infrastructures and to relieve fiscal pressure, to extend coverage of the service, to increase productive efficiency, to make better use of economies of scale and to eliminate cross subsidies. Now is the time to assess the situation and there have been many studies which, with different approaches, have studied the impact of private participation in the water industry.[15] It is obvious that in these nations the nature of private participation in the industry should be clear in a simple analysis of efficiency. Taking into account the initial situation, aspects such as the extension of the coverage and the quality of the service are key factors to be considered in order to avoid mistaken assessments.

It is difficult to state with certainty that in sectors such as the water industry a simple change in company ownership guarantees greater efficiency.[16] In order to introduce some economic rationality into the privatization process it is necessary to adopt some measures to encourage real competition between companies and a reduction in the asymmetrical information which exists between managers and the control organism (Littlechild, 1986, 1988; Rees, 1998; Saal and Parker, 2004). The real problem is the fact that the nature of the industry clearly restricts the possibility of creating competitive environments, and therefore it is necessary to find secondary solutions to encourage more efficient performance among companies in this sector. In the water industry, these solutions consist of the introduction of measures which promote rivalry in the process of granting licences –in countries such as Spain and France in which the service can be delegated to the private sector– and the comparative analysis of efficiency. The benchmark is currently becoming an instrument which can provide greater transparency for the sector.[17] Comparative analysis gives information to managers, political agents and citizens, stimulates the introduction of improvements in business practice and guides the strategy for public administration in terms of its regulatory powers and its control of the industry.[18] Finally, it should be added that while in other sectors based on network infrastructures, such as gas or electricity, vertical disintegration processes have been carried out to try to introduce competition in the production phases, in the water industry the belief still prevails that it is difficult to introduce business rivalry. There has still not been any in-depth research into the possibility of introducing competition into the phases of water production and sewage disposal (Garcia *et al.* 2007).

3.5. The importance of the environment

Over the last few years, researchers have stressed the importance in terms of efficiency measurement of some environmental variables which cannot be controlled by managers. These are factors which can explain those differences in performance which cannot be attributed to bad management. In the interests of correct decision making and in order not to penalize in comparative analyses the management units which operate in more complex environments, it is crucial to distinguish between the effects of factors which can be controlled by managers and the effects of factors which they cannot control.

Among the environmental factors, undoubtedly the most frequently analysed aspect is the existence of economies of density. In the water industry it is possible to distinguish between economies of product density and economies of customer density. This first situation is when there is an increase in production, for a determined network size and number of customers, there is a decrease in the average variable costs. This happens when there is an increase in per capita consumption without any associated change in the input quantities used. Furthermore, the existence of economies of customer density means greater levels of efficiency when there is an increase in the number of consumers without variations in the capital of the company. The existence of economies of density could partially explain why companies of a similar size, measured in terms of output, show important differences in costs.

In Ford and Warford (1969), Takada and Shigeno (1998), Kuwabara (1998), Mizutani and Urakami (2001), Garcia and Thomas (2001) and Antonioli and Filippini (2001), we find references to the existence of economies of product density. In general terms, the studies confirm the existence of this type of economies, although this is not always absolutely clear in all cases. For example, although Mizutani and Urakami (2001) obtain economies of product density for all company sizes, they state that the economies are greater in smaller companies and decrease in proportion to the size of the company. Antonioli and Filippini (2001) found that most water supply companies in Italy still operate at levels in which it would be possible to benefit from economies associated to higher levels of product density. Finally, Garcia and Thomas (2001) found that both in the long term and the short term the average costs are constant.

Regarding economies of consumer density, most researchers confirmed their existence. There is evidence of this in Mann and Mikesell (1976), Teeples and Glyer (1987a, b), Fabbri and Fraquelli (2000), Antonioli and Filippini (2001), Estache and Rossi (2002). On the contrary, Garcia and Thomas (2001) concluded that in the short term there is no evidence of the existence of economies of consumer density, whilst in the long term there are diseconomies. Moreover, Tupper and Resende (2004) also found evidence of economies of consumer density in the case of water distribution services, but not in the case of sewerage services.

In addition to economies of density, other variables have been considered to assess the influence of the environment in which each management unit operates. For example, it is common to introduce variables which are representative of the origin of hydric resources: the extraction costs of this resource are not the same when the water comes from a reservoir or a river (surface water) as when it is underground water. Furthermore, the original quality of the water conditions the treatment which it must receive to make it drinkable (Sauer, 2005; Sauer and Frohberg, 2006). The complexity of the scenario such as the orography of the area and the urbanization model planned can also influence efficiency in management since it affects the structure of the networks and the costs of pumping water. Furthermore, we could also consider a representative factor of the complexity of the non-controllable environment the seasonality of demand (Picazo-Tadeo *et al.* 2009). In tourist zones there may be peaks and troughs of demand which, depending on the season, may cause an excess in capacity or a more intensive exploitation of the resources. Finally, climatic variables

have also been considered as non-controllable input by suppliers. In areas where there is a shortage of rainfall and an excessive pressure on hydric resources, water utilities could distribute lower output in order to adjust available resources to existing demands (García-Valiñas and Muñiz, 2007).

4. Summary and some challenges for researchers

In this article, we have offered an overview of the research which has studied efficiency in the management of urban water services. The importance of the subject and the vast quantity of literature produced have lead us to carry out a summary which allows us to highlight what we have learned about this subject after four decades of research and what remains to be learned. Advances in analysis techniques, the developed systematization in some countries of data base processing and the different sensibilities of the populations expressed in social demands have been decisive in the development of research.

In summary, in response to the first of the objectives of this article, we can highlight the following research results:

1. There is no conclusive evidence regarding the existence of economies of scope in the industry. In this subject, the volume of research is scarce and the multiproduct nature of the industry has been taken into account only partially in all cases. Any possible analysis regarding the suitability of vertical integration of the different phases of the urban water cycle must take into account aspects such as transaction costs or the technological advantages related to synergies or specialization.

2. This is a sector with important economies of scale and density in which the promotion of mergers could, in certain cases, lead to benefits in terms of efficiency. Nevertheless, it is clear that economies of scale are not inexhaustible, since when there is greater scope for action there may be diseconomies of dispersion which can cancel out possible benefits related to the size of operations. Therefore, there is no generally applicable rule but there is a need to carry out case studies prior to taking a decision.

3. There is no evidence to conclusively prove the superiority of one form of ownership over the other. Rather than in terms of public management vs. private management, the debate should be redirected in order to reach any conclusions regarding the suitability of certain regulatory frameworks over others, and the effects that changes in legislation can generate in performance in the industry. Efforts should be made to promote competition –through comparative analyses which offers transparency to the sector and competitive processes in the awarding of licenses- and reducing the levels of asymmetrical information between management units and the organisms of regulation and control.

4. The environmental variables which cannot be controlled by the manager have a notable influence on the levels of efficiency reached by the management units.

Efficiency analysis in the industry demands caution in the specification of the models since, if this not the case, the management units which operate in more complex environments would systematically appear as the least efficient.

Although there has been extensive research in terms of efficiency analysis in the management of urban water services, there are still some lines of research which need to be developed over the forthcoming years. There still remains a lot to be learned in different fields and, in summary, we can specify a series of challenges to be met in the future:

1. It would be advisable to pay more attention to the quality of service as a determining variable of performance. It is necessary to be cautious in possible situations with apparent efficiency that hide defects in quality of service and customer care. Recent research such as that made by Lin (2005), Saal *et al.* (2007) and Picazo-Tadeo *et al.* (2008) demonstrate that quality influences levels of efficiency.[19] Not taking this circumstance into account could mean that in comparative analyses the most highly rated companies are those which give least importance to social interests. Apart from efficient management, citizens demand quality in this service. In this sense, a question which has still not been dealt with is the inclusion of variables which are representative of the rating that consumers make of quality in water services.[20]

2. In those studies which try to ascertain which type of ownership is more efficient, it would be advisable to be more precise regarding the legal framework chosen to supply this service. For example, in the case of public management it would be interesting to have information which would allow us to see whether this is controlled by a unit which directly depends on the local government or if it is the responsibility of a public company created for this purpose. With regard to private ownership, it would also be advisable to be more specific about the legal framework of the activity: it would be wise to distinguish between totally private ownership and semi-public enterprises, and to be more explicit regarding the type of contractual relation which exists. In this respect it would be interesting to study the influence of the length of contracts when the legal framework chosen is concession, a traditional practice in France and Spain.[21]

3. It would be interesting to carry out a study for the water industry along the lines of that made by Ohlsson (2003) in the case of urban waste disposal. Research suggests that private companies do not randomly accept responsibilities for the service from the local administration, but only accept responsibilities in the most favourable scenarios for profit-making. A study applied to the water industry could explain the fact that research which offers a comparative analysis of efficiency between public and private management has tended to opt for the latter option over the last few years.

4. It is necessary to conduct further research in terms of the evaluation of the changes in the regulatory framework in the sector, and to make international comparisons which can allow us to draw some conclusions regarding the superiority of certain regulatory scenarios over others.

5. There should be considerably more regional analysis concerning the optimum size of service management units and the sphere of operation. These studies could lead to mergers and disintegration processes which would involve improvements in efficiency which would in turn mean benefits for the different customers in the water industry. There is no common system of application in this case. The decision would depend on the initial scenario.

6. It is necessary to conduct further research to evaluate the existence of economies of scope in the sector. These studies could lead to conclusions regarding whether ort not it is preferable for one company to carry out all of the phases on the urban water cycle or to separate these phases and divide them between different companies. Moreover, considering the multiproduct nature of these companies would make it possible to estimate the specific efficiency indicators for each phase of production. Management need not be equally efficient in all tasks and the estimation of specific indicators would show the phases of the urban cycle in which there is greater potential for efficiency.

7. It would be strongly to create on a worldwide scale independent organisms for permanent research to guarantee good practice in the sector. A leading initiative on an international level is the IBNET (The International Benchmarking Water Network for Water and Sanitation Utilities), which that includes a searchable database with indicators from more than 2,100 utilities from more than 80 countries. We may also mention the experiences of ADERASA (the Association of Regulatory Bodies for Water and Sanitation in Latin America), the development of benchmarking in water utilities promoted by the OECD in emerging and transition economies and the benchmarking initiative of SEAWUN (South East Asia Water Utilities Network). On a national level, OFWAT is the initiative with most experience and the greatest powers. Other organisms which have developed benchmarking in the water industry include IRAR en Portugal (Regulatory Institute for Water and Waste), VEWIN in the Netherlands (Association of Dutch Water Companies) and SUNASS in Peru (National Superintendency of Sanitation Services). Additionally, it would be recommendable for this type of organisms, besides collecting data on business management, systematically introduced linear programming and econometric techniques with the aim of promoting good practice in the industry.

Notes

1. In comparison with the telecommunications, electricity and gas sectors, in the water services sector it is easier to identify the conditions which lead to a natural monopoly (Cowan, 1993; Vickers and Yarrow, 1988; Elnaboulsi, 2001).

2. This question is examined in more depth in Section 3.5.

3. In this table we specify the types of performance measurements used in the different studies, distinguishing: allocative efficiency in the combination of inputs (the capacity of a company to combine its inputs in a proportion which minimizes its production costs); technical efficiency oriented to inputs (the capacity of a company to produce a determined level of output with a minimum quantity of inputs); cost efficiency (the capacity of a company to produce a determined level of output at the minimum cost; cost efficiency is the

product of allocative and technical efficiency); technological change (an increase in the maximum quantity which can occur at the same level of inputs, and which is reflected in changes in the time of the production frontier); total productivity of factors (ratio of the output over the input; when there is more than one output and/or input this calculation requires weights which are normally based on price information).

4. Other approaches have been carried out based on price index numbers (Estache and Trujillo, 2003), analysis of accounting and financial status (Shaoul, 1997) or simple case studies (Lobina and Hall, 2000; Hall and Lobina, 2004; Hall, Lobina and de la Motte, 2005).

5. Although companies have a certain capacity to modify the level of water consumption, whether by reducing it through awareness campaigns in drought periods or by increasing it through the expansion or the coverage area, in general it is not possible to fix this level of consumption; in fact, a common assumption of these studies is the exogeneity of output. Therefore, more efficient management should aim to save resources by maintaining the level of supply instead of maintaining the use of resources and expanding the volume of water supplied, since this last option would not be feasible if users are not prepared to accept this increase. Moreover, there are environmental reasons which support this choice since the preservation water quality is strongly related to the intensity of its use. In our review of literature in this field the only study oriented to output is the study carried out by Picazo-Tadeo *et al.* (2008).

6. The environmental service is measured as turnover value and includes components such as water quality regulation, pollution alleviation, recreation and amenity, navigation, fisheries and charges from environmental services.

7. Different views are offered by Hayes (1987) who distinguishes wholesale and retail water supply and Kim and Clark (1988) who distinguish between water supply for residential use and for non-residential use.

8. See also the studies carried out by Strategic Management Consultants (2002) and Stone and Webster Consultants (2004) for OFWAT.

9. Unfortunately there has been little research aimed at estimating optimum size. We have only found references to volume of water in Mann and Mikesell (1976), Feigenbaum and Teeples (1983) –who coincide in 170 Hm^3/year–, Mizutani and Urakami (2001) –261 Hm^3/year– and Fraquelli and Moiso (2005) –90 Hm^3/year–. There are even fewer references to the population supplied such as Mizutani and Urakami (2001) –766.000 inhabitants–. In other cases we can find a scale efficiency index as in Byrnes *et al.* (1986) –0.9583 for public companies and 0.9609 for private companies–, Cubbin and Tzanidakis (1998) –0.96–, Ashton (2000a) –0.678–, Saal and Parker (2000) –0.83–, Antonioli and Filippini (2001) –0.95–, Ashton (2003) –0.9633–, Corton (2003) –1.241– and García Sánchez (2006) –0.9129–. Finally, we have also found studies which offer data on retuns to scale such as Crain and Zardkoohi (1978) –1.316 for public companies and 1.158 for private companies–, Bhattacharyya *et al.* (1995c) –0.99–, Garcia and Thomas (2001) –1.0016–, and Mizutani and Urakami (2001) –0.895 and 0.921–.

10. Renzetti and Dupont (2003), Bel (2006) and González-Gómez (2006) offer reviews of this question which give a more exhaustive vision than that which is presented here.

11. In the first group, those who conclude that public ownership is more efficient are Mann and Mikesell (1976), Bruggink (1982), Lambert *et al.* (1993) and Bhattacharyya *et al.* (1994, 1995a); those who conclude that private ownership is superior are Morgan (1977), Crain and Zardkoohi (1978), Bhattacharyya *et al.* (1995b), Estache and Kouassi (2002), Faria *et al.* (2005) and Picazo-Tadeo *et al.* (2007); and, finally, the results are inconclusive in the work of Feigenbaum and Teeples (1983), Byrnes *et al.* (1986), Fox and Hofler (1986), Estache and Rossi (2002); Kirkpatrick *et al.* (2006), García-Sánchez (2006) and Seroa da Motta and Moreira (2006).

12. Although with another objective, Carpentier *et al.* (2006) conclude that the price of water in French cities is higher on average when there is private ownership of water services, partially due to the fact that in more complex environments local governments are more likely to delegate management of this service.

13. Saal and Parker (2000, 2001, 2004 and 2006) and Saal *et al.* (2007).

14. Previously, Shaoul (1997), having analysed the accounting and financial status of companies in the industry, rejected the hypothesis that private ownership had encouraged efficiency in the sector and that privatization had meant an improvement for consumers. Ashton (2000a) also concluded that privatization was not the cause of the increase in the variations observed in the rate of growth undergone in the productivity of factors since 1989.

15. A detailed analysis of the problems which exist in terms of the reforms introduced in the water industry in developing countries is beyond the scope of this study. C.f. Anwandter and Ozuna (2002), Shirley (2002), Estache and Trujillo (2003), Corton (2003), Nickson and Franceys (2003), Tupper and Resende (2004), Lin (2005), Estache (2006), Kirkpatrick *et al.* (2006), Casarin *et al.* (2006) and Mugisha (2007). It is also advisable to read the working papers and reports of international organisms such as the United Nations, the OECD, the Asian Development Bank or the Inter-American Development Bank. Given their research experience in this field, it is especially advisable to consult World Bank documents, such as the recent studies by Brocklehurst and Janssens (2004), Foster (2005) and Van den Berg et al (2006). An examination of the causes of the abandonment of Latin America by international operators in recent years can be found in Ducci (2007). A critical vision of the privatization process in the water industry can be found in Lobina and Hall (2000), Hall and Lobina (2004), Lobina (2005), Hall *et al.* (2005) and in the documents of the Public Services Internacional Research Unit.

16. Anwandter and Ozuna (2002) conclude in the case of Mexico that those reforms aimed at improving efficiency in the sector and based on decentralizing responsibility management at a municipal level and the creation of an autonomous regulatory organism are insufficient if they do not include measures which encourage real competition in the industry and which reduce the asymmetrical information which exists in the sector.

17. At an institutional level we can highlight the cases of the England and Wales, Australia, the Netherlands and Peru.

18. Some recent research which deals with the benchmark in the water industry are Corton (2003), Tupper and Resende (2004), Cubbin (2005), Lin (2005), Allan (2006), Ballance (2006), Seroa da Motta and Moreira (2006) and García-Valiñas and Muñiz (2007). These studies reflect the importance of comparative analysis in markets in which there is no direct competition between companies, and their possible application in the water industry.

19. It is necessary to incorporate variables which are representative of service quality such as water loss in the distribution network, the fulfilment of sewerage criteria, the existence of water restrictions. This takes into account the possible existence of a trade-off between the use of resources by the company and the quality of the service provided.

20. An important limitation for research in the industry in many nations is the reluctance of companies to divulge information regarding their management. In order for research to advance over the forthcoming years, it is of paramount importance for companies to be more generous in facilitating information and for public administrations to oblige companies to make this information available.

21. When these concessions are long term, there may be potential for monopolistic practices: the service provider may be less sensitive to situations which are not part of the legal agreement; control by public administration tends to decrease with time and questions related to public interest can become secondary considerations. Conversely, when the concession period is too short, although at first there may be a competitive response, this can also dissuade company investment in infrastructure and mean that less attention is paid to the technical aspects of management.

References

Alchian, A. and H. Demsetz (1972), "Production, Information Cost and Economic Organization", *American Economic Review,* II-62, 777-795.

Allan, G. (2006), "Assessing capital efficiency in the water and sewerage industry in England and Wales: Ofwat's approach", *Utilities Policy*, 14, 224-233.

Anwandter, L. and T. JR. Ozuna (2002), "Can Public Sector Reforms Improve the Efficiency of Public Water Utilities?", *Environment and Development Economics*, 7(4), 687-700.

Antonioli, D. and M. Filippini (2001), "The Use of Variable Cost Function in the Regulation of the Italian Water Industry", *Utilities Policy*, 10, 181-187.

Ashton, J. K. (2000a), "Total Factor Productivity Growth and Technical Change in the Water and Sewerage Industry", *The Service Industries Journal,* 20(4), 121-130.

Ashton, J. K. (2000b), "Cost efficiency in the UK water and sewerage industry", *Applied Economics Letters*, 7, 455-458.

Ashton, J. K. (2003), "Capital Utilisation and Scale in the English and Welsh Water Industry", *The Service Industries Journal*, 23(5), 137-149.

Aubert, C. and A. Reynaud (2005), "The Impact of Regulation on Cost Efficiency: An Empirical Analysis of Wisconsin Water Utilities", *Journal of Productivity Analysis*, 23, 383-409.

Ballance, A. (2006), "The regulation of capex in water", *Utilities Policy*, 14, 234-239.

Bel, G. (2006), *Economía y política de la privatización local*, Marcial Pons, Madrid, Spain.

Bhattacharyya, A.; P. Parker and K. Raffiee (1994), "An Examination of the Effect of Ownership on the Relative Efficiency of Public and Private Water Utilities", *Land Economics,* 70(2), 197-209.

Bhattacharyya, A.; T. R. Harris; R. Narayanan and K. Raffiee (1995a), "Specification and estimation of the Effect of Ownership on the Economic Efficiency of the Water Utilities", *Regional Science and Urban Economics,* 25, 759-784.

Bhattacharyya, A.; T. R. Harris; R. Narayanan and K. Raffiee (1995b), "Technical Efficiency of Rural Water Utilities", *Journal of Agricultural and Resource Economics,* 20(2), 373-391.

Bhattacharyya, A.; T. R. Harris; R. Narayanan and K. Raffiee (1995c), "Allocative Efficiency of Rural Nevada Water Systems: A Hedonic Shadow Cost Function Approach", *Journal of Regional Science*, 35(3), 485-501.

Bishop, M.; J. Kay and C. Mayer (1994), *Privatization and Economic Performance,* Oxford University Press, New York.

Bottasso, A. and M. Conti (2003), *Cost Inefficiency in the English and Welsh Water Industry: An Heteroskedastic Stochastic Cost Frontier Approach,* Mimeo, DIEM Università di Genova, Italy.

Brocklehurst, C. and J. G. Janssens (2004), *Innovative contracts, sound relationships: urban water sector reform in Senegal*, Water supply and sanitation sector board discussion paper series 1, The World Bank, Washington D.C.

Bruggink, T. H. (1982), "Public Versus Regulated Private Enterprise in the Municipal Water Industry: A Comparison of Operating Costs", *Quarterly Review of Economics and Business*, 22, 111-125.

Byrnes, P.; S. Grosskopf and K. Hayes (1986), "Efficiency and Ownership: Further Evidence", *Review of Economics and Statistics*, 68, 337-341.

Carpentier, A.; C. Nauges; A. Reynaud and A. Thomas (2006), "Effets de la délégation sur le prix de l'eau potable en France: Une analyse à partir de la littérature sur les effets de traitement", *Economie et Prévision*, 174(3), 1-20.

Casarin, A. A.; J. A. Delfino and M. E. Delfino (2007), "Failures in water reform: Lessons from the Buenos Aires's concession", *Utilities Policy* 15, 234-247.

Clark, R. M. and R. G. Stevie (1981), "A Water Supply Cost Model Incorporating Spatial Variables", *Land Economics*, 57(1), 18-32.

Coelli, T. J.; Estache, A.; Perelman, S. and Trujillo, L. (2003), "A Primer on Efficiency Measurement for Utilities and Transport Regulators", *World Bank Publications,* Washington, D.C.

Coelli, T. and D. Lawrence (Eds.) (2006), *Performance Measurement and Regulation Network Utilities,* Edward Elgar.

Coelli, T. and S. Walding (2006), "Performance Measurement in the Australian Water Supply Industry: A Preliminary Analysis", in Coelli, T. and D. Lawrence (Eds.) (2006), *Performance Measurement and Regulation Network Utilities,* Edward Elgar.

Corton, M. L. (2003), "Benchmarking in the Latin American Water Sector: The Case of Peru", *Utilities Policy,* 11, 133-142.

Cowan, S. (1993), "Regulation of Several Market Failures: The Water Industry in England and Wales", *Oxford Review of Economic Policy,* 9(4), 14-23.

Crain, W. M. and A. Zardkoohi (1978), "A Test of the Property-Rights Theory of the Firm: Water Utilities in the United States", *Journal of Law and Economics,* 21, 395-408.

Cubbin, J. and G. Tzanidakis (1998), "Regression versus Data Envelopment Analysis for Efficiency Measurement: An Application to the England and Wales Regulated Water Industry", *Utilities Policy,* 7, 75-85.

Cubbin, J. (2005), "Efficiency in the water industry", *Utilities Policy*, 13, 289-293.

Ducci, J. (2007), *Salida de operadores privados internacionales de agua en América Latina*, Inter-American Development Bank. Washington D.C.

Elnaboulsi, J. C. (2001), "Organization, Management and Delegation in the French Water Industry", *Annals of Public and Cooperative Economics*, 72 (4), 507-547.

Estache, A.; A. Gómez-Lobo and D. Leipziger (2000), *Utility privatization and the needs of the poor in Latin America. Have we learned enough to get it right? Infrastructure for Development: Private Solutions and the Poor*. London, UK.

Estache, A. and E. Kouassi (2002), *Sector Organization, Governance, and the Inefficiency of African Water Utilities*, World Bank Policy Research Working Paper 2890, September 2002. Washington, D.C.

Estache, A. and M. A. Rossi (2002), "How Different is the Efficiency of Public and Private Water Companies in Asia?", *The World Bank Economic Review,* 16(1), 139-148.

Estache, A. and L. Trujillo (2003), "Efficiency Effects of «Privatization» in Argentina's Water and Sanitation Services", *Water Policy,* 5(4), 369-380.

Estache, A. (2006), "PPI Partnerships vs. PPI Divorces in LDCs", *Review of Industrial Organization* 29, 3-26.

Fabbri, P. and G. Fraquelli (2000), "Costs and Structure of Technology in the Italian Water Industry", *Empirica,* 27, 65-82.

Faria, R. C.; G. Souza and T. B. Moreira (2005), "Public Versus Private Water Utilities: Empirical Evidence for Brazilian Companies", *Economics Bulletin*, 8(2), 1-7.

Feigenbaum, S. and R. Teeples (1983), "Public Versus Private Water Delivery: A Hedonic Cost Approach", *Review of Economics and Statistics*, 65, 672-678.

Ford, J. L. and J. J. Warford (1969), "Cost Functions for the Water Industry", *Journal of Industrial Economics*, 18, 53-63.

Foster, V. (2005), *Ten years of water service reform in Latin America: Toward an Anglo-French model*, Water supply and sanitation sector board discussion paper series 3, The World Bank, Washington D.C.

Fox, W. F. and R. A. Hofler (1986), "Using Homothetic Composed Error Frontiers to Measure Water Utility Efficiency", *Southern Economic Journal*, 53(2), 461-477.

Fraquelli, G. and V. Moiso (2005), *Cost Efficiency and Scale Economies in the Italian Water Industry*, Higher Education and Research on Mobility Regulation and the Economics of Local Services (HERMES), Working Paper, 8, Torino. Italy.

García Sánchez, M. I. (2006), "Efficiency Measurement in Spanish Local Government: The Case of Municipal Water Services", *Review of Policy Research*, 23(2), 355-371.

García-Valiñas, M. A. and M. A. Muñiz (2007), "Is DEA Useful in the Regulation of Water Utilities? A Dynamic Efficiency Evaluation (A Dynamic Efficiency Evaluation of Water Utilities)", *Applied Economics*, 39, 245-252.

Garcia, S. and A. Thomas (2001), "The Structure of Municipal Water Supply Costs: Application to a Panel of French Local Communities", *Journal of Productivity Analysis,* 16, 5-29.

Garcia, S. and A. Thomas (2003), "Regulation of Public Utilities under Asymmetric Information. The case of Municipal Water Supply in France", *Environmental and Resource Economics*, 26, 145-162.

Garcia, S.; M. Moreaux and A. Reynaud (2007), "Measuring economies of vertical integration in network industries: An application to the water sector", *International Journal of Industrial Organization*, 25, 791-820.

Gattoufi, S; M. Oral and A. Reisman (2004), "Data Envelopment Analysis Literature: A Bibliography Update (1951-2001)", *Socio-Economic Planning Sciences*, 38, 159-229.

González-Gómez, F. (2006), "¿Está justificada la privatización de la gestión del agua en las ciudades?" *Ciudad y Territorio. Estudios Territoriales*, 147, 139-157.

Hall, D. and E. Lobina (2004), "Private and Public interests in water and energy", *Natural Resources Forum*, 28, 268-277

Hall, D.; E. Lobina and R. de la Motte (2005), "Public resistance to privatisation in water and energy", *Development in Practice*, 15(3/4), 286-301.

Hayes, K. (1987), "Cost Structure of the Water Utility Industry", *Applied Economics,* 19, 417-425.

Hunt, L. C. and E. L. Lynk (1995), "Privatisation and Efficiency in the UK Water Industry: An Empirical Analysis", *Oxford Bulletin of Economics and Statistics,* 57(3), 371-388.

Kim, H. Y. (1987), "Economies of Scale in Multi-product Firms: An Empirical Analysis", *Economica,* 54, 185-206.

Kim, H. Y. and R. M. Clark (1988), "Economies of Scale and Scope in Water Supply", *Regional Science and Urban Economics,* 18, 479-502.

Kim, E. and H. Lee (1998), "Spatial integration or urban water services and economies of scale", *Review of Urban and Regional Development Studies,* 10(1), 3-18.

Kingdom, W. (2005), *Models of aggregation for water and sanitation provision*, Water supply & Sanitation Working Notes, 1, World Bank. Washington D.C.

Kirkpatrick, C.; D. Parker and Y. F. Zhang (2006), "An Empirical Analysis of State and Private Sector Provision of Water Services in Africa", *The World Bank Economic Review,* 20(1), 143-163.

Knapp, M. R. J. (1978), "Economies of Scale in Sewage Purification and Disposal", *Journal of Industrial Economics,* 27(2), 163-183.

Kuwabara, H. (1998), "Industrial Organization and Cost Analysis of Water Utilities", *Journal of Public Utility Economics*, 50, 45-54.

Lambert, D. K.; D. Dichev and K. Raffiee (1993), "Ownership and Sources of Inefficiency in the Provision of Water Services", *Water Resources Research,* 29 (6), 1573-1578.

Leibenstein, H. (1966), "Allocative Efficiency and X-Efficiency", *The American Economic Review*, 56, 392-415.

Lin, Ch. (2005), "Service Quality and Prospects for Benchmarking: Evidence from the Peru Water Sector", *Utilities Policy*, 13(3), 230-239.

Littlechild, S. (1986), "Economic Regulation of Privatized Water Authorities", *Department of the Environment*, HMSO, London.

Littlechild, S. (1988), "Economic Regulation of Privatised Water Authorities and Some Further Reflections", *Oxford Review Economic Policy*, 4, 40-68.

Lobina, E. (2005), "Problems with private water concessions: A review of experiences and analysis of dynamics", *Water Resources Development*, 21(1), 55-87.

Lobina, E. and D. Hall (2000), "Public Sector Alternatives to Water Supply and Sewerage Privatization: Case Studies", *Water Resources Development*, 16(1), 35-55.

Lynk, E.L. (1993), "Privatisation, Joint Production and the Comparative Efficiencies of Private and Public Ownership: The UK Water Industry Case", *Fiscal Studies*, 14(2), 98-116.

Mann, P. C. and J. L. Mikesell (1976), "Ownership and Water System Operation", *Water Resources Bulletin,* 12(5), 995-1004.

Mizutani, F. and T. Urakami (2001), "Identifying Network Density and Scale Economies for Japanese Water Supply Organizations", *Papers in Regional Science*, 80, 211-230.

Morgan, W. D. (1977), "Investor Owned vs. Publicly Owned Water Agencies: An Evaluation of the Property Rights Theory of the Firm", *Water Resources Bulletin,* 13(4), 775-781.

Mosheim, R. (2006), "A Shadow Cost Function Model of the US Water Industry Incorporating Water Quality and Ownership Effects", in Coelli, T. and D. Lawrence (Eds.), *Performance Measurement and Regulation Network Utilities,* Edward Elgar.

Mugisha, S. (2007), "Effects of incentive applications on technical efficiencies: Empirical evidence from Ugandan water utilities", *Utilities Policy*, 15, 225-233.

Nauges, C. and C. Van den Berg (2007), *How "natural" are natural monopolies in the water supply and sewerage sector? Case studies from developing and transition economies*, World Bank Policy Research Working Paper 4137. February, 2007. Washington D.C.

Nickson, A. and R. Franceys, (2003), *Tapping the market: The challenge of institutional reform in the urban water sector*, Palgrave Macmillan. Hampshire. New York.

OECD (2000), *Global trends in urban water supply and waste water financing and management: changing roles for the public and private sectors*, Centre for Co-operation with Non-members Environment Directorate, CCNM/ENV(2000)36/FINAL OECD. Paris.

OECD (2003), *Improving Water Management,* OECD. Paris.

Ohlsson, H. (2003), "Ownership and production costs: choosing between public production and contracting-out in the case of Swedish refuse collection", *Fiscal Studies*, 24, 451-476.

Picazo-Tadeo, A. J.; F. González-Gómez and F. J. Sáez-Fernández (2009), "Accounting for Operating Environments in Measuring Water Utilities' Managerial Efficiency", *The Service Industries Journal*, 29, forthcoming.

Picazo-Tadeo, A. J.; F. J. Sáez-Fernández and F. González-Gómez (2007), "The Role of Environmental Factors in Water Utilities' Technical Efficiency. Empirical Evidence from Spanish Companies", *Applied Economics*, in press, doi: 10.1080/00036840601007310.

Picazo-Tadeo, A. J.; F. J. Sáez-Fernández and F. González-Gómez (2008), "Does service quality matter in measuring performance of water utilities?", *Utilities Policy,* 16(1), 30-38.

Raffiee, K.; R. Narayanan; T. R. Harris; D. Lambert and J. M. Collins (1993), "Cost Analysis of Water Utilities: A Goodness-of-Fit Approach", *Atlantic Economic Journal*, 21(3), 18-29.

Rees, J. A. (1998), *Regulation and private participation in the water and sanitation sector*, Global Water Partnership Technical Advisory Committee, Backgrounds Papers 1. Stockholm, Sweden.

Renzetti, S. and D. Dupont (2003), Ownership and Performance of Water Utilities, *The Journal of Corporate Environmental Strategy and Practice*, 42, 9-19.

Saal, D.S. and D. Parker (2000), "The Impact of Privatization and Regulation on the Water and Sewerage Industry in England and Wales: A Translog Cost Function Model", *Managerial and Decision Economics,* 21(6), 253-268.

Saal, D. S. and D. Parker (2001), "Productivity and Price Performance in the Privatized Water and Sewerage Companies of England and Wales", *Journal of Regulatory Economics,* 20(1), 61-90.

Saal, D. S. and D. Parker (2004), "The Comparative Impact of Privatization and Regulation on Productivity Growth in the English and Welsh Water and Sewerage Industry: 1985-1999", *International Journal of Regulation and Governance* 4(2), 139-70.

Saal, D. S. and D. Parker (2006), "Assessing the Performance of Water Operations in the English and Welsh Water Industry: A Lesson in the Implications of in Appropriately Assuming a Common Frontier", in Coelli, T. and D. Lawrence (Eds.), *Performance Measurement and Regulation Network Utilities.* Edward Elgar.

Saal, D. S.; D. Parker and T. G. Weyman-Jones (2007), "Determining the Contribution of Technical Change, Efficiency Change and Scale Change to Productivity Growth in the Privatized English and Welsh Water and Sewerage Industry: 1985–2000", *Journal of Productivity Analysis*, 28, 127-139.

Sabbioni, G. (2005), "Econometric Measures of the Relative Efficiency of Water and Sewerage Utilities in Brazil", *Public Utility Research Center*, *University of Florida*, May 10, 2005.

Sabbioni, G. (2008), "Efficiency in the Brazilian sanitation sector", *Utilities Policy,* 16(1), 11-20.

Sauer, J. (2005), "Economies of Scale and Firm Size Optimum in Rural Water Supply", *Water Resources Research*, 41, 1-13.

Sauer, J. and K. Frohberg (2007), "Allocative Efficiency of Rural Water Supply – A Globally Flexible SGM Cost Frontier", *Journal of Productivity Analysis*, 27, 31-40.

Shleifer, A. (1985), "A theory of yardstick competition", *RAND Journal of Economics*, 16(3), 319-327.

Sepälä, O. T.; J. J. Hukka and T. S. Katko (2001), "Public-Private Partnerships in Water and Sewerage Services. Privatization for Profit or Improvement of Service and Performance?", *Public Works Management & Policy,* 6(1), 42-58.

Seroa da Motta, R. and A. Moreira (2006), "Efficiency and regulation in the sanitation sector in Brazil", *Utilities Policy,* 14, 185-195.

Shaoul, J. (1997), "A Critical Financial Analysis of the Performance of Privatised Industries: The Case of the Water Industry in England and Wales", *Critical Perspectives on Accounting,* 8, 479-505.

Shih, J-S; W. Harrington; W. A. Pizer and K. Gillingham (2004), *Economies of Scale and Technical Efficiency in Community Water Systems*, Discussion Paper 04-15, Resources for the Future. Washington, D.C.

Shirley, M. (ed.) (2002), *Thirsting for Efficiency: The Economics and Politics of Urban Water System Reform*, Elsevier Press, Oxford.

Stone and Webster Consultants (2004), *Investigation into evidence for economies of scale in the water and sewerage industry in England and Wales*, Final Report. London.

Strategic Management Consultants (2002), *Optimum entity size in the water industry of England and Wales: a review of factors which influence the size of companies*. Northumberland, UK.

Takada, S. and R. Shigeno (1998), "Cost Structure of Water Supply in Japan: The Estimation of Economics of Density and Economies of Scale", *Journal of Public Utility Economics*, 50, 37-40.

Teeples, R. and D. Glyer (1987a), "Cost of Water Delivery System: Specification and Ownership Effects", *Review of Economics and Statistics*, 69(3), 399-408.

Teeples, R. and D. Glyer (1987b), "Production Functions for Water Delivery Systems: Analysis and Estimation Using Dual Cost Function and Implicit Price Specifications", *Water Resources Research*, 23(5), 765-773.

Thanassoulis, E. (2000a), "The use of data envelopment analysis in the regulation UK water utilities: Water distribution", *European Journal of Operational Research,* 126, 436-453.

Thanassoulis, E. (2000b), "DEA and its use in the regulation of water companies", *European Journal of Operational Research,* 127, 1-13.

Torres, M. and C. J. Morrison-Paul (2006), "Driving Forces for Consolidation or Fragmentation of the US Water Utility Industry: A Cost Function Approach with Endogenous Output", *Journal of Urban Economics*, 59, 104-120.

Tupper, H. C. and M. Resende (2004), "Efficiency and Regulatory Issues in the Brazilian Water and Sewage Sector: An Empirical Study", *Utilities Policy,* 12, 29-40.

Tynan, N. and B. Kingdom (2005), *Optimal size for utilities? Returns to scale in water: evidence from benchmarking*, Public Policy for the private sector, note 283, The World Bank. Washington, D.C.

Van den Berg, C.; S. Pattanayak; J.-C. Yang and H. Gunatilake (2006), *Getting the assumptions right: private sector participation transaction design and the poor in Southwest Sri Lanka*. Water supply and sanitation sector board discussion paper series 7. The World Bank. Washington D.C.

Vickers, J. and G. Yarrow (1988), "Regulation of Privatized Firms in Britain", *European Economic Review*, 32, 465-472.

Woodbury, K. and B. Dollery (2004), "Efficiency Measurement in Australian Local Government: The Case of New South Wales Municipal Water Services", *Review of Policy Research*, 21(5), 615-636.

Abstract

El análisis de la eficiencia en la gestión del servicio urbano de aguas es una práctica que ofrece una valiosa información tanto a los gestores del servicio como a los órganos reguladores para introducir mejoras en la conducta empresarial y en el diseño de las políticas públicas. A partir del trabajo precursor de Ford y Wardford (1969) han sido muchas las tentativas orientadas en esta línea. Debido a la importancia del tema y al volumen de publicaciones existente hemos creído oportuno hacer un balance de la investigación realizada a lo largo de cuatro décadas. En la panorámica efectuada se exponen los principales interrogantes planteados a lo largo del tiempo, se hace una síntesis de los resultados obtenidos y, finalmente, se apuntan algunos retos para la investigación en próximos años.

Palabras claves: Gestión del agua; eficiencia; conducta empresarial; agua.

Clasificación JEL: L95, L20, D21, Q25.