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COST EFFICIENCY AND ECONOMIES OF SCALE IN THE ITALIAN WATER INDUSTRY

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Cost efficiency and economies of scale in the Italian Water Industry

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Abstract

This paper analyses the ongoing reform of the Italian water sector, with particular attention to the industry cost efficiency and to the assessment of scale economies at ATO level, by estimating a stochastic cost frontier. The ATOs should be local optimum size areas defined by regional bodies, where the management of water and sewerage services is unified. Our study highlights the impact on costs of this integrated management of water service introduced by the reform. We analysed 18 ATOs through their operational and strategic planning which provides the management guidelines for the next 20 years (at least). In particular, we estimated a trans-logarithmic cost frontier to assess the behaviour of returns to scale, the inefficiency score and the impact of network characteristics. The results show - on average - inefficiency scores about 28%, partially explained by network characteristics. On the other hand, the presence of relevant scale economies suggests that the situation could be improved by a reduced fragmentation at local level.

Key Words: water sector, economies of scale, cost efficiency, stochastic frontiers.

JEL Classification Numbers: D24, L51, L95.

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1. Introduction

Managerial efficiency and the supply structure of water sector are two key issues extremely up to date in Italy. Galli Law (no. 36/1994) and the 2000 Government rules forced local authorities towards a partial privatisation, changing the municipal firms into limited companies. At the same time, in order to reduce the local fragmentation a great importance is given to a correct size of the firms waiting for a reduction of the costs and improving quality of the services provided. Galli law required the creation of 91 ATOs (*Ambiti Territoriali Ottimali*, Optimum Size of Territorial Areas), where the management of water services must be unified. A vertical integrated structure is supposed to minimize the sum of production and transaction costs: in each territorial area the same firm will manage the water and sewerage service and waste water treatment.

In this paper we analyse the ongoing regulatory reform of the Italian water sector, with particular attention to the impact on the management efficiency. We focus on cost structure and on the optimum size of the firms; at the same time we investigate the efficiency in resource allocation and its evolution over time. The analysis takes into account the output characteristics such as the network length and the level of losses. In brief, the main aim of this paper is to investigate the quality of the first applications of the reform, by answering questions such as: are ATOs, with their current size, able to benefit from scale economies? Was the cost planning, which is the basis to fix the tariffs applied to customers, efficiently conceived?

The empirical research is based on a thirty-year unbalanced panel data of business plans of 18 ATOs at national level, for a total of 407 observations. In order to verify both scale economies and inefficiency, we estimate a stochastic cost frontier, using the methodology proposed by Battese and Coelli (1995). The presence of scale economies gives a measure of the potential cost reduction related to the increase of the size. On the other hand, the measure of the inefficiency is a quality index of the resources allocation provided by each ATO.

The results show that -on average- inefficiency score is about 21%. On the other hand, the presence of relevant scale economies suggests that a reduction in local fragmentation could improve the supply structure of water service in Italy.

The remaining part of the paper is organised as follows: Section 2 introduces the main items of the restructuring process of the Italian water service. Section 3 shortly reviews the theoretical literature on scale economies and efficiency in the water sector and illustrates the database. Section 4 develops the econometric model. Section 5 comments on the empirical results and Section 6 contains the policy implications and the conclusions.

2. The reform of the Italian Water System

Four are the main problems in the Italian water system: service fragmentation, low efficiency and magnitude of size; insufficient water supply (occurring during summertime); quality of water and services and, consequently, level of customer satisfaction; tariffs (in many cases not even covering operational costs and among the lowest in Europe).

In order to face these problems, in 1994 Galli law created a new subject: the ATO, a local institution where the management of water services is unified. The union and the strong reduction of some 13,000 firms should guarantee the minimum efficient size, a rationalisation of investments and a better coordination of joint costs of water service.

The ATO management has to be assigned, through a competitive bidding, to one private or mixed private-public firm. However, a transitory period is required to allow the reorganisation of the main incumbents. Galli Law (Law 36/94, art. 10) gives two possibilities in favour of current providers: public firms can maintain their concession without a competitive bidding, but cannot compete for other ATOs; the private company continues to operate up to the expiry of its own concession. For this reason, in most ATOs we can find several firms and this leads to fragmentation within the ATO itself. The major problem still remains the size of the ATOs and the size of the firms inside them. In every single ATO the service is managed by a large number of units. For instance, in a very small region such as Val d'Aosta there is a joint management of 74 local town Councils, and in Piedmont there are 6 ATOs and 44 firms. At the same time we can not forget the absence of a strong managerial incentives toward efficiency.

The reform implies a complex articulation of phases in which the ATO creation is a fundamental point. Currently there are 87 ATOs out of 91[1]. In the last two years there has been a strong acceleration of the process, because starting with the last 2002 government budget law (Law 448/2002) the access to EU founding is subject to the enforcement of the reform.

Giving the situation of natural monopoly characterising this sector, ATOs play an important role. The goals are based on the so-called *Piano d'Ambito* (PA), a plan implemented by single utility firms under the control of the local Water Authorities. The PA finds and faces the peculiar problems of each ATO. It also includes the financial plan and the tariff systems. Tariffs must cover operational and financial costs and, through a price cap mechanism, stimulate the efficiency of utility companies.

3. Previous empirical evidence and data description

Literature is quite poor especially as regard the specific analysis of the evolution of firm efficiency over time. Anyway, Table 1 summarizes a selection of international papers reporting evidences on scale economies and firm inefficiency. Empirical studies provide no conclusive result.

Ashton (1998) studied ten privatised Wacs (public quoted water and sewerage companies in England and Wales) over the period 1987-1997. He found evidence of relevant scale economies. Saal and Parker (2000, 2001, 2004) considered the same ten Wacs over the period 1985-1999 and found no presence of scale economies.

In Italy there is mainly support of weak scale economies, disappearing over 150,000–200,000 customers (Fabbri and Fraquelli, 2000, Fraquelli et al. 2003). Antonioli and Filippini (2001), on a sample of 32 Italian firms observed over the period 1991-1995, found weak scale economies in the case of an equi-proportional increase in delivered water, customers and length of mains, and strong economies of output density in relation to the change of the amount of delivered water with the network characteristics being fixed.

As far as previous empirical evidences and output measures are concerned, the studies provide a wide set of variables. In addition to the usual output concerning the

[1] Annual report of *Comitato di Vigilanza sull'uso delle risorse idriche (Surveillance Committee for the Use of Water Resources)*, Rome, 2004

water delivered, in many cases we find edonic variables such as: the amount and the quality of delivered water, the amount of network losses, the number of customers, the population density, the firm size, the length of mains, the type of source, the environmental data.

Our database refers to an unbalanced panel of 18 ATO business plans (out of 62 available), over a period of 20 – 30 years, for a total of 407 observations. The units of the sample are distributed throughout Italy: 8 ATOs are located in Central Italy, 6 in the North and 4 in the South. As far as the legal form is concerned, 9 ATOs chose the co-operative form, and 9 the municipal partnership.

The size of the ATOs measured by the number of workers is characterised by an average number of 378 employees, with a minimum of 128 and a maximum of 1,438. The average distributed water is 59 million m^3 per year, with an average population of 366,500 inhabitants (Table 2).

4. Model Specification and Estimation Procedures

4.1 The choice of the stochastic frontier approach

We adopt a translog cost function approach. We assume that firms are price takers on input markets and that output is exogenously determined. This appears to be appropriate for a regulated industry where firms are relatively small players on input markets and are required to satisfy market demand at a price set by the regulator. We estimated a total cost function given that relevant investment programs characterize the industry[2] over the considered period.

The translog specification is a flexible function form, imposing no a priori restriction on production technology. In particular, we adopt a stochastic cost frontier approach, enabling us to analyse the evolution of inefficiency over time and between firms, distinguishing cost reductions induced by technical change from those deriving from efficiency improvements. This methodology computes the cost deviation from the best practice frontier per year and per firm[3], and this deviation is attributed to both

[2] See Saal and Parker (2000, 2001, 2005)

[3] See Battese and Coelli (1995). Here we simply highlight that the inefficiency concept is well represented by the distance of the observed firm costs in the real world and the minimum value of an optimisation problem, given the output level. In an econometric estimate this deviation can be attributed both to inefficiency, and to other random effects, as the measurement error.

inefficiency and other random factors. Aigner et al. (1977) and Meeusen and van den Broeck (1977) originally proposed this method, which reduces restrictions and simplifications in the stochastic estimate, by assuming that the firm production function is known, but its efficiency is not. We apply the one-step approach by Battese and Coelli (1995), by means of all parameters of the model, output, input, technical and potential inefficiency determinants are estimated simultaneously.

4.2 The specification of the stochastic frontier cost function

Water companies operate in networks having different sizes and environmental characteristics, which directly affect costs. For this reason, the cost level between firms is explained by several factors. In our study the attention is focused on the Italian tariff computation model. This is based on the operational costs added to the financial cost of the capital (equity and debts) with the deduction of a price cap improvement of efficiency. The output is measured by the total volume of delivered water. Input factors mainly consist in labour, electricity costs, materials and capital. The cost function is specified as:

$$TC = f(Y, Pl, Pe, Pmk, LEN, DLOSS, t) \quad (1)$$

where *TC* represents total costs, *Y* is the amount of delivered water measured in cu.m., and *Pl*, *Pe* and *Pmk* are respectively the price of labor, the purchase price of electricity and the price of materials, services and capital. In addition to these variables, we also include the network length *LEN* and an indicator of level of losses *DLOSS* as output characteristics. The time trend variable accounts for technological progress.

The labour price was obtained by dividing the total labour cost by the number of employees, the energy price by dividing the total expenses by the water introduced in the network, the price of material, services and capital by dividing the relative cost by the network length.

We took into account output characteristics as the water service cannot leave out of consideration environmental variables and other values affecting production.[4] Exogenous differences in operating environment can influence the technology of every

[4] See Spady and Friedlaender (1978), the first study to emphasize the importance to consider the hedonic variable in the sector analysis, when the simple quantities produced are not exhaustive in the output evaluation. Feigenbaum and Teeples (1983) made the first application to the water industry.

firm and the distance from the cost frontier. The dummy *DLOSS* takes value one when in the ATO the value of losses (introduced water minus distributed water) is greater than the average of the whole sample. We consider the average value given that the losses are a structural phenomenon in the water industry. In this way, we emphasize the sub sample with the highest value of losses and we investigate whether this affects the cost level. A higher level of losses often is an index of a bad state of infrastructures and also can imply a higher level of water produced and introduced in the network all factors being equal. The inclusion of a network variable *LEN* allows to distinguish between economies of output density and economies of scale (see Section 4.3).

The trans-log specification of the cost function in (1) can be written as:

$$
\begin{aligned}
TC_{it} &= \beta_0 + \beta_y Y_{it} + \beta_{Pj} P_{jit} + \beta_{len} len_{it} + \\
&+ 1/2 \sum_j \sum_n \beta_{Pjn} P_{jit} P_{nit} + 1/2 \beta_{y^\wedge 2} (Y_{it})^{\wedge 2} + 1/2 \beta_{len^\wedge 2} (len_{it})^{\wedge 2} + \\
&+ \sum_j \beta_{y*Pj} Y_{it} P_{jit} \sum_j \beta_{Pj*len} P_{jit} len_{it} + \beta_{y*len} Y_{it} len_{it} + \\
&+ \beta_{d\_loss} d\_loss_{it} + \beta_t t_{it} + \nu_{it} + \upsilon_{it}
\end{aligned}
\qquad (2)
$$

$$j, n = Pl, Pe$$

The translog cost function must satisfy a set of regularity conditions: it must be linearly homogeneous in factor prices, non-decreasing in factors prices and output, symmetric and concave.[5]

The model is estimated by using the Maximum Likelihood method in order to simultaneously estimate the parameters of the stochastic cost frontier and the variables of the inefficiency model.[6]

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[5] We imposed homogeneity by normalizing the dependent variable and inputs prices with the price of one of the inputs, in particular, the capital price. Therefore, in the estimated function the components of vector prices are reduced to two: labour and materials – services. This procedure is equivalent to impose the following restrictions:

$$\sum_j \beta_{Pj} = 1; \sum_j \beta_{Pjn} = 0; \sum_j \beta_{y*Pj} = 0; \sum_j \beta_{Pj*len} = 0;$$

Symmetry is a priori imposed by assuming that $\beta_{Pjn}=\beta_{Pnj}$. Concavity and monotonicity are verified ex post, if the Hessian is a negative semi-definite matrix, and if marginal costs are positive.

6 We used Frontier 4.1 program. The program is developed by Tim Coelli within CEPA (Centre for Efficiency and Productivity Analysis, University of Queensland, Australia). www.uq.edu.au/economics/cepa/software.htm.

4.3 The analysis of the economies of scale

The analysis of scale economies emphasizes increase in costs due to an increase in output, keeping all other variables fixed. In network industries however, the output varies together with the change in output characteristics. The inclusion in the cost function variables such as the network length allows for the distinction of economies of output density and scale economies (Antonioli, Filippini, 2001). In our study, the economies of output density are defined as the relative increase in total costs brought about by the relative increase in output, keeping all other variables fixed. They are measured by the inverse of output cost elasticity:

$$EOD = \frac{1}{\partial \ln TC / \partial \ln Y} \quad (3)$$

Scale economies are defined as the relative increase in total costs brought about by a proportional increase in output and network length, keeping all other variables fixed. They can be measured by the inverse of the sum of the elasticity with respect to outputs and the network length:

$$ES = \frac{1}{\left(\frac{\partial \ln TC}{\partial \ln Y} + \frac{\partial \ln TC}{\partial \ln LEN} \right)} \quad (4)$$

The presence of density or scale economies shows that the average cost falls when the output or the size of firm increases. This measure indicates cost savings when the economies are greater that one. Therefore we can have useful information about the optimum ATO size from an operating point of view.

4.4 The analysis of inefficiency

Two parts compose the error term:

v_{it}, standard error term ~ i.i.d. N(0, σ^2_v) and independent from υ_{it}

υ_{it}, non-negative random variable associated with cost inefficiency: it indicates the distance from the cost frontier due to the inefficiency of every firm in every year. This assumption lets us consider inefficiency of every firm dependent on exogenous variables *firm* and *time specific*:

$$\upsilon_{it} = \sum_m \delta_m z_m + w_{it} \quad (5)$$

The variables denoted by parameter δ might explain the relative efficiency of the firm. They can be the density, the number of large industrial users, the level of pumping costs, the percentage of water pumped from rivers, etc. In literature there are very few examples, none applied at the Italian water sector. In this analysis we have alternatively included the available variables, and the model that better explains the relative efficiency of firms is:

$$\upsilon_{it} = \delta_0 + \delta_d dens_{it} + w_{it} \quad (6)$$

where *dens* is a proxy of population density, obtained by dividing the number of residents by the network length. Density may have ambiguous effects on costs inefficiency. A higher value of this variable is expected to reduce cost inefficiency because it is cheaper to distribute water of not extensively scattered customers. On the other hand, a higher density may create congestion problems.

w_{it} is the random variable making the inefficiency effects stochastic. The inefficiency in the model has a normal distribution truncated at zero with mean $\Sigma_m \delta_m z_{mit}$ (in vectors $\delta' z_{it}$) and variance σ^2_υ, $\upsilon_{it} \sim N^+(\delta' z_{it}, \sigma^2_\upsilon)$. υ_{it} are independently but not identically distributed. Then the overall cost inefficiency of production for firm *i* at time *t* is defined by:

$$CE_{it} = \exp(\upsilon_{it}) = \exp(\delta' z_{it} + w_{it}) \quad (7)$$

taking a value between one (maximum efficiency) and infinity. Given that υ_{it} is a stochastic variable and then it is not observable, we consider the estimation of CE_{it} as based on conditional expectations of υ_{it} given the observable values of the standard error of estimate ($\nu_{it} + \upsilon_{it}$).[7]

[7] u_{it} arises from the truncation at zero at the normal distribution with variance σ_{it}^2, its conditional expected value is given by

$$E(u_{it}) = \sigma^2_{it} \frac{\phi(0)}{\Phi(0)}$$

where the numerator is density and the denominator is the cumulative density function of a standard normal variable evaluated at the mean value of the pre-truncated distribution of the inefficiency component of the error term. See Jondrow (1982), Battese and Coelli (1988 and 1993).

5. Empirical results

The estimate of the parameter of the model is given in Table 3.The first order coefficient can be interpreted as frontier cost elasticity for the average operator of the industry, since all variables were normalized to their sample mean and are in natural logarithm. All signs of the first order parameters are as expected. Elasticity in relation to output, network length and factor prices is positive and significant. Variable costs are in a very weak relation whit the time variable: there is not an annual cost reduction due to technical progress.

The analysis of scale economies is reported in Table 4. As expected, for smaller firms the economies of output density are very high. As the delivered water increases, the value decreases but remains always up to 1. The results show the presence of strong scale economies, that fall up to 90 million cubic metres (about 1 million of inhabitants). As a matter of fact, a higher level of bureaucracy and complexity characterizes the management of a large size utility company: the area to be supplied is more extensive and it can feature a higher altitude and a lower population density. However, we have to consider that in the Italian water sector the average size of the ATOs is 59 million cubic metres and many are the cases of very small dimensions. The results suggest that existing ATOs can obtain cost reduction through further mergers, approaching the optimum size of 90 million cubic metres of delivered water. The behaviour of the scale elasticity can be attributed to the introduction of the integrated management of the water and sewerage service. The previous studies of the Italian water sector, based on non-integrated firms, highlight lower benefits with increasing dimensions.

On the hand of efficiency, one of the focal points of every PA is inducing allocative efficiency to allow cost reduction, also by applying the price- cup formula in tariff computation. We investigated the efficiency evolution over time provided by the investment and improvement programs of the local ATO (Tables 5). We found evidence of increasing inefficiency rates followed by decreasing rates over time. The average inefficiency of the sample is 28%, the value in the first year and in the last year is 21%, the maximum value is 32% in the 10th year. It can be important to note that ATO programs provide for a concentration of investment programs in the first ten years. The results show a positive relationship between inefficiency and population density, evidence of possible congestion problems in the ATOs with a higher density.

The evaluation of the results cannot forget that the efficiency of network services is strictly linked to environmental and morphological conditions in which the utility firm operates. A particular mountainous or congestioned ATO should have higher costs than others under the same output and network conditions. This can explain the persistence of a certain level of inefficiency in some cases.

6. Policy implications and conclusions

The most important findings of this paper concern scale economies, the role of vertical integration and the level of inefficiency. The scale economies in ATOs show an optimum size that is sharply greater than the current size of the utility companies operating in the Italian Water Industry. Vertical integrated activity inside every ATO seems generate scale economies. If we compare the trend of cost elasticity of ATOs whit that of specialised firms (in previous researches) we can see a strong increase of the optimum size and higher economies for the same size. Strong inefficiency differences throughout the investment and improvement programs arranged in each ATO indicate that the mechanisms of control are insufficient.

The results suggest two main policy implications. The high degree of efficiency partially explained by the level of population density requires the improvement of benchmarking methods. The price cap system does not work if it is not jointed to a correct comparison with other local operators. So it is necessary to enforce yardstick competition creating a good national cost standard, taking into account the morphological and environmental characteristics. At the same time it is necessary to accelerate the introduction of competitive bidding for the concession of the service in every ATO. On the other and, it is important to revise the optimum size of ATOs previously defined by Galli law. The scale elasticity up to one till one million served population allows cost reduction by increasing the size of a great part of ATOs. Suitable controls must be defined in the ATOs with the largest density and showing the greatest value of inefficiency.

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Tab. 1 - Economies of Scale and Firm Inefficiency in the Water Industry

Author	Object	Model	Main variables	Results	Economies of scale and density
Feigenbaum, Teeples (1983)	57 private firms and 262 public firms USA in the '70s. Multi-dimensionality of the output, also qualitatively evaluated as service to customers.	Trans-logarithmic cost function with hedonic variables.	- Labour, capital, energy and water as input - Water measured, water treated - Customers/mains, technical data of sewerage service, average production/day - % of bayed water input	Treatment level of water have a positive impact on costs. Equal efficiency between private and public companies.	Density and bayed water have a positive impact on costs
Bhattacharyya, Parker, Raffiee (1994)	257 companies USA, of which 32 private, year1992. The impact of privatisation on costs and on economies of scale.	Stochastic cost function.	- Water delivered - Output price, input vector price - Variable costs (labour, materials, energy) - Capital stock, Dummy public/private company	The public firms are more efficient that the private one.	Increasing returns to scale.
Bhattacharyya, Harris, Narayanan, Raffiee (1995)	190 public firms and 31 private firms USA. Study of the impact of privatisation on efficiency.	Stochastic cost function and trans-logarithmic cost function.	- Water delivered - Variable costs (labour, materials, energy) - Network losses, dummy for typology of source	No significant differences between private and public firms	The private firms are more efficient that the state owned only with a little size
Ashton (1998)	10 privatised companies in England and Wales over the period 1987-1997.	Stochastic cost function.	- Water delivered - Input vector price - Customers	Presence of economies of scale before the privatisation of 1989.	Increasing returns to scale.
Fabbri, Fraquelli (2000)	173 Italian public firms. Analysis of economies of scale. Identification of the best functional form.	Trans-logarithmic cost function, Cobb Douglas cost function, hedonic variables.	- Water delivered - Input vector price - Customers and density - Treatment cost/total costs	The functional form and the choice of variables strongly influence the results on economies of scale. The trans-logarithmic model with hedonic variables is the best one.	Increasing returns to scale.
Saal, Parker (2000)	10 privatised companies in England and Wales over the period 1985-1999. Productivity dynamic after the privatisation.	Index number approach: TFP and labour productivity.	- Multi-output: population in state of water delivered, sewerage service - Input vector price - OFWAT quality parameters.	No privatisation effect on TFP, but an excessive substitution capital-labour. The growth in profit is not due to an increasing productivity, but to a growth in prices.	Absence of economies of scale.
Saal, Parker (2001)	10 privatised companies in England and Wales over the period 1985-1999. Study of the impact of privatisation on efficiency.	Trans-logarithmic cost function.	- Multi-output: water and sewerage industry - Input vector price: labour, capital, energy, materials and services - Dummies public/private company	There is not any privatisation effect on costs.	Scope economies due to quality.
Antonioli, Filippini (2001)	32 Italian companies over the period 1991-1995. Analysis of costs structure and of economies of scale.	Cobb Douglas cost function.	- Water delivered, customers, network length - Variable costs (labour and materials), capital stock - Main losses - Dummy sewerage service.	Strong economies of output density.	Absence of economies of scale.
Fraquelli, Giandrone (2003)	103 plants processing urban waste waters in Italy, in 1996. Analysis of treatment processes and economies of scale.	Cobb Douglas cost function.	- Volumes treated, quality characteristics - Input prices - Technical dummy variables	Pollution load has a very significant role in explaining costs. Grater costs but high quality for advanced processes	Strong economies of scale for the smaller structure. Scope economies from vertical integration.
Bottasso, Conti (2004)	Analysis of the evolution of operating cost efficiency for the whole English and Welsh water industry over the period 1995-2001.	Heteroskedastic stochastic variable cost frontier.	- Water delivered, capital stock, labour, RPI index. - Network length, dummy sewerage service. - Average pumping head, proportion of river sources.	The industry operating cost efficiency has improved and the efficiency differences between firms are narrowed after the 1994 price review.	Strong economies of scale for the smaller structure in the short run.

Tab. 2 - Descriptive Statistics

	Minimum	Mean	Median	Maximum	Standard deviation	Coefficient of variation
Water delivered (Megalitres)	18.900	59.202	43.000	250.000	50.584	0,854
Network length (KM)	2.510	6.994	6.249	20.187	3.502	0,501
N° employees	128	378	305	1438	281	0,746
Town Councils	34	103	64	306	75	0,728
Population served	22.677	366.570	250.040	1.892.610	396.031	1,080
Pop/network length	35,35	96,94	83,18	253,22	54,11	0,558
Total costs (000 euro)	21.380	76.270	58.548	304.119	55.400	0,726
Labour cost (000 euro)	6.574	15.699	12.143	57.481	11.000	0,701
Capital cost (000 euro)	35,00	14.061	10.910	64.886	12.732	0,905
Materials and services cost (000 euro)	6.964	28.687	20.547	117.547	26.868	0,937
Pl	27,29	43,80	40,52	78,13	11,00	0,251
Pms	0,14	0,47	0,45	0,98	0,16	0,350
Pk	0,01	2,17	1,65	10,08	1,85	0,849

Tab. 3 - ML Estimates for the Parameters

		coefficient	standard-error
β_0	*constant*	-0,13*	0,02
β_y	*output*	0,39*	0,04
β_{Pl}	*wage*	0,40*	0,04
β_{Pe}	*electricity*	0,23*	0,03
β_{len}	*length*	0,56*	0,03
β_{y*Pl}	*output*wage*	0,42*	0,08
β_{y*Pe}	*output* electricity*	0,03	0,06
$\beta_{y\wedge 2}$	*output*output*	0,10*	0,05
β_{Pl*Pe}	*wage* electricity*	-0,03	0,06
$\beta_{Pl\wedge 2}$	*wage*wage*	0,09*	0,04
$\beta_{Pe\wedge 2}$	*electricity* electricity*	0,06*	0,02
β_{y*len}	*output* length*	0,23*	0,08
β_{Pl*len}	*wage* length*	-0,43*	0,08
β_{Pe*len}	*electricity* length*	0,19*	0,06
$\beta_{len\wedge 2}$	*length * length*	-0,09*	0,04
β_{d_loss}	*dummy losses*	0,08*	0,02
β_t	*trend*	0,003*	0,00
d_0	*constant*	0,27*	0,01
d_d	*density*	0,22*	0,03
σ^2		0,01*	0,00
γ		0,99*	0,00
log likelihood			354,93

(*)significant to 95%

- All the variables except for time trend were normalized by their sample mean value prior to transformation into logarithms.

Tab. 4 - Density and scale economies

Water delivered (Megaliter/day)	Economies of output density	Economies of scale
25.306	18,53	2,18
31.658	9,90	1,77
34.685	8,32	1,64
38.830	6,95	1,50
43.000	6,05	1,40
50.891	4,98	1,26
52.213	4,85	1,24
62.148	4,12	1,12
97.811	2,96	0,91
250.000	1,87	0,65

Tab. 5 - Evolution of inefficiency

Year	Inefficiency
1	22%
5	27%
10	32%
15	31%
20	25%
25	22%