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"Gheorghe Asachi" Technical University of Iasi, Romania

WATER UTILITIES AND THE PROMOTION OF SUSTAINABLE WATER USE: AN INTERNATIONAL INSIGHT

Extended abstract

Giulia Romano[1*], Nicola Salvati[1], Martina Martini[2], Andrea Guerrini[2]

[1]*University of Pisa, Department of Economics and Management, Via Ridolfi, 10, 56124, Pisa, Italy*
[2]*University of Verona, Via dell'Artigliere, 19, 37129, Verona, Italy*

Background

In the European Union (EU), the Water Framework Directive (2000/60/EC) is based on the idea that water management needs to take account of economic, ecological and social issues and that its prime objective is the sustainable use and management of water resources. Throughout the EU there is growing concern regarding drought events and water scarcity. Policymakers therefore face the challenge of balancing the increasing human demand for water and the protection of the ecosystems' sustainability. Residential customers account for the majority of water demand in urban areas, mainly through household appliances, such as baths and washing machines. Implementing actions aimed at reducing water demand can deliver potential benefits not only at economic and financial levels, but also considering environmental and social purposes. Water conservation generally refers to the technical water savings that can be achieved through a particular technology or policy intervention. Sustainable use of water resources may be defined as a "pattern of use which ensures satisfaction of needs for both the present and future generations" (Bithas, 2008). Water conservation policies can have different characteristics and use a variety of instruments, all of which should encourage the efficient use of resources (Bithas, 2008). These instruments include supply restriction, water pricing, incentives for the implementation of high-efficiency household appliances and information campaigns to improve the knowledge of activities useful in reducing water consumption.

Since a number of environmental problems, including water scarcity, are caused by consumer lifestyles, it is necessary to raise water conservation awareness and the knowledge of daily life activities that are useful in reducing water consumption. Information campaigns motivate households to attempt to implement more water-efficient behaviors, and provide information on how to reduce usage. Nieswiadomy (1992) and Renwick and Green (2000) found that public education campaigns have reduced water usage. Furthermore, as argued by Barrett (2004), although it is true that higher prices will encourage better water use, without the assistance of non-price measures, price increases may become only a means of raising water-utility revenues rather than reducing water consumption.

Objectives

This paper aims to contribute to the existing literature on sustainable water use by analyzing whether Italian and Portuguese water utility companies pursue the objective of encouraging the reduction of household water consumption through web information campaigns, and by identifying which factors affect the water utility companies' willingness to promote these campaigns. To achieve this target we use a new methodology based on M-quantile regression to build a performance measure for 161 water utility companies. In this work the variable studied is a count for a construct of performance measurement, in which we use an extended version of the M-quantile regression model developed by Tzavidis et al. (2013) for count data.

Cross-national comparisons give the possibility of having a larger database to identify international best practices and provide guidance to utility managers and policy makers. Portugal and Italy are two Mediterranean countries that have similar characteristics such as climate, legislation, institutional framework and room for improvement in the efficiency (Cruz et al., 2012). Nevertheless, there are also some differences such as the scale and

* Author to whom all correspondence should be addressed: e-mail: g.romano@ec.unipi.it

model of management, the actual role of local government and the reforms experienced (Cruz et al., 2012). To the best of our knowledge, this is the first study to address these relevant issues and, therefore, it can provide potential guidance to policy makers in defining the water management framework and in selecting firms to manage water services that are more inclined to promote sustainable water use and the reduction of household water consumption.

Outline of the work

This work is divided in four main parts:

- The first part offers a review of the literature. It focuses on water conservation policies, which can have different characteristics and use a variety of instruments, all of which should encourage the efficient use of resources.
- The second part offers a brief overview of the Italian and Portuguese water industries, showing the main features of this two Mediterranean countries, their similarities and differences.
- The third part describes the process of data collection and analysis and offers an outline of the methodology used.
- The fourth part provides the key findings of our empirical research and the resulting policy implications.

Methods

Using the latest available Report from Co.N.Vi.Ri. (Italy's National Supervisory Board on Water Resources) (2011), AIDA database of Bureau Van Dijk, Istat (the Italian National Institute of Statistics) website, the Annual Report from ERSAR (the Portuguese National Authority for Water and Waste) (2011), APDA (the Portuguese association for water distribution and wastewater collection) database, corporate annual reports and websites, and other documents available, we listed 114 Italian and 47 Portuguese water utilities for which there is information about all the variables analyzed: country (Italy-Portugal), ownership (public or mixed-private firms), diversification strategies (mono-utilities or multi-utilities), size (specified by annual sales and the population served), the expenditure for the consumption of 100 (Italian utilities) or 120 (Portuguese utilities) cubic meters of water (tariff), and the average annual rainfall during the period from 2000 to 2009 in the Italian provinces and from 2005 to 2010 in the Portuguese districts where the water utility companies' main business was located.

For each company we hand-collected data about suggestions for reducing household water consumption and regarding the sustainable reporting information had given through the corporate websites. Using dummy variables, we reported the following 14 items: 1. Existence of a corporate website, 2. Presence on the home page of a link or notice regarding household water conservation best practices; 3. Presence on the websites of information regarding household water conservation best practices; 4. Promotion of the practice of turning off the tap while washing; 5. Promotion of the practice of taking a shower instead of a bath; 6. Promotion of the practice of using a high efficiency toilet or flushing the toilet less; 7. Promotion of the practice of washing fruit and vegetables by soaking in a container; 8. Promotion of the practice of using the washing machine and dishwasher with a full load; 9. Promotion of the practice of periodically checking the tightness of taps and valves; 10 Promotion of the practice of applying flow reducers to taps; 11. Promotion of the practice of washing the car using a bucket; 12. Promotion of the practice of closing the main water tap in the case of long absences; 13. Promotion of the practice of watering plants and flowers in the evening; 14. Presence of a sustainability report on the websites. Regression analysis is a standard tool for modelling the relationship between a response variable y and some covariates x. It summarises the average behavior of y given x and has been one of the most important statistical methods in applied research for many decades. However, in some circumstances, the mean does not give a complete picture of a distribution. It does not consider, for example, the extreme behavior of y conditional on x. Quantile regression summarises the behavior of different parts (e.g. quantiles) of the conditional distribution of y at each point in the set of the x's. In the linear case, quantile regression leads to a family of hyper-planes indexed by a real number q € (0,1). Given a set of covariates x and a response variable y for each value of q, the corresponding model $Q_y(\mathrm{q}|\mathrm{x}) = x\beta_{\mathrm{q}}$ shows how the q-th quantile of the conditional distribution of y given x varies with x. The set of regression quantile parameter estimates satisfies the criterion of the minimum sum of absolute asymmetrically weighted residuals and estimates of β_{q} are obtained using linear programming methods. M-quantile regression further extends this idea by a 'quantile-like' generalisation of regression based on influence functions. The relationship between sample M-quantiles and standard M-estimates of a regression function is shown by sample quantiles and the sample median. In fact, the M-quantile regression line of order q is defined as the solution (Eqs. 1-2)

$$Q_y(\mathrm{q}|\mathrm{x},\psi_{\mathrm{q}}) = x\beta_{\psi\mathrm{q}} \tag{1}$$

$$\int \psi_{\mathrm{q}}\left(y - Q_y(\mathrm{q}|\mathrm{x},\psi_{\mathrm{q}})\right) dF(y|x) = 0 \tag{2}$$

where: F denotes the distribution of y given x underlying the data and Ψ_q denotes the influence function associated to the q-th M-quantile. Being a robust regression model, it can be fitted using an IRLS algorithm, which guarantees the convergence to a unique solution. M-quantiles are somehow less intuitively interpretable than quantiles. However, M-quantile regression also shares other advantages of robust regression connected to the great flexibility in modelling that comes from using different influence functions such as the Hubers or the Hampel function.

The use of M-quantile regression with discrete outcomes is challenging, since in this case there is no agreed definition of an M-quantile regression function (Tzavidis et al., 2013). A popular approach for modelling the mean of a discrete outcome as a function of predictors is through the use of generalised linear models, by assuming that the response variable follows a Poisson distribution and using the logarithm as link function. (Tzavidis et al., 2013) consider extending the robust version of the estimating equations for generalized linear models. In particular, for M-quantile regression the estimating (Eq. 2) can be re-written as (Eq. 3-4):

$$\sum_{j=1}^{n}\left\{\psi_{q}\left(r_{j_q}\right)\frac{1}{\sigma\left(Q_{yj}\left(q\left|x_j,\psi_q\right.\right)\right)}\cdot\frac{\partial Q_{yj}\left(q\left|x_j,\psi_q\right.\right)}{\partial\beta_{\psi_q}}\cdot w(x_j)-a\left(\beta_{\psi_q}\right)\right\}=0 \tag{3}$$

$$r_{j_q}=\frac{y_j-Q_{yj}\left(q\left|x_j,\psi_q\right.\right)}{\sigma\left(Q_{yj}\left(q\left|x_j,\psi_q\right.\right)\right)} \tag{4}$$

$$Q_{yj}\left(q\left|x_j,\psi_q\right.\right)=\exp\left\{x_j\beta_{\psi q}\right\} \tag{5}$$

$$\sigma\left(Q_{yj}\left(q\left|x_j,\psi_q\right.\right)\right)=\left[\exp\left\{x_j\beta_{\psi q}\right\}\right]^{\frac{1}{2}} \tag{6}$$

$$\frac{\partial Q_{yj}\left(q\left|x_j,\psi_q\right.\right)}{\partial\beta_{\psi_q}}=\exp\left\{x_j\beta_{\psi q}\right\}^{x_j} \tag{7}$$

where Eq. 4 is the Pearson residual, Eq. 5 , Eq. 6, Eq.7 is a correction term for obtaining unbiased estimators (Tzavidis et al., 2013).

The M-quantile regression for count data can be used to construct a performance measure of the Italian and Portuguese water utility companies. A key concept in the application of M-quantile methods to data is the identification of a unique 'M-quantile coefficient' associated with each datum observed. For most values in the *x*-range, the fitted M-quantile surface $\hat{Q}_{yj}\left(q\left|x_j,\psi_q\right.\right)$ will increase monotonically with *q*, starting below all the *y*-data values when *q*=0 and finishing above all *y*-data values when *q*=1. If the *q*-th M-quantile surface passes through y_j, then we set the performance measure for the *j*-th company to $q_j = q$. In the continuous *y* case the M-quantile coefficient for observation *j* is simply defined as the unique solution q_j to the equation $y_j = Q_{yj}\left(q\left|x_j,\psi_q\right.\right)$. However, with count data and $Q_{yj}\left(q\left|x_j,\psi_q\right.\right)$ defined by the Poisson M-quantile regression model, values of y_j observed can never be part of the strictly positive domain of $Q_{yj}\left(q\left|x_j,\psi_q\right.\right)$.

$$\hat{Q}_{yj}\left(q\left|x_j,\psi_q\right.\right)=\begin{cases}\min\left\{1-\varepsilon,\frac{1}{\exp\left\{x_j\hat{\beta}_{\psi 0\varsigma}\right\}}\right\}, y=0\\ y_j, y_j\rangle 0\end{cases} \tag{8}$$

For a detailed discussion see Tzavidis et al. (2013). Thus, the performance of each company is defined by q_j that solves (Eq.8). We applied the M-quantile regression for count data to the number of pieces of information given through the corporate websites (*y* variable) in order to study the distribution of *y* given the auxiliary variable: country, annual rainfall, diversification, ownership, tariff, population served, or annual sales. Then we evaluated the performance of each company by the identification of unique q_j for each company. These coefficients were then averaged from observations based on the group to define a group-level M-quantile coefficient. Table 1 reports the average values for each group defined by the auxiliary variables. Four variables (annual rainfall, tariff, population served, and sales) are continuous, so they were divided into three categories: low (the first 33% of the distribution of the variable, first tertile), medium (from 33% to 66% of the distribution, second tertile), high (the last 33% of the distribution).

Table 1. Group level M-quantile coefficients

Country		***Annual rainfall***		***Diversification***		***Ownership***		***Tariff***		***Population served***		***Annual sales***	
Italy	0.417	Low	0.496	Mono	0.435	Publicly	0.442	Low	0.437	Low	0.365	Low	0.328
Portugal	0.472	Medium	0.466	Multi	0.430	Mixed-Private	0.417	Medium	0.463	Medium	0.375	Medium	0.489
		High	0.337					High	0.399	High	0.564	High	0.481

Information campaigns on sustainable water use are mainly promoted by water companies located in Portugal. So, Portuguese water utilities seem to be more sensitive to promoting the reduction of household water consumption. Moreover, considering the data obtained regarding the amount of rainfall, as expected we find that companies located in geographical areas characterized by drought and water scarcity, such as the south of Italy (which also includes the two main Italian islands, Sicily and Sardinia) and the Alentejo and Algarve regions in Portugal, tend to pay more attention to the promotion of sustainable water use than others. The ranking referring to the average annual rainfall shows that an increase in rainfall reduces the companies' willingness to promote sustainable water use.

A second issue is the degree of diversification, used to group firms in mono- and multi-utility companies. The data show that when companies operate only in the water industry they have a slightly higher inclination to foster public information campaigns on their own websites, promoting sustainable water use and the reduction of household water consumption. So, multi-utility companies, on average, seem to be less sensitive to water sustainability issues, since they are involved in multiple and different problems which affect their multi-businesses.

Ownership also seems to have an impact on water utility companies' willingness to promote sustainable water use through the firm's website. A fully publicly owned company pays greater attention to this issue than a mixed or totally private firm. This finding could be explained by considering a public shareholder's goal of maximizing the benefits of the community through the preservation of water resources, avoiding any waste and excess consumption. In contrast, private shareholders are more oriented towards the company's profit; consequently, they have less interest in decreasing water consumption since this determines a contextual decrease of revenues and net income.

The evidence that has emerged regarding the expenditure for 100/120 cubic meters of water show that companies who apply lower tariffs (the first and second tertiles) are more interested in a reduction of water consumption, while those who apply higher tariffs pay less attention to this issue. Tariffs are frequently used as a tool for improving water savings. So, some water utilities seem to discourage higher consumption through tariffs charged to citizens than encourage more sustainable behavior through information campaigns on the web. However, if the price elasticity score is lower than -1.00, this choice improves revenues and net income of the companies and the expenditure of citizens.

The last aspect considered in this paper concerns the presence of some scale incentives for the implementation of sustainable water use campaigns. The evidence relating to the clusters defined on the basis of both revenues and population show that the incentives exist. Larger companies that provide water services to many citizens (the upper tertile) have a greater willingness to invest resources in water conservation campaigns, since their potential recipients are very numerous. Moreover, due to the higher number of people to reach and to inform, the best tool is probably a website, since it is the most efficient and the least expensive. In contrast, the same campaign is not cost-effective for a company that serves only few thousand customers.

Moreover, larger firms (second and third tertile) in terms of total annual sales (large mono-utility companies and also multi-utility companies that serve relatively few water customers and operate in other areas) have a higher incentive to promote water conservation campaigns than their smaller counterparts since they have, on average, more resources to invest in effective websites/campaigns that are able to encourage the reduction of household water consumption and the promotion of sustainable water use.

Concluding remarks

This paper applies the M-quantile regression for count data to a dataset of 161 Italian and Portuguese water utility companies for determining the factors that affect water utility companies' willingness to foster public information campaigns aimed at promoting sustainable water use and reducing household water consumption. This knowledge can provide guidance to policy makers in entrusting the service to the companies that are more inclined to fulfill the objectives of sustainability and conservation. Larger firms, companies located in drought regions and in the driest areas, companies that are publicly owned and apply lower tariffs embody the type of institutions that make greater use of web information. We find also that Portuguese utilities seem to be more sensitive than Italian companies to promoting the reduction of household water consumption through web information campaigns.

Keywords: Italy, M-quantile regression, Portugal, sustainable water use, water utilities

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