An empirical analysis of the determinants of water demand in Italy

Giulia Romano [a, *], Nicola Salvati [a], Andrea Guerrini [b]

[a] Department of Economics and Management, University of Pisa, Via Ridolfi, 10, Pisa 56124, Italy
[b] Department of Business Administration, University of Verona, Via dell'Artigliere, 19, Verona 37129, Italy

ABSTRACT

This paper investigated factors affecting household water consumption in major Italian towns. Specifically, water demand in 103 Italian towns was analyzed over a five-year period (i.e., 2007 to 2011). Data was collected from each towns on the potential determinants of water consumption, including tariffs, income per capita, weather conditions and geographical and population characteristics. Previously, it was unclear whether a larger presence of public ownership would lead to improved water conservation practices and reductions in water consumption. Consequently, in addition to more commonly studied variables, water utilities ownership was included as a factor that could affect household water consumption. A mixed-effects model was used that contained both fixed effects and random effects.

The results of this study provided interesting insights into the factors driving residential water consumption. The results confirmed that an applied tariff had a negative effect on residential water consumption. Further, the data showed that towns with larger populations served had higher levels of consumption. In relation to climatic and geographical features, only altitude exerted a significant negative effect on water consumption and temperature and precipitation had no effect on demand. Income per capita was also found not to have a significant effect on water consumption. The results of the study confirmed that water utilities ownership did not have a significant effect on water consumption. Tariffs were found to be significantly lower in towns where the water service was managed by publicly owned water utilities and, thus, water consumption in these towns was higher.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

As the European Environmental Agency (EAA) stated, "understanding household consumption patterns is about understanding human behavior" (EAA, 2012). The most important uses of water have been identified as urban (i.e., households and industry connected to the public water supply system), industry, agriculture, and energy (i.e., cooling in power plants). Water consumption patterns in Europe have changed significantly in the last 50 years, due to factors such as higher incomes, globalization of economy, technological breakthroughs, decreasing household sizes, ageing population, and habits and cultures. Five countries (France, Italy, Germany, Spain, and the UK) account for 49% of the total municipal water demand in the European Union (EU, 2012). Italy has the highest water use per capita in Europe (EU, 2012) and is one of the

highest users among OECD countries (OECD, 2009), this partly due to a very low price elasticity (EU, 2012; OECD, 2009) and low prices compared to the other countries (OECD, 2009). However, Italy is considered a water-stressed country and has one of the least available water per capita of the 25 EU countries (EAA, 2008).

Water consumption could potentially be affected by factors, including utilities' policies (e.g., tariffs and ownership structure), demographical issues (e.g., population served, income per capita, household characteristics), weather conditions, and geographical characteristics. Research on water consumption and the determinants of water use is a growing area of study; however, further research is needed (Dalhuisen et al., 2003), as the effects of some variables have not been studied in depth. This study sought to identify the determinants of water consumption by focusing on major Italian towns for the period 2007 to 2011. As well as examining factors, such as tariffs, income, weather, and geographical characteristics, this study extended the findings of Romano et al. (2014a) by considering whether water utilities ownership affected household water consumption. Compared to the Romano et al.'s (2014a) study, this research had a longer observation

* Corresponding author. Tel.: +39 050 2216409; fax: +39 050 2210603.
  E-mail addresses: giulia.romano@unipi.it (G. Romano), nicola.salvati@unipi.it (N. Salvati), andrea.guerrini@univr.it (A. Guerrini).

period (five years) and used a more robust method; that is, a mixed-effects model that included random intercepts and random slopes to capture the time trends for each town. It was designed to provide insights into the factors affecting water consumption to better support sustainable policies and strategies being developed or extended by decision makers, water managers, and politicians.

The ownership of water utilities is a highly debated issue in Italy (Guerrini et al., 2011) and throughout the world (Hall, 2001; Carvalho et al., 2012). The management of water and wastewater systems in Italy is the responsibility of public, private, and mixed ownership firms. Additionally, some municipalities and provinces still manage their water services directly. Recent research on Italian water utilities has shown that the conflicting interests of public and private shareholders often impacts the performance of firms, such that, wholly publicly owned utilities maximize the amount of realized investments per capita, keeping tariffs lower, while private shareholders direct firms toward higher productivity and profitability (Guerrini and Romano, 2014). A recent Italian paper (Romano et al., 2015a) showed that, after accounting for endogeneity (i.e., water utilities were not randomly distributed between totally publicly or not totally publicly owned utilities), ownership did not influence the tariffs levied by water utilities.

Given the inherent contradiction between a water utility's interest in increasing sales and water conservation (Barrett, 2004), it important to analyze whether water utility ownership influences water consumption patterns.

The remainder of this paper is structured as follows. The next section describes the process of data collection used in this research and outlines the methodology and analysis adopted. The third section reviews the literature on the determinants of residential water demand. The fourth section outlines the key findings of the research and discusses its main implications. The final section summarizes the findings of the study, offers suggestions for future research, and discusses the limitations of this research.

2. Material and methods

Similar to previous studies, community-level data was used in place of household-level data, as the latter were unavailable. In Italy, Mazzanti and Montini (2006) used municipal panel data observed over four years (1998—2001) from approximately 125 municipalities. Musolesi and Nosvelli (2007) used municipal panel data from 102 municipalities for the same time period and Statzu and Strazzera (2009) analyzed 256 municipalities for a period of six years (2000—2005) using municipal panel data. Further examples can be found in Schleich and Hillenbrand (2009).

While not optimal, the community-level data allowed us to consider major towns in Italy and analyze water consumption in Italy over a five-year period. The average consumption of drinking water for domestic use (CONS) in the major towns of each Italian province was collected via data from the Italian National Institute of Statistics (Istat, 2013). Using Istat databases, we also collected information about the population served (POP) and the altitude at the center (ALT, in m) for each town. Data on the average annual precipitation (PREC, in mm) and average annual mean temperature were measured as the average between minimum and maximum values (TEMP, in °C) and collected through the Italian Ministry of Agriculture, Food and Forestry (MIPAAF) database. We also collected data on the annual cost for domestic use of 192 cubic meters of water (TARIFF), from reports of Cittadinanzattiva, an Italian non-profit organization. Data was only available on the major town of each Italian province. Cittadinanzattiva estimated that 192 cubic meters of water was the average annual consumption of a three-member household in Italy. Further, data on the average taxable income of individuals per capita (INCOME) in major

towns is publicly available and was collected from the Ministry of Economy and Finance.

As stated above, the dataset covered a five-year period from 2007 to 2011 and 515 observations from 103 major towns were analyzed. Currently, there are 106 provinces in Italy; however, three were excluded from the analysis, as they became effective in 2009. Further, in Sardinia four provinces were created in 2005, but abrogated in 2012 following a referendum. These provinces were also excluded, as the necessary data was unavailable.

Information was collected on the water utilities that manage the water services of each major town and these utilities were classified on the basis of their ownership (OWN) with a dummy variable '1' referring to wholly publicly owned water utilities and '0' to not wholly publicly owned water utilities (i.e., to indicate private or mixed ownership). Water services managed directly by the municipality or the province were classified as publicly owned water utilities (i.e., '1'). Finally, the geographical area (AREA) was classified in relation to the location of each major town where the North of Italy was '1', Center, '2' and South '3'. Table 1 summarizes the variables used and the sources of data.

A mixed-effects model with random effects was used to analyze the data as it allowed for correlations (in the unconditional distribution) to be taken of random effects for the same town. For more technical details on the estimation methods used see Searle et al. (1992). The linear mixed models were fitted using the default REML option of the *lme* function (Venables and Ripley, 2002, Sect. 10.3) in R.

We could have used a regression model where the variable town was defined by a factor with a lot of levels and the feature of interest was the extent to which different levels of each factor affected the variable of interest. However, in this case, the interpretation of the values of the covariates would have been difficult. A linear mixed model is a variant of regression model where parameters in a regression model are treated not as constants, but as (realizations of) random variables. The random effects are attributable to an (usually) infinite set of levels of a factor of which only a random sample is deemed to occur in the data. For these reasons, mixed-effects model was used.

3. Theory

Arbués et al. (2003) and Worthington and Hoffmann (2008) undertook literature reviews of studies on residential water demand throughout the world. Worthington and Hoffmann (2008) showed that from 1980 to 2006 only 24% of the studies reviewed related to Europe and that the majority of studies considered the US or Australia (for further references see March and Saurì, 2009). Further, since 2006, many empirical studies on water demand have considered developing countries. For example, David and Inocencio (1998) analyzed the Manila Case, Zhang and Brown (2005) two Chinese towns, Marinoski et al. (2014) the Brazilian context and Araral and Wang (2013) the South-East Asia; however, very few studies have considered Italy.

A number of European countries have been considered in studies on water consumption (see Romano et al., 2014a and references therein). Specifically, studies with a regional and local focus have been conducted in Italy by Mazzanti and Montini (2006), Musolesi and Nosvelli (2007), and Statzu and Strazzera (2009); these studies considered the Emilia Romagna Region, the Cremona Province, and the island of Sardinia, respectively. Recently, Romano et al. (2014a) examined provincial Italian capitals using a dataset from a three-year period (2007—2009). However, even if a large number of determinants of residential water demand have been investigated, the effect of these determinants remains unclear. Table 2 provides an overview of the studies undertaken in the last