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Analysis

# Efficient water-using technologies and habits: A disaggregated analysis in the water sector

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ABSTRACT

This paper studies the determinants of owning water-efficient technologies and practicing the corresponding water-saving habits, and the potential relationship between both decisions as poor water-saving habits related to these technologies could lead to significant losses in water-use efficiency. We explore this relationship using a cross-section database of households in the city of Granada, distinguishing between electrical and non-electrical water-saving appliances. This distinction is made to account for the difference in the technical characteristics and to provide useful information for policy design. Our results show significant differences in the determinants of each decision. Moreover, a negative relationship between pro-environmental habits and efficient technologies in the case of non-electrical devices has been detected.


## 1. Introduction

Water scarcity has emerged as an increasingly serious environmental problem. The Intergovernmental Panel on Climate Change (IPCC) has predicted that "freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems" (Bates et al., 2008, p. 3). Consequently, numerous measures to promote sustainable water consumption have been established by governments. In this sense, both pricing and non-pricing instruments have been used to match water demand and supply at residential level.

The effect of price on residential water demand has been widely studied in the literature.[1] However, water supply managers have often been hesitant to implement pricing policies to promote reductions in water consumption due to the relatively low sensitivity of residential water demand to water prices. Instead, they may use non-pricing policies that are also more politically acceptable than other more stringent policies such as price increases[2] or water restrictions.[3] Among these non-pricing policies we can distinguish those aimed at affecting water-use habits, such as public information campaigns or moral suasion initiatives, and those intended to encourage the investment in efficient water-using appliances,[4] such as subsidies. These two environmental behaviors that policies aim at promoting may be classified into efficiency behaviors and curtailment behaviors (Stern and Gardner, 1981a,b). Efficiency behaviors refer to one-time behaviors (water-saving technologies), and curtailment behaviors refer to individuals' actions that reduce water consumption implying inconvenient and sacrificial actions (water conservation habits).

Several studies have aimed at analyzing the effect of water-saving technologies and water conservation habits on water demand (Kenney et al., 2008; Renwick and Archibald, 1998; Renwick and Green, 2000). However, the actual water savings arising from the installation of water-efficient devices and appliances may be lower than the potential water savings if efficient water-using technologies and water conservation habits are not jointly implemented. That

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[1] See Arbués et al. (2003) and Worthington and Hoffman (2008) for comprehensive literature reviews.

[2] In spite of water bills generally representing a small share of households' income, water prices are an emotional and politicized issue in many regions (OECD, 2003). As a consequence, pricing policies often face social and political resistance (Dinar et al., 2015; Maxwell, 2012; OECD, 2003).

[3] In April 2015, the Governor of California, Jerry Brown, ordered mandatory water use restrictions in response to the state's four-year drought. However, he stated that forcing water use restrictions could be politically contentious as "this will be somewhat of a burden— it's going to be very difficult" (Nagourney, 2015).

[4] We use the term "efficient water-using appliances" to reflect that water-using technologies may be efficient in a multicriteria manner. According to the European labeling framework, appliances such as washing machines or dishwashers can be considered efficient if not only they save water, but also reduce energy consumption and noise.

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is, lower gains in water-use efficiency[5] could emerge if water-efficient technologies are not properly used or if they are used more in response to the decrease in the water bill caused by the efficient technology (Berkhout et al., 2000).[6] Moreover, the European Commission (EC, 2012) alerts EU members to the water-use efficiency losses in all the main water-using sectors (industry, energy production, agriculture, households), and this issue has entered the political agenda of several European countries. The European Commission proposes several initiatives such as taking into account this potential effect in policy design or using a consistent mixed instrument approach including fiscal, behavioral and technological aspects.

In this context, the interaction between habits and technologies is crucial as the adoption of efficient water-using technologies must go hand in hand with water conservation habits in order to achieve higher water-use efficiency gains. Identifying consumer profiles with a higher probability of practicing poor water conservation habits should be an additional feature to consider in the design of public policies, especially those policies encouraging the adoption of efficient water-using technologies.

The aim of this paper is to investigate the interactions between owning water-efficient technologies and practicing the corresponding water conservation habits. We are interested in determining whether households equipped with efficient water-using technologies have a higher proclivity towards water conservation. Moreover, we also analyze the key drivers of both pro-environmental behaviors, as this information may be relevant to tailor policies to their opportunities and needs. As an original contribution, we consider two groups of efficient technologies, namely electrical (efficient washing machines and dishwashers) and non-electrical water-using appliances (efficient dual-flush toilets and low-flow shower-heads and taps), and we identify some water conservation habits associated with each one of these technologies. The main reason for this disaggregation is that the differences in technical characteristics also imply differences in terms of the public policies affecting each type of technology. That is, the adoption and use of electrical water-using appliances are affected by both public policies to encourage reductions in water consumption as well as those promoting reductions in energy use, whereas non-electrical devices are mainly affected by public policies focusing on water savings. Discriminating between efficient electrical and non-electrical water-using technologies allows us to analyze if there exists a difference between the effect of efficient technologies that are purely water-efficient and technologies and the one of technologies that are both water and energy-efficient on water conservation habits.

From a methodological point of view, we estimate a recursive bivariate probit model for each pair of decisions (i.e., being equipped with efficient water-using technology and practicing the associated water conservation habit) using cross-sectional survey data on households in the city of Granada (Spain). The choice of this framework is based on several considerations. First, our dependent variables are ordinal indices constructed by adding the types of efficient water-using appliances and the water conservation habits practiced by the household, respectively. One of the caveats of this study is that the ordinal dependent variables do not rank each one of these actions based on their effectiveness at reducing household water consumption. That is, water conservation actions are treated equally. However, making this simplifying assumption still allows us to identify the effect of being equipped with efficient water-using technologies on the practice of water conservation habits. Second, the methodology allows us to account for the correlation between unobservable traits affecting household's decision and to test whether being equipped with efficient technologies is affecting its corresponding water-saving habit. In other words, it allows us to determine whether households with efficient water-using technologies have a significantly different probability of manifesting a specific water conservation habit. Our analysis goes beyond the analysis conducted by Martínez-Espiñeira and García-Valiñas (2013) in that we distinguish different types of decisions based on the technical characteristics of the technologies as they may differ in the factors driving each type of decision. Finally, it is also a more flexible bivariate specification to account for the possible effect of efficient water-using technologies on its corresponding water conservation habits.

As mentioned above, we use data from a survey conducted during 2011 in the city of Granada. We have chosen these data for several reasons. First, the city of Granada is part of the region of Andalusia, located in the South of Spain and one of the most water-stressed regions in Europe. Second, due to increasing concerns over water scarcity, several pricing and non-pricing policies aiming at reducing water consumption have been implemented in the past years. Finally, despite the lack of information on residential water and energy consumption, the survey contains information about the characteristics of households' appliances. This information on water conservation habits and attitudes towards the environment enables us to assess the differences in terms of perception of efficient use of resources depending on the water-using technologies observed in each household. This is not an objective measure of the correct use of efficient resources and it is not our goal here to provide such a measure. Our objective is instead to capture the perceived effect of being equipped with water-saving technologies on the households' water conservation habits. It may well be in fact that the household considers itself water-efficient just for the mere fact of owning the new technology or believes that the latter may suffices to consume less. Therefore, the household may not perceive the importance of their water conservation habits and put less emphasis on them. Inskeep and Attari (2014) created a water shortlist that ranks efficient water-using technologies and water conservation habits based on their average potential for water reduction. According to this water shortlist, the installation of efficient technologies is the action with the highest potential for water reductions (45.1%), and water conservation habits have a lower but still important potential for water reduction (30.2%). Thus, in the current context of water scarcity, it becomes important to promote consumers to perform both in order to obtain the maximum possible reduction in water consumption.

Our results show that there are indeed differences between electrical and non-electrical water-using activities in terms of both the relationship between efficient technologies and water conservation habits, and the determinants affecting them. In particular, households with efficient electrical appliances have a higher probability of manifesting the corresponding water conservation habits whereas those with efficient non-electrical devices show a lower probability of practicing the related habits. Among the differences, it is also interesting to notice that environmental concern is not a significant determinant for all the behaviors analyzed in this study.

The outline of the paper is as follows. First, a brief literature review is presented, explaining the main contributions related to the determinants of water conservation habits and technology adoption. Section 3 describes some public policies aimed at promoting water

[5] In order to define water-use efficiency, we follow the approach by Gleick et al. (2004) and Pérez-Urdiales (2016) where "the theoretical maximum water-use efficiency occurs when society actually uses the minimum amount of water necessary to do something".

[6] This second possibility would relate to the so-called "rebound effect", that is, smaller water savings than expected from the installation of water-efficient equipment due to behavioral changes that partially offset technical efficiency gains (Fielding et al., 2012). The existence of a potential rebound effect on the water sector has been previously analyzed in the literature (Bennear et al., 2013; Campbell et al., 2004; Davis, 2008; Mayer et al., 1998). However, it is beyond the scope of this paper to examine this effect as we do not observe behavioral changes over time.