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The Perception of Residential Water Tariff, Consumption, and Cost: Evidence of its Determinants Using Survey Data

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Abstract
In a survey of 1,500 households in Zaragoza (Spain), we found that respondents did not accurately know what the price of water was, and what the characteristics of the water tariff were, how much water they consumed, or how much it cost them; they thought they consumed less water than they actually did, and thought that their consumption level was normal; they believed they paid more than they really did, and considered the payments to be appropriate or expensive. Based on this sample of households, this paper analyses what determines the level of accuracy in the perception of consumers about their water tariff, their water consumption, and their total water cost, or, in other words, what determines the closeness between their perception and reality. The methodology applied is based on maximum likelihood estimates using various probit/logit models. The results obtained allow to identify the collectives to whom an information policy should be directed in order to approximate their perceptions closer to the real tariff, consumption and cost of water in households, and to point out the kind of information that should be transmitted in order to contribute to the preservation of water resources.

Keywords Pricing policies · Water tariffs · Price perception · Tariff perception · Consumption perception · Cost perception

1 Introduction

The growing scarcity of fresh water and the increase in insecurity about its availability in the quantities, quality and immediacy required in many regions of the world suggest the need for public intervention to promote the sustainability of water resources (OECD 2012;

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UN Environment 2019). To this purpose, demand management policies and, within these, water pricing policies are of particular importance (World Bank 1993; EEA 2012; OECD 2009, 2016). Water prices can contribute to sustainability and encourage a more efficient use of water resources and a more equal distribution of water access costs. Water pricing policies are mainly applied in urban settings, in the supply of water to households and firms.

The effectiveness of water prices in encouraging rationalisation of water consumption depends directly on the magnitude of the price elasticity of demand, i.e., the percentage change in water demanded after a one percent increase in its price. In this regard, the higher the elasticity, the greater the effectiveness of the pricing policy, all else unchanged. The economic literature studying demand in household water generally finds very low or non-significant values of price elasticity (for a survey, see Arbués et al. 2003; Worthington and Hoffman 2008; Nauges and Whittington 2010). The scarcer literature on industrial demand finds higher values (see Renzetti 1992; Worthington 2010; Gracia-de-Rentería and Barberán 2021), although if elasticity is estimated by industries, there are also many non-significant values, in particular, in the less water-intensive industries (Gracia-de-Rentería et al. 2019).

One of the factors which might be influencing these results is the level of accuracy in the consumers' perception about the price of water, i.e. how close their perception of price is to reality. As already shown by Carter and Milon (2005) and Gaudin (2006), we would expect less price knowledge to be associated with less sensitivity to price changes, thus making this instrument less effective for managing demand. In this vein, the implementation of non-uniform pricing structures in urban water supply services (mainly two-part tariffs, with a fixed charge for access to the service and a variable charge that depends on the volume of water consumed, and increasing or decreasing block rates, which apply different prices to different blocks of consumption; see OECD 1999, 2010) makes it difficult to know the price, especially in the case of households (Brent and Ward 2019).

Hence the usefulness of exploring the relationship between consumers' perception and reality of the price of water, and especially of analysing the factors influencing the higher or lower accuracy of that perception. This analysis can be focused directly on the marginal price (i.e. the price that the consumer must pay for the last litre of water he consumes), the average price (i.e. the price resulting from the ratio between the amount of the water bill for a consumer and the quantity of water consumed by that consumer), or on the tariff (i.e. the system of procedures and elements which determines a consumer's bill); or indirectly through other related variables, particularly water consumption and cost (i.e. the amount of water billed and the amount of the bill). These results can support, where applicable, the design and adoption of policies to improve the quality of information provided by the water utility to consumers and to bring their perception closer to reality, thus increasing the effectiveness of pricing policies.

The above is the framework for the present research. In a survey of 1,500 households located in Zaragoza (Spain) in 2012, we found that the residents of the city did not know accurately the tariff and the price of water, how much water they consumed, or how much it cost them. They thought they consumed less water than they actually did, and thought that their consumption level was normal. They believed they paid more than they really did, and considered the payments to be appropriate or expensive.

As a consequence, the main objective of this paper is to analyse what determines the accuracy of perceptions of consumers about their water tariff, consumption, and cost, in order to draw conclusions which could be useful for water demand management policies. In particular, we expect to find out which collectives should be targeted by an information policy to improve the approximation of their perceptions to reality, and what the content of this information should be. The methodology is based on estimates of various probit/logit models applied to the aforementioned sample of Zaragoza households.

The economic literature on this specific topic is rather scanty. A few papers analyse the relationship between perceived and real consumption and the determinants of this relationship: Hamilton (1985), Beal et al. (2013), Attari (2014), and Fan et al. (2014). Similarly, García-Valiñas et al. (2021) make this type of analysis for the water cost, in addition to consumption. Also, Carter and Milon (2005) analyse the relationship between perceived and real water prices, the determinants of water price knowledge, and the effect of this knowledge on consumption and price elasticity. Finally, Brent and Ward (2019) study the perception of water cost, price, and tariff structure, analyse the determinants of the relationship between perception and reality, and explore the effect of information provision on consumption. The results obtained in these studies are diverse, in line with the heterogeneity of their case studies and methodologies.

The analysis of water price perception by consumers is also part of the research agenda of the vast economic literature dealing with water demand estimation (see Arbués et al. 2003; Gracia-de-Rentería and Barberán 2021). But in this area the analysis is directed exclusively to solve the problem of price specification in the water demand function, mainly, the choice between marginal price and average price or a combination of both (as proposed by Shin 1985), or, alternatively, the inclusion of a difference variable (defined, according to Nordin 1976, as the difference between the total bill and what the consumer would have paid if all units were charged at the marginal price). This problem of price specification arises when urban water utilities apply, as is often the case, non-uniform tariff structures, the consequences of which are that the marginal price and the average price differ for the same consumer, and the marginal price does not report infra-marginal changes in the tariff. These studies do not analyse the determinants of the discrepancy between the perceived and real price of water, but focus on the search for operational solutions for the estimate of water demand functions in a context of imperfect information for consumers (e.g. Binet et al. 2014), and exceptionally try to explain how some socioeconomic factors influence whether users respond to the average price or marginal price (e.g. Ma et al. 2014).

This paper aims to make some contributions to the existing literature. First, it contributes to increasing the scarce previous empirical evidence on this issue. Second, in addition to the usual socio-demographic variables used in the literature, the specific variables used in our econometric analysis allows to examine the effect that the accuracy of knowledge of one variable (water tariff, consumption, or cost) may have on the accuracy of knowledge of the other variables, but also the effect on that knowledge of actual consumption or cost, and of individuals' views on their own consumption and cost and on society's water use. Finally, we intend to contribute to the debate on the information that should be transmitted to consumers to increase the effectiveness of water pricing in reducing consumption.

The paper is structured as follows. Section 2 describes the water tariff system, consumption, cost, and water bill in the city of Zaragoza. Section 3 presents the database and methodology used in the applied exercises. Sections 4 and 5 specify and estimate three models for identifying the variables explaining the degree of households' accurate perception of the water tariff, consumption, and total cost. Finally, Sect. 6 contains the main conclusions of the paper.

2 Case Study: the Water Tariff System in Zaragoza

The city of Zaragoza is in north-east Spain, on the river Ebro, and had 679,624 inhabitants in 2012 (684,686 in 2022). As is typical of large cities in Spain, most housing is in the form of blocks of flats, mostly 3 to 12 storeys, with a negligible number of detached homes

with gardens. The city is located in a Mediterranean continental climatic region, characterised by aridity, irregular rainfall, extreme thermal contrasts between winter and summer, and sporadic but recurrent droughts. The city's water supply and sanitation are managed by the City Council (*Ayuntamiento*).

The water consumed by households in the year studied is subject to a fee, calculated according to a two-part tariff, with a fixed and a variable charge (Barberán and Arbués 2009; Ayuntamiento de Zaragoza 2012). The fixed charge depends on the size of the meter installed in each dwelling to measure water consumption; the variable charge depends on how much water is consumed, according to the records of that meter. In turn, each of these two parts of the tariff is divided into two items, water supply and sanitation, depending whether the purpose of the fee is to cover the costs of capturing, treating, and transporting drinking water, or the costs of collecting, transporting, and processing wastewater, respectively. The meters are read quarterly.

The 2012 tariff for calculating the fixed charge treats as identical the usual sizes in household supply. This charge is €47.15/year per household. The tariff for calculating the variable charge has increasing prices per consumption blocks. More specifically, this tariff has three blocks: up to 0.2 m^3/day of consumption, the price is €0.467/m^3; from 0.2 to 0.616 m^3/day, the price is €1.119/m^3; and above 0.616 m^3/day, it is €2.798/m^3. In addition, the amount invoiced for the application of this tariff is subject to VAT at a rate of 10%.

Alongside the above general tariff, which is applied to all domestic users, there are two special tariffs, applicable under request: a per capita tariff, applicable to households of more than 6 members; and a reduced tariff, with three levels of rebate according to income levels, applicable to lower-income households. There is also a rebate of 10% of the variable charge, which the benefited households do not have to request, for all households where the annual consumption has fallen by at least 10%, if the two years prior to the time of billing are compared. The structure of the water tariff of Zaragoza is similar to other large and mid-sized Spanish cities (OECD 2010; García-Rubio et al. 2015).

The water bill is issued each quarter by the City Council and sent by ordinary mail to the home address of the holder of each supply contract. The bill contains detailed information on the tariff and on the user's water consumption and cost. The average time lapse between the time of consumption and reception of the bill is 70 days, and 120 days until the payment is made by direct debit from the bank account indicated by the contract holder.

3 Material and Methods

The database was constructed based on a 2012 survey of 1,500 households in Zaragoza. The sample was obtained by random sampling from the 2012 Census of households with municipal water supply in the city (*Padrón municipal de agua por contador*) partitioned by household size. Thus, 300 households were surveyed in each of the five sizes: one, two, three, four, and five or more members. After several filtering, due to problems in allocating responses to some of the survey items, we finally had 1,368 observations with data on all the variables used in the econometric exercises.

The information gathered on each household in the sample refers to the following: the people making up each household and their characteristics, and the characteristics of their home; the household reference person's opinion and knowledge on water consumption, cost, price and tariffs; and the water consumption recorded each quarter on the household's water meter. The general tariff in force in 2012 was applied to this consumption, thus

obtaining the data on the cost of water for each household and on its average and marginal prices. The data on recorded water consumption were provided for this study by Zaragoza City Council.

As the design of the survey included a uniform selection of households according to the five established sizes and therefore this representation did not match the universe of households in the city of Zaragoza, we weight each observation so that its relative weight would take into account the real composition of the city's households. The weighting of each observation, w_{ih}, is calculated as follows:

$$w_{ih} = N_{ih}/n_{ih},$$

where N_{ih} is the total number of households in the city of Zaragoza of the size h ($h = 1, 2, 3, 4, 5$ or more), and n_{ih} is the number of households of the same size h effectively surveyed.

In the applications carried out, the dependent variable is either dichotomous or ordered (with three or four values). Therefore, in the first case, logit and probit models have been estimated, choosing between them the one with a higher value of the logarithm of the likelihood function. In the second case, ordered logit and probit models have been estimated, applying the same selection criteria (Wooldridge 2019).

4 Baseline Model: the Perception of the Water Tariff

4.1 Specification

In the base model, our goal is to analyse which are the factors influencing the accuracy of consumers' perception on the marginal price of water. However, when we come to examine the perception of marginal price, major problems arise that make the task very difficult. Thus, 98.4% of those surveyed have absolutely no knowledge of the highest price paid per cubic metre, according to the water tariff. Of those who had an answer (only 23 people), half of them made errors of perception greater than 50%. For this reason, we adopt a different strategy for approximating knowledge of the marginal price. Specifically, we are going to estimate which factors explain that respondents recognise at least that the marginal price of water rises alongside consumption. The figures are somewhat better than those presented above: 28.3% of households know that the price increases as consumption increases, 54.9% do not answer, and the remaining 16.8% think the price is constant or decreasing.

The proposed specification is as follows:

$$ACCURACY\ TARIFF_i = X_i'\beta + \mu_i \tag{1}$$

The dependent variable is *ACCURACY TARIFF*, which takes the value 1 if the surveyed individual recognises that the price of water rises as consumption rises, and 0 otherwise.

We have classified the explanatory variables represented in the vector X_i' in four categories: socioeconomic characteristics; effective level of consumption or cost; accuracy of perception of consumption and cost; and opinion of own and society's water use. The inclusion of socioeconomic variables and the level of effective consumption or cost is aimed at identifying which social groups have a better knowledge of the tariff, and these are the variables traditionally analysed in the literature in this topic (e.g. Brent and Ward 2019). Variables related to accuracy in the perception of the user's own consumption and cost levels aim to reveal the interaction between the degree of knowledge of the different components of the water bill, and are a novelty in the literature. Opinion variables aim to identify how

opinion on own and society's water use may influence knowledge of the tariff, and have occasionally been analysed in this literature, either directly or indirectly through indicators of environmental attitudes (Beal et al. 2013; Attari 2014; Fan et al. 2014; García-Valiñas et al. 2021). The variables included in each category are listed and described below.

(a) **Socioeconomic variables**

- *GENDER*: a variable which takes the value 1 if the respondent identifies as male, and 0 otherwise.
- *AGE*: the age of the respondent.
- *NATIONAL*: 1 if the respondent was born in Spain, and 0 otherwise.
- *HIGHER*: 1 if the respondent has completed higher education, and 0 otherwise.
- *SKILLED*: 1 if the respondent's declared habitual work is as a director/manager, technician or professional, and 0 otherwise.
- *SIZE:* number of members of the household.
- *INCOME:* the net annual household income declared by respondent. Income appears in the sample grouped into twelve different intervals, from €300 or less to over €10,000.

(b) **Effective level of consumption and cost variables**

- *EFFECTIVE CONSUMPTION*: the household's consumption in litres in 2012.
- *EFFECTIVE COST*: the total charge (the sum of the fixed and variable charges), in euros, paid by the household during 2012.

(c) **Accuracy of perception variables**

- *ACCURACY CONSUMPTION* and *ACCURACY COST*: these two variables reflect the accuracy of the individuals' knowledge of how much water their household uses, and the cost they pay for water, respectively.

  Our strategy for the construction of these variables has been to set a percentage discrepancy between real consumption or cost, on the one hand, and those perceived by consumers, on the other, below which we assume that the household has an acceptable level of knowledge of its water consumption and cost. The problem, logically, is in setting that percentage. Brent and Ward (2019), for example, use two alternative criteria: if the consumer's error is below the median, or below 50%. We adopt four alternative criteria. Firstly, we create a dichotomous variable taking the value 1 if the respondent shows a percentage accuracy of 95% or more compared to their real consumption or cost (the percentage of accuracy is calculated as one minus the percentage of discrepancy, in absolute terms, between the perceived and real magnitudes), and 0 otherwise. Only 1.21% of the observations take value 1 for consumption, and 3.57% for cost. Secondly, we relax the percentage up to 66.6% accuracy, also in absolute value. Now the observations taking the value 1 for consumption are 8.03% of the total, and for cost, 20.16%.

  The two criteria above discriminate too crudely between households based on their level of knowledge of their water consumption or cost. To refine the analysis, we use a third criterion in which the respective variables are discrete variables with the following values: 3, if observing a percentage of accuracy of 66.6% or higher (always in absolute values); 2, if observing a percentage of accuracy from 33.3% to 66.6%; and 1, if observing a percentage of accuracy of less than

33.3% or if the respondent answers 'don't know' to the question on their water consumption/cost.

Finally, with the fourth criterion, we opt for assigning the three previous values (3, 2, and 1) exclusively to individuals who give some kind of numerical answer to the question on their consumption/cost, and add a final value 0 for those who answer 'don't know' to these questions. With this, we try to reflect that the lack of response is probably providing evidence of the worst visibility problems: bear in mind that 63.52% of respondents revealed they had absolutely no knowledge of the amount of water their household consumed, and 42%, of the cost they were paying.

This last criterion is the one that, in our opinion, best reflects differences in perception between households. At the same time, we consider that the adoption of this fourfold strategy when defining the accuracy variables contributes to reinforcing the robustness of the results achieved.

- *ACCURACY SAVINGS REBATE*: a variable reflecting the respondents' knowledge of their treatment in the rebate applicable on water bill to reward savings in consumption. It takes the value 1 if the respondent answers correctly as to whether or not he enjoys this rebate, and 0 otherwise.
- *ACCURACY INCOME REBATE*: a variable reflecting the respondents' knowledge of their treatment in the rebate applicable on water bill for people with low income. It takes the value 1 if the respondent answers correctly as to whether or not he enjoys this rebate, and 0 otherwise.
- *OVERESTIMATED CONSUMPTION*: 1 if respondents overestimate their real consumption, and 0 otherwise.
- *OVERESTIMATED COST*: 1 if respondents overestimate their real cost, and 0 otherwise.

(d) **Opinion variables**

- *SCARCITY*: 1 if respondents believe that water is scarce in Spain, and 0 otherwise.
- *EXCESS*: 1 if respondents think that households consume more water than necessary, and 0 otherwise.
- *REDUCTION*: 1 if respondents think that most households would accept a possible proposal to reduce their water consumption when there are shortages, and 0 otherwise.
- *OWN COST*: 1 if respondents believe that the water cost borne by their own household is expensive, and 0 otherwise.
- *OWN CONSUMPTION*: 1 if respondents think that the level of water consumption in their own household is high, and 0 otherwise.

The descriptive statistics of all the variables are shown in Tables 4 and 5 in Appendix.

4.2 Estimates

The model specified in (1) is estimated for the four scenarios determined by the different construction criteria of the variables *ACCURACY CONSUMPTION* and *ACCURACY COST*.

The first diagnosis performed with the data is the analysis of possible multicollinearity problems between the different explanatory variables, for which we calculate the variance inflation factor (*VIF*) of each one. If an explanatory variable presents a *VIF* higher than 10,

we assume there is evidence that this variable is a linear combination of others present in the specification. This is only the case for the variables *EFFECTIVE CONSUMPTION* and *EFFECTIVE COST*. If they are not considered simultaneously in the specification, these problems disappear, so this option is taken from this point in the econometric exercise.

We also left the variable *INCOME* out of the specifications, for two reasons. Firstly, because of the small number of households in the sample who disclosed their net income: 34% of households did not indicate any income figures at all, either because they were unaware of them or because they did not want to provide them. Second, there is ample evidence of the propensity of those surveyed to underestimate their income (Morelli et al. 2015). In any case, the educational variable (*HIGHER*) and the job-type variable (*SKILLED)*, both included in the specification, are usually considered in empirical literature as suitable proxies for household income (Psacharopoulos and Patrinos 2018).

4.3 Results and Discussion

Table 1 shows the results of the four estimated models to explain households' perception of the water tariff. The results of the four models are substantially coincident.

The results obtained are relevant in four main aspects. First, they allow the identification of the collectives to whom a water tariff information policy should be directed to improve perception among households residing in Zaragoza: the oldest, and those with less skilled work, i.e., those with lower income.

Second, these results allow us to see what information measures could be implemented to improve perception of the tariff. The significant positive relationship obtained between accuracy of perception of consumption and accuracy of perception of savings-consumption rebate, on the one hand, and the accuracy of perception of the tariff, on the other, point to the advisability of providing better information on households' own water consumption. This recommendation is in line with the findings of related research analysing such information policy, which obtained significant reductions in consumption (Aitken et al. 1994; Anda et al. 2013; Fielding et al. 2013), and is also consistent in a context where users believe that they consume less water than they actually do.

Third, the estimates suggest some information measures could be counterproductive. The absence of a significant relationship between accuracy of perception of the cost and accuracy of perception of the tariff, together with the significant positive relationship between the belief that the own cost is expensive and the accuracy of perception of the tariff, in a context where users believe they pay more than they actually do, seem to indicate that informing the household of the real cost it bears will not help to improve knowledge of the tariff, and could even make it worse. This conclusion is in line with Wichman (2017) and Brent and Ward (2019), who find that improving information on water costs leads to increased consumption, as the users realise they were overestimating the cost.

Fourth, results also show how some opinion-leading measures may be influencing consumers knowledge. The fact that the probability of knowledge of the tariff is lower if respondents believe that households in Spain consume more water than necessary, together with the absence of a significant relationship between that probability and the belief of respondents that water is a scarce resource in Spain, seems to indicate that awareness of water scarcity and its inappropriate use are not leading to greater efforts to acquire knowledge on the tariff, but may even be having the opposite effect. This result, combined with the positive sign, noted above, which accompanies the belief that water cost borne by the

Table 1 Results of estimates of water tariff perception

		ACCURACY TARIFF							
		ACCURACY MAX. CONSUMP./MAX. COST.: binary (0,1)		ACCURACY CONSUMP./COST: binary (0,1)		ACCURACY CONSUMP./COST: ord. (1 to 3)		ACCURACY CONSUMP./COST: ord. (0 to 3)	
		Coeff.	$\partial P(Y=1)/\partial X_j$	Coeff.	$\partial P(Y=1)/\partial X_j$	Coeff.	$\partial P(Y=1)/\partial X_j$	Coeff.	$\partial P(Y=1)/\partial X_j$
Socioeconomic variables	GENDER	0.05		0.05		0.04		0.04	
	AGE	-0.01***	-0.003***	-0,009***	-0.003***	-0,009***	-0.003***	-0.008***	-0.003***
	NATIONAL	0.18		0.16		0.17		0.14	
	HIGHER	-0.16		-0.17		-0.17		-0.18	
	SKILLED	0.29**	0.10**	0.27**	0.09*	0.26**	0.09*	0.25*	0.09*
	SIZE	0.04		0.03		0.03		0.02	
Effective level of consumption or cost variables[a]	EFFECTIVE COST	0.0003		0.0004		0.0004		0.0006	
Accuracy of perception variables	ACCURACY CONSUMPTION	-0.38		0.35**	0.13**	0.16**	0.05**	0,20***	0.07***
	ACCURACY COST	-0.05		-0.0002		0.04		0.05	
	ACCURACY SAVINGS REBATE	0.51***	0.15***	0.51***	0.15***	0.50***	0.15***	0.51***	0.15***
	ACCURACY INCOME REBATE	-0.04		-0.06		-0.06		-0.08	
	OVERESTIMATED CONSUMPTION	-0.32***	-0.11***	-0.27***	-0.09***	-0.22**	-0.07**	-0.006	
	OVERESTIMATED COST	-0.14		-0.13		-0.09		-0.05	
Opinion variables	SCARCITY	-0.006		-0.008		-0.01		-0.01	
	EXCESS	-0.32***	-0.11***	-0.31***	-0.10***	-0.31***	-0.10***	-0.30***	-0.10***
	REDUCTION	0.29***	0.09***	0.29***	0.09***	0.29***	0.09***	0.28***	0.09***
	OWN COST	0.20**	0.07**	0.21**	0.07**	0.22***	0.07***	0.23***	0.08***
	OWN CONSUMPTION	0.22		0.20		0.20		0.19	
Constant		-0.58*		-0.62**		-0.95***		-1.05***	
Number of observations		1.368		1.368		1.368		1.368	
LR c^2 ($Prob > c^2$)		81.99 (0.00)		86,73 (0.00)		86.29 (0,00)		96.57 (0.00)	
Log-likelihood function		-146,050.75		-145,513.54		-145,543.32		-144,518.07	
Pseudo R^2		0.0597		0.063		0.0630		0.0696	
AIC/BIC		292,238.7/292,263.9		291,065.1/291,164.3		291,124.6/291,223.8		289,074.1/289,173.3	

The table shows, in columns, the value of the estimated coefficient of each variable and the marginal effect of the significant variables over the probability that the endogenous variable takes the value 1 (or one of the extreme values if the dependent variable is ordered). The results displayed correspond to a *probit* or *logit* model, chosen according to the usual criterion of which one has the highest log-likelihood

*Coefficient/marginal effect significant at 10%; **Coefficient/marginal effect significant at 5%; ***Coefficient/marginal effect significant at 1%

[a]Given the problems of high correlation between *EFFECTIVE CONSUMPTION* and *EFFECTIVE COST*, we tried alternatively introducing one or the other variable in the specification, showing the estimate with the greatest explanatory power in the table

respondent's household is expensive, suggests that individuals' decisions to seek out information about the tariff are determined more by private interests than by social values (such as awareness of water scarcity).

5 Complementary Models: the Perception of Water Consumption and Cost

In this section we specify and estimate two complementary models, to identify the explanatory variables for accuracy in respondents' perception of their own water consumption and cost. Both magnitudes are related to the average price of water and, therefore, the analysis of their perception by consumers contributes indirectly to explaining their sensitivity to changes in the price or in the tariff structure.

5.1 Specifications

The specifications of the probit/logit models are, respectively:

$$ACCURACY\ CONSUMPTION_i = Z_i'\gamma + \nu_i \tag{2}$$

$$ACCURACY\ COST_i = W_i'\delta + \varepsilon_i \tag{3}$$

The construction of the dependent variables was explained in the previous section, since these variables were introduced there as explanatory variables. The independent variables Z_i' and W_i' are the same as in the specification (1), plus the variable *ACCURACY TARIFF*. The variable *ACCURACY COST* is an explanatory variable in the estimate of the variable *ACCURACY CONSUMPTION*, and this variable in turn is explanatory in the estimate of *ACCURACY COST*. Models (2) and (3) are estimated for each of the four alternative criteria for construction of the dependent variables, explained above. When the endogenous variable is dichotomous (values 0 and 1), the explanatory accuracy variable is also; if the endogenous variable is ordered (values 0/1 to 3), so is the explanatory accuracy variable.

5.2 Results and Discussion

5.2.1 Perception of Consumption

Table 2 displays the results of the four models estimated to explain households' perception of their water consumption. As can be seen, the results of these four estimates are fairly consistent with each other, although they are richer in the last one, which distinguishes between four groups of households according to their knowledge of their water consumption. Therefore, we will focus on the results obtained in this last model.

In the light of the results of this model, there are some collectives who could be the main focus of an information policy aimed at bringing their perception of their own consumption closer to their effective consumption: people who were not born in Spain, those with less skilled work (and thus, lower income), smaller households, and households with higher water consumption levels.

The significant negative relationship found between the effective consumption and the probability of knowing about it is particularly worrying from the point of view of water

Table 2 Results of estimates of water consumption perception

		ACCURACY CONSUMPTION								
		ACCURACY MAX. CONSUMP.: binary (0,1)		ACCURACY CONSUMP.: binary (0,1)		ACCURACY CONSUMP.: ordered (1 to 3)			ACCURACY CONSUMP.: ordered (0 to 3)		
		Coeff.	$\partial P(Y=1)/\partial X_j$	Coeff.	$\partial P(Y=1)/\partial X_j$	Coeff.	$\partial P(Y=1)/\partial X_j$	$\partial P(Y=3)/\partial X_j$	Coeff.	$\partial P(Y=0)/\partial X_j$	$\partial P(Y=3)/\partial X_j$
Socieconomic variables	GENDER	0.45		0.12		0.16			0.07		
	AGE	-0.001		0.002		-0.004			-0.005		
	NATIONAL	1.02		0.63***	0.04***	0.75**	-0.05***	0.02***	0.72***	-0.13***	0.005***
	HIGHER	0.33		0.13		0.17			0.11		
	SKILLED	0.71		0.17		0.30			0.35*	-0.07	0.003
	SIZE	0.49		0.10**	0.01**	0.32***	-0.03***	0.009***	0.31***	-0.06***	0.003***
Effective level of consumption or cost variables[a]	EFFECTIVE CONSUMPTION	-0.002		-0.005***	-0.0005***	-0.02***	0.001***	-0.0005***	-0.02***	0.003***	-0.0001***
Accuracy of perception variables	ACCURACY COST	-1.34		0.21		0.18			0.21***	-0.04***	0.002**
	ACCURACY TARIFF	-0.53		0.36***	0.04***	0.39**	-0.03*	0.01*	0.51***	-0.11***	0.005**
	ACCURACY SAVINGS REBATE	0.44		-0.23		-0.14			-0.16		
	ACCURACY INCOME REBATE			0.55**	0.04***	0.41			0.34		
	OVERESTIMATED CONSUMPTION	-1.45***	-0.01*	-0.88***	-0.12***	-2,77***	0.36***	-0.16***	-4.74***	0.83***	-0.19***
Opinion variables	SCARCITY	-0.17		0.03		0.27			.18		
	EXCESS	-0.67		-0.13		-0.25			-0.40***	0.08***	-0.003**
	REDUCTION	-0.44		0.05		0.21			0.24		
	OWN COST	-0.68		-0.20*	-0.02*	-0.56***	0.04***	-0.02***	-0.56***	0.11***	-0.005***
	OWN CONSUMPTION	1.50**		0.21		0.45			0.47*	-0.10*	0.005
Constant	CONSTANT	-5.63***		-2.02***							
Number of observations		1,154		1.368		1.368			1.368		
LR c^2 ($Prob > c^2$)		81.28 (0.00)		132.85 (0.00)		278.72 (0.00)			430.24 (0.00)		
Log-likelihood function		-12,713.33		-61,122.20		-115,355.75			-162,710.39		
Pseudo R^2		0.1516		0.1535		0.2428			0.3939		
AIC/BIC		25,460.66/25,546.53		122,280.4/122,374.4		230,749.5/230,848.7			325,460.8/325,565.2		

See notes to Table 1

*Coefficient/marginal effect significant at 10%; **Coefficient/marginal effect significant at 5%; ***Coefficient/marginal effect significant at 1%

resource sustainability, as it indicates that the higher the consumption, the lower the concern about it seems to be.

The significance, with a positive sign, of the coefficients of the variables of accuracy of perception of the cost and tariff highlights the interdependence between the levels of knowledge of individuals about the different dimensions of the information included in the water bill. The significance, with a negative sign, of the coefficient of the variable indicating the belief that the cost of water is expensive, in a context of widespread overestimation of the cost, reinforces this conclusion. Therefore, improving the information on cost and tariff could contribute to improve the knowledge of consumption, since it seems to provide an incentive to acquire information on this variable.

In a first reading, the significant negative relationship between overestimation of consumption and accuracy in the perception of consumption seems to suggest that the policy of providing information about one's own consumption should be targeted as a priority also to those who overestimate consumption. However, there is evidence that those who overestimate consumption consume less water than those who underestimate it, so this policy would be inappropriate for the goal of water sustainability (Fan et al. 2014).

The estimates also show that a belief that one's own consumption is high has a positive influence on the accuracy of perception of consumption and, therefore, in the acquisition of information on this variable. Given that this belief originates in the subjective perception that one is consuming more than other people, this belief could be preserved and empowered by information and awareness-raising policies, particularly supplying comparative information on one's own consumption together with the consumption of similar households in the same area (peer comparisons) or a socially desirable standard consumption. Some research provides evidence of the positive effect on consumption reduction of those social comparisons (Aitken et al. 1994; Ferraro and Price 2013; Brent et al. 2015; Schultz et al. 2019), because social comparison raises the moral costs of water consumption, thus imposing a kind of moral tax (Brent and Ward 2019). Therefore, a policy of providing comparative information selectively aimed at households with high consumption levels could contribute to sustainability.

Finally, our estimates show, for the perception of consumption, the same result we found for the perception of the tariff structure: the probability of knowing the effective consumption is reduced if respondents believe that households in Spain consume more water than necessary. This result suggests that raising awareness of the existence of excessive water use in society will not contribute to incentivising users to acquire information on their own water consumption; in fact, the opposite is true. Therefore, it seems that the belief in the existence of excessive water use could be interpreted as a lack of trust in the behaviour of other water users. On this issue, Jorgensen et al. (2009) show that trust plays an important role in households' water consumption behaviour, as individuals make no effort to save water if they feel that others are not minimising their water use (interpersonal trust). Similarly, Corral-Verdugo et al. (2002) find that the more individuals perceive that others are wasting water, the less motivated they are to save it. Also, the lack of a significant relationship between the probability of knowing the effective consumption and the respondent's belief that water is a scarce resource in Spain indicates that awareness of water scarcity does not influence the effort to acquire information about one's own consumption.

5.2.2 Perception of Cost

Table 3 shows the results of estimates of the perception of water cost for the four alternative criteria for construction of the dependent variable. The first thing we notice is that

Table 3 Results of estimates of water cost perception

		ACCURACY COST									
		ACCURACY MAX. COST: binary (0,1)		ACCURACY COST: binary (0,1)		ACCURACY COST: ordered (1 to 3)			ACCURACY COST: ordered (0 to 3)		
		Coeff.	∂P(Y=1)/∂Xj	Coeff.	∂P(Y=1)/∂Xj	Coeff.	∂P(Y=1)/∂Xj	∂P(Y=3)/∂Xj	Coeff.	∂P(Y=0)/∂Xj	∂P(Y=3)/∂Xj
Socieconomic variables	GENDER	-0.01		0.10		0.16			0.14		
	AGE	-0.001		-0.009*	-0.001*	-0.009*	0.002*	-0,001*	-0.010*	0.002***	-0.001**
	NATIONAL	0.01		-0.47*	-0.08	-0.21			-0.10		
	HIGHER	-0.29		0.08		0.12			0.02		
	SKILLED	0.02		0.15		0.03			0.1		
	SIZE	0.08		0.05		0.01			-0.02		
Effective level of consumption or cost variables[a]	EFFECTIVE COST	0.001		0.0006		0.0005			-0.02**	0.0005**	-0.0003**
Accuracy of perception variables	ACCURACY CONSUMPTION	-0.47		0.53*	0.09*	0.33***	-0.07***	0.04***	0.46***	-0.11***	0.06***
	ACCURACY TARIFF	-0.02		0.03		0.20			0.23*	-0.05*	0.03*
	ACCURACY SAVINGS REBATE	0.17		0.49		0.23			0.32*	-0.08*	0.04*
	ACCURACY INCOME REBATE	0.10		0.20		0.37			0.37**	-0.09**	0.04**
	OVERESTIMATED COST	-0.52***	-0.05**	-2.27***	-0.47***	-2.61***	0.57***	-0.53***	-2.86***	0.43***	-0.57***
Opinion variables	SCARCITY	0.01		-0.10		-0.07			-0.08		
	EXCESS	-0.04		0.32*	0.05*	0.24*	-0.05*	0.03*	0.23**	-0.06**	0.03**
	REDUCTION	0.25		0.08		-0.04			0.10		
	OWN COST	0.14		-0.06		-0.03			0.26**	-0.06**	0.03**
	OWN CONSUMPTION	-0.09		-0.38		-0.29			-0.19		
Constant	CONSTANT	-2.04***		0.39							
Number of observations		1.368		1.368		1.368			1.368		
LR χ^2 (*Prob* > χ^2)		38.54 (0.0021)		154.69 (0.00)		306.17 (0.00)			350.40 (0.00)		
Log-likelihood function		-37,597.459		-112,465.64		-198,836.22			-299,574.75		
Pseudo R^2		0.0547		0.1406		0.1293			0.1172		
AIC/BIC		75,230.92/75,324.9		224,967.3/225,061.3		397,710.4/397,809.6			599,189.5/599,293.9		

See notes to Table 1

*Coefficient/marginal effect significant at 10%; **Coefficient/marginal effect significant at 5%; ***Coefficient/marginal effect significant at 1%

there is much less consistency among the results than in Table 2; here again, we focus the discussion on the fourth criterion.

Again, based on these results, we can identify which collectives could be the particular focus of a policy designed to increase information on the cost of water consumption in households: the oldest, and those which pay a higher cost.

The significant negative relationship between the effective cost and the probability of knowing that cost is, again, a worrying result from the point of view of water resource sustainability, indicating that the cost of water does not seem to be of concern to those households that consume and pay the most.

The significant positive relationship found between accuracy of perception of consumption, tariff, and benefiting from the saving-consumption and low-income rebates, and the accuracy of perception of cost, again indicates the interdependence between the levels of individuals' knowledge of the different dimensions of the information included on the water bill.

As in the estimates of consumption perception, the significance, with a negative sign, of the coefficient of the variable reflecting overestimation of cost should be interpreted with caution. There is evidence that those who overestimate cost consume less water than those who underestimate it, so a policy of providing information about one's own cost aimed to those who overestimate cost would be inappropriate for the goal of water sustainability (Brent and Ward 2019).

Finally, the accuracy of perception of cost increases when the belief that the own cost of water is expensive increases, indicating that users who subjectively see their water costs as higher have more incentive to acquire information; in other words, this result points to self-interest as the motivation for becoming better informed.

6 Conclusions

The effectiveness of water prices as an instrument for managing water demand depends on how much the consumers are actually aware of them. Therefore, an information policy appropriately directed at users would be expected to make prices more effective, leading to an increase in the price elasticity of demand for water, which is especially desirable in the current context of water scarcity.

Our empirical analysis has allowed us to identify the factors influencing the accuracy of individuals' perception of the water tariff, consumption, and cost. Based on these results, we have identified the collectives who should be the priority targets of information policies to bring their perception closer to reality, mainly the elderly and those in less qualified employment, as well as those who consume the most water and pay the most.

The results obtained are also useful to show what kind of information measures could be implemented to improve perception of the tariff, consumption, and cost. Specifically, we identified, firstly, that encouraging knowledge of one of those elements may have an effect on knowledge of the other two; secondly, that the belief that the cost household pays for residential water is expensive encourages it to acquire information of the tariff; thirdly, that the belief that the household consumption is high favours knowledge of consumption; and fourthly, that the belief that water is scarce in the country has no impact, while beliefs in the existence of excessive and unnecessary water consumption in the country negatively influence the acquisition of information on tariff and consumption.

These results also clearly show the difficulties such an information policy will face. It is not enough to simplify the information included in the water bill, although this measure is easy to apply and could have immediate effects on price visibility and consumer behaviour, in line with the results obtained in other fields when the tax burden is made more salient (Chetty et al. 2009; Taubinsky and Rees-Jones 2018). The information content to be supplied, to whom and how to supply it, must also be carefully selected.

Leaving aside the provision of information on the tariff and prices, the improvement of which is clearly needed, the question of whether it is convenient to improve both consumption and cost visibility needs to be answered. In line with the literature, the results of this paper suggest that the most recommendable policy may be to focus on improving the visibility of water consumption alone. Also, it would have to be decided whether to provide only information on the household's own consumption or to do so together with comparative information on peers or on a social standard, and whether such information should be provided to all users or only to those who meet certain conditions, such as having higher than standard consumption. Our results provide indications in the latter direction, which need to be tested empirically.

In any case, the limited empirical evidence available on the study of the determinants of the accuracy of the perception of water tariffs, consumption and costs, together with the sizeable differences in methodology and results in literature, makes it clear that further research and a broader sample of countries to be studied are needed.

Appendix

Table 4 Descriptive statistics of the endogenous and exogenous variables used in the estimates

	GENDER	*AGE* (years)	*NATIONAL*	*HIGHER*	*SKILLED*	*SIZE* (household members)	*EFFECTIVE CONSUMPTION* (m^3/year)	*EFFECTIVE COST* (€/year)	*ACCURACY CONSUMPTION*		*ACCURACY COST*	
									≥ 95%/≥ 66.6% (dichotomous)	*3 cats./4 cats. (ordered)*	*≥ 95%/≥ 66.6% (dichotomous)*	*3 cats./4 cats. (ordered)*
Average	0.47	58.88	0.88	0.19	0.12	2.41	78.45	100.66	0.01/0.08	1.26/0.62	0.04/0.20	1.55/1.12
Median	0	59	1	0	0	2	70.00	83.36	0/0	1/0	0/0	1/1
Maximum	1	98	1	1	1	5	509.58	1,047.87	1/1	3/3	1/1	3/3
Minimum	0	18	0	0	0	1	4.07	49.05	0/0	1/0	0/0	1/0
Standard deviation	0.50	16.94	0.32	0.40	0.32	1.17	46.62	56.90	0.11/0,27	0.59/0.95	0.19/0.40	0.81/1.17

Table 5 Descriptive statistics of the endogenous and exogenous variables used in the estimates (continued)

	ACCURACY TARIFF	*ACCURACY SAVINGS REBATE*	*ACCURACY INCOME REBATE*	*OVER ESTIMATED CONSUMPTION*	*OVER ESTIMATED COST*	*SCARCITY*	*EXCESS*	*REDUCTION*	*OWN COST*	*OWN CONSUMPTION*
Average	0.28	0.84	0.84	0.70	0.88	0.58	0.54	0.71	0.43	0.08
Median	0	1	1	1	1	1	1	1	0	0
Maximum	1	1	1	1	1	1	1	1	1	1
Minimum	0	0	0	0	0	0	0	0	0	0
Standard deviation	0.45	0.36	0.37	0.46	0.33	0.49	0.50	0.45	0.49	0.27

Source: By the authors

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Declarations

Ethics Approval There are no relevant waivers or approvals.

Consent to Participate Authors consent to their participation in the entire review process.

Consent for Publication Authors allow publication if the research is accepted.

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