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A meta-analysis of residential water demand studies

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Abstract Although widely studied, the residential water demand remains a controversial issue. The purpose of the current study is to investigate systematic variations across related studies using meta-analysis approach. Particularly, a meta-analytical regression is performed to assess the sensitivity of the price, income and household size elasticities to a number of characteristics including demand specification, data characteristics, price specification, tariff structure, functional form, estimation technique and location of demand. The empirical results of the study reveal that these characteristics have differing influence on the reported elasticities. Obviously, these findings lie in their importance for regulators and policy makers and for academics alike. Among others, two important conclusions emerge. First, water use in summer and winter seasons and water use for indoor and outdoor purposes are found to be important factors affecting the price elasticity. This suggests that peak-load water pricing may be an effective tool for managing water demand. Second, the three elasticities tend to be differently estimated across various regions of the world as well as between developed and developing countries. Therefore, decision makers in a given country would not rely on the findings of studies conducted on other countries in formulating their policies.

Keywords Household size elasticity · Income elasticity · Meta-analysis · Price elasticity · Residential water demand

1 Introduction

Residential water demand studies have attempted to model the demand equation and find the corresponding elasticities. The latter will serve as important indicators for decision makers to implement suitable policies in order to promote water conservation and enhance social equity across consumers regarding their ability to afford to the water goods. However, the existing huge literature shows that the demand elasticities have widely varied

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from study to study yielding a conclusion that there has been no definitive answer as to which estimates are the best. Obviously, to investigate this question, the researchers usually rely on qualitative literature reviews. However, this traditional narrative technique, while trying to explain the variation in the results, may not lead to comprehensive and concise conclusions. Furthermore, qualitative literature reviews can be sensitive to the subjective decision of the reviewer to highlight some study attributes over others. Alternatively, meta-analysis is an increasingly popular approach employed to quantitatively survey literature (Gallet 2010). It consists in using a statistical framework and a larger sample of empirical studies to analyse and summarise the research results.

The purpose of the current article is to synthesise the empirical studies on the factors that influence the magnitude of the price, income and household size elasticities in the residential water demand topic. In particular, the systematic effects in water demand elasticities can be estimated by regressing the reported elasticities of previous empirical researches on a number of variables that capture study and data characteristics.

With respect to residential water demand, two previous meta-analyses have been conducted analysing the price and income elasticities (Dalhuisen et al. 2003 and Espey et al. 1997). However, in addition to the price and income elasticities, the current study tries to explain the variations in the household size elasticity estimates. Household size, i.e., the number of people living in a household, is considered also as a key determinant of residential consumption (Arbués et al. 2003, 2004 and Worthington and Hoffman 2008). When the dependent variable is total household consumption, the higher the number of people living in the household is, the larger the aggregate demand is supposed to be. Nonetheless, the per capita consumption decreases with the rise in the household size due to economies of scale. The relevance of the household size in residential water consumption has already been recognised in the literature. Barberán and Arbués (2009) pointed out that taking into account the household size is of special relevance to encompass the equity objective in water tariff. This is confirmed later by Arbués et al. (2010), who argued that knowing how household size might affect demand is beneficial for regulators. The latter needs to include the household size in the design of water pricing as a demand-side water management measure.

Besides investigating the household size elasticity, the current meta-analysis goes beyond the two earlier meta-analyses by using a larger sample of recent studies up to and including 2012. It investigates the effect of new moderator variables, with the aim of further explaining the observed variation in the three elasticities. Among others, it accounts for the influence of the indoor versus outdoor water consumption, the use of the Stone-Geary functional form and the effect of development level of countries (developing vs. developed countries). Furthermore, this study uses more recent techniques in the meta-analysis literature to investigate the key elasticities of residential demand for water.

This article is structured as follows. Section 2 presents in detail the data set employed and the meta-regressions modelling approach. Section 3 provides the empirical results and their discussion. Finally, some conclusions and policy implications close the article.

2 Data description and meta-regressions modelling

2.1 Data description

The collection of different empirical studies on a given subject is still among the difficult and time-consuming steps in the meta-analytical approach. In order to avoid a possible random selection bias, an in-depth research procedure was adopted to retrieve residential water demand studies. First, an extensive keyword-based research was undertaken by using academic databases such as ScienceDirect, Springer, JSTOR, Wiley, NBER, MPRA, RePEc and Ideas, by looking into papers and online retrieval engines for Google Scholar, EBSCO host and ProQuest and by consulting the Websites of some international organisations such as World Bank, OECD and FAO. Second, given that some relevant studies may not be identified by bibliographic electronic databases, a manual research was carried out to identify the articles and journals related to the topic. The latter were mostly found in the available literature reviews such as in Arbués et al. (2003) and Worthington and Hoffman (2008). Therefore, a reference "chasing" was adopted by identifying relevant studies from the bibliography of literature reviews and then manually locating them from the Web (Dalhuisen et al. 2003). Third, given the difficulties to get access to some articles, we directly contacted the corresponding authors by E-mail to acquire their studies.

The above research procedure was carried out based on several alternative keywords such as "residential water demand", "domestic water demand", "price elasticity AND water", "income elasticity AND water" and "household size elasticity AND water". The bibliography-related research was limited to studies published between 2002 and 2012. The decision to use only studies published since 2002 is justified by the following reasons. First, in order to prevent a potential overlapping data with the meta-analysis of Dalhuisen et al. (2003) that used studies published until 2001, we limited our research to those appeared after this year. Second, among the new features of the current meta-analysis, it goes beyond the two previous meta-analyses by (1) accounting for the variations in the household size elasticity estimates, (2) differentiating between the indoor and outdoor water consumption and (3) addressing the differences between developed and developing countries regarding the price, income and household size elasticities. A look at the residential water demand literature shows that these mentioned features are mostly undertaken in the recent studies because earlier empirical works mainly concerned with the developed countries and focused on determining only the price and income elasticities. Third, the number of studies collected for this meta-analysis gives a satisfactory number of observations that allows performing a complete statistical analysis of the data.

Before conducting the analysis and following Dalhuisen et al. (2003) and Espey et al. (1997), we excluded the positive values of the price elasticity due to their perverse nature (Dalhuisen et al. 2003). Regarding the household size elasticity, we considered only the positive estimates. In fact, in the residential water demand studies, the household size effect depends on whether the dependent variable is expressed in terms of per capita or per household water use. In the former case, the household size is expected to show a negative effect, since the per capita water consumption in a household generally decreases with a large household size. In the latter case, an increase in the number of household members is expected to increase the level of household water consumption. When examining the empirical studies, we found that the number of studies using the per capita water consumption as dependent variable is very small compared to the number of studies using the household water consumption as dependent variable. Therefore, we considered only this latter category in order to avoid any confusion or distortion in interpreting the results.

At the end, 100 studies were identified yielding 638 price elasticity estimates. The latter ranges from −3.054 to −0.002 with a mean of −0.365 and a median of −0.291. For the income elasticity, the total number of studies is reduced to 72, yielding 332 estimates. They range from −0.440 to 1.560 with a mean of 0.207 and a median of 0.159. Finally, for the household size elasticity, the number of studies is reduced to 23, yielding 70 estimates. The minimum and maximum values in the sample are 0.011 and 1.410, respectively, while the mean and median values are 0.355 and 0.322, respectively.[1]

In the three meta-regressions, the price, income and household size elasticities will serve as dependent variables, while the explanatory ones, called moderator variables, reflect the study and data characteristics. Definition and descriptive statistics for all the variables are presented in Table 1. For the sake of synthesis, the moderator variables are grouped into eight groups. The first one, the demand specification, contains some explanatory variables that their inclusion or exclusion from the water demand equation may affect the magnitude of the price, income or household size elasticities.[2] These variables are income, household size, population density, lagged dependent variable, seasonal dummies, difference variable, temperature and rainfall. The data characteristics are contained in the second group. They are represented by means of information about whether the data used corresponds to the summer or winter season; whether the data are related to indoor or outdoor water use; whether the data are aggregated or at the household level; the frequency of observations (daily, monthly, quarterly or yearly) and lastly the nature of data series (cross section, time series or panel data).

The third and forth groups of variables refer to the price specifications and rate structures, respectively. We include a series of indicator variables denoting whether the marginal price, average price, or Shin or other price specification is employed in the demand equation.[3] We considered also dummies indicating whether the tariff structure is increasing block tariff, decreasing block tariff, flat tariff or the tariffs for which no information can be retrieved from the underlying studies.

In the fifth group, the functional form, we have identified four variables that gather information about different functional forms of the water demand equation. Particularly, we differentiate between the linear, log-linear, Stone-Geary and other functional forms. Variables related to the used estimator are presented in the following group, the estimation technique, in which we differentiate between the OLS, instrumental variables (e.g., 2SLS and 3SLS), fixed effects/random effects and other estimators. The seventh group, the location, shows three indicator variables denoting whether the study is conducted on the USA, on a European country or on another part of the world. Finally, the last set of variables tries to capture the effect of other study characteristics. Particularly, we include a dummy variable indicating whether the study is conducted on a developing country, a dummy variable denoting whether the reported elasticities are long-run elasticities, a dummy variable capturing the effect of applying the discrete/continuous choice approach and a dummy variable related to the publication status of the study.

2.2 Meta-regressions modelling

The current meta-analysis seeks to explain the variations in the price, income and household size elasticities in the residential water demand topic using a multivariate meta-regression framework specified in the following equation:

[1] Due to limited space, the complete list of studies used in this meta-analysis is not provided here but is available upon request from the author.

[2] Evidently, the income and household size are not controlled for in the two meta-regressions of the income and household size elasticities, respectively.

[3] The Shin price specification is used to address the price perception issue. Shin (1985) introduced a price-perception parameter to test whether consumers respond to average price, marginal price, or a combination of the two. Different values of this parameter, combined with different rate structures, yield different theoretical results about the ordering of perceived, marginal, and average price values (Arbués et al. 2003).

Table 1 Variable definition and summary statistics

Variable	Description	Price regression Mean (SD)	Income regression Mean (SD)	HH size regression[b] Mean (SD)
Dependent variables				
PE	Price elasticity	−0.365 (0.339)	_	_
IE	Income elasticity	_	0.207 (0.239)	_
HSE	Household size elasticity	_	_	0.355 (0.288)
Independent variables				
Demand specification				
Income	= 1 if income included in specification, 0 otherwise	0.905 (0.292)	_	_
Household size	= 1 if household size included in specification, 0 otherwise	0.418 (0.493)	0.527 (0.500)	_
Pop density	= 1 if population density included in specification, 0 otherwise	0.120 (0.326)	0.120 (0.326)	_
Lag	= 1 if lagged dependent variable included in specification, 0 otherwise	0.136 (0.343)	0.087 (0.282)	0.157 (0.366)
Seasonality	= 1 if seasonal dummies included in specification, 0 otherwise	0.315 (0.464)	0.168 (0.375)	0.100 (0.302)
Difference	= 1 if difference variable included in specification, 0 otherwise	0.115 (0.320)	0.096 (0.295)	0.257 (0.440)
Temperature	= 1 if temperature included in specification, 0 otherwise	0.561 (0.496)	0.484 (0.500)	0.428 (0.498)
Rainfall	= 1 if rainfall included in specification, 0 otherwise	0.592 (0.491)	0.572 (0.495)	0.414 (0.496)
Data characteristics				
Summer data	= 1 if summer data are used, 0 otherwise	0.051 (0.221)	0.075 (0.264)	_
Winter data	= 1 if winter data are used, 0 otherwise	0.061 (0.239)	0.066 (0.249)	_
Indoor use	= 1 if data concern indoor water use, 0 otherwise	0.040 (0.197)	0.018 (0.133)	_
Outdoor use	= 1 if data concern outdoor water use, 0 otherwise	0.062 (0.242)	0.012 (0.109)	_
Household data	=1 if household level data are used, 0 if aggregated data are used	0.418 (0.493)	0.472 (0.500)	0.571 (0.498)
Daily data[a]	= 1 if data used are of daily frequency, 0 otherwise	0.172 (0.378)	0.153 (0.361)	0.228 (0.422)
Monthly data	= 1 if data used are of monthly frequency, 0 otherwise	0.396 (0.456)	0.231 (0.422)	0.314 (0.467)
Quarterly data	= 1 if data used are of quarterly frequency, 0 otherwise	0.280 (0.449)	0.325 (0.469)	0.342 (0.478)
Annual data	= 1 if data used are of yearly frequency, 0 otherwise	0.250 (0.433)	0.289 (0.454)	0.114 (0.320)
Cross section[a]	= 1 if cross section data are used, 0 otherwise	0.222 (0.416)	0.271 (0.445)	0.200 (0.402)
Time series	= 1 if time series data are used, 0 otherwise	0.034 (0.182)	0.039 (0.194)	_
Panel data	= 1 if panel data are used, 0 otherwise	0.742 (0.437)	0.689 (0.463)	0.800 (0.402)

Table 1 continued

Variable	Description	Price regression Mean (SD)	Income regression Mean (SD)	HH size regression[b] Mean (SD)
Price specification				
Marginal price[a]	= 1 if marginal price is used, 0 otherwise	0.376 (0.484)	0.379 (0.485)	0.442 (0.500)
Average price	= 1 if average price is used, 0 otherwise	0.567 (0.495)	0.512 (0.500)	0.457 (0.501)
Shin price	= 1 if Shin, fixed or other price is used, 0 otherwise	0.056 (0.230)	0.108 (0.311)	0.100 (0.302)
Rate structure				
Increasing tariff	= 1 if tariff structure is an increasing block tariff, 0 otherwise	0.579 (0.493)	0.608 (0.488)	0.814 (0.391)
Decreasing tariff	= 1 if tariff structure is a decreasing block tariff, 0 otherwise	0.042 (0.201)	0.036 (0.186)	_
Flat tariff	= 1 if tariff structure is a flat tariff, 0 otherwise	0.097 (0.296)	0.171 (0.377)	0.157 (0.366)
Unknown tariff[a]	= 1 if tariff structure is unknown, 0 otherwise	0.280 (0.449)	0.183 (0.387)	0.028 (0.167)
Functional form				
Log-linear[a]	= 1 if specification is double logarithmic, 0 otherwise	0.695 (0.460)	0.789 (0.408)	0.900 (0.302)
Linear	= 1 if specification is linear, 0 otherwise	0.125 (0.331)	0.066 (0.249)	0.057 (0.233)
Stone-Geary	= 1 if specification is Stone-Geary, 0 otherwise	0.031 (0.174)	0.063 (0.243)	_
Other func. forms	= 1 if functional form is other than linear, log-linear or Stone-Geary.	0.147 (0.354)	0.081 (0.273)	0.042 (0.203)
Estimation technique				
OLS[a]	= 1 if OLS estimator is used, 0 otherwise	0.224 (0.417)	0.231 (0.422)	0.100 (0.302)
IV	= 1 if instrumental variables estimator is used, 0 otherwise	0.200 (0.400)	0.147 (0.355)	0.314 (0.467)
FE/RE	= 1 if fixed or random effects estimator is used, 0 otherwise	0.147 (0.354)	0.177 (0.382)	0.142 (0.352)
Other estimators	= 1 if the estimation technique is other than OLS, IV, FE or RE, 0 otherwise	0.427 (0.495)	0.442 (0.497)	0.442 (0.500)
Location				
USA[a]	= 1 if the study is conducted on USA, 0 otherwise	0.329 (0.470)	0.271 (0.445)	0.100 (0.302)
Europe	= 1 if the study is conducted on European countries, 0 otherwise	0.219 (0.414)	0.268 (0.443)	0.214 (0.413)
Other locations	= 1 if the study is conducted on other parts of the world, 0 otherwise	0.451 (0.498)	0.460 (0.499)	0.685 (0.467)
Other study characteristics				
Developing country	= 1 if the study is conducted on a developing country, 0 if it is conducted on a developed country	0.326 (0.469)	0.388 (0.488)	0.614 (0.490)

Table 1 continued

Variable	Description	Price regression Mean (SD)	Income regression Mean (SD)	HH size regression[b] Mean (SD)
Long-run	= 1 if it is a long-run elasticity, 0 for a short-run elasticity	0.158 (0.365)	0.207 (0.406)	0.014 (0.119)
Discrete/ continuous	= 1 if the demand regression is based on the discrete/continuous choice, 0 otherwise	0.048 (0.215)	0.057 (0.232)	0.157 (0.366)
Published	= 1 if the study is published, 0 for an unpublished study	0.692 (0.461)	0.656 (0.475)	0.828 (0.397)

[a] An omitted category

[b] In the case of the household size elasticity regression, the dash related to the income variable indicates that this latter is found to be included in all the corresponding studies. For the other moderator variables, the dashes indicate that these variables are not available for the sample of studies related to the household size elasticity

$$y_{ij} = \alpha_0 + \sum_{k=1}^{K} \alpha_k X_{ijk} + \varepsilon_{ij} \tag{1}$$

where y_{ij} is the ith effect size (price, income or household size elasticity) from study j. α_0 is the intercept, while α_k provide the meta-regression coefficients that reflect the impact of K moderator variables, X_{ijk}. ε_{ij} is the residual term, which is assumed to be normally distributed with zero mean and variance σ^2.

The simplest way followed by many analysts (e.g., Loomis and White 1996; Rosenberger and Loomis 2000 and Zamparini and Reggiani 2007) in estimating the meta-regressions is the use of the standard statistical technique, the ordinary least squares (OLS). However, the effect sizes of different primary studies are estimated with different number of observations, which reveals a real concern related to a risk of heteroscedasticity in the meta-regression error terms (Dalhuisen et al. 2003). Therefore, the OLS method is not efficient and yields biased estimates. To circumvent this estimation bias, it is appropriate to use the White or Huber-White standard errors. This procedure does not affect the parameter estimates of the model, but provides robust standard errors of the parameters. It is used in many meta-analyses, including Gallet (2010), Lindhjem (2007), van Houtven et al. (2007), Brander et al. (2007), Espey and Espey (2004) and Dalhuisen et al. (2003).

More recently, weighted least squares (WLS) method using the inverse of standard errors as weights and panel data models appear as more reliable methods that take into account many issues in meta-regression estimation such as heteroscedasticity, data heterogeneity and non-independence (Nelson and Kennedy 2009 and Stanley and Doucouliagos 2012, 2013). According to Nelson and Kennedy (2009), heteroscedasticity occurs due to the use of different sample sizes and estimation approaches. Data heterogeneity arises because studies adopt different primary study designs and methods such as including different explanatory variables, using various functional forms and estimation techniques. Finally, non-independent or correlated observations may occur when using data sources by more than one primary study or when considering multiple effect size estimates derived from each primary study. In comparing different models, in the case of heterogeneity issue, random effects is preferable to fixed-effects meta-regression (Benos and Zotou 2013 and Stanley and Doucouliagos 2012). Furthermore, based on simulation results, Stanley and Doucouliagos

(2013) demonstrated that whether or not there is excess of heterogeneity; WLS meta-regression outperforms both the fixed and random effects. The WLS procedure is being attractive in meta-analysis literature (Stanley and Doucouliagos 2012, 2013; Delmas et al. 2013; Benos and Zotou 2013; Asenso-Boadi et al. 2008; Scheierling 2006; Nelson 2004 and de Blaeij et al. 2003) and is based on the hypothesis that estimations of primary studies with large sample sizes have lower variances and should therefore have a higher weight (Mulatu et al. 2003 and Day 1999). Moreover, the WLS allows mitigating the effects of correlation, heterogeneity and possible publication bias in the meta-sample (Dimitropoulos et al. 2011).

The discussion provided above calls for the use of WLS meta-regressions for the price, income and household size elasticities. The WLS uses as ideal weights the inverse standard errors of effect sizes. However, because most of the standard errors in our data set are missing or not reported in primary studies, a common practice is followed here by employing as weights a monotonic transformation of the primary study sample size. For instance, Nelson and Kennedy (2009) counted 36 meta-analyses in environmental economics that used WLS, from which 13 studies used weights based on primary study sample size. Particularly, in the current study, the WLS is based on the square root of sample sizes as weights while using robust standard errors clustered at the level of individual studies to correct for the potential dependencies among observations. To assess the robustness and stability of the impact of the moderator variables, a number of regression models are also estimated. In particular, we use three techniques: a random effect maximum likelihood (REML),[4] a robust OLS with White-corrected standard errors and a bootstrap OLS with 500 replications. This latter is mainly used to deal with non-normality of the residuals and to get more reliable standard errors.

3 Results

3.1 Publication bias assessment

As a preliminary test in meta-analysis procedure, it is of great utility to investigate the presence of publication bias, which is considered as a selectivity bias issue. Publication bias means that the results reported in a paper affect its probability of being published. That is, authors, referees and editors tend to have preference towards studies with statistically significant results and “reasonable” effect size estimates, while those that are counter to expectations or resulting in “unreliable” effect sizes are left in the “file drawer” (Rosenthal 1979). The best way to reduce the publication bias is to include both published and unpublished (dissertations, unpublished manuscripts and other grey literature) studies in the meta-database (Warren and Chen 2013 and Ashenfelter et al. 1999), as we did in this meta-analysis.

Publication bias can be detected by the so-called funnel plot, which is a simple and famous scatter plot illustrating the relationship between effect size estimates on the horizontal axis and a measure of study size on the vertical axis (Harbord et al. 2009). Testing for publication bias essentially involves examining the distribution of effect sizes about the mean. In the absence of bias, it is expected to find a symmetric distribution about the mean, while it tightens with the increase in the sample size (Warren and Chen 2013). In fact, this

[4] The REML is estimated using the Stata’s metareg routine.

is more or less the behaviour we see in this meta-analysis illustrated by Figs. 1, 2 and 3, which display the funnel plots along with the evolution of effect sizes over years for the price, income and household size elasticities, respectively.[5]

An eye test of the three funnel plots indicates that the fact that the plots are slightly skewed to the left (particularly for the price elasticity) or to the right (particularly for the household size elasticity) is an indication of a possible publication bias. In the residential water demand literature, publication bias may arise because studies reporting positive price elasticity estimates have low chance to be published. However, as argued by Florax (2001, p. 7), "because a positive relationship between the price of water and demand is extremely rare in practice, this distortion of a funnel-like shape is not necessarily indicative of publication bias". Moreover, in the current meta-analysis, we consider only the negative (positive) price elasticity (household size elasticity) estimates, which lessens the potential publication bias issue.

Finally, we can say that no major truncation around the mean can be observed for the three elasticities, and the effect does not appear to be systematic. The slight observed asymmetry may be due to reasons other than publication bias, such as heterogeneity due to study methodology, sampling errors and genuine differences in population effect sizes (Nelson 2011). Regarding the evolution of the price, income and household size elasticities during the considered period (Figs. 1b, 2b and 3b), we notice a little convergence across effect sizes over the years. This indicates that the residential water demand topic has not converged on optimal strategies and further research efforts are needed.

3.2 Meta-regressions results

The empirical results of the three meta-regressions using the WLS with cluster-robust standard errors estimator are displayed in Table 2. Given that all the moderator variables are dummies, they should be interpreted with caution. Their importance lies in their signs and significance rather than their marginal values (Espey et al. 1997). Overall, the meta-regressions of the three elasticities have adequate R^2 values, which are typical for meta-analyses (Nelson and Kennedy 2009 and Brons et al. 2002).

The estimation results show that when included in the residential water demand model, both the income and household size variables present a negative and statistically significant effect on the price elasticity estimates. The income and household size are not only key determinants of residential water demand but also they tend to render the water demand more price-elastic. The use of the lagged dependent variable in the demand model, which implies the use of a dynamic model, significantly decreases the household size and income elasticities while including seasonal dummies and population density (except for the meta-regression of the household size elasticity) tends to decrease the three elasticities (in absolute terms). Regarding the climatic factors, while inclusion of temperature as independent variable influences only the price elasticity (positive effect), rainfall tends to make the water demand more income and household size-inelastic. The above findings compare favourably with the conclusions previously reached by Dalhuisen et al. (2003)

[5] Note here that the common approach consists in using the precision (inverse of standard errors) or standard errors on the vertical axis. However, as explained previously, these latter are not available and, therefore, the square root of sample size are used instead. Such a practice is recently adopted by many meta-analysts in constructing the funnel plots, including Delmas et al. (2013) and Dimitropoulos et al. (2011).

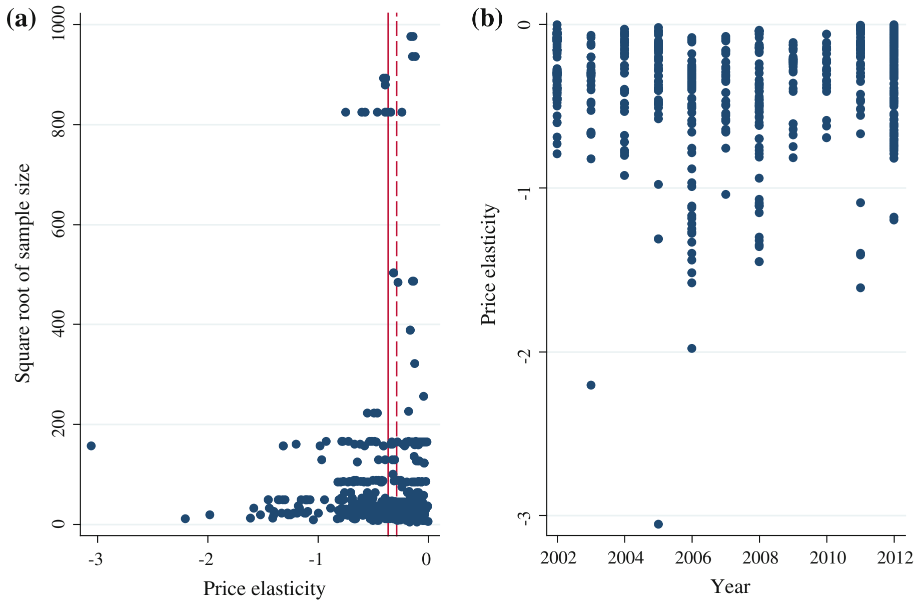

Fig. 1 **a** Funnel plot of PE versus sample size; **b** evolution of PE over years. *Note* The *solid line* indicates the mean PE, whereas the *dashed* one the median PE

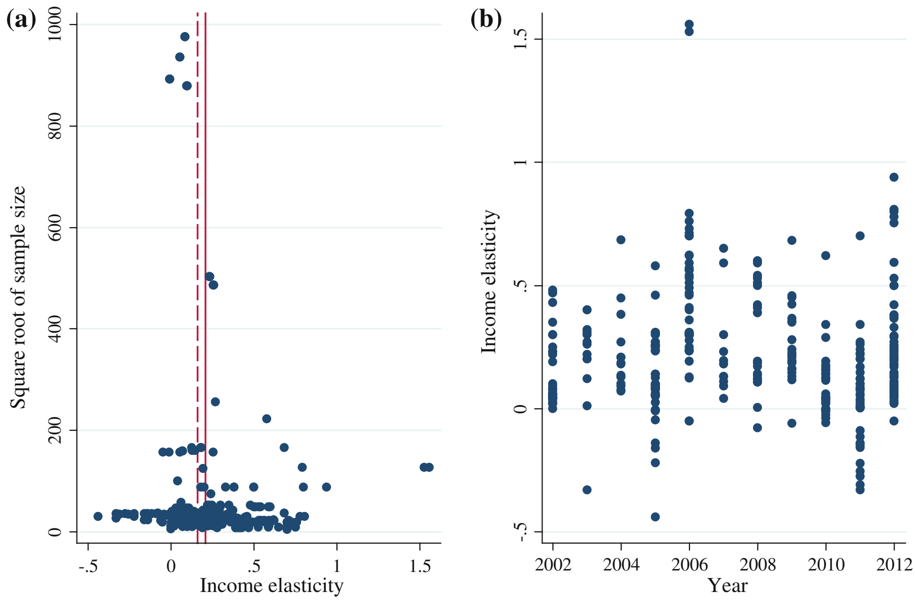

Fig. 2 **a** Funnel plot of IE versus sample size; **b** evolution of IE over years. *Note* The *solid line* indicates the mean IE, whereas the *dashed* one the median IE

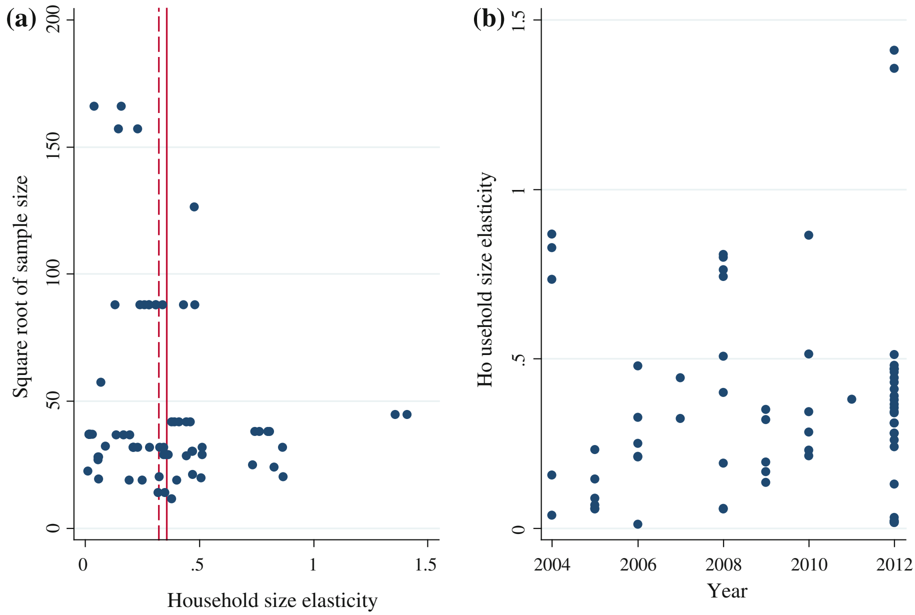

Fig. 3 **a** Funnel plot of HSE versus sample size; **b** evolution of HSE elasticity over years. *Note* The *solid line* indicates the mean HSE, whereas the *dashed* one the median HSE

and Espey et al. (1997) regarding the importance of including several control variables in the demand specification along with price, income and household size variables.[6]

With respect to data characteristics, the demand studies using summer data appear to exhibit higher values (in absolute terms) of price elasticity. But, since water use in summer (winter) is strongly related to outdoor (indoor) activities, water demand is found to be more price-elastic for outdoor use conversely to indoor use. This is an expected finding since outdoor activities require more water quantities that provide more flexibility for users to respond to price changes (Espey et al. 1997). With regard to the income elasticity, it seems to be deflated even when differentiating between indoor and outdoor water use. This "ambiguous" finding was somewhat found in Dalhuisen et al. (2003) study, where the income elasticity tends to increase in winter season.

Regarding the frequency of observations and setting the daily water consumption as the baseline category, the results suggest that monthly, quarterly or yearly water use tends to deflate both the price and income elasticities. On the other hand, the household size elasticity is significantly smaller for monthly consumption, while it becomes larger in the case of quarterly water consumption. Regarding the nature of data series, the price elasticity is insensitive to whether the study uses cross section, time series or panel data, contrarily to the income and household size elasticities, which significantly increase when using time series and panel data, respectively, compared to the baseline category, cross section data.

[6] It is worth noting in what follows that the comparisons of the current results with those of Dalhuisen et al. (2003) and Espey et al. (1997) should partly be taken with caution due mainly to differences in the data used and in some considered variables.

Table 2 Results using WLS with cluster-robust standard errors

Variable	Price elasticity	Income elasticity	Household size elasticity[a]
Demand specification			
Income	−0.1613* (0.0897)	–	–
Household size	−0.1151* (0.0642)	0.0619 (0.0577)	–
Pop density	0.2042* (0.1071)	−0.2035** (0.0790)	–
Lag	0.0880 (0.0855)	−0.2093** (0.0849)	−0.1899*** (0.0435)
Seasonality	0.1073** (0.0532)	−0.1745*** (0.0603)	−0.4587*** (0.1217)
Difference	0.0388 (0.0845)	−0.1203 (0.0994)	0.4149 (0.2543)
Temperature	0.1068* (0.0660)	0.1533 (0.1023)	0.0456 (0.0906)
Rainfall	−0.0266 (0.0677)	−0.1535* (0.0889)	−0.3745** (0.1387)
Data characteristics			
Summer data	−0.1643*** (0.0611)	−0.1077 (0.0731)	–
Winter data	0.0239 (0.0852)	−0.0911 (0.0739)	–
Indoor use	0.1538* (0.0803)	−0.2447** (0.1094)	–
Outdoor use	−0.5123*** (0.1126)	−0.2346* (0.1291)	–
Household data	−0.0448 (0.0606)	0.0070 (0.0579)	−0.0222 (0.1855)
Monthly data	−0.2289*** (0.0862)	−0.2447** (0.1163)	−0.1534** (0.0565)
Quarterly data	−0.1375* (0.0844)	−0.1786* (0.1064)	0.3149** (0.1333)
Annual data	−0.2144* (0.1152)	−0.1037 (0.1095)	0.4157 (0.3441)
Time series	−0.1491 (0.1457)	0.3656*** (0.1288)	–
Panel data	−0.0817 (0.1063)	0.1093 (0.0703)	0.5612*** (0.1356)
Price specification			
Average price	0.0063 (0.0728)	0.1854** (0.0869)	0.1581*** (0.0549)
Shin price	−0.3463*** (0.0967)	0.1555* (0.0925)	0.3272** (0.1593)
Rate structure			
Increasing tariff	0.2019** (0.0943)	0.1150 (0.0774)	0.5582** (0.2156)
Decreasing tariff	0.2331** (0.0998)	−0.6202*** (0.1996)	–

Table 2 continued

Variable	Price elasticity	Income elasticity	Household size elasticity[a]
Flat tariff	0.1724* (0.1014)	−0.0299 (0.0885)	0.8782*** (0.2651)
Functional form			
Linear	0.1127 (0.0841)	0.0309 (0.1241)	0.2420** (0.1095)
Stone-Geary	0.3618*** (0.0829)	−0.2240** (0.1049)	–
Other func. forms	0.1817** (0.0806)	−0.0379 (0.1090)	0.8502*** (0.1492)
Estimation technique			
IV	−0.0643 (0.0651)	−0.0369 (0.0527)	−0.0365 (0.0247)
FE/RE	−0.0633 (0.0500)	−0.0037 (0.0115)	0.0859 (0.0643)
Other estimators	−0.0570 (0.0647)	0.1263 (0.0786)	0.0338 (0.0411)
Location			
Europe	−0.1203 (0.0861)	−0.0517 (0.0875)	−1.1743*** (0.3137)
Other locations	−0.2704** (0.1361)	0.0585 (0.0984)	−0.6078** (0.2806)
Other study characteristics			
Developing country	0.1835 (0.1381)	−0.0723 (0.0651)	−0.3058*** (0.0980)
Long-run	−0.1954*** (0.0929)	0.0008 (0.0643)	−0.4661*** (0.1151)
Discrete/continuous	−0.2488** (0.0986)	−0.3738** (0.1645)	−0.3526 (0.2389)
Published	−0.0264 (0.0745)	0.1320* (0.0672)	−0.2426** (0.0924)
Constant	0.0075 (0.1748)	0.1039 (0.1311)	0.2729 (0.5239)
R^2	0.459	0.520	0.893
Observations	638	332	70

Cluster-robust standard errors are included in parentheses

***, ** and * indicate statistical significance at 1, 5 and 10 % levels

[a] In the case of the household size elasticity results, the dash related to the income variable indicates that this latter is found to be included in all the corresponding studies; as such, it cannot exhibit an estimated coefficient. For the other moderator variables, the dashes indicate that these variables are not available for the sample of studies related to the household size elasticity

Setting the marginal price as the omitted category, the price specification seems to have significant influence on demand elasticities. Particularly, the income and household size elasticities are found to be inflated when using average or Shin or any other price specification. For the price elasticity, there is no significant difference when including the average or marginal price, while the Shin or any other price specification makes the demand more price-elastic. With respect to rate structures, both the decreasing and flat tariffs provide their expected effect on the three elasticities. Particularly, when the decreasing tariff is implemented, the water becomes more price- and income-inelastic, while the flat tariff tends to inflate the price and household size elasticities. That is, these two tariff structures encourage the users to consume unlimited water quantities, which contravenes the environmental objectives of water pricing. On the other hand, ambiguous estimated coefficients are obtained for the increasing block tariff, which is expected to deflate the price and household size elasticities. These findings regarding the price and pricing specifications are somewhat different from those of the two earlier meta-analyses. Particularly, we got to clearly assess the influence of the decreasing and flat tariffs, while Dalhuisen et al. (2003) and Espey et al. (1997) found that the increasing block tariff makes the residential demand for water more price-elastic.

Compared to the log-linear baseline functional form, the meta-regressions coefficient of the linear functional form is insignificantly different from zero except for the household size elasticity. Accordingly, the choice between the two most used functional forms in the residential water demand literature (linear and log-linear) seems to have a little influence on the demand elasticities. On the other hand, the absolute values of the price and income elasticities are deflated when adopting the Stone-Geary or any other functional form (e.g., semi-logarithmic, translog). This latter category tends to provide larger values of household size elasticity. In their meta-analyses, Dalhuisen et al. (2003) and Espey et al. (1997) found no significant difference between the linear and log-linear functional forms. Obviously, disaggregating the functional form group into new categories (Stone-Geary, other functional forms) and including them in the meta-regressions of the present study brings new relevant insights. Regarding the estimation techniques and setting the OLS as the baseline category, no significant differences are found between all the competitive techniques, including the instrumental variables and fixed and random effectsestimators. These results compare favourably with those of the two earlier meta-analyses.

With respect to the geographical location and compared to the omitted dummy variable which is in this case the United States, it is clear that Europe has no different pattern, while other locations show a negative and statistically significant coefficient in the price elasticity meta-regression. Therefore, residential water demand seems to be more price-elastic in the countries from different regions other than the United States and Europe. These results confirm those of Dalhuisen et al. (2003), who found also that the elasticities in the United States, Europe and other locations are noticeably different. Furthermore, we explicitly differentiate between developing and developed countries by including, in the meta-regression, a dummy variable indicating whether the study is conducted on a developing country. Nevertheless, an insignificant coefficient is obtained. On the other hand, while no significant differences are found for the income elasticity neither in terms of geographical variables nor between developed and developing countries, the magnitude of the household size elasticity seems to be reduced in Europe or any other part of the world compared to the United States. Particularly, it presents lower values in developing countries with regard to developed ones. Yet, for the data set used in this analysis, the mean value of household size elasticity estimates is 0.273 in developing countries, while it stands at 0.484 in developed countries. This can be partly explained by the fact that, conversely to the developed countries and given its limited financial resources, a household from a developing country does not significantly increase its water consumption when a new element is added to the family. This may offer a relevant insight for policy makers about the substantial water affordability issues facing the households (particularly the poor) from developing countries.

The empirical results show also that the price sensitivity is significantly higher in the long-run than in the short-run. This indicates that a longer response period gives consumers more options to adjust to the price changes. However, the difference between the long-run and short-run income elasticities is no longer significant, while the household size elasticity is smaller in the long-run. These outcomes were previously obtained by Dalhuisen et al. (2003) and Espey et al. (1997) in the case of price and income elasticities. Studies based on the correct modelling approach, the discrete/continuous choice approach, tend to provide inflated absolute values of the price elasticity, while they significantly provide smaller income elasticity.[7] This result contradicts the one found previously by Dalhuisen et al. (2003) in the case of the income elasticity. Finally, the empirical results reveal an interesting finding about the sound feature of publication bias mainly discussed in the meta-analysis literature. We find that there exists no significant difference between published and unpublished studies regarding the magnitude of the price elasticity. This can be explained by the fact that publication may be a poor indicator of study quality since there are now many academic journals, which while offering the capacity for easier publication of research findings may also make it easier for poor quality research to be published (van den Bergh and Button 1997). On the other hand, published studies tend to report higher (lower) values of the income (household size) elasticity. The publication quality was not addressed by Espey et al. (1997), since they considered only journal articles. Nonetheless, Dalhuisen et al. (2003) found that unpublished studies tend to provide smaller absolute values of the price elasticity and larger income elasticity estimates.

3.3 Robustness check

The estimation results for the three meta-regressions using REML, robust OLS and bootstrap OLS[8] are displayed in Table 3. A first look at the results of the three meta-regressions reveals that the signs and the significance of most variables are robust. Contrasting the results based on WLS (Table 2) with those presented in Table 3, the following important changes have occurred. First, results reveal that there exists a significant difference among the price elasticity estimates related to the aggregation level of data used in empirical analyses. That is, studies using household (i.e., individual) data produce more elastic estimates than those using aggregated data, the omitted category. These findings differ (at least in the case of price elasticity) from those of Dalhuisen et al. (2003) and Espey et al. (1997), who did not find a statistically significant difference between elasticities derived from the household level and aggregate level studies. However, they support the recommendation of Espey et al. (1997, p. 1374) when stressing that "household level studies are nonetheless quite valuable for the additional micro level information they can provide".

Second, the coefficients related to the rate structures become no longer significant in the case of price elasticity meta-regression. While the significant and expected coefficients related to decreasing and flat tariffs are now lost compared to Table 2, we have nevertheless circumvented the ambiguous coefficient associated with the most adopted pricing structure, the increasing block tariff. This latter shows also the expected positive coefficient in the case of income elasticity meta-regression.

[7] Sebri (2013), Miyawaki et al. (2011), Olmstead (2009) and Martínez-Espiñeira (2003) are still among the few authors who have applied this approach to the context of water demand.

[8] Due to the limited number of observations, the meta-regression of the household size elasticity is not estimated by the bootstrap OLS.

Table 3 Estimation results using REML, robust OLS and bootstrap OLS

Variable	Price elasticity			Income elasticity			Household size elasticity[a]	
	REML	Robust OLS	Bootstrap OLS	REML	Robust OLS	Bootstrap OLS	REML	Robust OLS
Demand specification								
Income	−0.2253*** (0.0529)	−0.2218*** (0.0560)	−0.2218*** (0.0611)	–	–	–	–	–
Household size	−0.1074*** (0.0324)	−0.1036*** (0.0341)	−0.1036*** (0.0349)	−0.0039 (0.0333)	−0.0141 (0.0375)	−0.0141 (0.0397)	–	–
Pop density	0.1364** (0.0562)	0.1183* (0.0635)	0.1183* (0.0651)	−0.0621 (0.0558)	−0.0479 (0.0625)	−0.0479 (0.0668)	–	–
Lag	0.0713 (0.0475)	0.0589 (0.0557)	0.0589 (0.0589)	−0.1083* (0.0557)	−0.0920 (0.0707)	−0.0920 (0.0745)	−0.1641* (0.0961)	−0.1654** (0.0686)
Seasonality	0.0543 (0.0365)	0.0547* (0.0326)	0.0547* (0.0333)	−0.1410*** (0.0416)	−0.1405*** (0.0428)	−0.1405*** (0.0463)	−0.5263*** (0.1081)	−0.5295*** (0.1241)
Difference	0.0328 (0.0504)	0.0374 (0.0516)	0.0374 (0.0553)	−0.2274*** (0.0593)	−0.2272*** (0.0559)	−0.2272*** (0.0581)	0.4254 (0.2702)	0.4103 (0.2482)
Temperature	0.0960** (0.0376)	0.0948*** (0.0348)	0.0948*** (0.0360)	0.1644*** (0.0413)	0.1698*** (0.0612)	0.1698*** (0.0612)	−0.0354 (0.1043)	−0.0480 (0.1115)
Rainfall	−0.0516 (0.0412)	−0.0536 (0.0392)	−0.0536 (0.0409)	−0.1204*** (0.0408)	−0.1199** (0.0548)	−0.1199** (0.0550)	−0.3583*** (0.1108)	−0.3535** (0.1330)
Data characteristics								
Summer data	−0.0598 (0.0582)	−0.0590 (0.0559)	−0.0590 (0.0583)	−0.2264*** (0.0653)	−0.2324*** (0.0642)	−0.2324*** (0.0679)	–	–
Winter data	0.0502 (0.0605)	0.0564 (0.0517)	0.0564 (0.0562)	−0.2723*** (0.0759)	−0.2804*** (0.0688)	−0.2804*** (0.0724)	–	–
Indoor use	0.1028 (0.0734)	0.0927 (0.0620)	0.0927 (0.0651)	−0.2460** (0.1045)	−0.2370** (0.0994)	−0.2370** (0.1046)	–	–
Outdoor use	−0.4135*** (0.0626)	−0.4176*** (0.0723)	−0.4176*** (0.0771)	−0.2517** (0.1239)	−0.2449** (0.0992)	−0.2449** (0.0996)	–	–

Table 3 continued

Variable	Price elasticity			Income elasticity			Household size elasticity[a]	
	REML	Robust OLS	Bootstrap OLS	REML	Robust OLS	Bootstrap OLS	REML	Robust OLS
Household data	−0.0689** (0.0335)	−0.0699** (0.0303)	−0.0699** (0.0323)	0.0515 (0.0362)	0.0556 (0.0396)	0.0556 (0.0405)	−0.0870 (0.1293)	−0.1032 (0.1214)
Monthly data	−0.1810*** (0.0525)	−0.1864*** (0.0520)	−0.1864*** (0.0561)	−0.1472** (0.0583)	−0.1393* (0.0717)	−0.1393* (0.0771)	−0.1228 (0.0838)	−0.1221 (0.0970)
Quarterly data	−0.0924 (0.0606)	−0.0899* (0.0499)	−0.0899* (0.0518)	−0.0441 (0.0623)	−0.0359 (0.0696)	−0.0359 (0.0775)	0.3827** (0.1813)	0.3795** (0.1900)
Annual data	−0.1902*** (0.0569)	−0.1880*** (0.0507)	−0.1880*** (0.0540)	−0.0147 (0.0558)	−0.0153 (0.0692)	−0.0153 (0.0744)	0.2815 (0.1904)	0.2574 (0.1848)
Time series	−0.0266 (0.0871)	0.0066 (0.0990)	0.0066 (0.1021)	0.2174** (0.0920)	0.1972** (0.0954)	0.1972** (0.1002)	–	–
Panel data	0.0247 (0.0421)	0.0257 (0.0463)	0.0257 (0.0478)	0.0479 (0.0370)	0.0420 (0.0410)	0.0420 (0.0425)	0.4956*** (0.1235)	0.4859*** (0.1259)
Price specification								
Average price	0.0022 (0.0361)	0.0072 (0.0405)	0.0072 (0.0428)	0.0158 (0.0381)	0.0085 (0.0523)	0.0085 (0.0553)	0.1557 (0.1112)	0.1495 (0.0972)
Shin price	−0.3431*** (0.0586)	−0.3323*** (0.0892)	−0.3323*** (0.0919)	0.0934* (0.0557)	0.0940 (0.0601)	0.0940 (0.0641)	0.2901* (0.1708)	0.2840* (0.1536)
Rate structure								
Increasing tariff	0.0447 (0.0446)	0.0355 (0.0491)	0.0355 (0.0524)	0.1589*** (0.0525)	0.1631*** (0.0599)	0.1631*** (0.0604)	0.6370*** (0.2384)	0.6341*** (0.1988)
Decreasing tariff	0.0369 (0.0848)	0.0240 (0.0748)	0.0240 (0.0763)	−0.5008*** (0.1092)	−0.4904*** (0.1361)	−0.4904*** (0.1372)	–	–
Flat tariff	0.0399 (0.0534)	0.0296 (0.0568)	0.0296 (0.0586)	0.0466 (0.0548)	0.0533 (0.0664)	0.0533 (0.0667)	0.9698*** (0.3396)	0.9579*** (0.2877)
Functional form								
Linear	0.0077 (0.0492)	0.0014 (0.0568)	0.0014 (0.0592)	0.0259 (0.0529)	0.0092 (0.0465)	0.0092 (0.0527)	0.2059** (0.0908)	0.2040** (0.0957)

Table 3 continued

Variable	Price elasticity			Income elasticity			Household size elasticity[a]	
	REML	Robust OLS	Bootstrap OLS	REML	Robust OLS	Bootstrap OLS	REML	Robust OLS
Stone-Geary	0.2938*** (0.0716)	0.2888*** (0.0541)	0.2888*** (0.0582)	−0.1445** (0.0568)	−0.1398*** (0.0526)	−0.1398** (0.0578)	–	–
Other func. forms	0.1163*** (0.0444)	0.1137** (0.0472)	0.1137* (0.0492)	−0.0299 (0.0503)	−0.0332 (0.0591)	−0.0332 (0.0633)	0.8017*** (0.1476)	0.7969*** (0.1143)
Estimation technique								
IV	−0.1111** (0.0482)	−0.1138** (0.0478)	−0.1138** (0.0514)	−0.0135 (0.0483)	−0.0173 (0.0495)	−0.0173 (0.0500)	−0.0403 (0.0749)	−0.0400 (0.0863)
FE/RE	−0.1142** (0.0503)	−0.1176*** (0.0429)	−0.1176** (0.0462)	−0.0009 (0.0450)	−0.0049 (0.0439)	−0.0049 (0.0461)	0.0663 (0.0780)	0.0674 (0.0741)
Other estimators	−0.0975** (0.0434)	−0.0969** (0.0427)	−0.0969** (0.0448)	−0.0006 (0.0432)	−0.0128 (0.0559)	−0.0128 (0.0564)	0.0316 (0.0784)	0.0319 (0.0572)
Location								
Europe	−0.0014 (0.0481)	−0.0020 (0.0532)	−0.0020 (0.0577)	−0.0611 (0.0583)	−0.0472 (0.0636)	−0.0472 (0.0688)	−1.2719*** (0.2580)	−1.2705*** (0.2286)
Other locations	−0.1998*** (0.0520)	−0.1906*** (0.0517)	−0.1906*** (0.0566)	0.0070 (0.0608)	0.0113 (0.0616)	0.0113 (0.0680)	−0.7789*** (0.2676)	−0.7831*** (0.2510)
Other study characteristics								
Developing country	0.1981*** (0.0530)	0.1857*** (0.0565)	0.1857*** (0.0564)	−0.0247 (0.0430)	−0.0179 (0.0423)	−0.0179 (0.0422)	−0.3385*** (0.0899)	−0.3411*** (0.0725)
Long-run	−0.1913*** (0.0355)	−0.1807*** (0.0475)	−0.1807*** (0.0475)	−0.0093 (0.0411)	−0.0143 (0.0384)	−0.0143 (0.0414)	−0.4077** (0.2076)	−0.4137*** (0.1148)
Discrete/continuous	−0.3538*** (0.0663)	−0.3602*** (0.0734)	−0.3602*** (0.0759)	−0.2093*** (0.0694)	−0.2008* (0.1066)	−0.2008* (0.1117)	−0.3247*** (0.1205)	−0.3238** (0.1620)
Published	−0.0373 (0.0390)	−0.0346 (0.0409)	−0.0346 (0.0401)	0.0525 (0.0373)	0.0517 (0.0476)	0.0517 (0.0511)	−0.2869*** (0.0928)	−0.2880*** (0.0709)
Constant	0.1211 (0.1008)	0.1238 (0.0900)	0.1238 (0.0976)	0.1992** (0.0869)	0.1988** (0.0923)	0.1988** (0.0984)	0.4970 (0.4335)	0.5385 (0.4284)

Table 3 continued

Variable	Price elasticity			Income elasticity			Household size elasticity[a]	
	REML	Robust OLS	Bootstrap OLS	REML	Robust OLS	Bootstrap OLS	REML	Robust OLS
R^2	0.369	0.387	0.387	0.313	0.371	0.371	0.813	0.873
Observations	638	638	638	332	332	332	70	70

Standard errors are included in parentheses

***, ** and * indicate statistical significance at 1, 5 and 10 % levels

[a] In the case of the household size elasticity results, the dash related to the income variable indicates that this latter is found to be included in all the corresponding studies; as such, it cannot exhibit an estimated coefficient. For the other moderator variables, the dashes indicate that these variables are not available for the sample of studies related to the household size elasticity

Third, the estimation techniques, which prove insignificant in Table 2, show now negative and statistically significant coefficients in the case of price elasticity. That is, compared to the baseline OLS, all other estimation techniques (instrumental variables, fixed and random effects, etc.) tend to make the residential water demand more price-elastic. A final substantial change has occurred to the developing countries variable, which was insignificant in the case of price elasticity, but it displays now a positive and significant coefficient under the three methods (REML, robust OLS and bootstrap OLS). This finding means that the residential water is less price-elastic in developing countries compared to developed ones. Thus far, the mean value of price elasticity estimates in the current data set is about −0.340 in developing countries, while it stands at around −0.378 in developed countries. This may be explained by the fact that households in developing countries may rely, in addition to the metered water, on other type of sources (Nauges and Whittington 2010). The latter may provide water with lower prices. Therefore, water can be considered as a heterogeneous commodity in developing countries, since its quality, quantity and reliability vary with the type of source (Mu et al. 1990).

4 Conclusions and policy implications

The aim of the current article is to provide a statistical review of the empirical literature on the residential water demand topic. Therefore, it has conducted a meta-analysis on the price, income and household size elasticities. The meta-analysis technique has several advantages compared to the traditional narrative review. Particularly, it estimates the influence of numerous and diverse characteristics of the primary studies on the results (effect sizes).

To carry out the three meta-regressions on the price, income and household size elasticities, we have constructed a large database gathering the characteristics of empirical studies. Furthermore, to check the robustness of our results, we have employed different estimation techniques recently proposed in the meta-analysis literature.

From the meta-regression analysis, the following main results are obtained. The long-run price (household size) elasticity estimates are higher (lower) in absolute values. Hence, basing long-run policy instruments on short-run elasticities may lead to some distortions. The use of the discrete/continuous choice modelling approach is associated with inflated absolute values of price elasticity, while they significantly provide smaller income and household size elasticities. This result contradicts the one found previously in Dalhuisen et al. (2003) analysis in the case of the income elasticity. Therefore, corroborating the recommendation of Dalhuisen et al. (2003), further studies based on the discrete/continuous choice approach are needed to check the appropriateness of this theoretically correct approach in the presence of multiblock tariffs.

An interesting finding derived from the current meta-analysis suggests that the three elasticities differ across the geographic location, namely the United States, Europe and other parts of the world, as well as according to the development level of countries (developing vs. developed countries). Therefore, decision makers in a given country would not rely on the findings of studies conducted on other countries when formulating some policies. Further, our analysis shows that studies using household data provide a more price-elastic water demand than those based on aggregated data. Hence, for policy makers, it is of great utility to rely on micro-level data in order to formulate suitable policies because individual-level data better reflect the heterogeneity of households' preferences towards water consumption. Price elasticity is found to be inflated (in absolute values) when water is used in summer and for outdoor purposes contrarily to indoor consumption. The increase in outdoor usage occurs generally during dry seasons. Therefore, peak-load water pricing may be an effective tool for managing water demand. The role of pricing tool cannot be denied as a valuable policy in promoting water conservation and enhancing social equity although some overlap in the estimated coefficients related to the rate structure specifications is obtained.

Summing up, if one examines the existing literature reviews (e.g., Arbués et al. 2003 and Worthington and Hoffman 2008) and the two previous meta-analyses of Dalhuisen et al. (2003) and Espey et al. (1997) on the subject of residential water demand, the findings of the current meta-analysis are not surprising. Furthermore, while they provide new interesting insights and appear to be beneficial to academics and policy makers alike, they open the way for future researches regarding many features such as the disaggregation of water demand analysis into indoor and outdoor as well as summer and winter water consumption and the use of the discrete/continuous choice approach and the Stone-Geary demand function.

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