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Residential Water Consumption: A Cross Country Analysis

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Abstract

Survey data from 10 OECD countries are used to model household water demand. Statistically significant results include: (1) an inelastic average price response is estimated for every country; (2) households not charged volumetrically consume more water than households that are; (3) household size, residence size, higher education, full-time employment and household income increase water consumption; (4) attitudinal characteristics do not have a statistically significant effect on consumption but increase the probability of undertaking water saving behaviors; and (5) promotion of water saving behaviors would be more effective if households faced a volumetric water charge.

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I. Introduction

An increasing number of countries face concerns over maintaining water reliability in response to climate variability and rising populations. This is because, in many locations, the cost of augmenting water supplies is much more expensive than providing water from existing sources. Supply augmentation may also require several years of planning and large capital investments before the water is available. In response to these challenges, governments are developing strategies to restrain water demand, particularly with residential consumers.

One of the principal policy levers to regulate water demand available to governments and water utilities is to impose a volumetric charge on households for the water they use. To better understand the impact of volumetric water prices on water consumption, and also socio-economic and attitudinal variables on water saving behaviors, we use a unique data set of over 10,000 households collected by the OECD Secretariat in 2008 from 10 countries. The survey data include responses to a range of water consumption, household characteristics and attitudinal questions.

The common survey instrument used by the OECD permits us to make valid cross-country comparisons on household water consumption while simultaneously accounting for household characteristics, environmental attitudes, environmental behaviors and actions, differences in water prices and the way households are charged for water. Statistically significant results from analysis of the data include: (1) households that do not face a volumetric charge for their water consume, on average, more water than those that do pay volumetrically; (2) households in all ten countries have a lower water consumption the higher is the average volumetric price of water; (3) the use of dual-flush toilets and water tanks to collect rain water have a negative effect on water consumption; (4) household characteristics that include the number of people in the household (adults and children), residence size, higher education, full-time employment and household income all have a positive effect on household water consumption; (5) environmental attitudes, as measured in the survey, do not have a statistically significant effect on overall water consumption but do increase the likelihood of undertaking some specific water saving behaviors; (6) households that incur a volumetric water charge have a higher likelihood that they will undertake water saving behaviors, as do households that face a higher average water price; and (7) the water demand of high-income households is less price elastic than that of low and medium-income households.

Section II provides a brief review of the literature on water pricing and residential water demand while section III presents a summary and corroboration of the OECD data. Section IV presents the multiple regression analysis, section V checks for the robustness of these results and section VI describes the results of the probit analysis. Section VII reviews the policy implications and section VIII concludes.

II. Review of the Literature

The large literature on residential water demand is summarized and reviewed by several authors including: Dalhuisen et al. (2000); Ferrara (2008); Hanemann (1998); Renzetti (2002, 17-34); Shaw (2005, 100-135); Schleich and Hillenbrand (2008); and Young and Haveman (1985); among others. We review the past findings in terms of (1) the water price variable, (2) the elasticity of demand and (3) household characteristics.

Water Price

A key issue in residential demand studies is whether consumers respond to the average water price, or the marginal price corresponding to the last unit of water consumed, or some combination of the two. One of the earliest studies by Howe and Linaweaver (1967) argues that consumers should respond to the marginal price corresponding to the current level of consumption. By contrast, Taylor (1975) posits that under block rate pricing structures the effect of marginal price on consumption only reflects the behavior of the consumer at the last block of consumption, but does not determine the response to intra-marginal changes. He proposes including in an estimated model both the marginal price corresponding to the last block of consumption and either (1) the total cost or (2) the average price of all units consumed prior to the last block. In an extension of Taylor's work, Nordin (1976) proposes a water demand model that includes both the marginal price and an 'expenditure difference' variable that represents the total water bill less the total cost that the consumer would have to pay *if* all units of water consumed were charged at the marginal price. More recently, discrete/continuous choice models have been developed to account for the multiple prices and potential endogeneity associated block tariff structures (Hewitt and Hanemann 1995; Olmstead et al. 2007).

Foster and Beattie (1981) provide evidence in favor of an average price specification in residential water demand estimation because of (1) the complexity of water tariff under block rate structures and (2) the inclusion of sewer charge and fixed service charge in the water bill that, together, impair consumers' ability to identify and respond to a marginal price. Accordingly, they argue that because consumers are more likely to be aware of their total water cost and consumption, and thus the average price paid, a model of residential water demand that depends on the average price is appropriate. Arbues et al. (2003) provide a comprehensive survey of residential water demand studies and observe that, in many cases, the choice of a marginal or average price variable in models does not substantially affect estimated price elasticities. They also note that the choice of the price variable (marginal or average) remains an unresolved issue in empirical work.

Price Elasticity of Demand

Hundreds of price elasticities of residential water demand have been estimated and summaries for OECD countries are available in OECD (1987, p. 51) and OECD (1999a, p. 134). Almost all the existing studies find that the price elasticity of demand is inelastic and significantly different from zero. Two meta-analysis studies also find that the price elasticity of residential water demand is inelastic. In particular, Espey et al. (1997) used 124 elasticity estimates to obtain a median short-run price elasticity of demand of -0.38 and a median long-run price elasticity of demand of -0.64. Dalhuisen et al. (2003) combined 296 price elasticity estimates to derive an overall mean price elasticity of -0.41.

High-income households appear to be less price elastic in terms of their water consumption than low-income households. Renwick and Archibald (1998) use data from two communities in California and find that higher income households have a statistically significant smaller consumption response to water price changes than lower income households.

For the volumetric price to influence water consumption, consumers must be metered. Nauges and Thomas (2000) calculate that a one per cent increase in the proportion of single housing units (all of which have water meters) in 116 French communities would, all else equal, result in a 0.44 per cent reduction in residential water demand. Gaudin (2006) shows using US data that if consumers are informed about the volumetric price that they pay on their water bill, this can increase the price elasticity of demand by 30-40 per cent.

The price elasticity of water demand tends to be greater for outdoor or so-called discretionary uses (Renwick and Green 2000). Consumers also appear to be more responsive to price changes the longer they have to adapt (Dalhusien et al. 2000). The observation that outdoor use is more price elastic than indoor use provides support for the use of seasonal pricing and scarcity pricing to reduce water consumption in periods of high demand, such as the summer months. The finding that the price elasticity of demand can be much greater in the long run is important for water authorities when they evaluate the effects of raising the volumetric price of water (Nauges and Thomas 2003).

Household and Residential Characteristics

Factors other than price and income have been shown to affect residential water demand. A variable that has a positive effect on household water consumption is the number of people at a residence (Hanke and Maré 1984; Lyman 1992). The age distribution within the household also affects residential water use with older people, all else equal, consuming less water than younger people (Lyman 1992). Nauges and Thomas (2000) support this finding and observe that communities with more seniors have lower water consumption. By contrast, Schleich and Hillenbrand (2009) find the converse, namely, that as people get older they consume more water per person.

Residential characteristics associated with houses and properties have, in some studies, been shown to affect household water consumption. Nieswiadomy and Molina (1989) find a statistically significant effect that household water consumption increases with house size, and also lawn size. Lyman (1992) also finds a statistically significant and positive effect on household water consumption from lawn size, as does Renwick and Green (2000). Lot size also appears to be associated with a lower price elasticity of demand (Mansur and Olmstead 2007). Nauges and Thomas (2000, p. 83) using French data from 116 communities find that, all else equal, the older the house the more water is consumed.

III. Survey Data

The survey data for our analysis come from an environmentally-related questionnaire implemented using a web-based access panel by the OECD Secretariat. On-line surveys offer the advantages of lower costs and quicker return times than mail surveys and are widely used in marketing research. Despite these benefits a concern with the use of on-line surveys is that the quality of the responses and the representativeness of the on-line sample to the population are inferior relative to more traditional survey methods.[1] A summary of comparisons between mail and web-based surveys and an empirical test of their equivalence by Deutskens et al. (2006), however, provide evidence that in terms of response characteristics, accuracy and composite reliability the two methods are indistinguishable. Recent evidence, at least in terms of medical research, also supports the hypothesis that the reliability between web-based and telephone interviews are similar (Rankin et al. 2008).

The data were obtained from approximately 10,000 respondents in 10 OECD countries (Australia, Canada, Czech Republic, France, Italy, Korea, Mexico, Netherlands, Norway and Sweden). Respondents were asked a series of questions in terms of their household and residential characteristics (age, income, household size and composition, employment status, residence size, type of residence, etc.), environmental attitudes and general activities (concern about the environment, member of environmental organization, participation in civil society, etc.). Households also provided data on their water saving behaviors (turning off water while brushing teeth, taking shower instead of bath specifically to save water, plugging the sink when washing dishes, etc.), the adoption of water saving devices (water efficient washing machines, low volume or dual-flush toilets, etc.), their water consumption, total water cost and their type of water charges.

Definitions of the relevant variables used in the data analysis are provided in the Appendix. In the analysis, only water consumption responses in the range of 40-4,000/kL per household per year were included in the reported models and tables so as to control for unreasonably small or large reported consumption levels by some respondents. Overall, 17 per cent of respondents who reported their household water consumption were considered to have provided unreasonably small values (12 percent) or large values (five percent). Summary statistics shows that of the 10,251 households in the survey, 1,993 respondents provided details about their water consumption, of which 1,660 households reported water consumption in the range 40-4,000/kL per year. As a proportion of the households responding to the question whether they face water charges, 80 per cent stated that they were subject to such charges, and as a proportion of these households, 84 per cent incur water charges based on their level of consumption.

Table 1 is a summary of the observations per country and the mean and median values for water consumption by household (kL per household), water price (€/kL), household income (€), household size (# people) and size of residence (square meters). The substantial differences between the mean and median values for water consumption by household in Table 1 are caused by the large consumption values provided by some respondents. Countries with the highest median levels of annual water consumption (Korea and Mexico) appear to have the lowest average water price where this price is constructed from the OECD data by dividing household water expenditures by household water consumption. France has the lowest average level of annual household water consumption and the highest average water price. Measures of household income by country reflect the relative rankings of per capita income in the OECD such that Norway has the highest average household income and Mexico the lowest. Differences in household size reflect, to a great extent, variation in the demographic transition across countries. Countries with younger populations (such as Korea and Mexico) have the largest households. Larger household size and lower average water prices may, together, help to explain the comparatively high levels of household water consumption in both Korea and Mexico.

Data Corroboration

Given that the data were obtained from a direct survey, it is useful to corroborate the responses to other sources. Table 2 provides various estimates of per capita residential water consumption in liters per day for the 10 OECD countries included in the survey. A comparison between the values from previously published sources and those from the OECD (10) survey indicates the median survey responses are broadly similar to that reported in the literature.

Another way to corroborate the survey responses is to use the burden of water charges as a percentage of income or household expenditures. Unlike cross-country comparisons using water prices, there is no need to make conversions into a common currency and over time as the water burdens are already directly comparable. A comparison from two published data sources of the average burden (OECD 1999b and 2003) to those calculated from the survey is provided in Table 3. With the exception of the water burden for Canada and Sweden, the ratios calculated from the survey are similar to earlier studies.

The calculated price elasticities of demand can also be used for comparative purposes. For all ten countries there is an inelastic price elasticity of demand that ranges from a low of -0.27 for Norway to a high of -0.59 for Italy while the average price elasticity across the entire sample is -0.48. These price elasticities are in the range of residential demand elasticities calculated in previous studies and are within one standard deviation of the mean price elasticity of -0.41 from a meta-study of 296 price elasticity estimates (Dalhuisen et al. 2003).

Another method of data corroboration is to check for internal consistency in the data. In a region with a single pricing structure, a scatter plot of reported expenditures against reported quantities should fall narrowly along a curve that is decreasing (increasing) in slope with a decreasing (increasing) block tariffs or resemble a straight line if there is a uniform volumetric price. The absence of such a curve in a scatter plot would indicate many households were not providing accurate expenditure and/or water consumption responses. However, in regions with multiple water suppliers and with different pricing structures no distinct curve should be expected.

The left panel of Figure 1 is a scatter plot of reported water expenditures and household water consumption for urban households in the Picardy region of France using the OECD data. It shows a clear pattern that is consistent with accurate reporting of water consumption and expenditure data by households. The right panel in Figure 1 shows the same points in the left panel, but with the inclusion of reported data from rural households from the same region. In the right panel of Figure 1, the previous signal is obscured because of multiple water suppliers and pricing structures. Scatter plots for households in most of the regions in the OECD (10) provide a similar pattern with a strong signal/curve consistent with accurate reporting of water consumption and expenditure data, but tempered by multiple pricing and noise, especially when both rural and urban households are included.

IV. Model Results: Multiple Regression Analysis

The analysis is grouped into two categories. In this section, we regress household water consumption in thousands of liters (kL) against a range of socio-economic characteristics including whether households are charged according to their actual water consumption and, where relevant, the average price charged (€/kL). In section VI we undertake ordered probit estimation to regress water saving behaviors against a wide range of continuous and categorical variables. Combined, the estimation seeks to answer the following questions:

(1) Is there a significant difference in water consumption between households that are charged volumetrically for water and those which are not?
(2) How do general attitudes towards the environment (environmental awareness, membership in environmental organization…) influence water consumption?
(3) How does household water consumption vary with differences in the average water price? and
(4) Who would be most adversely affected by increases in average water price?

Volumetric Water Charges

The estimated annual water consumption by households is regressed against a range of independent variables including a dummy variable equal to one for households where the water bill is volumetrically based on the amount of water consumed. Using an artificially nested model developed by Mackinnon et al. (1983) we are not able to reject a log-linear form for the estimated model. Using the Ramsey (1969) test we fail to reject the null hypothesis of no functional form misspecification in the log-linear model.[2]

Various methods of estimation were employed including weighted least squares (WLS) accounting for heteroskedasticity, ordinary least squares with heteroskedasticity-consistent standard errors, quantile (median) regression, and truncated regression to test the robustness of the results.[3] In all cases, for the OECD (10), the coefficient on the dummy variable for a volumetric water charge is negative and statistically significant different from zero at the five per cent level of significance. Thus, the survey data indicate there is a robust and significant difference in water consumption between those households that face volumetric charges and those that do not.

Table 4 presents model results with the inclusion of a large number of possible independent variables. Table 5 is a specific model estimated by WLS using a general-to-specific estimation procedure, developed in Hendry (1985) and described in detail in Hendry (1995). This approach has been shown to work well at obtaining the correct specification in Monte Carlo simulations (Hoover and Perez 1999). The specific model results in Table 5 indicate that the following variables have a statistically significant effect on water consumption: volumetric water charge (-); number of adults in the household (+); number of children in the household (+); higher education (+); residence size (sq. m.) (+); full-time employment (+); use of a dual-flush toilet (-); and use of a water tank to collect rain water (-).

Average Water Price

To determine the effect of water charges on household water use, we construct an average price of water (€/kL) based on water expenditures and quantities consumed by households. Ideally, a marginal price as well an average price should be included in the analysis but marginal price data or the type of water tariff (increasing block, decreasing block, fixed price) faced by consumers are not available from the OECD survey. Nevertheless, the effects of different average water prices on household water consumption, while also accounting for other relevant socio-economic variables, provide important information about the effectiveness of price and non-price approaches as methods to regulate water demand.

Results from a general or unrestricted model that includes all independent variables hypothesized to affect household water consumption are provided in Table 6. A specific model using a general-to-specific modeling approach estimated with WLS is presented in Table 7. A key result is that the coefficient of the average price variable ─ the overall price elasticity for the OECD (10) ─ is -0.48 and statistically significant at the one per cent level of significance. Statistically significant and positive coefficients were estimated for: household income; the number of adults and the number of children in the household; the residence size; and age of the respondent. In addition to the average price variable, the coefficient on the dual-flush toilet dummy variable is statistically significant and negative.

Table 8 provides a similar set of results to Table 7 but accounts for country effects which are identified by an interaction terms between country dummies and the natural logarithm of the average price of water. The estimated coefficients on the interaction terms in Table 8 are the individual country price elasticities. The results show that on average, at the one per cent level of significance and for all countries, households charged volumetrically and that have a higher average price of water have lower water consumption than households with a lower average price after controlling for a range of socio-economic and attitudinal factors that are hypothesized to affect water demand. The variables that have positive and statistically significant coefficients at the one per cent level include the number of adults and the number of children in the households, size of the residence, and age of the respondent. By contrast, there is no evidence (see Table 6) that attitudes to the environment or participation in environmental groups or activities, as measured in the survey, have a statistically significant effect on residential water consumption.

In summary, the results indicate higher average water prices and the use of dual-flush toilets are causally associated with lower water consumption. A robust finding is that the estimated coefficients for the variables on the number of people in the households (adults and children) and residential size are statistically significant and positive such that these variables increase household water consumption.

Household Characteristics

To better understand the impact of an increase in water charges on households, Table 9 presents a model that includes interaction terms between low-income households (lower quartile) and high-income households (upper quartile) with the natural logarithm of the average water price. The results indicate that the coefficient on the high income and price interaction term is positive and statistically significant from zero at the five per cent level of significance while the interaction between the low income and price term is insignificant. This implies that higher incomes households are less responsive to changes in the average price of water than medium and low-income households.

Table 10 summarizes the substantial differences in the average income of households across the ten countries and the average price paid for water in €/kL for households reporting 40-4,000 kL/year water consumption. The median value of the average price paid for water over the relevant sub-sample is 1.30 €/kL with the lowest value observed for Mexico (0.31 €/kL) and the highest for France (2.88 €/kL). The overall proportion of household income spent on residential water consumption is a little less than one per cent and varies from a low of 0.46 per cent in Korea to a high of 1.91 per cent for the Czech Republic. The data also indicate that households in the two lowest income deciles in the OECD (10) as a whole spend, as a percentage of income, between two and three times as much on their water bill than households in the highest-income decile.

V. Robustness Checks: Multiple Regression Analysis

A necessary condition for a least squares estimator to be consistent is that there is no correlation between any of the explanatory variables and the error term. There are two possible sources of such a correlation in our analysis. First, if there is a block rate water tariff the household average price variable is endogenously determined by household consumption. Second, the household price variable is constructed from self-reported data, which may be reported with error.

Endogeneity

To test whether the reported results are robust to possible endogeneity problems, we construct an instrumental variables (IV) estimator and apply a Hausman (1978) test for a difference between the two estimators. For each household, we use the average value of the price variable of all other households in the same country and in the same region and urban/rural classification as the instrument for price of the household of interest. By construction, these measures are uncorrelated with the error component for each household but correlated with the signal component to yield a valid instrument. The Hausman test finds no statistically significant evidence of endogeneity. The IV estimate for price elasticity is -0.44 which is statistically significant and close to the WLS price elasticity of -0.48 (see Table 7). Overall, the results are consistent with different methods of estimation.[4]

Errors in Variables

The IV procedure used for endogeneity corrects for the classical errors in variables problem where reporting noise is added to the data in answering the survey and the noise does not affect actual behavior. A possible concern is that households misperceive their water expenditures and/or consumption which results in a misperceived average price of water. If true, the perception errors would affect consumer behavior and this would be different to the standard errors in variables problem. However, the average response to actual price changes will be identical to the average response to a perceived price changes *if*, as we would expect, a unit change in the actual price causes, on average, a unit change in the perceived price. A sufficient, but not necessary, condition for this to hold is that price perceptions are unbiased estimates of the true price variable. In this case the true price elasticity to the actual change in price will be the same as the estimated price elasticity with a proportional price misperception.[5]

Sample Selection Bias

Another possible concern is that there may be sample selection bias such that there is a difference in terms of those households that reported their water consumption and those that did not. To test for this possibility, a Heckman two-step test (Heckman 1979) was undertaken for four different models. In all cases the inverse Mills ratio (λ) is statistically insignificant such that there is no evidence of sample selection bias.[6]

Outliers

Some of the reported water consumption numbers by respondents appear to be either unreasonably small or large. To reduce the noise to signal ratio, the reported model results do not include households with levels of water consumption below 40 kL/year and in excess of 4,000 kL/year. To test the robustness of the results to removing outliers, Table 11 presents the results with the inclusion of all possible observations including the outliers. These results can be compared to the results in Table 7 with the outliers removed.

As we would expect, the average price response is larger in Table 11 because of the abnormally high levels of reported water consumption from some respondents. Nevertheless, the results (with and without outliers) are similar. The coefficients on the key independent variables (price, income, adults, children, residence size, and age of respondent) remain statistically significant and the coefficients on all variables have the same sign in the two samples (Tables 7 and 11). This suggests that, although there is substantial noise in the data and especially when outliers are included, there remains a sufficiently strong enough signal between key independent variables and household water consumption to make useful inferences from the data.

VI. Model Results: Probit Analysis

A key policy lever in managing water demand is campaigns to conserve water use through a change in water-use practices. In the OECD (10) survey, respondents were asked to provide an indication of what water savings practices they undertook and their frequency (Never, Occasionally, Often, Always and Not Applicable). Using these responses, a series of ordered probit models were estimated to test whether a range of right-hand side variables increase the probability of undertaking water-savings behaviors.

Table 12 indicates that the largest overall effect on increasing the probability of respondents undertaking water saving behaviors is whether households incur a volumetric water charge. Volumetric water charges increase the probability of: (1) turning off the water while brushing teeth; (2) taking a shower instead of a bath; (3) watering the garden in the coolest part of the day; and (4) collecting rainwater and recycling waste water. A contrary result is obtained to the behavior ‘plugging in the sink when washing dishes’. By contrast to the estimates with household water consumption as the dependent variable, some attitudinal variables, such as having a high level of concern about the environment, do have a statistically significant and positive effect on the marginal probability of undertaking water saving behaviors. Based on the regression results in section IV, however, the increased probability of water saving behaviors is insufficient to show a statistically significant effect of attitudinal characteristics on household water consumption.

Using water saving data from Australia and given various assumptions about the water savings associated with household behaviors, it is possible to estimate the effect on residential water consumption of volumetric water charges from increases in the probability of undertaking water saving behaviors. These savings in kL per year for a three-person household — the median reported household size in Australia and the OECD (10) — are presented in Table 13 for illustrative purposes to show the relative importance of different water saving behaviors. The table indicates that the overall effect of facing volumetric water charges that increase the probabilities of undertaking water saving behaviors is to reduce household water consumption by about 30 kL per year, provided that all the water saving behaviors are applicable to the household.

VII. Policy Implications

The survey results provide a number of insights for policy makers interested in managing residential water demand to constrain household water consumption. The results indicate the effectiveness of charging households for the amount of water they use as an approach to regulate residential water demand relative to charging households independent of their water use. This finding is supported by the responses to a question in the OECD survey on the factors that would encourage households to reduce water consumption. In total, 85 per cent of respondents rated ‘money savings’, one of seven possible listed factors in the questionnaire, as either ‘very important’ or ‘fairly important’ in terms of reducing water consumption. Volumetric water charges also increase the probability of undertaking water saving behaviors.

A key result is that residential water consumption is price inelastic and statistically different from zero in all 10 surveyed countries. Among the four water saving devices (water efficient washing machines, low volume or dual-flush toilets, water flow restrictor taps/low-flow shower head and a water tank to collect rainwater) included in the survey instrument, only a low volume/dual-flush toilet and a water tank to collect rainwater are found to have a statistically significant and negative effect on water consumption. Although social norms and general attitudes towards the environment do not appear to have a statistically significant effect on total household water consumption, some attitudinal variables do have a statistically significant and positive effect on the probability of undertaking water saving behaviors, as does charging housing volumetrically for their water use. These findings suggest that a volumetric charge for water use and a higher average water price would, in tandem with information/education campaigns about water saving behaviors and the adoption of some water saving devices such as dual-flush toilet, help to regulate residential water demand.

The survey results suggest that charging households based on the amount of water they consume can assist in regulating residential water demand. To effectively price water, however, the volumetric price must not only include the marginal costs of the water supplier but also the external costs that water abstraction and consumption imposes on others. In cases where raising the short-run price of water can postpone supply augmentation and, thus, generate a lower average price of water to consumers in the long run, a scarcity price component should also be included in the price charged to all consumers (Griffin 2001). In periods of low water supply, a scarcity price charged to all consumers can be used to help balance supply and demand; and the extra revenue over and above average costs of supply could be refunded back to households in the form of a reduced fixed water fee, and possibly in ways that would advantage low-income households (Grafton and Ward 2008).

VIII. Conclusions

Using a common survey instrument that collected household survey data from 10 OECD countries, a detailed analysis coupled with data corroboration and comprehensive robustness checks finds that households that are charged volumetrically for water have statistically significant lower water consumption than households that are not. Households that incur a volumetric charge for their water also have a greater likelihood they will undertake some water saving behaviors. Another key finding is that in all ten countries there is a robust, statistically significant and negative relationship between the average price of water and household water consumption.

Attitudinal characteristics of households, as measured in the survey, do not have a statistically significant effect on water consumption. However, some environmental attitudes increase the marginal probability of undertaking water saving behaviors. The most important causal factor overall, however, in increasing the marginal probability of undertaking water saving behaviors is whether households face a volumetric charge for water. This suggests that water demand management policies that include campaigns to promote water saving behaviors (such as taking a shower instead of a bath) and use water saving devices (such as dual-flush toilet) would be more effective if households faced a volumetric charge for their water consumption.

Appendix: Definition of Variables

Age of residence	age of dwelling in years
Age of respondent	age of household head in years
Adults	number of adults in the household
Australia dummy	dummy=1 if household is in Australia. Other country dummies are Canada, Czech Republic, France, Italy, Korea, Mexico, Netherlands, Norway, Sweden
Average Price	average water price (Euros / kL) constructed as the ratio of water expenditures and consumption for those households charged volumetrically
Children	number of children in the household
Efficient shower	dummy=1 for having water flow restrictor taps / low flow shower head
Dual-flush/efficient toilet	dummy=1 for having low volume or dual-flush toilet
Efficient washer	dummy=1 for having water efficient washing machine
Employed full time	dummy=1 for full-time job
Employed part time	dummy=1 for part-time / casual job or student
Enviro attitudes	an index of attitudinal questions about the environment. Lower values mean the respondent has 'greener' views
Enviro issues rank	ranking of environmental issues relative to other issues on a 1-6 scale.
Enviro member	dummy=1 if member / contributor / donator to an environmental organization
Enviro responsibility	degree of agreeing that each household can contribute to a better environment on a 5 point Likert scale
Enviro supporter	dummy=1 if supported / participated in activities of an environmental organization
High education	dummy=1 for diploma / bachelor / postgraduate
High Income	dummy=1 for income in top quartile
Household size	adults plus children in the household
House	dummy=1 for a detached or semi-detached house
Household income	household income in thousands of Euros
Household Water Consumption	volume of water used in kL with observations less than 40kL and greater than 4,000 kL removed as outliers
Household Water Consumption_all	volume of water used in kL with all observations
Low income	dummy=1 for income in low quartile
Money-saving motive	degree of importance of 'money saving' in encouraging the household to reduce water consumption. Values 1-4, higher values mean more important.
Owner occupied	dummy=1 if household owns the residence
Pollution concern	degree of concern with water pollution on a 5 point Likert scale
Rainwater tank	dummy=1 for having water tank to collect rainwater
Resources concern	degree of concern with natural resources depletion on a 5 point Likert scale
Size of garden	size of garden in square meters
Size of residence	size of residence in square meters
Urban location	dummy=1 for living in an urban or suburban region
Volumetric charge dummy	dummy=1 for households being charged according to amount of water used
Voter	dummy=1 if respondent has voted in the past 6 years

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Table 1: Mean and median values for key variables by country and OECD (10)

	Household Water Consumption (kL/year)			Average Water Price (€/kL)			Household Income (thousand €/year)			Household Size (# persons)			Residence Size (sq. meters)		
	Mean	**Median**	**N**	**Mean**	**Median**	**N**	**Mean**	**Median**	**N**	**Mean**	**Median**	**N**	**Mean**	**Median**	**N**
Australia	442	190	163	1.292	0.662	177	34.981	31.138	913	2.872	3	1006	93	75	701
Canada	491	194	52	1.346	0.880	53	38.548	33.841	932	2.632	2	1003	115	125	853
Czech Republic	200	105	193	1.805	1.440	191	11.710	10.211	636	3.023	3	701	89	75	669
France	130	100	338	3.108	2.875	323	32.349	30.650	1007	2.568	2	1075	96	75	1057
Italy	404	200	256	1.188	0.929	252	30.735	26.000	1300	3.119	3	1417	110	125	1400
Korea	508	220	111	0.667	0.361	157	24.912	21.617	946	3.704	4	1000	92	75	982
Mexico	407	265	201	0.709	0.314	196	6.782	5.158	948	3.814	4	1009	106	75	951
Netherlands	180	103	198	2.277	1.935	189	28.467	25.800	948	2.296	2	1015	89	75	896
Norway	183	140	57	2.510	1.717	35	58.627	53.023	968	2.556	2	1019	121	125	996
Sweden	215	130	91	2.618	2.357	87	28.743	25.239	935	2.309	2	1006	94	75	998
OECD (10)	294	140	1660	1.770	1.302	1660	30258	25800	9533	2.891	3	10251	101	75	9503

Table 2: Comparison of average water consumption, liters per person per day

Estimate of per capita household water consumption (Liters per person per day)

Country	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	2004	2006	OECD 2008 Median
Australia		256	285								268		177[a]	173[b]	**192**
Canada		255				350					326				**263**
Czech Republic		138	157	165			137			121		113			**103**
France												137			**110**
Italy			211					251		249		213		147[b]	**205**
Korea		62	69	103		160	164	169	181	175	181	183			**186**
Mexico															**182**
Netherlands				122	130	128	129	125	128	129	130			98[b]	**137**
Norway			154	175								140		143[b]	**151**
Sweden	229	207	196	195	197	195	201	203	199	191				135[b]	**137**

Sources:
1. Data 1970 - 1997: *The Price of Water - Trends in OECD Countries*, OECD (1999a), p.19
2. Data 2004, 2006: Calculated from *International Statistics for Water Services*, IWA (2008), p.10 and Productivity Commission 2008 (p. 23, using data for Sydney) and assuming a three person household.
3. OECD 2008 is from this survey

Notes:
1. a = Productivity Commission
2. b = IWA
3. Blank cells indicate data for that period or source is not available

Table 3: Comparison of the burden of water charges as percentage of income or expenditures

Country	OECD ([a] = 1999b; [b] = 2003)			Productivity Commission (2008, p. 21)[1]	OECD 2008 survey
	year	denominator	%	%	%
Australia	1996	income	0.79[a]	0.65	0.62
Canada	1996	income	1.05[a]		0.74
Czech Republic	1996	income	2.2[a]		1.91
France	1995	income	0.9[b]		1.01
Italy	1997	expenditures	0.7[b]		0.90
Korea	1997-98	expenditures	0.6[b]		0.46
Mexico	2000	income	1.3[b]		1.42
Netherlands	1999	income	0.6[b]		0.75
Norway	1996	income	0.45$_{a}$		0.50
Sweden	1996	income	0.59$_{a}$		0.98

Notes:

1. Based on New South Wales and as a percentage of total expenditure on goods and services in 2003-2004.
2. OECD (1999b) data refers public water supply and is obtained from Table 22.
3. OECD (2003) data refers to public water supply and is obtained from Table 2.2.
4. Blank cells indicate data not available.

Table 4: Effect of a volumetric charge on water consumption (general and unrestricted model, WLS)

Dependent Variable: Household Water Consumption (ln)
Method: Least Squares
Included observations: 1510

Variable	Coefficient	Std. Error	*t*-Statistic	*P*-value
Volumetric charge dummy	-0.437	0.139	-3.133	0.002
Household Income	0.001	0.001	0.711	0.478
Adults	0.150	0.019	7.986	0.000
Children	0.053	0.018	2.981	0.003
High education dummy	0.083	0.034	2.441	0.015
Size of residence (sq. m.)	0.156	0.041	3.847	0.000
Size of garden (sq. m.)	-0.014	0.018	-0.801	0.423
Age of residence	0.000	0.001	0.043	0.966
Age of respondent	0.005	0.002	2.524	0.012
Employed full time	0.114	0.041	2.794	0.005
Employed part time	0.095	0.058	1.646	0.100
Owner occupied residence	-0.014	0.052	-0.274	0.784
Urban location	0.019	0.034	0.553	0.580
House dummy	0.071	0.058	1.222	0.222
Voter dummy	-0.084	0.096	-0.872	0.384
Enviro supporter	0.092	0.079	1.168	0.243
Enviro member	0.007	0.046	0.142	0.887
Enviro attitudes	-0.021	0.025	-0.831	0.406
Efficient washer	0.000	0.035	-0.008	0.994
Dual-flush/efficient toilet	0.013	0.035	0.389	0.697
Efficient shower	-0.092	0.033	-2.789	0.005
Rainwater tank	-0.060	0.035	-1.706	0.088
Money-saving motivation	0.010	0.023	0.447	0.655
Australia dummy	0.680	0.126	5.390	0.000
Canada dummy	1.001	0.163	6.148	0.000
Czech Republic dummy	0.208	0.061	3.402	0.001
Italy dummy	0.807	0.096	8.375	0.000
Korea dummy	0.752	0.134	5.592	0.000
Mexico dummy	0.560	0.137	4.096	0.000
Netherlands dummy	0.146	0.055	2.641	0.008
Norway dummy	0.124	0.066	1.876	0.061
Sweden dummy	0.124	0.082	1.504	0.133
Constant	4.296	0.220	19.490	0.000

Weighted Statistics			
R-squared	0.962	Mean dependent var	4.944
Adjusted R-squared	0.961	S.D. dependent var	3.733
S.E. of regression	0.733	Akaike info criterion	2.239
Sum squared resid	794.561	*F*-statistic	13.965
Log likelihood	-1657.831	Prob(*F*-statistic)	0.000

Table 5: Effect of volumetric water charge on water Consumption (specific model and WLS)

Dependent Variable: Household Water Consumption (ln)
Method: Least Squares
Included observations: 1546

Variable	Coefficient	Std. Error	*t*-Statistic	*P*-value
Volumetric charge dummy	-0.377	0.160	-2.360	0.018
Household Income	-0.000	0.001	-0.522	0.602
Adults	0.176	0.020	9.030	0.000
Children	0.059	0.019	3.077	0.002
High education dummy	0.080	0.036	2.205	0.028
Size of residence (sq. m.)	0.141	0.038	3.711	0.000
Age of respondent	0.002	0.002	1.051	0.294
Employed full time	0.091	0.039	2.305	0.021
Dual-flush/efficient toilet	-0.071	0.035	-2.057	0.040
Rainwater tank	-0.088	0.039	-2.281	0.023
Australia dummy	0.624	0.150	4.151	0.000
Canada dummy	0.723	0.206	3.508	0.001
Italy dummy	0.631	0.090	6.986	0.000
Korea dummy	0.544	0.161	3.386	0.001
Mexico dummy	0.457	0.135	3.389	0.001
Constant	4.497	0.196	22.902	0.000

Weighted Statistics			
R-squared	0.934	Mean dependent var	4.943
Adjusted R-squared	0.933	S.D. dependent var	2.961
S.E. of regression	0.767	Akaike info criterion	2.317
Sum squared resid	899.118	*F*-statistic	20.933
Log likelihood	-1774.704	Prob(*F*-statistic)	0.000

Table 6: Effect of average water price on water consumption (general model and WLS)

Dependent Variable: Household Water Consumption (ln)
Method: Least Squares
Included observations: 1337
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	*t*-Statistic	*P*-value
Average Price (ln)	-0.466	0.025	-18.844	0.000
Household Income (ln)	0.007	0.032	0.210	0.834
Adults	0.150	0.019	7.717	0.000
Children	0.080	0.018	4.454	0.000
High education dummy	-0.003	0.036	-0.089	0.929
Size of residence (sq. m.)	0.149	0.039	3.814	0.000
Size of garden (sq. m.)	-0.007	0.017	-0.391	0.695
Age of residence	-0.001	0.001	-0.791	0.429
Age of respondent	0.003	0.001	2.247	0.025
Employed full time	0.004	0.038	0.095	0.924
Employed part time	0.023	0.051	0.441	0.659
Owner occupied residence	-0.019	0.044	-0.424	0.672
Urban location dummy	-0.004	0.037	-0.099	0.922
House dummy	0.071	0.043	1.628	0.104
Voter dummy	-0.112	0.068	-1.651	0.099
Enviro supporter	-0.007	0.055	-0.135	0.893
Enviro member	0.001	0.044	0.013	0.990
Enviro attitudes	0.012	0.024	0.496	0.620
Efficient washer	0.036	0.035	1.025	0.306
Dual-flush/efficient toilet	-0.067	0.035	-1.888	0.059
Efficient shower	-0.060	0.034	-1.763	0.078
Rainwater tank	-0.006	0.037	-0.169	0.866
Money-saving motivation	0.015	0.025	0.593	0.553
Australia dummy	0.072	0.069	1.040	0.299
Canada dummy	0.403	0.122	3.292	0.001
Czech Republic dummy	-0.101	0.065	-1.555	0.120
Italy dummy	0.117	0.064	1.817	0.070
Korea dummy	-0.187	0.092	-2.037	0.042
Mexico dummy	-0.301	0.108	-2.789	0.005
Netherlands dummy	-0.046	0.056	-0.817	0.414
Norway dummy	0.074	0.083	0.887	0.375
Sweden dummy	0.164	0.069	2.382	0.017
Constant	4.408	0.361	12.205	0.000

Weighted Statistics			
R-squared	0.854	Mean dependent var	4.875
Adjusted R-squared	0.851	S.D. dependent var	1.381
S.E. of regression	0.534	Akaike info criterion	1.606
Sum squared resid	371.213	*F*-statistic	30.804
Log likelihood	-1040.500	Prob(*F*-statistic)	0.000

Table 7: Effect of average water price on water consumption (specific model and WLS)

Dependent Variable: Household Water Consumption (ln)
Method: Least Squares
Included observations: 1384

Variable	Coefficient	Std. Error	*t*-Statistic	*P*-value
Average Price (ln)	-0.485	0.019	-25.604	0.000
Household Income (ln)	0.043	0.023	1.831	0.067
Adults	0.123	0.015	8.149	0.000
Children	0.075	0.014	5.352	0.000
Size of residence (sq. m.)	0.158	0.029	5.408	0.000
Age of respondent	0.004	0.001	3.093	0.002
Dual-flush/efficient toilet	-0.065	0.027	-2.351	0.019
Canada dummy	0.319	0.153	2.081	0.038
Italy dummy	0.072	0.050	1.452	0.147
Korea dummy	-0.210	0.072	-2.914	0.004
Mexico dummy	-0.335	0.060	-5.564	0.000
Sweden dummy	0.203	0.057	3.556	0.000
Constant	4.032	0.237	17.020	0.000

Weighted Statistics

R-squared	0.937	Mean dependent var	4.873
Adjusted R-squared	0.936	S.D. dependent var	2.153
S.E. of regression	0.544	Akaike info criterion	1.630
Sum squared resid	405.791	*F*-statistic	86.225
Log likelihood	-1114.800	Prob(*F*-statistic)	0.000

Table 8: Effect of average price on water consumption (individual country effects and WLS)

Dependent Variable: Household Water Consumption (ln)
Method: Least Squares
Included observations: 1384

Variable	Coefficient	Std. Error	*t*-Statistic	*P*-value
Household Income (ln)	0.010	0.022	0.471	0.638
Adults	0.148	0.017	8.681	0.000
Children	0.082	0.017	4.903	0.000
Size of residence (sq. m.)	0.151	0.031	4.858	0.000
Age of respondent	0.004	0.001	3.225	0.001
Dual-flush/efficient toilet	-0.067	0.030	-2.192	0.029
Canada dummy	0.421	0.137	3.074	0.002
Italy dummy	0.200	0.054	3.702	0.000
Korea dummy	-0.157	0.087	-1.808	0.071
Mexico dummy	-0.228	0.069	-3.283	0.001
Sweden dummy	0.178	0.121	1.468	0.142
Constant	4.212	0.226	18.627	0.000
Average Price in Australia (ln)	-0.441	0.049	-9.097	0.000
Average Price in Canada (ln)	-0.476	0.145	-3.277	0.001
Average Price in Czech Rep. (ln)	-0.423	0.046	-9.274	0.000
Average Price in France (ln)	-0.407	0.030	-13.733	0.000
Average Price in Italy (ln)	-0.586	0.056	-10.545	0.000
Average Price in Korea (ln)	-0.551	0.072	-7.641	0.000
Average Price in Mexico (ln)	-0.566	0.045	-12.467	0.000
Average Price in Netherlands (ln)	-0.404	0.041	-9.846	0.000
Average Price in Norway (ln)	-0.272	0.095	-2.879	0.004
Average Price in Sweden (ln)	-0.414	0.100	-4.117	0.000

Weighted Statistics			
R-squared	0.842	Mean dependent var	4.879
Adjusted R-squared	0.839	S.D. dependent var	1.337
S.E. of regression	0.536	Akaike info criterion	1.608
Sum squared resid	391.754	*F*-statistic	50.390
Log likelihood	-1090.438	Prob(*F*-statistic)	0.000

Table 9: Effect of average water price on water consumption (specific model, WLS and with income-price interactions)

Dependent Variable: Household Water Consumption (ln)
Method: Least Squares
Included observations: 1384

Variable	Coefficient	Std. Error	*t*-Statistic	*P*-value
Household Income (ln)	0.008	0.027	0.288	0.773
Adults	0.145	0.015	9.589	0.000
Children	0.092	0.014	6.708	0.000
Size of residence (sq. m.)	0.167	0.029	5.811	0.000
Age of respondent	0.006	0.001	4.710	0.000
Dual-flush/efficient toilet	-0.051	0.028	-1.842	0.066
Canada dummy	0.517	0.192	2.697	0.007
Italy dummy	0.282	0.051	5.552	0.000
Korea dummy	-0.119	0.073	-1.620	0.106
Mexico dummy	-0.210	0.104	-2.018	0.044
Sweden dummy	0.294	0.112	2.626	0.009
Low income dummy × Average price (ln)	0.034	0.050	0.685	0.494
High income dummy × Average price (ln)	0.054	0.026	2.047	0.041
Average Price in Australia (ln)	-0.480	0.042	-11.425	0.000
Average Price in Canada (ln)	-0.661	0.197	-3.350	0.001
Average Price in Czech Republic (ln)	-0.342	0.042	-8.096	0.000
Average Price in France (ln)	-0.364	0.027	-13.381	0.000
Average Price in Italy (ln)	-0.783	0.048	-16.242	0.000
Average Price in Korea (ln)	-0.599	0.075	-7.984	0.000
Average Price in Mexico (ln)	-0.583	0.050	-11.616	0.000
Average Price in Netherlands (ln)	-0.347	0.043	-8.140	0.000
Average Price in Norway (ln)	-0.201	0.062	-3.231	0.001
Average Price in Sweden (ln)	-0.481	0.090	-5.361	0.000
Constant	4.082	0.277	14.713	0.000

Weighted Statistics			
R-squared	0.949	Mean dependent var	4.893
Adjusted R-squared	0.949	S.D. dependent var	2.311
S.E. of regression	0.524	Akaike info criterion	1.564
Sum squared resid	374.064	*F*-statistic	65.905
Log likelihood	-1058.463	Prob(*F*-statistic)	0.000

Table 10: Summary of prices, price responses and water cost burdens by country

Country	(1) Median water price (total water cost/total consumption in €/kL)	(2) Water Use Response to Change in Average Water Price (elasticity)	(3) Average water bill (€/year)	(4) Average income (€/year)	(5) Total water bill (% of total income)
Australia	0.66	-0.44	226	36,546	0.62
Canada	0.88	-0.48	332	45,021	0.74
Czech Republic	1.44	-0.42	229	12,008	1.91
France	2.88	-0.41	343	34,015	1.01
Italy	0.93	-0.59	270	30,015	0.90
Korea	0.36	-0.55	116	25,466	0.46
Mexico	0.31	-0.57	104	7,365	1.42
Netherlands	1.93	-0.40	230	30,738	0.75
Norway	1.72	-0.27	318	63,809	0.50
Sweden	2.35	-0.41	394	40,063	0.98
OECD (10)	**1.30**	**-0.48**	**233**	**27,649**	**0.86**

Table 11: Effect of average water price on water consumption (specific model, WLS and with all possible observations)

Dependent Variable: Household Water Consumption_all (ln)
Method: Least Squares
Included observations: 1742

Variable	Coefficient	Std. Error	*t*-Statistic	*P*-value
Average Price (ln)	-0.705	0.017	-40.386	0.000
Household Income (ln)	0.071	0.024	2.984	0.003
Adults	0.151	0.019	7.939	0.000
Children	0.093	0.019	4.786	0.000
Size of residence (sq. m.)	0.227	0.038	6.022	0.000
Age of respondent	0.004	0.001	2.763	0.006
Dual-flush/efficient toilet	-0.059	0.037	-1.583	0.114
Canada dummy	0.270	0.107	2.532	0.011
Italy dummy	0.075	0.053	1.414	0.157
Korea dummy	-0.661	0.075	-8.828	0.000
Mexico dummy	-0.542	0.074	-7.356	0.000
Sweden dummy	0.214	0.075	2.832	0.005
Constant	3.615	0.245	14.728	0.000

Weighted Statistics			
R-squared	0.602	Mean dependent var	4.875
Adjusted R-squared	0.599	S.D. dependent var	1.153
S.E. of regression	0.730	Akaike info criterion	2.216
Sum squared resid	921.443	*F*-statistic	168.172
Log likelihood	-1917.096	Prob(*F*-statistic)	0.000

Table 12: Summary of the marginal effects on probability (often or always) of water saving behaviors

	Marginal effects on probability of behavior ("Often" or "Always")				
	Turn off the water while brushing teeth	Take shower instead of bath specifically to save water	Plug the sink when washing dishes	Water the garden in the coolest part of the day to save water	Collect rainwater/ recycle waste water
Volumetric charge dummy	0.130***	0.041***	-0.033***	0.047***	0.133***
Age of respondent	-0.001**	0.001**	0.005***	0.004***	0.004***
High education dummy	0.057***	0.017***			-0.142***
Employed full time			-0.0283**		
Employed part time					
Income	-2.29E-03***	-1.63E-04	1.42E-03***	-8.82E-04***	-2.12E-03***
Money-saving motivation	0.034***	0.030***	0.014*	0.042***	0.033***
Size of residence (sq. m.)	-0.061***		-0.041***		-0.030**
Size of garden (sq. m.)				0.040***	0.051***
Household size	0.016***	-0.008***	-0.008*		0.021***
House dummy	0.068***		0.092***	0.086***	-0.144***
Urban location dummy	0.030**		-0.080***	-0.0262*	-0.092***
Enviro issues rank	-0.020***	-0.006**	-0.016***	-0.027***	-0.021***
Pollution concern	0.022***		-0.0165**	-0.015*	
Resources concern	0.029***			0.0410***	0.040***
Voter dummy	0.037**		0.030*		0.040*
Enviro supporter	0.072***	0.026**	0.078***	0.065***	0.098***
Enviro member			0.034**		0.040**
Enviro responsibility	0.036***	0.030***	0.023**	0.041***	

Notes:

1. Black cells indicate the given effect is not statistically different from zero at the 10 per cent level of significance.
2. * = significantly different from zero at the 10 per cent level of significance
3. ** = significantly different from zero at the 5 per cent level of significance
4. *** = significantly different from zero at the 1 per cent level of significance

Table 13: Water consumption effect (kL per year) of volumetric water charges by water saving behaviors

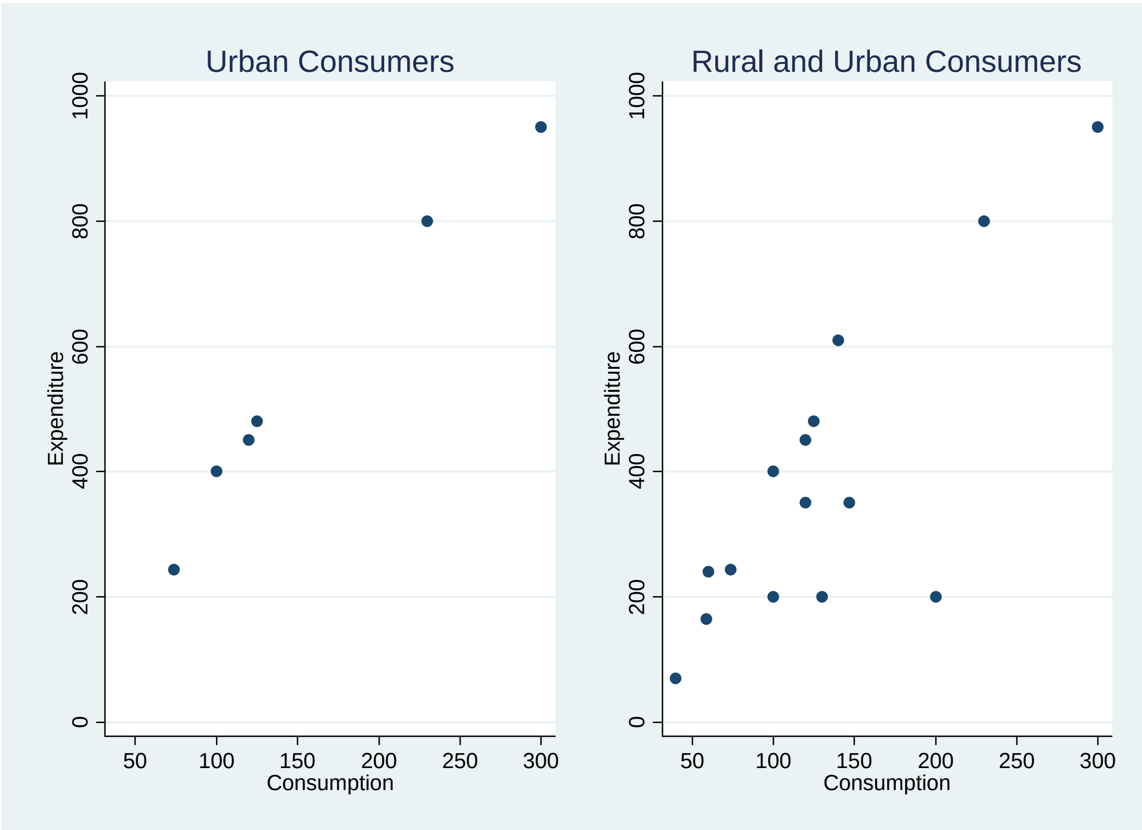
Water Saving Behaviors and Estimated Savings Per Year for a Three Person Household

Turn off the water while brushing teeth	Take shower instead of bath specifically to save water	Plug the sink when washing dishes	Water the garden in the coolest part of the day to save water	Collect rainwater	Recycle waste water	**TOTAL**
Per person	Per person	Per household	Per household	Per household	Per person	Per household
-0.688kL	-0.611kL	1.046kL	-2.813kL	-5.426kL	-5.702kl	-28.196kL

Notes:

1. Total water savings based on the assumption of a four person household and assuming 'Never' = 0%, 'Occasionally' = 30%, 'Often' = 60% and 'Always' = 100% of defined water savings.
2. Turning off the tap while brushing your teeth (assume two minutes per time) in the morning and at bedtime can save up to 20 liters/day or 7.3 kL per year based on average tap flows at a rate of 15-30 liters per minute and assumption that brushing of teeth would take 5 liters/minute (source: South Australia Water 2008).
3. Showers of eight minutes duration using water efficiency shower head will use takes 72 liters of water while, on average a bath tub, will hold about 150 liters for a normal bath. Assuming a household member takes a shower instead of bath can, thus, save 78 liters /day or 28.47 kL per person per year (source: Madden and Carmichael 2007).
4. The average tap flows at a rate of 15-30 liters per minutes. Dishwashing by hand in a sink without running the tap continuously takes 18 liters (source: South Australia Water 2008). Estimated water savings from washing in sink is based on assumption it takes five minutes to do the dishes *without* using a plug at a rate of 23.2 liters per minute. This generates savings of at least 98 liters/day or 35.8 kL/year per household if dishes are done once per day.
5. Watering the garden consume around 400 liters per day depending on aspect, vegetation type, soil type and residence size. Watering the garden in the early morning or evening can save up to 50% of water from evaporation (200 liters per day). Assuming the garden is watered every day this will save up to 73 kL per year (source: Edwards 2004).
6. A 5,000 liter water tank connected to 100 square meters of roof when the water is only used for garden watering can provide around 59 kL of water per year depending on the total rainfall and pattern of rainfall and if used for toilet flushing and for the washing machine (source: ACTEW 2007).
7. Recycling grey water from kitchen and bathroom can collect 33.5 kL per capita per year while recycling water from laundry can save up to 13 kL per person per year (source: Troy et al. 2005, pp. 59-62).

Figure 1: Household water expenditures plotted against household water consumption for Picardy, France



End Notes:

1. Summary data that compare key socio-economic characteristics from census and other sources with those from the OECD sample are available for a selection of the countries. A comparison of the data indicates that the on-line OECD sample is representative of the overall population in terms of key variables such as household, residence size, etc.
2. Full test results across all methods of estimation are available from the authors on request.
3. Results from the different methods of estimation are available on request.
4. The Hausman test and the IV results are available from the authors on request.
5. For instance, if the estimated model were $\ln q = \alpha + \beta \ln(p * \varepsilon)$ where q is household water consumption, p is the true average water price and ε is the multiplicative error term from misperception then the estimating equation can be rewritten as $\ln q = \alpha + \beta \ln p + \beta \ln \varepsilon$ such that the estimated price response would be identical to the true price response without the price misperception.
6. The Heckman test results are available from the authors on request.