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A Panel Data Estimation of Domestic Water Demand with IRT Tariff Structure: The Case of the City of Valencia (Spain)

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Abstract: In urban water provisioning, prices can improve efficiency, contributing to the achievement of the environmental objective. However, household responses to price changes differ widely based on the household characteristics. Analyses performed at the aggregate level ignore the implications of water demand incentives at the individual household level. A large data sample at the household level enables estimation of econometric models of water demand, capturing the heterogeneity in domestic consumption. This study estimated the domestic water demand in the city of Valencia and its elasticity, along with the demands of its different districts and neighbourhoods (intra-urban scale analysis). Water price structure in Valencia is completely different from that of other Spanish cities: it is a price structure of increasing volume (increasing rate tariffs, IRT). For this estimation, from a microdata panel at the household level, the demand function with average prices for the period 2008–2011 was estimated using panel data techniques including a fixed effect for each neighbourhood. The domestic water demand elasticity at the average price in Valencia was estimated at −0.88 (which is higher than that estimated for other Spanish cities). This value indicates an inelastic demand at the average price of the previous period, which can cause consumers to overestimate the price and react more strongly to changes.

Keywords: urban water consumption; water pricing; urban areas; intraurban analysis; unobserved heterogeneity; micro database

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1. Introduction

The city of Valencia is located in the Mediterranean region, in the east of the Iberian Peninsula and in the Jucar river basin. In this geographic area, water problems are a constant issue due to a combination of climatic factors, resource availability and demand evolution [1–3]. As in the entire Mediterranean region, the problems associated with water resource scarcity generate significant tensions between the different uses of water. Likewise, competition between different water uses in many areas of developed countries (especially in cities) exerts strong pressure on water resources, causing greater possibilities of suffering from scarcity situations.

The Júcar River Basin presents a *Water Explotation Index Plus* (WEI+) of 40.79% in the summer months when rainfall is lowest, and the demand for water for agricultural and tourist use is highest [4]. The Basin Plan of the Jucar Hydrographic Demarcation planning cycle for 2015–2021 [5] established a water deficit of 265 Hm^3 per year. This means that, with the resources available in the river basin itself, it is not possible to meet all the existing water rights, the possible future demand growth (with adequate guarantees) and the ecological flow regime [6].

Valencia constitutes a large, important urban area within a river basin, in which agricultural demands represent a very important percentage (about 80%). Due to this, the urban area of Valencia, with a growing population and highly seasonal service activities, must compete for water resource use with an important agricultural area and a natural park (This Natural Park has a total area of 21,120 hectares that include a lake, pastures, marshes and orchard lands; 5880 hectares belong to the municipality of Valencia. The declaration of Natural Park was made through Decreto 89/1986, de 8 de julio, del Consell de la Generalitat Valenciana, de régimen jurídico del Parque Natural de la Albufera. Since 1990, the park has been included in the list of "Wetlands of International Importance" (according to the Ramsar Convention, Iran of 2 February 1971), and since 1991, it has been considered a Special Protection Area for Birds (SPAB) in accordance with the Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds, modified by Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds and protected by Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora).

The problem may worsen. As the *Intergovernmental Panel of Climate Change* (IPCC) indicated in its Fifth Assessment Report [7], according to projections, climate change will reduce both surface and underground water resources, causing an intensification in competition for water use among different sectors. In this context, urban areas will be particularly affected and will suffer to a greater extent from increased temperatures, extreme storms and rainfall, water scarcity and droughts and floods [8–11]. In Europe, the size and growth of the urban population and the increasing complexity of providing this population with all the necessary services make cities very vulnerable to the effects of climate change, making it necessary to promote adaptation measures that reduce the risks for people [12,13].

Despite the fact that domestic water use constitutes a relatively small percentage of total use, its special characteristics (in terms of legal priority and quality of the resources necessary for its supply) can cause the other uses to be displaced, sometimes generating serious situations of water deficit or stress. In this sense, it should be noted that urban water use, specifically domestic use, in the city of Valencia is above the Spanish average [14] (according to data from 2018, in Spain 133 litres per person per day, and in the Valencian community 175 l. per person per day; according to 2019 data, in Valencia 149.7 L per person per day, with great differences by neighbourhood), and frequently comes into conflict with agricultural and environmental uses, which represent a high percentage of total use.

Water resource management has been changing over time, moving from a traditional form of management based on modifying the supply to satisfy all demands, to other approaches focused on managing demand itself. The holistic approach of integrated water resources management (IWRM) has been accepted internationally as the best way to manage increasingly limited water resources and competing demands. Thus, demand management plays a predominant role in opposition to the supply approach when it comes to achieving the objectives of efficiency, environmental sustainability and equity [15]. This water demand management has been promoted by international organisations dedicated to water resources. One early example is the European Water Framework Directive [16]. Its transposition into the Spanish legal system consolidated the importance of managing these resources from a holistic perspective, by considering the economic value of water and introducing the importance of the recovery cost of resources. New holistic approaches to water resource management have led to the dominance of certain economic instruments to address water problems. However, the use of any policy that tries to affect consumer behaviour requires a detailed understanding of water demand determinants and consumers' sensitivity to those policies. That is why this article deals with the water demand with special reference to the price.

In the case of domestic water demand, the price is the main tool used to achieve the objectives of efficiency, sufficiency and equity. In the applied price structures, one can basically distinguish between uniform price structures; increasing blocks (IBT); or less commonly, increasing volume (increasing rate tariffs or IRT). The choice of the structure and the inclusion or exclusion of a fixed part in the price causes differences between the average and the marginal price paid by the user.

The focus of the analysis in this study is the domestic water demand in the city of Valencia in the period between 2009 and 2011. The analysis considers the city's different districts and neighbourhoods (intra-urban scale analysis) and specifies the average price paid for water, including all fixed and variable payments in the bill and the increasing volume price structure (IRT) used in the city of Valencia. For this, a data panel at the household level was used. Panel data models are considered most appropriate, as they can help to control multicollinearity problems and unobservable heterogeneity between individuals [17–21]. With the use of data panels at the household level, according to the literature [22,23], the estimates improve and better capture the differences in the individual behaviour of consumers.

The use of an increasing volume price structure (IRT) and data panels at the household level are the main contributions of this research. In general, as discussed below, few studies analyse the water demand in cities using this type of data due to the difficulty in obtaining such data. The use of aggregate data is the most common approach in the literature, despite the fact that the use of microdata has advantages in the estimation of domestic demand functions when explaining the consumption variability [23–33]. On the other hand, although some studies use the average price and a database of microdata, we have not found any article analysing an IRT pricing structure with a specification of the average price that includes all charges.

With an extensive database of microdata, the panel data estimation method was chosen as it has advantages over other methods. The estimates present higher degrees of freedom and provide more information by being able to determine some effects that cannot be identified using time series or cross-sectional data [34]. The estimation offers significant results for all parameters. These estimates explain approximately 34% of water consumption in the city of Valencia. Considering that the number of variables included in the model was small, we consider that the use of microdata effectively improves the estimates.

The paper is organised as follows. After this introduction, Section 2 briefly reviews the literature on domestic consumption water prices as a management instrument, the main methodologies and estimating techniques, the determinant variables of domestic water demand and block structures in water prices. Section 3 deals with data and the empirical model. Section 4 shows the estimation and the results. Section 5 offers a discussion. Finally, Section 6 presents the conclusions. In addition, the article has three appendices with tests and other estimates results, which are referenced in Sections 4 and 5.

2. Theoretical Framework

2.1. Domestic Consumption Water Prices as a Management Instrument

Traditionally, public intervention in environmental policy can take place through normative instruments, economic or market instruments and voluntary instruments [35]. Normative instruments are regulations that establish restrictions on certain behaviours considered harmful to the environment, which must be completed with control systems for punishable non-compliance (the least flexible way to introduce these instruments is the establishment of restrictions or standards). This type of instrument is considered very effective and usually has low management costs, although it is less efficient than market instruments. Economic instruments are designed and implemented with the purpose of adapting individual decisions to collective objectives. Basically, economic instruments can use price or quantity mechanisms. In the former, the regulator modifies the price through taxes or subsidies and the agents react to this change by modifying the quantities. In quantity mechanisms, the regulator intervenes by setting the optimal quantity, and the agents, through their actions, modify the market price.

In water policy, these instruments can take three basic forms [36,37]: the use of water prices to generate incentives (through tariffs or taxes), quantity mechanisms (through the use of pollution rights markets) and cooperative mechanisms (based on the voluntary adoption of new practices reducing resource pressures). The latter can be adopted without any payment (voluntary instruments) or through subsidies (price instrument).

In that way, in the field of domestic water demand management, instruments can be grouped into two categories: price instruments and non-price instruments. Price instruments have received the most attention in the urban sphere and in water resources in general. However, it is increasingly considered that economic instruments should be used in combination with non-price instruments, such as regulatory policies (e.g., restrictions on the use of water); standards or fines for non-compliance with reduction of leak rates; information campaigns and user awareness of the adoption of new consumption habits and water-saving technologies; or some incentive to adopt these new technologies [35,38].

Despite all this, the most widely used instrument in domestic water demand management continues to be price, considered a powerful instrument that constitutes an efficient information system to determine the decisions made by producers and consumers [39,40]. Since the water user must pay not only for the supply service but also for the collection, distribution and sewerage, prices can be used to encourage efficient resource use and promote the internalisation of environmental and social costs, to raise revenues, to cover the service costs and infrastructure or to achieve equity objectives [41].

To determine the total price of water, it is necessary to determine the desired objectives, the price structure that best fits the objectives (different price structures can send different signals) (price structure: rules or procedures determining service conditions and payments for various water users' categories [42]) and the form or legal nature of each payment. The requirement that the price must meet multiple objectives implies complexity in setting a domestic water consumption price [40,43,44]. Although it is possible to achieve more than one objective at the same time, there are often conflicts between them, which makes it advisable to use other instruments outside the tariff.

The different water price components can include fixed payments (independent of the volume consumed) and/or volumetric payments (depending on the quantity consumed by the user). Fixed payments can be uniform or non-uniform. That is, they may be differentiated between consumers with different characteristics (socioeconomic, meter calibre, seasonal or dwelling characteristics). In the same way, volumetric payments can also be established in various ways depending on the objectives underlying the price application. See Table 1.

IBT structures have become widespread because they can be designed so that consumers with lower consumption pay a lower price that guarantees an affordable minimum consumption for lower-income households and that consumers with higher consumption pay a higher price that helps to avoid excessive consumption. However, it is possible that at least some of these objectives are not met with the application of this type of structure because it either does not generate the necessary incentives for the efficient use of the resource or may even generate adverse redistributive effects.

Nonetheless, it is very common for domestic water prices to be "in two parts" combining a fixed charge with a volumetric rate. Therefore, different pricing structures can arise depending on whether a uniform or differentiated fixed charge and one type of volumetric rate or another applies. Thus, different objectives are achieved. The objective combination assigned to the price, the structure type proposed for each service provided and the legal nature adopted (in practice, users pay taxes, public prices, special contributions, a water surcharge and prices subject to private law, which are usually called tariffs [45]) set a total domestic water price. When prices present non-linear structures, a difference appears between the average price and the marginal price paid for a water unit.

In Spain, where, as indicated, much of the territory is subject to water stress, pricing policies in general and in cities in particular have become highly relevant in recent years [15,38,46]. In general terms, the price structures in Spain are in two parts. The fixed part depends either on the meter size (the most common) or on the home type or is associated with a minimum consumption. Only 2.9% of the population is not burdened with a fixed part. The most commonly applied variable part is IBT. A uniform tariff is very unusual (only 5.2% of the population has a uniform rate), and IRT is practically non-existent [47]. However, given that drinking water supply is a municipal responsibility in Spain, there is a great diversity of price structures [48]. It could be said that there is a different water price for each of the Spanish municipalities. In some cases, the differences are even more pronounced, since supply tariffs are not established per household (which is most common) but per capita (provided that the municipal registration is proven).

Table 1. Classification of the types of water price structures.

TYPE OF PAYMENT	SUBTYPE	DESCRIPTION	
FIXED CHARGES	DIFFERENTIATED	A fixed amount is paid that can be different for different users or groups. The differentiation can be defined by water meter calibre, season of the year, hourly discrimination, family size or income level.	
	NON-DIFFERENTIATED	An equal fixed amount is paid by all users.	
	UNIFORMS	The payment depends on the units consumed but the same price is paid for all of them.	
		INCREASING BLOCKS (IBT)	The payment depends on the consumption, but a higher price per unit is paid the higher the consumption bracket. Units are paid for at different prices.
VOLUMETRIC PAYMENTS	NON-UNIFORMS	DECREASING BLOCKS	Payment depends on consumption, but a lower price per unit is paid the higher the consumption bracket. Units are paid for at different prices.
		DIFFERENTIATED BY VOLUME (VDT or IRT))	The payment depends on the consumption, but a higher price per unit is paid the higher the consumption bracket. Units are paid at the same price (as of the last consumption block)

Source: Authors.

Another important issue when comparing the prices paid for water in Spain is progressivity analysis. This progressivity can be measured considering only the variable part of the prices [49] or considering both the fixed and variable parts. In this second case, a price will be progressive if, when consumption increases, the average price paid per m^3 is higher. This depends on both the fixed charges applied and the structure of the variable part: the greater the proportion of fixed charges in the total bill, the greater the escalation of the variable part must be to achieve an average price that grows with consumption. Hence, the design diversity of water prices in Spain has a strong influence on both the price levels paid by water consumers and the tariff progressivity.

2.2. Estimation of Domestic Water Demand: A Literature Review

In this section, a review of the literature on the estimation of domestic water demand is carried out. This review is limited to water demand studies in urban areas in developed countries due to the differences between developed and undeveloped countries in terms of water needs and management possibilities [50]. The main methodologies and techniques used in the estimates and the variables used in the literature to explain domestic water demand are examined.

2.2.1. Main Methodologies and Estimating Techniques

Studies dedicated to water demand analysis for urban or domestic uses are numerous. In the 1960s and 1970s, the first studies of urban water demand in North American cities were published using aggregate data [51–53]. Since then, the study of urban or domestic water demand has been approached from different perspectives and using different methodologies. Accordingly, the results have also been diverse.

A set of studies [17,19,54,55] have reviewed the contributions to the estimation of urban water demand, synthesising the main determinants, the variables used and the methodological problems present in the literature. Some reviews [17,19] basically use the variables employed to estimate the demand for water for residential or domestic uses as criteria for classifying academic research. Other studies [55] that also review the contributions to the literature as a synthesis of the different determinants of urban water demand emphasise variables of a sociodemographic nature, in which other disciplines (such as geography or demographics) can add value to the advances made in this field by economists. Other approaches [54] review methodological developments in modelling urban water demand since the 1980s based on four main areas: scale, uncertainty, non-linearity and dynamic models.

In the literature, domestic water demand analysis has been approached using both different functional forms and different estimation methodologies and techniques. The choice of a linear function is common in the literature, although a possible criticism is its easy estimation [17]. A linear demand function implies that the elasticity is lower for lower prices, but the quantity variation before a price change is the same for any price level. On the other hand, a linear function includes the possibility that, for a given price, the water consumption is 0, which seems counterintuitive in principle, but it also admits the intuition that, for a zero price, the consumption is positive. Despite all this, many authors have used this specification in their work [25,26,56–63].

Another functional form used in studies of water demand is the double logarithmic functional form, which implies constant elasticity for any price level and has the advantage of being able to directly interpret the parameters in elasticity terms. This functional form, despite having been criticised for being inconsistent with utility theory, has been the chosen functional form (together with the semi-logarithmic functional form) in different analyses [17,27,64–69].

The urban water demand study from the equity perspective led to the estimation of Stone-Geary demand functions (Stone, 1954), revealing the part of domestic consumption that is insensitive to prices changes. This makes it possible to determine the consumption volume considered basic and to draw conclusions about the equity or acceptability of the different price structures [70–76].

The choice between one functional form or another has been incorporated into research by introducing the comparison between different functional specifications in the analyses [70,73,76–78]. Different tests are often used (box-cox, Ramsey test; Akaike's information criterion or Schwarz's criterion, among others) to choose the most appropriate functional form from the available data set [18,24,28,30].

The results obtained in the demand estimates were synthesised using meta-analytic regression. Some studies have reviewed the main results in the price and income elasticities obtained in the urban water demand estimates [18,24] or have added household size estimates obtained in the meta-analysis [50]. The results and conclusions of these three meta-analytical estimates were very similar. It is accepted that domestic water demand is inelastic with respect to price and that, therefore, it generally presents values lower than 1. The average price elasticity obtained for developed countries ranges between -0.51 [24,79] and -0.378 [50]. However, the ranges of the estimates of the works used for the meta-analytic regressions are very wide, ranging from values very close to zero to values above -1 [26,27,60,80]. Additionally, the works using microdata show higher price elasticity values than those that use aggregate data. Uniform tariffs increase the price elasticity. Techniques other than OLS offer greater elasticities (especially those studies that use DCC models in which the mean elasticity values are above −1) and obtain greater elasticities in the long term than in the short term [81].

Therefore, the results obtained in the demand estimates are very varied and the values range of the estimated price elasticities is too large to be conclusive [82]. The differences in the results of the different studies can be attributed to several causes, including local differences and difficulty in capturing heterogeneity in consumer behaviour.

The revenue effect on water consumption resulted in elasticities with a positive sign (although with small values), indicating that water is a necessary-normal good. The revenue elasticity was estimated in a range between 0.1 and 0.4 [17]. The results obtained for the elasticity related to family size offered positive values less than unity (a meta-analysis mean value was 0.484 [50]).

2.2.2. Determinant Variables of Domestic Water Demand

The literature on estimating urban water demand has provided information on the determinants that affect consumers' decisions about the amounts of water they use at home. The variables incorporated in the different studies are very varied due to the characteristics of the study areas analysed or the incorporation of a specific objective into the analysis. The explanatory variables can be grouped into those that refer to the consumers' socioeconomic characteristics (revenue, size and composition of families or educational level), those that indicate dwellings' characteristics (surface area, size, facilities or type of housing), those that have to do with the urban structure (gardens, swimming pools or land use) and those related to the users' preferences (conservation, consumption habits or technology adoption). In studies that use data from different geographical areas or in which the aim is to capture seasonality existence in consumption, some measure of temperature or precipitation is also included as an explanatory variable [62,69,83].

Different measures have been used for the revenue variable in the literature depending on the data availability. In the studies using aggregated data (municipalities, provinces or countries), some aggregate measure was used, such as average gross disposable income [71]. In household level analysis, few studies have used some measure of personal or family income [29,31], and it is usual to use a proxy variable for the variable income [17]. The most commonly chosen proxy is the cadastral value of the housing property [28]. Another alternative is to construct a monthly income proxy variable (using the cadastral value and the interest rate of mortgage loans adjusted with the average wage change for manufacturing workers in the period considered) [26].

In other cases, the following are used: the average salary of a worker in the autonomous community with the age and educational level of the head of the family [30] or virtual revenue (wages corrected by Nordin's difference variable) [34,72,83]. In studies using microdata, it is very common to find an approximation to household income levels through variables such as studies levels, housing surface, number of cars or some combination of them variables [17,19].

The effects of the family size and composition on water demand are other topics covered in depth in various studies [47,84]. Households with more members tend to consume more, although scale economies in water consumption cause the increase in consumption to be less than proportional to the increase in the number of people in the household [50].

Other studies consider that consumers' age is relevant in consumption decisions and include (as an independent variable) some measure of the age distribution in the study area [73,75,85–87]. The age effect on water consumption and on consumers' response to price changes is misleading, as households with younger people are expected to consume more and respond less to prices due to a greater need for uses related to hygiene but older people have more time to spend at home and on activities such as gardening [87,88]. Education level is considered a relevant variable to explain domestic water consumption. People with higher levels of education are expected to have a better predisposition to adopt conservation habits [63,76,84,89]. Additionally, the differentiation between property and rental has been considered, but in the case of Spain, it is non-significant due to the high rate of home ownership [87].

Two variables usually included in models are surface area and dwelling age, as these data are relatively easy to obtain. It is expected that the larger the surface area of a dwelling is, the higher the water consumption will be due to its positive relationship with other variables such as family size, revenue levels and the greater number of water points. The housing age results are more confusing. An older house is expected to have fewer water-saving devices, but also to be occupied by older people with higher income levels [89].

Other more specific and difficult characteristics to obtain (especially at the household level) are number of bathrooms, availability of air conditioning, differences between outdoor and indoor consumption, existence of swimming pools and availability of certain electrical appliances [31,69,87,90–93]. Most of the studies including these types of variables are obtained from surveys and are significant when explaining differences in consumption.

The introduction in the analyses of some type of variable that allows analysis of the consumer's response to differences in the information included in water bills has been significant in some studies (more information, greater consumer response to prices) [94,95], but not all [87]. Other studies have examined the effect on consumer behaviour of information campaigns and education and conservation programs [64,96,97] or the influence of structural and contingent factors [98].

Finally, the effect on the demand and on the behaviour of domestic water consumers has been analysed through the installation of so-called smart meters. The advantage of these meters is that they offer a large amount of information both to the service provider (who can analyse users' behaviour) and to consumers (about how much water they are consuming) [99–101].

2.2.3. Block Structures in Water Prices

The problems in estimating an urban water demand function when the price schemes are non-linear have been explored in numerous articles from different perspectives: the tariff design or the evaluation of the objectives of economic efficiency, environmental sustainability or equity of urban water tariffs [15,102,103], the effects of block structures on water prices [26,27,57,104], and the comparison between different pricing structures. An IBT-con (in which the tariff depends on the total household consumption) was compared with an IRT-cap (in which the tariff depends on per capita consumption), revealing that the latter is more effective in achieving its objectives [105]. The effects on the price elasticity of the application of an IBT with a uniform price (UP) have also been examined [31].

The non-linearity in prices causes a problem in this variable specification. This is discussed extensively in the literature. Non-linear price structures in urban water services lead to differences between the average price and the marginal price that consumers pay for water. A perfectly informed user should react to the marginal price [83], but in the case of imperfect or incomplete information, the consumer may react to another measure such as the average price [67,95,106] or some combination of both [26,64,66].

In the presence of block pricing structures and fixed charge water bills, it is difficult to capture the variation effect in intramarginal tariffs on consumption (that is, those of the blocks price not corresponding to the usual level of consumption if the marginal price is taken as a measure) [17]. An intra-marginal tariff variation only affects consumers through a revenue effect. In order to include this revenue effect in the demand estimation, the introduction of a difference variable was proposed. This was defined as the total invoice value minus the invoice value if all units were paid at the marginal price [107,108]. Thus, consumers are considered to react to the marginal price plus this variable that adjusts the effect of the intramarginal tariff and fixed charges [26,85,109–111].

Water consumers are usually unaware of the true price structure applied and are not willing to assume the information costs involved in knowing it. Therefore, it is easier for them to react to changes in average price than marginal price. This is the argument in favour of using the average price instead of the marginal price or the marginal price adjusted by the difference variable [17]. In general, the choice of measure is an empirical question related to the consumer's perception of each of the ways of quantifying the water price [33,58]. In turn, the different price structures applied to water consumption or the complexity of the bills influence which is the most appropriate price measure in the study of water demand [95].

A proposed model to empirically measure if water consumers react to the marginal price or the average price in the presence of non-linearities was adapted from one on electricity demand. This model incorporated a price perception variable that was a combination of average price and marginal price applied to residential electricity consumption. An electricity demand model with decreasing block rates allowed estimation of a price perception parameter [112]. This model was applied to the domestic water demand to determine if the perception of water price changes in the presence of increasing or decreasing block tariffs [26,64,66]. Recent research on price perception suggests that consumers respond to the mean price [80] and that the perceived price underestimates the true price [33].

Regarding the studies that have made estimates of the price elasticity of the water demand in Spanish cities, 60% of them use the average price [28–30,32,71,91] and 40% use the marginal price together with the Nordin difference variable [32,72,83,85].

Additionally, related to the price variable, many studies have investigated its optimal design in urban areas [29,113–115] and the evaluation of the capacity of different structures to achieve different objectives [41,116–120].

Finally, some studies that have tried to determine the causes of price differences in Spain concluded that climatological (relative scarcity) and political factors influence price diversity [49,121]. The extremely atomised local panorama and the strong power of regional governments have led to a highly complex system with a wide range of water price levels and structures [48]. The climatic differences among Spanish geographical areas generate different price elasticity values. Whereas the estimated average elasticity for the whole of Spain is −0.29, the average elasticity value for the entire Mediterranean area is −0.41. This is the second largest of the five climatic areas, behind the northern area, which has an elasticity of −1.32 [122].

3. Data and Empirical Model

3.1. Data

The population studied corresponds to the total number of users of the domestic water supply service (water consumption is associated with providing a household, not a person). A representative random sample of the city of Valencia was obtained by proportional allocation of each neighbourhood over the total city. This sample enables analysis of domestic water demand in the city of Valencia through its different districts and neighbourhoods. From an administrative point of view, the city of Valencia is divided into 19 districts and 87 neighbourhoods. In socioeconomic terms, there are important differences among them that can affect the behaviour of drinking water consumers. Figure 1 shows a map of the boundaries of the districts and Figure 2 a map of the neighbourhoods according to the current territorial division. The districts are numbered from 1 to 19, while the neighbourhoods are coded using two figures. The first neighbourhood digit indicates the district to which it belongs (this coding was used in our analysis).

The data used in the estimates make up a data panel with information from 4023 homes in the city of Valencia between 2009 and 2011 assigned to the different districts/neighbourhoods of the city. The available sample information consists of the bimonthly consumption of each household (m^3 of water invoiced), the number of people who living in each dwelling (according to the municipal register), its surface area and age.

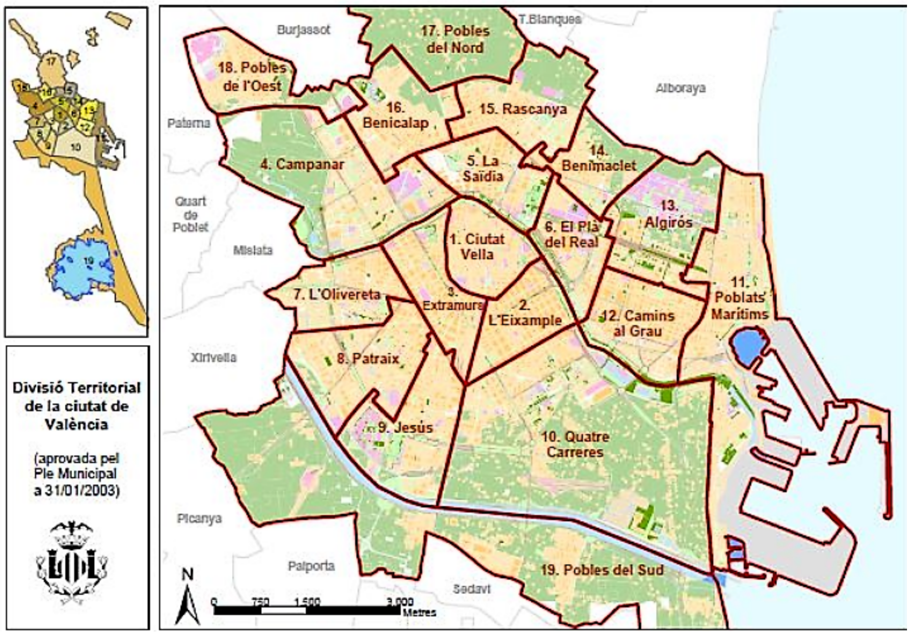

Figure 1. Territorial division of the city of Valencia: districts. Source: Valencia City Council.

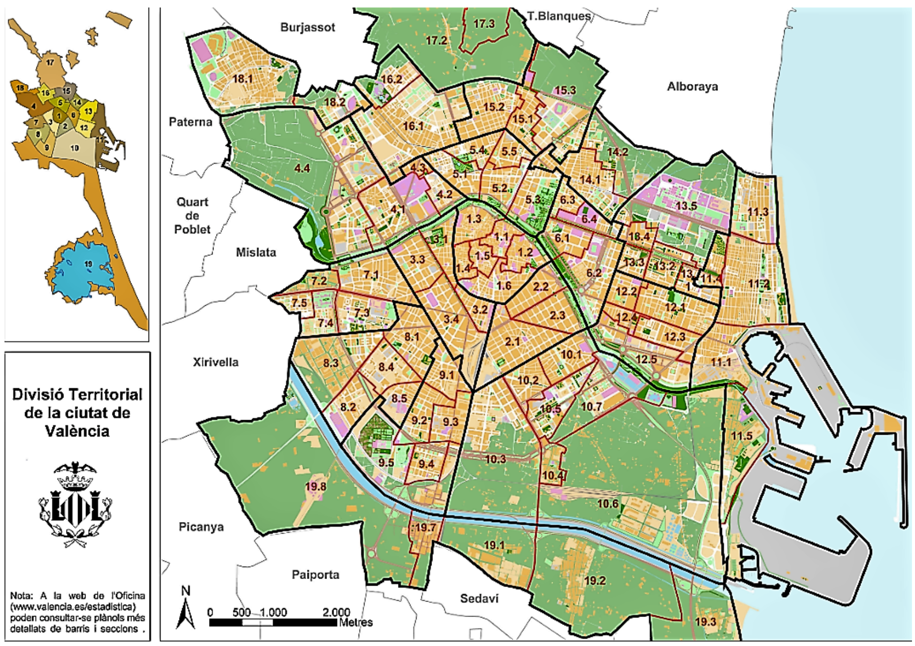

Figure 2. Territorial division of the city of Valencia: neighbourhoods. Source: Valencia City Council.

The consumption data (billing and cubic meters) were obtained from the company Aguas de Valencia (EMIVASA). The specification of the price variable chosen in this study is the average price per m^3 paid every two months by the users. This is obtained by dividing the total billed in each period by the cubic meters consumed.

The water bill in the city of Valencia includes all the payments that a user must make for the services that make up the urban water cycle. Therefore, payments for supply, sewerage and sanitation are included. Each of these payments has a different structure so the bill is extremely complex for consumers. However, this set of payments that the consumer makes in each of his invoices can be summarised in a simple structure of the water price. This consists of a fixed part and a volumetric part (€/m^3). The latter will be different depending on whether the user consumes more or less than 12 m^3 in the two-month period (IRT tariff with two blocks).

As a result of applying this structure, average prices are always higher than marginal prices for two reasons. On the one hand, the fixed part is very large with respect to the variable part (the percentage that the fixed part represents on the total invoice is above 60% in the entire period considered). On the other, the variable part it is very little progressive.

The lack of progressivity in the tariff is due to the application as an IRT and not as an IBT, the small price difference existing between the two consumption blocks, and the existence of only two blocks with a very small limit (12 m^3), especially if we consider that this limit is per dwelling and not per capita.

The total billed includes, in addition to the fixed and variable parts of the current price structure in Valencia, the payment of the waste tax (TAMER) that users of water supply service in Valencia have to pay together with the water bill. Thus, the average price paid for each dwelling in each period (two-month period) is obtained from the water consumption made and the application of the current tariffs and charges.

The fact that the TAMER tax was not yet included in 2008 meant that the data for that year could not be used because their inclusion would distort the estimates. Therefore, the data panel only considered information from 4023 households for three years (from 2009 to 2011) with bimonthly water consumption data (18 data during the analysis period). Thus, the sample size was 72,414 (4023 × 18). However, since there is a problem of endogeneity between price and consumption (as explained later), price was lagged for one period (one two-month period), and another 4023 data were lost. Thus, the final data set contained 68,391 records.

The household size (total built surface expressed in m^2) and the dwelling age data (the construction year of the main premises) were obtained from the electronic cadastral register. The family size was obtained from the municipal register for the year 2011.

To measure the revenue levels of each dwelling, two approximations were used given the impossibility of obtaining data for this variable at the household level. An approximation of value for each dwelling was calculated by multiplying the mean cadastral value of the neighbourhood where it is located by its total surface area. As this variable presented multicollinearity problems, only the variable surface was included as an approximation of the household income. From the 2011 census, five wealth indicators—proportion of people aged 16 years or older with university studies, proportion of people aged 16 years or older with studies, occupation rate, number of cars per 100 inhabitants and proportion of passenger cars over 16 hp—were selected and used to replicate the synthetic income level indicator for the different districts and neighbourhoods, following the methodology used by the Valencia City Council Statistics Office to calculate this income indicator in 2001 [123]. Thus, a single value indicated the relative socioeconomic level of each neighbourhood in the city.

3.2. Empirical Model

From the definition of the variables in the previous section, the general expression of the domestic water demand to be estimated can be specified as:

$$Y_{it} = f(X_{it}, AP_{it}, Z_i) \tag{1}$$

where Y_{it} is the consumption of each household i in each period, t and X_{it} are the socioeconomic variables of each household in each period, AP_{it} is the average price of each household in each period (total of the bill divided by m^3 consumed in each period) and Z_i denotes the variables related to dwellings that do not vary over time.

With a panel data sample, there are data for each of the i study units (SUs) for each period of time t that capture unobservable differences in behaviour. The origin of these differences may be differences among the SUs or among time periods. Depending on the source of this difference, the specification and estimation of the models change. In the first case, SUs with the same observable characteristics behave differently due to the existence of factors specific to each SU that are unobservable. In the second case, the same SU can behave differently in different time periods due to unobservable temporal factors. The unobservable individual and/or temporal effects should be considered in the model specification to avoid a biased estimation of the parameters that capture part of these effects.

According to the objective of the analysis, the model can be specified as constants coefficients, panel data with individual effects, panel data with temporal effects or a panel data model with individual effects and temporal effects. To specify the appropriate model when a panel of data is available, it is necessary to determine whether the model heterogeneity comes from the independent term or only from the error term. That is, it must be tested whether a pooled model specification is better than the other three, using tests such as the Lagrange multipliers test and the F-test [124].

If the data pool specification is ruled out, the choice between fixed effects or random effects is based on comparing the estimates using the Hausman test. If there are systematic differences between the two estimates, the equality null hypothesis is rejected, and there is correlation between regression error and regressors (Cov (X_{it}, u_{it}) $\neq 0$). In this case, it is preferable to use fixed effects with consistent estimates. If the null hypothesis is accepted, the random effects model with more efficient estimates is preferred.

In this paper, the determination of the functional form used in the model and the way to solve the endogeneity problem (the price lagging for one two-month period is a solution to solving the endogeneity problem caused by the price specification as the average price while also allowing one to overcome the lack of consumer information on the price structure [17,54]) was previously established through tests (see Appendix A). (From the point of view of consumer behaviour, the user should react to a greater extent to the price invoiced in the previous period than to that of more distant periods. That is why in the case of the city of Valencia, where billing is not monthly but bimonthly, it has been ruled out using an outdated price for more than one period (two bimesters or more), since it does not improve the model either.) The functional form that best specified the model was a log–log form. This functional form allows price-consumption elasticity to be directly estimated (interpretation of the parameter as the value of the price elasticity).

The basic panel data model used explains the household water consumption in the period (C_{it}) according to the price paid by the household in the previous period ($P_{i,t\text{-}1}$), the housing surface (S_i), the number of individuals per dwelling (I_i), the revenue (R_i) and a neighbourhood fixed effect (γ_k):

$$log(C_{it}) = \beta_0 + \beta_1 log(P_{it-1}) + \beta_2 log(S_i) + \beta_3 I_i + \beta_4 log(R_i) + \sum_{k=2}^{k} \gamma_k N_k \quad (2)$$

The variables of the model have been included in level or in logarithms depending on the more natural interpretation of their coefficient, given that the model's explanatory capacity does not depend substantially on this decision. For example, surface is expressed in logarithms and we speak of a percentage increase in the surface, whereas the number of individuals is expressed in level and we speak of an increase of one person in the household. The synthetic indicator irenta was included in the model to capture the revenue effect on consumption (Ri). Instead of this synthetic indicator, the five variables defining it could be included in the Equation (2). The dummy variable neighbourhood takes a value of 1 if household *i* belongs to neighbourhood *k* and zero otherwise, taking the Carme neighbourhood as the reference (neighbourhood 1).

4. Estimation and Results

Panel data techniques were used for estimating pooled, fixed and random effects with the temporary effects. The estimated model was a basic panel data model that included a neighbourhood fixed effect to capture differences in consumption by neighbourhoods in the city of Valencia. The (individual) household effect was not considered due to the high number of households in the sample and because the neighbourhood fixed effect included already captured much of the heterogeneity between households (at least that related to the neighbourhood to which the households belong).

The irenta variable was not significant in the models including the neighbourhood effect (it ceased to be so when this fixed effect was included), so the income index is fully captured by the neighbourhood effect. Thus, given that the neighbourhood fixed effect captures the same information and that the income index construction can be criticised, we decided to exclude the income index from the model. Neither of the five variables defining it turned out to be significant. Therefore, they were also excluded from the model. Hence, the estimated model is:

$$log(C_{it}) = \beta_0 + \beta_1 log(P_{it-1}) + \beta_2 log(S_i) + \beta_3 I_i + \sum_{k=2}^{k} \gamma_k N_k \tag{3}$$

Table 2 shows the estimates of the model with the three estimation methods. Furthermore, Appendix B includes the value sof the time effects in the fixed effects estimate (Table A3), and the idiosyncratic error and the variance of the time random effects (Table A4). This random time effect explains 1.2% of the variability observed in household consumption.

Table 2. Basic model estimation results. Pooled, fixed and random effects.

	Pooled	**Fix**	**Random**
Intercept	2.2989 ***		2.3054 ***
	(−0.0426)		(0.0446)
log (lag Price)	−0.8736 ***	−0.8767 ***	−0.8766 ***
	(0.0061)	(0.0061)	(0.0061)
log (Surface)	0.2440 ***	0.2434 ***	0.2434 ***
	(0.0078)	(0.0078)	(0.0078)
Individuals	0.0727 ***	0.0725 ***	0.0725 ***
	(0.0015)	(0.0015)	(0.0015)
Neighbourhood fixed effect *	Yes	Yes	Yes
R2	0.3402	0.3417	0.3417
Adj. R2	0.3395	0.3408	0.3409
Num. obs.	68,391	68,391	68,391

*** $p < 0.001$ * $p < 0.01$ *** $p < 0.05$.

Once the model had been estimated with the three methods, it was necessary to determine which of them was more appropriate. The Lagrange multipliers test and the F-test were carried out in order to test whether the pooled estimate was preferable to the random effects and fixed effects estimates (see Table A5 in Appendix B). These tests indicated that both the random effects and the fixed effects estimates were preferable to the pooled estimate. In turn, for the choice between the fixed effects and the random-effects, the Hausman test was applied (see Table A6), identifying the random estimate as the most appropriate.

Subsequently, it was tested whether the residuals verified the non-correlation hypothesis and homoscedasticity. The Breusch-Godfrey/Wooldridge correlation test for panel data (see Table A8) confirmed that there was a correlation in the residues vector. Likewise, the Breusch-Pagan test confirmed the existence of heteroscedasticity of the errors (see Table A8).

In the presence of correlation and heteroscedasticity, a robust variance estimation was performed using the Arellano method [125]. The main difference between the results of the previous model (Table 2) and the robust estimation of the variances of the coefficients is the loss of significance of the neighbourhood effect (see Table A9). In order to determine whether its effect was still significant overall, the joint significance of all the coefficients of the neighbourhood factor was tested using the Wald test. The test results indicated that the neighbourhood was still significant (Table A10).

5. Discussion

The four variables of the basic model are significan, regardless of the estimation method considered, and the coefficient values hardly change. The variables included in the model explain 34% of the variability in water consumption demand.

The domestic water demand elasticity at the average price in the city of Valencia was estimated at −0.88, which indicates an inelastic demand at the average price of the previous period. That is, consumers in the city of Valencia decrease their water consumption by 0.88% when the average price per m^3 increases by 1% in their bill from the previous period (two months ago).

This estimated value is in line with the results obtained in other studies [18,24,50], although somewhat above the average. The average price elasticity obtained in our estimates is higher than the elasticity estimated in studies of other Spanish cities [28,30,71,72,85]. This difference can be justified considering that the data are different (data panel), with a higher level of disaggregation at both the household and temporal level (bimonthly frequency), and the price specification (average price included both the fixed part of the supply tariffs and the fixed part corresponding to the TAMER tax, which can cause consumers to overestimate the price and react more strongly to its changes). In addition, the water price structure in Valencia is completely different from that of any other Spanish city studied to date.

On the other hand, it is possible that we are capturing changes in consumption that are due to variables other than price, although they ultimately cause a change in the average price. In this sense, in the last period (2010–2011) there was an increase in consumption with an increase in the average price [55].

In the same way, the elasticity value was influenced by some characteristics of the area that were not considered in the model. Very few studies refer to the fact that, traditionally, bottled water consumption is very high in the Valencian community, particularly in the city of Valencia. According to data from ANEABE (Spanish Association of Bottled Water Companies), the Valencian community has the third highest consumption of bottled water of any Spanish region [126]. In Valencia, the consideration of bottled water as a substitute for tap water may influence the elasticity value.

The proportion that water spending represents within the total family budget is one of the factors used in the literature to explain the low price elasticities in domestic demand [87]. In the period considered in this study, consumer income decreased while water prices rose. The introduction of the Tamer tax in 2009 meant, in some cases, a significant increase in the average price and the total bill. This implies that, on average, there may have been an increase in the proportion of water expenditure within the family budget. This may explain the greater sensitivity of Valencian consumers to price changes.

The estimated surface parameter is 0.24, which implies that 1% more surface area in the average home implies 0.24% more water consumption. The consumption elasticity value with respect to house size is positive and less than 1. Therefore, the larger the house size is, the greater the consumption will be. Since the household size may be associated with income levels, the estimated value could be interpreted in such a way that water consumption could be classified as a normal and necessary good, with values that may be an approximation to a revenue elasticity less than unity.

The estimation of the parameter associated with the individuals per household was 0.072. As this variable is defined in levels, the interpretation of the estimated parameter indicates that one more person in the home increases water consumption by 7.2%. In other words, an increase of 1 person increases the average size of families (2.55) by 39%, which leads to an increase in consumption of 7.2%. Therefore, an increase in family size will increase consumption less than proportionally, which could indicate the existence of economies of scale in consumption [17,19,32,47].

The neighbourhood fixed effect includes the factors related to the household characteristics that affect water consumption and that are not included by other variables of the model (resident average age, household composition revenue, etc.). In view of the estimation results, the average water consumption differs significantly in some neighbourhoods. Table A11 in Appendix C shows the percentage difference in water consumption in each neighbourhood with respect to the average in Valencia. Therefore, households in the Exposició and Ciutat Universitària neighbourhoods, both of which are in Pla del Real (District 6), consume on average 10% more water than the average across Valencia. At the other extreme, neighbourhoods of Penya-roja (District 12), La Roqueta (District 3) and Sant Pau (District 4) consume between 12% and 13% less than the average across Valencia.

To complete this analysis, the results of the neighbourhood fixed effect are presented on two maps that represent the consumption differences of each neighbourhood with respect to the city average for all periods. Figure 3 shows the results divided into two categories that represent the neighbourhoods whose consumption is above and below the average. Almost without exception, the neighbourhoods whose consumption is above the average are located in the southeast (the lower part of the map). None of the neighbourhoods that are above—La Petxina (033), El Calvari (043) and Ciutat Fallera (162)—exceed a consumption difference of 3%. Figure 4 represents the same results but divided into four categories. Within the neighbourhoods that consume above or below the city average, the greatest differences are highlighted.

Finally, from the results of the time effect estimated in the random model (Table A3 Appendix A), the most prominent effect is that, in summer, water consumption is reduced by between 5% and 10% compared to the annual average. This reduction was especially marked in the last two years (Figure 5). This behaviour seems to indicate a situation similar to that of the city of Zaragoza, which has been justified based on the non-significance of outdoor water use in those months, when many people go on holiday [30].

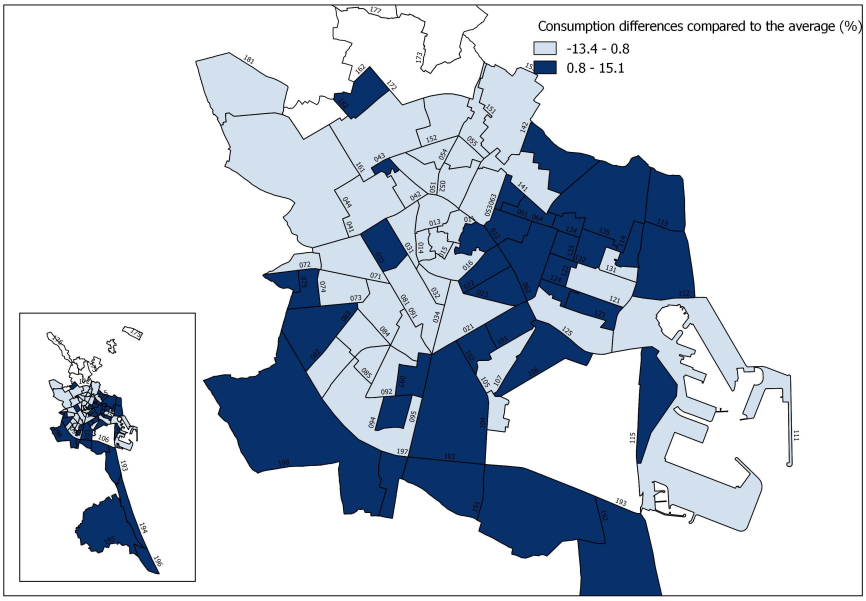

Figure 3. Neighbourhood effect map. Consumption differences (two brackets). Source: Authors.

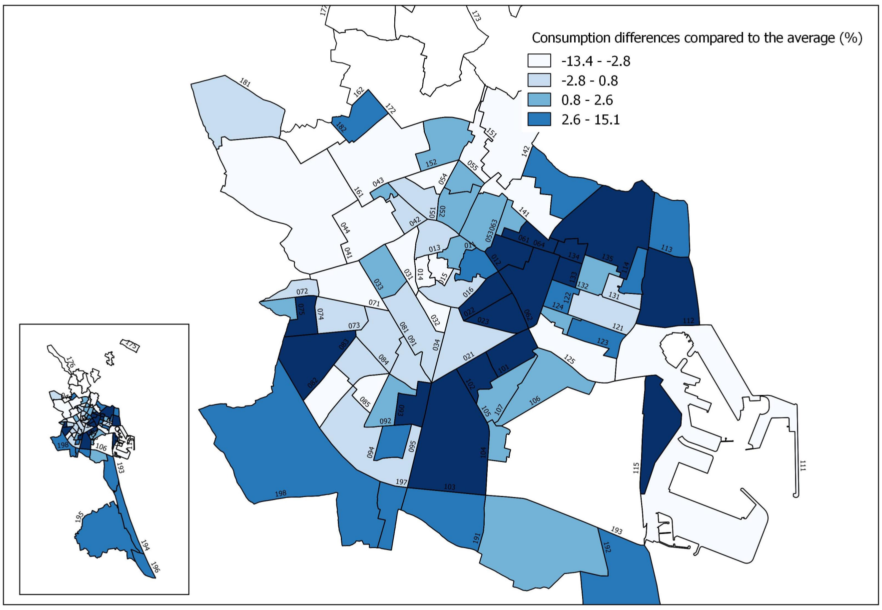

Figure 4. Neighbourhood effect map. Consumption differences (four brackets). Source: Authors.

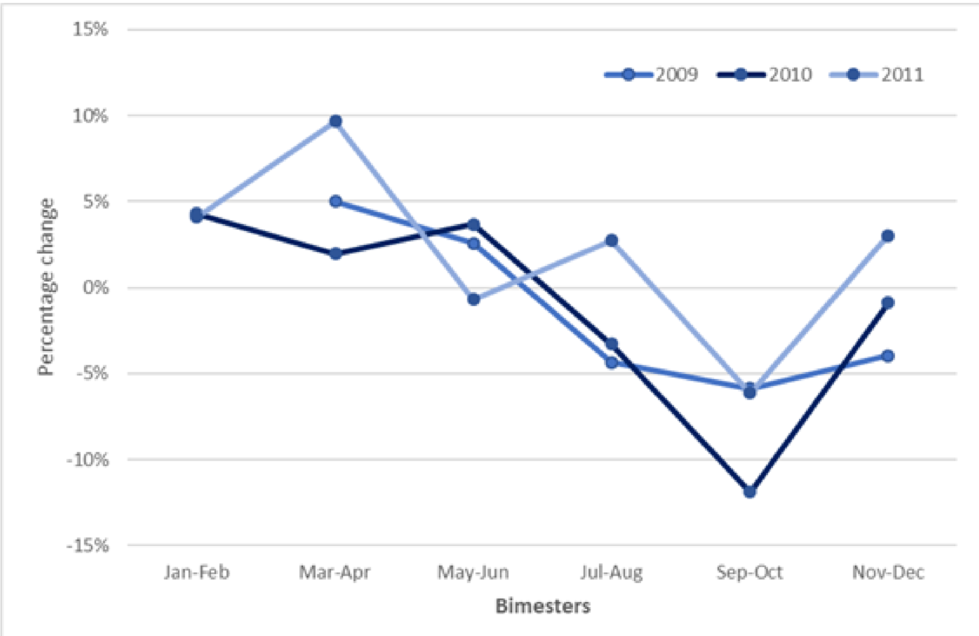

Figure 5. Random model time effects (2009–2011).

All in all, this study has certain limitations. The analysis presented is feasible because we use the average water price variable lagged one two-month period because it guarantees enough variation in the water price variable. With the use of marginal water prices, the within-variation would probably have been insufficient for a panel data analysis.

A second limitation is related to the fact that when you have a lot of data and a small model (as in this work) it is very possible that any null hypothesis will be rejected and that very small p-values will be obtained. The cause of rejection can be a very small and unimportant deviation from the null model.

Lastly, the lack of data availability at the household level means that this study does not include two important elements in water demand. The first is a technical variable (technology improvement) that affects water use because an technology improvement reduces water consumption without a negative impact on welfare (e.g., washing machines and dishwashers). The second one is associated with socioeconomic changes not related to the level of education of the population (environmental consciousness, water saving programs, etc.).

6. Conclusions

Despite many studies that examine the domestic water demand and some studies of various Spanish cities, there was hitherto no study of domestic water demand in the city of Valencia. The results in the literature reveal local differences in domestic water consumption. In this context (local character of domestic water consumption), this study tested the extent to which consumers in the city of Valencia are sensitive to changes in water prices. By doing so, this study contributes to broadening knowledge of the behaviour of drinking water consumers in a different geographical area. Moreover, the use of microdata is very limited in the literature due to the great difficulty in achieving representative samples at the household level. However, considering the small number of variables included in the model, it may be concluded that microdata use effectively improves estimates.

The prospect of a reduction in the water supply due to climatic factors and an increase in demand as a result of population growth will intensify situations of water stress. For this reason, managing domestic water demand use is of great interest (despite not representing a significant percentage of total use). In this sense, studies like this one can provide managers with knowledge that can lead to a better application of economic instruments (prices and taxes) to urban water demand.

As future lines of research, to overcome unobservable heterogeneity problems, the domestic water demand function should be estimated using a multilevel or mixed model and a quantile regression model. By specifying random effects using neighbourhood and time, the mixed model would allow us to delve into the differences in consumption behaviour between city neighbourhoods, introducing the neighbourhood and time random effects both in the intercept and in the slope of the function. With the analysis of the domestic water demand using a quantile regression model, consumers could be divided into five quantiles that represent their water consumption levels, and their behaviour could be estimated depending on the quantile. Through this methodology, it would be possible to analyse consumers' behaviour within each neighbourhood to capture the heterogeneity between individuals and between neighbourhoods. The estimation of this model would allow us to obtain both the consumption differences in levels and the elasticity differences of each consumer group.

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Appendix A

To choose the most appropriate form for the function, a linear and a log–log functional form were compared. The Akaike information criterion (AIC) was used to measure the relative quality of models for the available data set. Table A1 shows the AIC and corrected AIC values for a linear specification and a log–log specification. The log–log model shows greater explanatory power (a lower value of AIC).

Table A1. Akaike information criterion (AIC).

Functional Form	AIC	Corrected AIC
Lineal	469,644.6	
Log-Log	−55,891.8	314,405.8

Table A2 shows the Wu–Hausman test. With a p-value lower than 0.05, there is an endogeneity problem between average price and consumption.

Table A2. Wu–Hausman test.

	df1	df2	Statistic	p-Value
Weak instruments	1	68,312	16.908.414	0
Wu-Hausman	1	68,311	4.002.546	0

Appendix B

Table A3 includes the values of the time effects of fixed effects estimates. Each result shows the relative change in a period (a bimester) with respect to the mean of all periods. Table A4 shows, in the random effects estimate, the error variance (idiosyncratic) and the variance of the time random effect for the random estimate, the part of the variability in consumption that is explained by a time effect.

Table A3. Time effects of the fixed effects model (year and bimester).

	2009.2	2009.3	2009.4	2009.5	2009.6
	0.049927833	0.025831227	−0.43458494	−0.58610564	−0.039611617
2010.1	2010.2	2010.3	2010.4	2010.5	2010.6
0.042817454	0.019576919	0.036793129	−0.32691482	−0.118683849	−0.008752134
2011.1	2011.2	2011.3	2011.4	2011.5	2011.6
0.040897591	0.096527977	−0.006905997	0.027413934	−0.0613	0.030217067

Table A4. Basic model variances.

	Variance	SD	Share
Idiosyncratic	0.273057	0.522549	0.988
Time	0.003193	0.056507	0.012

In the Lagrange multipliers and F-test (Table A5), a p-value less than 0.0001 indicates the pooled model is discarded.

Table A5. Lagrange multipliers and F-test.

	Contrast Function	df1	df2	p-Value
Lagrange multipliers	χ^2 = 12,222	1		<0.0001
F-test	F = 41.71	16	68,299	<0.0001

In the Hausman test (Table A6), if the p-value is greater than the preset significance of 5%, then the random effects estimate is preferable to the fixed effects estimate.

Table A6. Hausman test.

	Contrast Function	df1	p-Valor
HAUSMAN	χ^2 = 0.38926	75	1

In the Breusch–Godfrey/Wooldridge correlation test for panel data (Table A7), a lag order of six was set to capture the possible seasonal component of order six (six bimesters per year). The *p*-value indicated that there was correlation in the residual vector.

Table A7. Breusch–Godfrey/Wooldridge test.

	Función de Contraste	df1	*p*-Value
Breusch-Godfrey/Wooldridge	χ^2 = 21,479	6	<0.0001

The Breusch–Pagan test (Table A8) to test the errors' homoscedasticity showed that there were heteroscedasticity problems (*p*-value less than 0.0001).

Table A8. Breusch–Pagan test.

	Value	df1	*p*-Value
Breusch-Pagan	6135.3	75	<0.0001

Table A9. Results of the robust estimation of the basic panel model.

	Estimate	Std. Error	t Value	Pr(>|t|)		Estimate	Std. Error	t Value	Pr(>|t|)
(Intercept)	23.053.594	0.1007629	22.8790	$<2 \times 10^{-16}$ ***	f(n)08.Vara Quart	0.0734184	0.0534231	1.3743	0.16936
log(lagprice)	-0.8766047	0.0167545	−52.3204	$<2 \times 10^{-16}$ ***	f(n)09.Cami Real	0.0112424	0.0550100	0.2044	0.83806
log(Surface)	0.2434381	0.0184463	13.1971	$<2 \times 10^{-16}$ ***	f(n)09.l'Hort Sanabre	0.0154626	0.0473300	0.3267	0.74390
Individuals	0.0724920	0.0042410	17.0931	$<2 \times 10^{-16}$ ***	f(n)09.la Creu Coberta	0.0604878	0.0581062	1.0410	0.29788
f(n)01.el Mercat	−0.0201751	0.0576685	−0.3498	0.72645	f(n)09.la Raiosa	0.0107683	0.0449136	0.2398	0.81052
f(n)01.el Pilar	−0.0531249	0.0562933	−0.9437	0.34532	f(n)09.Sant MArcel·li	0.0346893	0.0509436	0.6809	0.49591
f(n)01.la Seu	0.0158901	0.0689958	0.2303	0.81786	f(n)10.Ciutat Arts	0.0300390	0.0509568	0.5895	0.55553
f(n)01.la Xerea	0.0458530	0.0801007	0.5724	0.56702	f(n)10.En Corts	0.0561173	0.0517121	1.0852	0.27784
f(n)01.Sant Francesc	0.0030047	0.0596187	0.0504	0.95980	f(n)10.Fonteta	0.0234936	0.0599860	0.3917	0.69532
f(n)02.Gran Via	0.0578338	0.0501261	1.1538	0.24860	f(n)10.Malilla	0.0673517	0.0429048	1.5698	0.11647
f(n)02.Pla del Remei	0.0943695	0.0573456	1.6456	0.09985	f(n)10.Mont-Olivet	0.0927138	0.0427176	2.1704	0.02998
f(n)02.Russafa	0.0065793	0.0426814	0.1541	0.87749	f(n)10.na Rovella	0.0260931	0.0500730	0.5210	0.60234
f(n)03.Arrancapins	0.0105348	0.0437979	0.2405	0.80992	f(n)11.Betero	0.0490544	0.0548783	0.8939	0.37139 *
f(n)03.el Botanic	−0.0565705	0.0566049	−0.9994	0.31761	f(n)11.el Cabanyal	0.0696445	0.0424091	1.6422	0.10055
f(n)03.la Petxina	0.0342782	0.0481969	0.7112	0.47696	f(n)11.el Grau	−0.0276809	0.0545622	−0.5073	0.61193
f(n)03.la Roqueta	-0.1059012	0.0629947	−1.6811	0.09275	f(n)11.la Malva-rosa	0.0463644	0.0503930	0.9201	0.35755
f(n)04.Campanar	−0.0218721	0.0465804	−0.4696	0.63867	f(n)11.Natzaret	0.0731367	0.0530926	1.3775	0.16835
f(n)04.el Calvari	0.0319278	0.0551633	0.5788	0.56274	f(n)12.Aiora	−0.0147840	0.0411343	−0.3594	0.71929
f(n)04.les Tendetes	0.0030470	0.0560033	0.0544	0.95661	f(n)12.Albors	0.0389831	0.0520006	0.7497	0.45346
f(n)04.Sant Pau	−0.1023033	0.0558490	−1.8318	0.06699	f(n)12.Cami Fondo	0.0337846	0.0525803	0.6425	0.52053
f(n)05.Marxalenes	−0.0105461	0.0489650	−0.2154	0.8294	f(n)12.la Creu del Grau	0.0381572	0.0490739	0.7775	0.43684
f(n)05.Morverdre	0.0236611	0.0542480	0.4362	0.66272	f(n)12.Penya-roja	−0.1139060	0.0616241	−1.8484	0.06455
f(n)05.Sant Antoni	0.0132472	0.0542851	0.2440	0.80721	f(n)13.Ciutat Jardi	0.0326455	0.0440550	0.7410	0.45869
f(n)05.Tormos	−0.0350817	0.0558073	−0.6286	0.52960	f(n)13.Illa Perduda	0.0127551	0.0610371	0.2090	0.83447
f(n)05.Trinitat	0.0215169	0.0592643	0.3631	0.71656	f(n)13.l'Amistat	0.0924145	0.0554805	1.6657	0.09578
f(n)06.Ciutat Uni.	0.1233200	0.0877875	1.4048	0.16010	f(n)13.la Bega Baixa	0.0664033	0.0464535	1.4295	0.15288
f(n)06.Exposicio	0.1702098	0.0665674	0.2557	0.01056 *	f(n)13.la Carrasca	0.0576784	0.0712411	0.8096	0.41816
f(n)06.Jaume Roig	0.0317182	0.0627441	0.5055	0.61320	f(n)14.Benimaclet	−0.0301882	0.0415673	−0.7262	0.46769
f(n)06.Mestalla	0.0848382	0.0516155	1.6437	0.10025	f(n)14.Cami de Vera	0.0452799	0.0637507	0.7103	0.47754
f(n)07.la Fontsanta	0.0792724	0.0855573	0.9265	0.35417	f(n)15.Orriols	−0.0201584	0.0471542	−0.4275	0.66902
f(n)07.la Llum	0.0293388	0.0650343	0.4511	0.65190	f(n)15.Sant Llorenç	−0.0342434	0.0547941	−0.6249	0.53201
f(n)07.Nou Moles	−0.0255010	0.0419638	−0.6077	0.54340	f(n)15.Torrefiel	0.0214805	0.0432269	0.4969	0.61924

Table A9. *Cont.*

	Estimate	Std. Error	t Value	Pr(>|t|)		Estimate	Std. Error	t Value	Pr(>|t|)
f(n)07.Soternes	−0.0141970	0.0578008	−0.2456	0.80598	f(n)16.Benicalap	−0.0316659	0.0390803	−0.8103	0.41778
f(n)07.Tres Forques	−0.0123357	0.0545473	−0.2261	0.82109	f(n)16.Ciutat Fallera	0.0467826	0.0657453	0.7116	0.47673
f(n)08.Favara	−0.0432790	0.0638604	−0.6777	0.49796	f(n)18.Benimamet	0.0044381	0.0469580	0.0945	0.92470
f(n)08.Patraix	0.0101457	0.0419927	0.2416	0.80909	f(n)19.Castellar	0.0299472	0.0588475	0.5089	0.61083
f(n)08.Safranar	0.0056503	0.0527315	0.1072	0.91467	f(n)19.La Torre	0.0361821	0.0638281	0.5669	0.57081
f(n)08.Sant Isidre	−0.0292627	0.0527707	−0.5545	0.57922	f(n)19. A.Pobles Sud	0.0458048	0.0571420	0.8016	0.42279

Significance: *** 0.001; * 0.05; "." 0.1; " " 1.

In the Wald test, the H_0 stated that the coefficients were 0, and therefore these variables did not influence the model. With a *p*-value less than 0.05, H_0 was rejected, and coefficients were non-zero.

Table A10. Wald test.

	Contrast Function	df1	*p*-Value
Wald	48,592	−72	<0.0001

Appendix C

Table A11. Neighbourhood effects (Neighborhood and estimated effect).

12.Penya-roja	03.la Roqueta	04.Sant Pau	03.el Botanic	01.el Pilar
−13.36	−12.56	−12.20	−7.62	−7.28
08.Favara	05.Tormos	15.Sant Llorenç	16.Benicalap	14.Benimaclet
−6.30	−5.48	−5.39	−5.13	−4.99
08.Sant Isidre	11.el Grau	07.Nou Moles	04.Campanar	01.el Mercat
−4.89	−4.74	−4.52	−4.15	−3.99
15.Orriols	12.Aiora	07.Soternes	07.Tres Forques	05.Marxalenes
−3.98	−3.45	−3.39	−3.20	−3.02
01.el Carme	01.Sant Francesc	04.les Tendetes	18.Benimamet	08.Safranar
−1.97	−1.67	−1.66	−1.52	−1.40
02.Russafa	08.Patraix	03.Arrancapins	09.la Raiosa	09.Cami Real
−1.31	−0.95	−0.91	−0.89	−0.84
13.Illa Perduda	05.Sant Antoni	09.l'Hort Sanabre	01.la Seu	15.Torrefiel
−0.69	−0.64	−0.42	−0.38	0.18
05.Trinitat	10.Fonteta	05.Morverdre	10.na Rovella	07.la Llum
0.18	0.38	0.40	0.64	0.97
19.Castellar	10.Ciutat Arts	06.Jaume Roig	04.el Calvari	13.Ciutat Jardi
1.03	1.04	1.20	1.23	1.30
12.Cami Fondo	03.la Petxina	09.Sant MArcel·li	19.La Torre	12. Creu del Grau
1.41	1.46	1.50	1.65	1.85
12.Albors	14.Cami de Vera	19.Otros Pobles Sud	01.la Xerea	11.la Malva-rosa
1.93	2.56	2.61	2.62	2.67
16.Ciutat Fallera	11.Betero	10.En Corts	13.la Carrasca	02.Gran Via
2.71	2.94	3.64	3.80	3.82
09.la Creu Coberta	13.la Bega Baixa	10.Malilla	11.el Cabanyal	11.Natzaret
4.08	4.67	4.77	5.00	5.35
08.Vara Quart	07.la Fontsanta	06.Mestalla	13.l'Amistat	10.Mont-Olivet
5.37	5.96	6.52	7.27	7.30
02.Pla del Remei	06.Ciutat Uni.	06.Exposicio		

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