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Analysis of Water Tariff Reform on Water Consumption in Different Housing Typologies in Calvià (Mallorca)

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Abstract: This study analyses water prices and residential water consumption using micro data for three different housing typologies in Calvià with contrasting household characteristics. We examine the effect of a price reform of the sanitation fee (implemented in 2013) on the average prices and their water consumption in each of the areas. Our results conclude that the aggregate water consumption decreased only during the year of the reform, but increased the following year. The increase in the amount of water consumed by the houses of higher standards of living was greater than the small decrease in water consumption by families with medium and low-medium incomes. Thus, the reform had a very modest effect as regards reducing water consumption, and many households increased their consumption despite the higher prices. From a water policy perspective, we recommend a water tariff scheme differentiated according to the housing characteristics in order to find the most effective and fairest way to save water.

Keywords: water price reform; water consumption; Mallorca; housing typologies

1. Introduction

The demand for domestic water on the island of Mallorca (Spain) is a topic of continuous debate. Water scarcity on this Mediterranean island has been aggravated by a significant increase in population, both residential and seasonal, caused by the rapid development of tourism (which is the main driving force behind the economic growth on the island since the 1960s). The domestic water demand includes both the residential and tourist demands as both are supplied by the municipalities in Mallorca. Therefore, the aggregate data of the residential and floating populations are used to determine the urban water demand in the hydrological plans. It is well known that tourists consume more water than the local population [1–4]. However, official statistics frequently fail to differentiate this from the domestic water consumption [5], or to take into account the fact that the increasing number of residents and some housing typologies (especially high-income residential houses) increase the pressure on water resources [6–8].

The aggregate water consumption data in areal units may lead to an ecological fallacy problem when the statistical analysis and conclusions based on aggregate data are not applicable on an individual scale [9,10]. Several studies have shown that domestic water consumption varies significantly according to the characteristics of the properties, and also due to different water usage behaviours found in individual households [6,9,11,12]. This highlights the importance of an analysis of water consumption at the level of individual households. From the point of view of policymakers, several authors point out that under the increasing block pricing structure (where the price for each additional unit consumed increases when the level of consumption reaches a certain threshold), it is better to use micro data rather than aggregate data [13,14].

Several factors may influence the variation of single-family residential water use, either alone or together. These include socioeconomic and demographic attributes of households, physical features of properties, climate factors, water pricing and water regulation, and consumer-related factors (such as behaviour, attitude and perception of trust) [12]. All these factors affect water use behaviour and vary widely. On some occasions, this variation occurs in the opposite way for the same factor [9,12]. This is often due to difficulties involved in obtaining information for each factor, or a lack of individual household consumption data due to the privacy of this type of data. Most research on domestic water demand uses aggregate data, probably due to the simplicity of data collection from water supply operators. However, several studies estimate household water demand based on micro-level data. For example, the water demand analysis focused on the size of households (members), income, and the common hot water facilities of the residential users of the city of Zaragoza (Spain) [15,16]. In the same country (in the city of Granada), a study differentiates four residential water consumer profiles were identified based on different socioeconomic characteristics: occupation, household size, housing characteristics (size, equipment), and conservation habits [17]. The size of households (members) and income were also the variables used by [18] in a case study in Sri Lanka. Binet et al. [19] distinguished between the members of the households (children and working adults of non-working adults). Nieswiadomy et al. [20,21] introduced the house age and other variables related to the weather (evapotranspiration, temperature, etc.). Other variables that are usually introduced in the analysis of the residential water demand are lawn size [22] or swimming pools [23].

An interesting recent methodology is the end-use studies that aim to quantify and predict water demand for each end-use category, conducted mainly in the United States of America, the United Kingdom and Australia [24].

There is a broad consensus in the main international organisations regarding the need for market prices and incentives to play an important role as a mechanism to improve efficiency in water use and conservation [25–28]. In the specific case of the European Union, the Water Framework Directive 2000 (WFD) aims to achieve good water status for surface waters and groundwater in terms of environmental quality and availability of water for human uses. The WFD encourages water providers to design water pricing mechanisms aimed at achieving sustainability, efficiency, affordability, equity and cost recovery. However, in the case of Spain, it has been demonstrated that water demand is usually price inelastic and changes in prices have limited effects on saving and efficiency [14,29].

In December 2012, the Autonomous Government of the Balearic Islands substantially modified the sanitation fee through Law 15/2012 (which replaces Law 9/1991 from 1991). This law introduced important modifications in the water sanitation fee, both in its amount and its structure. More specifically, the fixed charge increased by 10%, and a rising multi-block tariff was introduced. The first objective of the reform was to reduce water consumption levels and recover (at least partially) the environmental costs. Thus, the changes introduced in the sanitation fee in January 2013 constitute a great opportunity to analyse the effects of this reform. In particular, we compare the evolution (before and after the modification of the sanitation fee) of water consumption of single-family residential users in three different housing typologies in the municipality of Calvià, Mallorca.

This paper has three main objectives. Firstly, we analyse water consumption behaviour for individual households in three residential typologies with important differences in housing characteristics. Secondly, our study determines the effects of the reform of the sanitation fee on the average water price paid by each of the three types of houses. Finally, we compare the effects of the reform on water consumption in each typology. The structure of this article is as follows: in the next section, we present the case study of Calvià, including materials and methods; Section 3 presents results and discussion; and finally, we evaluate the findings of this study and propose future research needs.

2. Materials and Methods

We selected the municipality of Calvià as a case study, for the period 2011 to 2014. This region is located in the south-western part of the island of Mallorca (Figure 1) in the Balearic Islands (Spain).

The municipality has a surface area of 14,490.84 ha between the mountains in the northern part (with a mean annual precipitation of around 800 mm) and the lower areas on the southern peninsula (with a mean annual precipitation of 350 mm). Calvià has different population centres (sub-municipal districts) such as Calvià vila, Capdellà, Illetes, Palmanova, El Toro, Costa d'en Blanes, Costa de la Calma, Magaluf, Peguera, Santa Ponça, and Son Ferrer, with a total population of 49,807 in 2011 and 50,363 in 2014. The three housing typologies used in this study are located in Santa Ponça and Son Ferrer (Figure 1) in the southern part of Calvià, with the same climate conditions. Santa Ponça has 160 ha and is mainly characterised by detached residential houses. Son Ferrer occupies an area of 60 ha and has two typologies of houses: detached single-family in the western part and semi-detached in the north-eastern part.

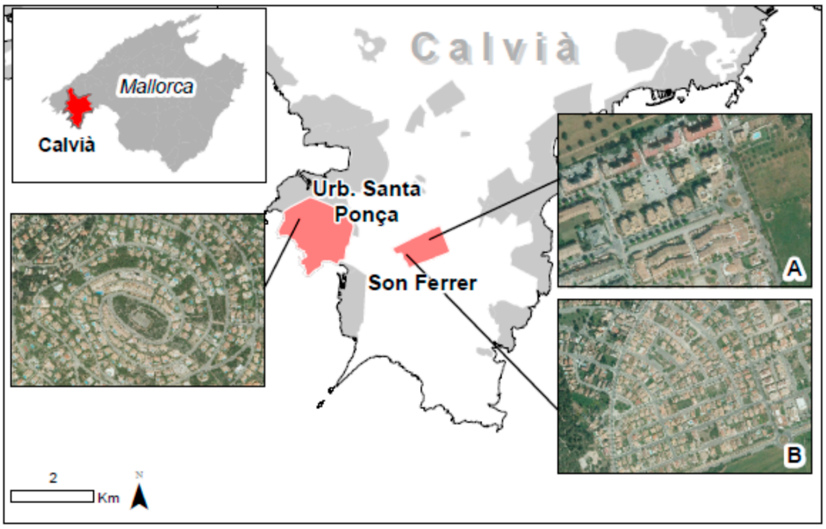

Figure 1. Location of the three housing typologies studied in the municipality of Calvià on the island of Mallorca: Santa Ponça, Son Ferrer semi-detached (**A**), and Son Ferrer (**B**).

We selected these three areas because they present household typologies with different social and physical characteristics (Table 1). While Santa Ponça households have large houses, gardens and swimming pools, and correspond to high-income families, the semi-detached houses in Son Ferrer have smaller houses, no gardens and no pools, and correspond to low-medium income families. The other area, Son Ferrer, presents households with an intermediate typology (as regards plot and house size, pool, and family members). It should be noted that the houses in Santa Ponça have a large irrigable plot (lawn), while the houses in Son Ferrer do not have any irrigable plots.

Thus, based on the differences in the household typologies outlined above, we sought to analyse whether the water price reform had led to different responses in water consumption for the included areas. Specifically, the income effect of an increase in water prices is expected to be less important for high-income families (Santa Ponça). On the other hand, the substitution effect may be larger, as a smaller share of the water consumption is a necessity. In this sense we considered water usages related to personal hygiene and washing (dishing and clothing) to be more of a necessity than water usages for gardens.

The sample data were obtained from the water supply companies that operate in the area of Calvià. From the initial database we excluded those observations with missing values or incomplete information during the study period. The data sample included 141 observations from three different typologies of single-family houses (see Table 1) exclusively dedicated to residential use (not tourist rent), with a regular water consumption during the analysed period. Water consumption came from bi-monthly (the period considered in the water bill in this municipality) water meter data in the houses over a period of four years.

Table 1. Average housing and household characteristics of the properties used in this study.

Number of Houses	Name	Typology	Plot Size, m^2	House Size, m^2	Swimming Pool (Size, m^2)	Number of Household Members	Year of Construction
44	Santa Ponça	High-income single-family residential houses with pool and garden	1077	361	45	3.1	1998 (1983–2008)
40	Son Ferrer	Medium-income single-family houses with pool and no garden	455	186	24	2.8	1991 (1971–2006)
57	Son Ferrer semi-detached	Low-medium income without pool or garden	132	100	NO	3.4	1989 (1987–1990)

The water management in the municipality of Calvia presents a set of particular characteristics. First, water tariffs incorporate two different components: the supply and sewage tariffs (regulated and determined by the municipality of Calvià), and the sanitation fee (regulated and determined by the Autonomous Government of the Balearic Islands). Secondly, the management and distribution of drinking water is provided by two private operators (Hidrobal in Son Ferrer, and Aterca S.A. in Santa Ponça), while the management of waste water collection and treatment in both areas is provided by the public operator (Calvià 2000). Tables 2 and 3 show the same structure for the supply and sewage tariffs, namely, a two-part tariff with a fixed charge and a variable charge with rising blocks. The sewage tariffs applied in Son Ferrer and Santa Ponça are the same (as they are managed by the same operator), and there have been no changes during the period studied. This is not the case for the water supply tariff because it is determined by two different operators. While the two areas have the same consumption blocks, a large difference is found in the charge applied to the first block, which is substantially higher (380%) in Santa Ponça than in Son Ferrer. Conversely, the fixed charge is higher in Son Ferrer (42%). For the period under study (2011–2014), the water-supply tariff in Son Ferrer did not change, while in Santa Ponça it increased slightly every year (Table 3). We calculated the total variation in the average price considering the amounts consumed as being constant for the year of reference, and applied the current tariffs of each year to each block. We selected 2011 as the reference year because it was an average year as far as climatology was concerned. Therefore, for each year we applied the current tariffs to the amount of water consumed in the 44 houses in Santa Ponça in order to obtain the mean annual price of supplying water. This price was 1.82 €/m^3 in 2011, 1.90 €/m^3 in 2012, 2 €/m^3 in 2013, and 2.11 €/m^3 in 2014. According to these data, the average price of supplying water in Santa Ponça increased 16% from 2011 to 2014. Since Calvià had different water supply operators prior to the evaluation of the effects of the reform, we analysed the similarity of water supply tariffs in the three areas. Accordingly, we applied the tariff of Son Ferrer (which remained constant over the period) to the amount of water consumed in 2011 for the sample in Santa Ponça, in order to obtain an average annual price. The same procedure was employed for a housing type that was representative of the water consumption in the area of Santa Ponça, which involved applying the currents tariffs of the two areas and comparing the average annual prices thus obtained. The result obtained was similar in both cases. We found that the difference in average annual prices was practically insignificant (for the period 2011–2014, the average difference was around 4%). Hence, the changes in the water bill are mostly related to the variations in the sanitation fee (Table 4).

Table 2. Monthly sewage tariff for the period 2011–2014 (charge per house).

Fixed Charge (€)	Variable Charge	
	Blocks (m^3)	Fee (€/m^3)
0.62625	0–7.5	0.1508
	7.5–22.5	0.1972
	22.5–37.5	0.2783
	>37.5	0.3595

Table 3. Monthly water supply tariff per area studied and for the period 2011–2014 (charge per house).

	2011			**2012**			**2013**			**2014**		
	Fixed Charge (€)	**Variable Charge**		**Fixed Charge (€)**	**Variable Charge**		**Fixed Charge (€)**	**Variable Charge**		**Fixed Charge (€)**	**Variable Charge**	
		Blocks (m³)	**Fee (€/m³)**		**Blocks (m³)**	**Fee (€/m³)**		**Blocks (m³)**	**Fee (€/m³)**		**Blocks (m³)**	**Fee (€/m³)**
SON FERRER (Hidrobal)	6.88	0–7.5	0.150	6.88	0–7.5	0.150	6.88	0–7.5	0.150	6.88	0–7.5	0.150
		7.5–22.5	0.979		7.5–22.5	0.979		7.5–22.5	0.979		7.5–22.5	0.979
		22.5–37.5	1.805		22.5–37.5	1.805		22.5–37.5	1.805		22.5–37.5	1.805
		>37.5	2.764		>37.5	2.764		>37.5	2.764		>37.5	2.764
SANTA PONÇA (Aterca S.A.)	4.01	0–7.5	0.724	4.13	0–7.5	0.723	4.32	0–7.5	0.763	4.58	0–7.5	0.8087
		7.5–22.5	1.000		7.5–22.5	0.998		7.5-22.5	1.054		7.5–22.5	1.1121
		22.5–37.5	1.805		22.5–37.5	1.810		22.5–37.5	1.911		22.5–37.5	2.0255
		>37.5	2.552		>37.5	2.740		>37.5	2.893		>37.5	3.0663

Table 4. Monthly sanitation fee for the period 2011–2014 (charge per house).

2011		2012		2013			2014		
Fixed Charge (€)	Variable Charge	Fixed Charge (€)	Variable Charge	Fixed Charge (€)	Variable Charge		Fixed Charge (€)	Variable Charge	
	Fee (€/m³)		Fee (€/m³)		Blocks (m³)	Fee (€/m³)		Blocks (m³)	Fee (€/m³)
					0–6	0.2779		0–6	0.2859
3.40	0.2677	3.53	0.2779	3.89	6–10	0.4167	4.00	6–10	0.4288
					10–20	0.5557		10–20	0.5718
					20–40	1.1115		20–40	1.1437
					>40	1.6662		>40	1.7145

This fee, with a fixed and a variable charge, imposes a tax on the wastewater treatment and purification service. Since it was established in 1992 (by Spanish Law 9/1991), the fixed charge was a constant tax per house and the variable charge was linear with a fixed price per m^3 consumed. Until 2012 this fee increased annually in accordance with the consumer price index in Spain, much like the rest of the taxes in the Autonomous Community of the Balearic Islands. In 2013 there was a major modification to the variable charge of the sanitation fee, shifting from a linear rate to an increasing block tariff. Initially, the purpose of this modification was to save water recover the environmental costs, and achieve sustainability, although the reform was published with the General Budget of the regional government for 2013.

Below, we discuss the methodological considerations that are important to evaluate the effect of the reform on water consumption. Information on water consumption is available for two month periods from 2011 to 2014 for all of the households. This means that data cover the two years before and the two years after the reform. There is an important advantage of working with six observations per year when evaluating the effect of the reform, because it becomes possible to take into account variations in precipitation for the same periods. For example, if yearly precipitation is high but very concentrated within a short period of time, the possible effect on annual water consumption could still be fairly small. We were interested in comparing consumption for the same household and the same two-month period before and after the reform. We calculated the difference in consumption for the four combinations that can be compared. Since our interest is to evaluate a change over time and not the level of consumption, the model (in terms of relevant variables) becomes substantially more simplified. The reason is that a set of variables (which are relevant to explain water consumption) did not change over time, and thus they were not relevant in our analysis. Instead, the key focus was on the reform that was implemented in January 2013, and we added information on rainfall to ensure that differences in rain could not explain either an effect or the lack of effect of the reform.

It is important to remember that in each of the housing typologies we only have a sample of houses and we are, in fact, interested in the population in each area. Hence, it is not sufficient to simply compare the water consumption in the samples in different periods, in order to evaluate whether the distribution of water consumption changed in the population. It is necessary to specify and test hypotheses, which will either be rejected or not.

A natural way to evaluate whether water consumption has changed from one period to the next would be to use the *t*-test on the average for paired data. There are, however, two important drawbacks to applying this test to our sample. First, since there are six observations for each household, the assumption of statistical independence of observations is not fulfilled. Second, the sample contains a set of outliers where the amount of water consumption changed drastically for the same two-month period for different years. In addition to these problems related to the use of the *t*-test itself, we also need to isolate the effects of the reform on the water consumption from those related to the variation in the levels of precipitation.

Thus, to deal with all these concerns, we proceeded in the following way. First, we used the average annual water consumption for each household to ensure that the assumption of independence was plausible. To handle the problem of outliers we performed a Wilcoxon matched pairs signed-rank test, which does not require normally distributed variables and is robust to the presence of heavy tails and outliers. The analysis was separately performed for each of the housing typologies and for all the possible combinations of years before and after the reform (see Table 5, from second to fifth columns).

Table 5. *p*-values [1] from the Wilcoxon matched pairs signed-rank tests.

	2011–2013	2011–2014	2012–2013	2012–2014	Rain in mm	Rainy Days
Santa Ponça	0.1179	0.8291 *	0.0274	0.8656	0.1125	0.0150 *
Son Ferrer	0.5587	0.8402	0.3933	0.5275	0.2422	0.1375
Son Ferrer semi-detached	0.5250	0.6478	0.0114	0.0440	0.5512 *	0.0199

Notes: [1] The *p*-value refers to testing the hypothesis that both samples come from a population with the same distribution of water consumption. * indicates that the number of households that increased their water consumption was greater than that of those in which it decreased, which is the opposite of the expected effect.

Second, to deal with the possible confounding effect of precipitation, we chose the two-month periods before and after the reform with the most similar levels of precipitation (in mm). Then, we again calculated the average annual water consumption for each household and used the Wilcoxon matched pairs signed-rank test (see the sixth column in Table 5).

An alternative way to handle the possible confounding effect of precipitation is to use days of rainfall instead of the amount in mm. In general, we chose the two-month periods before and after the reform with the most similar numbers of days with rain. In two cases the number of rainy days before or after the reform was the same for the two consecutive years. For these cases, we used the average water consumption for the household over that period.

We complemented the Wilcoxon matched pairs signed-rank test with a study of quartiles and Bowley's coefficient of skewness for the change in water consumption before and after the reform, when precipitation was used to obtain more adequate comparisons. The reason for studying not only the central position is that the price change could have affected a smaller share of the households. With information on the quartiles $(Q1, Q2, Q3)$ it is easy to calculate Bowley's coefficient of skewness: $(Q1 + Q3 - 2 \times Q1)/(Q3 - Q1)$. We deliberately chose Bowley's coefficient of skewness because of its robustness in cases with outliers. The idea behind studying skewness is that if the distribution is symmetrical, the reform is not having a substantial effect on a group that reduces its consumption. If the distances from the median to the first and the third quartile are very similar and far away from the median, it would only indicate large fluctuations which are unrelated to the reform. If, on the other hand, the coefficient is strongly negative, then the reform may have affected a smaller share of the households by strongly reducing their consumption, while the majority may have disregarded the reform completely. This could be interpreted as meaning that the reform had an effect, but only for a smaller share of the households.

3. Results and Discussion

3.1. Water Consumption in the Three Housing Typologies

The average volume of water consumed varies significantly between the three typologies. According to Table 6, in 2011 the average water consumption in the houses in Santa Ponça (characterised by larger swimming pools and gardens with a lawn) was 254% and 178% greater than for the semi-detached houses in Son Ferrer and the single-family houses in Son Ferrer, respectively. Water consumption patterns in the three areas are significantly different. During the period 2011–2014 the lowest average daily water consumption per house in Santa Ponça was 1182 litres, while the highest for Son Ferrer was 489 litres and 393 litres for the semi-detached homes (Table 6). There are differences in the characteristics of the households (plot and house size, swimming pool, average year of construction, etc.) that can cause significant variations in the average water consumption between the sub-municipal areas.

Table 6. Water consumption in the three typologies for the four years studied.

Water Consumption [1] (m^3)	Santa Ponça				Son Ferrer				Son Ferrer Semi-Detached			
	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014
Average (m^3/house/year)	487.8	496.9	431.5	558.1	175.4	178.5	158.2	154.4	137.7	143.6	135.8	134.8
Variation with respect to previous year (%)		1.9	−13.2	29.3		1.8	−11.4	−2.4		4.3	−5.4	−0.7
Average water consumption (m^3/house/day)	1.336	1.361	1.182	1.529	0.480	0.489	0.433	0.423	0.377	0.393	0.372	0.369
Average water consumption per capita (litres/person/day)	431	439	381	493	172	175	155	151	111	116	109	109

Note: [1] Data came from water consumed in the houses as reported in the bi-monthly water bill. We used the average number of household members to calculate the average water consumption per capita.

As we mentioned above, one of the major problems of the research conducted in this field is that most of the previous studies estimate housing water consumption per capita based on aggregate data. Official statistical water data show an average daily consumption of 150 litres/person/day for European households [30], 165 l/p/d for Spanish households and 124 l/p/d for the Balearic Islands [31]. Since our database includes micro data, we can calculate a more accurate indicator of water consumption per capita. In our sample, these values are between 381 and 493 l/p/d in Santa Ponça, 160 l/p/d in Son Ferrer and 110 l/p/d in the semi-detached sample. If we compare our results with those obtained with aggregate data, we can observe substantial differences. The consumption in Son Ferrer is similar to that obtained in Portugal [32], with an average daily consumption of 137 l/p/d. The study by [2] found that the water consumption per capita in Santa Ponça was 771 l/p/d, and 188 l/p/d in El Toro (near Son Ferrer and with a similar housing typology). However, the values obtained in Santa Ponça are quite similar to the 409 l/p/d obtained for detached houses in expansive low-density developments (with a private garden and a swimming pool) in Alicante, which is a tourist region with similar characteristics [3].

The analysis of the annual data around the sanitation fee reform shows an irregular evolution for the three typologies. In Santa Ponça, we observed a small increase in water consumption in 2012, a decrease in 2013 to volumes lower than 2011, and an increase in 2014 reaching the highest water consumption of the period under study. The trend in Son Ferrer and in the semi-detached houses of Son Ferrer is similar to that of Santa Ponça in 2012 and 2013 (a slight increase in water consumption in 2012, and a decrease in 2013), but quite different in 2014, with a continued decrease reaching the lowest consumption in the period studied. Thus, while water consumption decreased in 2013 in all three typologies, the evolution was very mixed during 2014.

According to the aggregate data in Table 7, it seems there is a relation between average annual water consumption and precipitation. The year 2014 recorded the lowest precipitation and had the highest mean annual temperature. The second driest year was 2012, 2011 was close to the average, and 2013 was the wettest (Table 7). The empirical evidence shows that precipitation influences water consumption; specifically, during the dry seasons outdoor water usage usually increases [13]. In 2013 (the wettest year), water consumption decreased, while in 2014 (which was the driest and had the highest mean annual temperature), water consumption increased in Santa Ponça while it decreased in the two sub-areas of Son Ferrer. While the existence of green gardens in the houses of Santa Ponça could explain this increase in water consumption in a dry year, there is no household characteristic that explains the decrease in water consumption in the Son Ferrer areas. Thus, in the next sections we analyse whether this divergence can be explained by the sanitation fee reform introduced in 2013.

Table 7. Precipitation, mean annual temperature and maximum temperatures recorded for the years studied.

Weather Variables	2011	2012	2013	2014
Precipitation (mm)	456.4	370.4	526.2	362
Mean annual temperature (°C)	17.8	17.5	17.1	18.3
Maximum temperature (°C)	36.2 (15 August)	37.7 (5 August)	35.8 (31 August)	34.2 (26 August)

3.2. The Reform of the Sanitation Fee

We calculated the total variation in the average water price by applying the current tariffs of each year, considering that the amount of water consumed is kept constant at the levels of 2011, which is used as the reference year. Table 8 shows the effects of the modifications on the structure of the different components of the tariff in 2013. This reform generated a significant increase in the sanitation fee in comparison with the previous year, but differed depending on the area analysed. For instance, the reform gave rise to an increment of 216% in Santa Ponça, 52% in Son Ferrer, and 27% in Son Ferrer (semi-detached). Therefore, it seems that the reform penalizes higher water consumption.

Table 8. Total average water price for each tariff in the urban areas studied.

Area		Sanitation Fee		Water-Supply Tariff		Sewage Tariff		Total Tariff		% of the Total Tariff		
		a	b	a	b	a	b	a	b	Sanitation	Water-Supply	Sewage
SON FERRER semi-detached	2011	0.57		1.10		0.23		1.89		30	58	12
	2012	0.59	4	1.10	0	0.23	0	1.91	1	31	58	12
	2013	0.75	27	1.10	0	0.23	0	2.07	8	36	53	11
	2014	0.77	3	1.10	0	0.23	0	2.10	1	37	53	11
SON FERRER	2011	0.50		1.19		0.23		1.91		26	62	12
	2012	0.52	4	1.19	0	0.23	0	1.93	1	27	61	12
	2013	0.79	52	1.19	0	0.23	0	2.20	14	36	54	10
	2014	0.83	6	1.19	0	0.23	0	2.24	2	37	53	10
SANTA PONÇA	2011	0.35		1.82		0.28		2.45		14	74	12
	2012	0.36	4	1.90	4	0.28	0	2.55	4	14	75	11
	2013	1.15	216	2.00	6	0.28	0	3.44	35	33	58	8
	2014	1.19	3	2.11	5	0.28	0	3.58	4	33	59	8

Notes: [a] €/m^3. [b] Variation with respect to previous year (%).

This effect, however, becomes blurred when we add the other components of the total water price (i.e., the water-supply and the sewage tariffs). Table 8 shows that, while the sanitation fee in Santa Ponça increased by 216% from 2012 to 2013, the average total price only increased by 35%. Yet, in Son Ferrer, we observe an increase of 52% in the sanitation fee and 14% in the total water price. Meanwhile, in the Son Ferrer semi-detached area the sanitation fee increased by 27% while the total average price increased by 8%. In order to determine the sensibility of the final price of water to variations in the sanitation fee, we calculated an indicator (defined as the percentage change in the final price divided by the percentage variation in the sanitation fee for each area). This indicator was 0.16 for Santa Ponça, 0.27 for Son Ferrer and 0.31 for Son Ferrer (semi-detached) for the year 2011. Therefore, it seems that the final price was non-sensitive to variations in the sanitation fee in the case we studied.

These differences are due to the varying weights of the sanitation fee in the final price. We can observe that before the reform of the sanitation fee in the year 2011, the weight of this fee in the total tariff was lower in Santa Ponça (14%) than in Son Ferrer (between 26% and 30%) (Table 8). The percentage of participation of the sanitation fee was lower when the amount of water consumed was higher. Before the reform, the semi-detached houses in Son Ferrer (with the lowest water consumption) paid 0.57 €/m^3 as a sanitation fee compared to 0.35 €/m^3 in Santa Ponça. This is due to the high fixed costs of the sanitation fee that benefit the biggest water consumers, since the average fixed cost decreases as the amount consumed increases. As an example, a house paid 3.7 €/m^3 as the sanitation fee for 2 m^3 of water consumed during two months; the same house would have paid 0.4 €/m^3 if it had consumed 40 m^3 in two months. According to [33], Spanish water tariffs do not encourage water saving because the fixed fee is too high, the variable fee is not sufficiently progressive, and marginal prices are too low. For example, the 2006 French Water law requires that the fixed charges should not exceed 40% of the water bill for urban municipalities [34].

3.3. The Effect of the Reform on Water Consumption in the Three Housing Typologies

To study the effect of the reform on water consumption, we calculated Wilcoxon matched pairs signed-rank tests. The results can be seen in Table 5, where *p*-values are included for each of the Wilcoxon matched pairs signed-rank tests (see the seventh column in Table 5).

For Santa Ponça and semi-detached houses in Son Ferrer we reject the hypothesis that the samples came from a population (in 2012 and 2013) with the same distribution of water consumption. This also happened in 2012 and 2014 for the semi-detached houses. The results indicate that the distribution of water consumption changed, but we cannot reject the same hypothesis when we compare 2011 and the years after the reform. If precipitation is taken into account by comparing the two-month periods (for years before and after the reform) with the most similar number of rainy days, the hypothesis is rejected for semi-detached houses in Son Ferrer. Accordingly, it is possible that the reform changed the distributions in the correct directions. When rainy days were used to make the comparison as fair as possible, of the semi-detached houses in Son Ferrer 31 reduced, 21 increased, and one did not change the water consumption. Note that the *p*-value for Santa Ponça is 0.015, but there were actually 29 households that increased and only 15 that decreased their water consumption. This is, of course, the opposite of what we would expect. For single-family houses in Son Ferrer the *p*-values were not small enough to reject the hypothesis, but at least more households decreased their water consumption than increased it.

Given these mixed results (without a particularly clear pattern), it is important to clarify whether precipitation, measured in mm as well as the number of rainy days, is related to water consumption. For this analysis we wanted to compare years either before or after the reform so as not to confound the possible effect with the main change in price that occurred between 2012 and 2013. Hence, we can compare two-month periods in 2011 and 2012, as well as in 2013 and 2014, where both pairs of periods had very similar water prices. For each of the two-month periods we identified the data pairs that had the largest difference in rainfall in mm. We saved the observations as two new variables, where the water consumption in periods of less rainfall was included as the first variable, and the consumption that was observed when more rainfall was recorded was taken as the second variable. The values were then averaged, to obtain a single observation for each household. The same procedure was used for rainy days.

With this information we conducted a Wilcoxon matched pairs signed-rank test to evaluate the hypothesis that the samples come from a population with the same distribution of water consumption despite the observed difference in precipitation. When evaluating the effect of precipitation in mm we obtained a *p*-value of 0.5362 for Santa Ponça. Using rainy days, the *p*-value was 0.3505. Bearing in mind the absence of a significant effect, the direction of the effect was not even as would be expected. The corresponding *p*-values for single-family houses in Son Ferrer were 0.3331 and 0.1969. While the *p*-values were not low enough to reject the hypothesis, at least the direction indicated that more households used less water when more precipitation was observed. For semi-detached houses in Son Ferrer, the *p*-values were 0.5726 for rainfall in mm and 0.3225 for rainy days. For precipitation in mm, the direction was not as expected.

The conclusion from this analysis is either that the comparisons of two-month periods did not contain sufficient differences in rainfall to give rise to different water consumptions, or that rainfall was not causing any particular change in water consumption. This does not mean, of course, that rainfall cannot affect water consumption when differences in seasons are considered. Despite the lack of significant effects, it is interesting to see that the *p*-values are lower for rainy days. It gives the impression that the number of rainy days is possibly more important for water consumption than the amount in mm, and it could be more relevant to use rainy days to obtain a fairer comparison before and after the reform. Schleich et al. [8] found evidence that households respond psychologically to the fact that it rained rather than to the total amount of rainfall. In this sense, Binet et al. [19] used the variable non-rainy days to explain the residential water demand for watering the garden. Therefore, we prefer to rely on the analysis with rainy days.

We focus the analysis on the quartiles and skewness when the number of rainy days is used in order to make the comparison as fair as possible for years before and after the reform (Table 9). The first quartile of the change in water consumption indicates that 25% decreased their average water consumption by about 7 m^3 or more for all of the typologies. The median is, however, very high for Santa Ponça. It is, in fact, even above 0 and the skewness is actually positive. Accordingly, there is no effect of reduced water consumption in that area when rainy days are used to control for precipitation. For Son Ferrer the median is negative and for semi-detached houses the hypothesis that the median is higher than or equal to zero is rejected. Both housing typologies in Son Ferrer show negative skewness, which gives the impression that the reform has had an effect on water consumption but, importantly, the effect is for a smaller share of the households.

Table 9. Quartiles and skewness difference of water consumption, for two-month periods measured in m^3 (adjusted for precipitation).

	Rainfall in mm				Rainy Days			
Area	**Q1**	**Q2**	**Q3**	**Skewness** [1]	**Q1**	**Q2**	**Q3**	**Skewness**
Santa Ponça	−24.58	−4.42	9.33	−0.71	−6.90	7.79	24.13	1.06
Son Ferrer	−8.08	0.00	3.58	−0.39	−7.02	−0.79	2.46	−0.65
Son Ferrer semi-detached	−5.08	0.17	3.08	−0.20	−6.67	−1.00 **	3.14	−0.56

Notes: [1] Skewness is measured by Bowley's skewness coefficient. We tested the hypothesis that the median is higher than or equal to zero and ** indicates rejection of that hypothesis at the 5% significance level.

These results indicate that the reform had, at most, a very modest effect on reducing water consumption and many households actually increased their consumption despite the higher prices. In fact, water consumption can differ greatly for the same two months for different years and this variation has surprisingly little relation to both the reform and rainfall. The average water consumption was calculated for the six observations in each year for each household, and then the quartiles for the change from 2011 to 2012 were observed. Both years are before the reform, and these differences in water consumption cannot be related to the reform. In Santa Ponça, the first quartile was a reduction of −16.6 m^3, the median was a reduction of 0.2, and the third quartile was an increase of 19.3. In Son Ferrer (single-family houses) the quartiles are −2.2, −0.9, and 4.0, and in Son Ferrer (semi-detached houses) the quartiles are −0.9, 1.2, and 3.75 for the same period. Since a large proportion of households increased their water consumption at the same time as a large proportion decreased their consumption, we can also exclude other weather-related factors, because all of the households are affected by the same meteorological conditions. Accordingly, the large variation (in particular in Santa Ponça) is related to household-specific circumstances which are unrelated to the reform.

4. Conclusions

This study analyses the effect of a price reform on residential water consumption in different housing typologies in Calvià (Mallorca). At first sight, the aggregate data show that the reform of the sanitation fee did not achieve its main objective, namely, to save water. The total water consumption decreased only during the first year after the implementation of the reform (2013), but increased again the following year. An analysis of these aggregate data reveals that the residential houses with larger swimming pools, green gardens, and the big water consumers (Santa Ponça) are what led to this unwanted result. The larger increase in the volume of water consumed by these houses exceeds the small decrease in the consumption of the other typologies.

A detailed analysis using micro data of the water consumption of each house reveals that while some households decreased their consumption after the reform, other households increased their consumption despite the higher prices. Water consumption can change substantially for the same two months observed for different years in some houses, and this variation has little relation to both the reform and precipitation. Household-specific factors that are unrelated to the reform are much more important.

The effects of the reform are weak and are not robust to changes in years or to how rainfall is taken into account in the analysis. Interestingly, the area where we observed this effect is in the medium-income households (i.e., Son Ferrer), where the increase in water prices was more moderate compared to high-income households (i.e., Santa Ponça). On the other hand, the households in Santa Ponça experienced an average increase (from 2012 to 2013) of about 35%, and there is no indication of reduced water consumption when the number of rainy days is used to control for differences in precipitation. These findings are important from a policy perspective. A high increase in prices does not necessarily reduce water consumption. These results are in line with the conclusions obtained by [35]. Thus, our results confirm the empirical evidence [36] that the domestic water demand is inelastic and usually depends on other factors, such as the characteristics of the houses.

From these findings, our results conclude that the proposed reform did not achieve the desired results in terms of water savings. The analysis of the base case tariff structure and their components are important factors when seeking to achieve the effectiveness of a price reform. In our case study, the modification has been insufficient as an incentive for the inhabitants of the high-standard houses to save water. Thus, it would be necessary to modify the block pricing to penalise excessive water consumption, as proposed by other authors (i.e., [33]).

The main policy implication of our research is that the effects on water consumption due to the water pricing reform depend on the household typology. Specifically, in households with the highest incomes and with larger water consumptions, the effect is lower than on the households with a low-medium family income, where they already consume less water. Consequently, the effect on the total water consumption is not significant, and the increase in water prices particularly affects families with lower incomes. Therefore, policymakers should pay attention to income effects of price reforms. In this regard, a tariff scheme differentiated between houses with and without a swimming pool, lawn, and other housing characteristics could be fairer.

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