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Hotel Water Demand: The Impact of Changing from Linear to Increasing Block Rates

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Abstract: Water is a key aspect for any tourist destination. The pressure of tourism on water resources, and specifically by the hotel sector on islands and coastal areas, threatens the sustainability of the resource and, ultimately, of the destination. Several international organizations propose price policy as an instrument to promote efficiency and penalize excessive water consumption. This study analyzes the short-term effectiveness of a water tariff reform, implemented by the regional government of the Balearic Islands in 2013, on hotel water consumption. The change consists in moving from a linear to an increasing block rate system. The study applies quantile regression with within-artificial blocks transformation on panel data for the period 2011–2015. The results conclude that the reform was not effective as a means to reduce the levels of water consumption. The disproportionate fixed component of the water tariff and the oversized initial block of the sanitation fee can explain the ineffectiveness of the reform.

Keywords: water price reform; hotel water consumption; tourism sustainability; Mallorca; increasing block rates

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1. Introduction

Tourism activity demands large amounts of water with high standards of quality [1–3]. Some studies estimate that tourists consume between two and three times more water than residents in developed countries, and up to fifteen times more in developing countries [4–6].

This problem is even more important in coastal and small-island destinations. These areas concentrate a significant part of world tourism activity, and they usually present problems related to water scarcity. This is the case of the island of Mallorca (Balearic Islands, Spain). The island, with more than eleven million tourists per year, is historically one of the most important tourist areas in Spain, and it presents the highest equivalent tourist population and overnight stay indicators. The combination of the climatic, geological, and topographical characteristics of this area determines the quantity and quality of the scarce water supply. In addition, the destination presents specific characteristics such as: (i) a significant increase in the number of tourist arrivals and accommodation facilities (mainly hotels), (ii) an increase in the category of hotels, (iii) a strong seasonal component in tourist arrivals (generally concentrated during the dry summer months), and (iv) the likely negative effects of climate change [7]. The consequences are an increase in water-related problems, shortages, reductions in the quality of the water supply, deterioration of the water supply, etc. [2]. These negative effects directly affect the success and sustainability of the destination and, most importantly, the resident population's quality of life.

For many years, this problem has been solved, as in other tourist destinations, by the implementation of measures mainly aimed toward increasing the water supply. After the International

Conference on Water and the Environment held in Dublin (ICWE, 1992, Dublin, Republic of Ireland) and the United Nations Conference on Environment and Development in Rio de Janeiro (UNCED, 1992, Rio de Janeiro, Brazil), water management policies underwent an important change. Water was defined as a vulnerable and scarce resource, and a new orientation in water policies was promoted. Specifically, the fourth principle of the ICWE states that water has to be considered as an economic good and, consequently, the price of water must cover all related costs in order to achieve a more conscious use of the resource, a key factor to guarantee its sustainability [8].

Based on the ICWE and UNCED principles, in 2000 the European Union approved the Water Framework Directive 2000/60/EC (WFD), which set a new context for water policies in the European Union. Particularly, water policy has shifted toward a more efficient management of demand and the conservation of water, such as the promotion of water-saving programs, water recycling and re-use, and the introduction of new water pricing structures. Among these measures, the WFD recommends the introduction of new tariff schedules that allow all water-related costs to be recovered (including financial, environmental, and resource costs), together with the implementation of stronger incentives for consumers to increase water use efficiency and water saving indicators [9–12].

Based on the principles of the WFD, in 2013, the regional government of the Balearic Islands introduced a significant modification into one of the most important components of water tariffs, namely, the sanitation fee that taxes the treatment of waste water. This reform consisted in raising the amount of the sanitation fee and moving the variable part of the fee from a flat rate to an increasing block rate. The main objectives of the reform were to recover the environmental costs of water, reduce water consumption levels, and penalize excessive consumption (i.e., the reform introduced an increase equal to six times the sanitation fee when the level of consumption reached the last block).

Few studies have analyzed the water demand for commercial and services uses, and the evidence is diverse. Most of those studies agree that water demand seems to be inelastic to the price and, thus, water pricing policies are not usually effective in reducing consumption levels [13–17].

In contrast, based on a monthly database of Los Angeles (California) urban water consumption for a 44-year period (that includes residential, commercial, industrial, and governmental water demand), ref [14] demonstrated that commercial water demand is price sensitive. The study also concludes that price and conservation policies have offset the impact of population growth on the total urban water demand.

This lack of research is even more evident in the case of the water demand resulting from tourism [18–20], probably due to the difficulty (usually due to confidentiality issues) involved in obtaining data associated with the water consumption levels in the tourism sector (i.e., data about hotel water consumption). Another common problem is that official water statistics usually include tourism water consumption in the “urban consumption” item, making it impossible to distinguish between resident and tourist water consumption. Thus, it seems crucial to conduct empirical studies to provide new evidence on the effectiveness of water pricing policies in the tourism sector.

The few empirical studies available highlight the difficulties in using the price mechanism to reduce hotel water consumption. For example, [18] estimates the derived water demand and price elasticity in the hotel sector in Zaragoza (Spain), and reveals that hotel water demand is inelastic to price changes. This result is similar to those obtained by [20] after analyzing water consumption at hotels in Hawaii, which demonstrated that water pricing was a non-effective tool to reduce hotel water consumption.

This study analyzes the short-term effects of a change in the water pricing policy on hotel water-consumption levels on the island of Mallorca, one of the most important tourist destinations in the Mediterranean Sea. Specifically, the study analyzes the effects of the modification introduced into the sanitation fee part of the water price in 2013, which moved from a linear to an increasing block rate. The study focuses on the hotel sector, since it is one of the most significantly affected by this change for several reasons. First, hotels are the most popular accommodation option among tourists that visit Mallorca. Second, as in other tourism destinations, hotels tend to present the highest water consumption levels among the different lodging categories [21]. Thus, the role of the hotel sector becomes relevant to guarantee the sustainability of the water resources of the destination.

The effectiveness of the water price reform is tested on a hotel sample that includes the water consumption from bimonthly water bills of 67 hotels in Mallorca. The study period is 2011–2015, covering the year of the reform (2013), and two years before and after it. The use of micro-level data is preferred rather than aggregated data, which is more common in previous studies [22,23]. The use of micro-level data allows a more detailed analysis of the reaction of demand to changes in the tariff system [24].

This paper applies a quantile regression with within-artificial blocks transformation on panel data to solve the endogeneity problem. This key concern is inherent to multi-block tariff systems, since the price is determined by the total amount of water consumed, while the purpose of the model is to estimate the effect of prices on water consumption. This transformation restricts the variation used to estimate the parameters and, hence, only uses variation that is free from endogeneity problems. It is important to highlight that the transformation also excludes cross-sectional variation so that unobserved time-invariant hotel-specific effects cannot distort the results. The same applies for seasonal variation within a year (i.e., like seasonal changes). This method makes it possible to isolate, exclusively, the effect of the price on water consumption and, thus, it identifies the price elasticity for hotel water consumption.

2. Study Area

Mallorca is the largest and the most populated island in the Balearic archipelago, situated in the western Mediterranean, off the east coast of the Iberian Peninsula (Figure 1). The island has a typical Mediterranean climate, with mild winters and very hot dry summers, which makes rainwater supply uncertain and highly variable over time. There is an important systematic mismatch between natural water supply (with 60% of rainfall concentrated between October and January and less than 10% in the summer months, from June to September) and water demand (reaching its peak during the summer months).

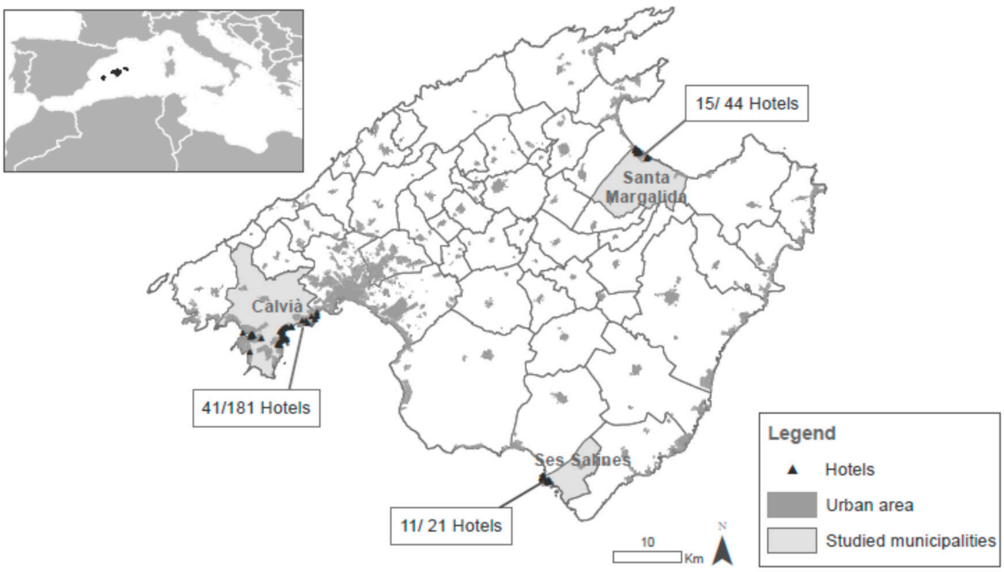

Figure 1. Location of the three municipalities on the island of Mallorca.

Groundwater constitutes the main natural source of raw water (77.8% of total water supply), while reservoirs only represent a very marginal part (just 2.4% of total water supply) [25,26]. Urban or domestic water demand accounts for the highest percentage (54% of the total water consumption), and includes the water consumed by residents and tourists, and the water used in different services and activities that make up the tourist industry (i.e., bars, restaurants, shows, etc.).

The island of Mallorca is one of the most important Mediterranean tourism destinations. In 2017, with a resident population of 868,693 inhabitants (77.8% of the archipelago's total population), the island received 11.6 million tourists, with an increase of almost three million in the last six years [27]. If we analyze the evolution during the last decades, from the half a million of visitors received in 1962, 2.9 million in 1972, five million in 1988, seven million in 2000, and 11.6 million in 2017, the number of tourists has been growing constantly. The tourist sector of the island is mainly based on the mass tourism model, with visitors looking for the traditional combination of sun and sand. Thus, tourist arrivals present a pronounced seasonality, mostly concentrated during the period June–September (63.4% of the total), versus the low season period, which corresponds to the winter months (8.7% of total arrivals). The consequence of this model is that the human pressure index reached 1.47 million in 2017 (on 8 August). The hotel lodging option is still the most usual form of accommodation among tourists (67.3% of all tourists), and it accounts for up to 45.01 million overnight stays, the highest in Spain. At the same time, hotels present the highest levels of water consumption, with an average consumption of 541.6 L per guest and night [28].

This demographic situation gives rise to an important pressure on the island's water resources, and policymakers have tried to develop and implement several measures to guarantee the water supply and the sustainability of its water resources. The Hydrological Plan of the Balearic Islands [25], following the recommendations of the WFD, proposes different measures and programs to achieve a sustainable water use, guarantee the quality of the supply in the long term, and retrieve the environmental status of aquatic ecosystems. This directive also recommends the introduction of water tariff structures that incorporate all the real costs of water (not only production but also treatment).

Three representative tourist municipalities on the island were selected for our study: Calvià, Ses Salines, and Santa Margalida, in southwestern, southeastern, and northeastern Mallorca, respectively (Figure 1). All three municipalities are coastal regions and their hotel plants are mainly focused on the sun-and-sand market segment, representing altogether 64,450 beds, i.e., 27.25% of Mallorca's total hotel plant.

3. The Water Price Reform

Following the recommendations of the WFD, water tariffs on Mallorca try to cover the various services provided by the water authorities. Specifically, the tariff structure identifies two types of services: supply and waste water services. Supply services include water collection and storage (surface water), extraction services (groundwater), or production services (desalination). This is all commonly known as the "upstream" supply service, and it is provided by the regional government of the Balearic Islands, along with public and private operators. These operators are responsible for getting the water to the municipal network. The municipalities are then responsible for the "downstream" supply service, which consists of the services of water treatment and distribution to final consumers. Finally, waste water services include both urban waste water collection, and the treatment and purification services.

The water tariff structure on Mallorca therefore includes two main parts: one tariff to cover the supply services and another tariff to cover waste water services. The tariff system for supply services combines two different components, a fixed and a variable charge. The fixed charge is intended to reflect the fixed costs of the water services (including amortization of investments). On the other hand, the variable charge depends on the amount of water consumed, and it can consist of a flat or linear rate (where the price is the same for each unit used), or of a non-linear rate (where different prices are charged depending on the amount of water consumed). The non-linear rate option is widely used in Europe, usually based on an increasing block rate, where the price for each additional unit consumed increases when the consumption reaches a certain threshold, with these threshold values being the ones that determine the successive blocks.

In the case of waste water services, the tariff system includes two different charges: the sewage tariff (that covers the cost of waste water collection), and the sanitation fee (that covers the costs of waste water treatment and purification).

The municipalities can determine the amount and structure of the water supply and sewage tariff system (i.e., collecting period, linear or block rate, etc.), and introduce allowances or discriminatory practices. The water tariff system supported by the hotel plant on the island of Mallorca thus presents a heterogeneous structure in each municipality, not only in terms of the type of tariff, but also regarding the amount charged and the billing period (Tables 1 and 2).

Table 1. Water supply tariffs per municipality and year.

		2011			**2012**			**2013**			**2014**			**2015**		
		Fixed charge (€/bed)	Variable charge per UE		Fixed charge (€/bed)	Variable charge per UE		Fixed charge (€/bed)	Variable charge per UE		Fixed charge (€/bed)	Variable charge per UE		Fixed charge (€/bed)	Variable charge per UE	
			Blocks (m^3)	Fee (€/m^3)		Blocks (m^3)	Fee (€/m^3)		Blocks (m^3)	Fee (€/m^3)		Blocks (m^3)	Fee (€/m^3)		Blocks (m^3)	Fee (€/m^3)
			0–7.5	0.1500		0–7.5	0.1500		0–7.5	0.1500		0–7.5	0.1500		0–7.5	0.1500
		1.72	7.5–22.5	0.9790	1.72	7.5–22.5	0.9790	1.72	7.5–22.5	0.9790	1.72	7.5–22.5	0.9790	1.72	7.5–22.5	0.9790
	Hidrobal		22.5–37.5	1.8050		22.5–37.5	1.8050		22.5–37.5	1.8050		22.5-37.5	1.8050		22.5–37.5	1.8050
Calvià			>37.5	2.7640		>37.5	2.7640		>37.5	2.7640		>37.5	2.7640		>37.5	2.7640
(Monthly)			0–7.5	0.7240		0–7.5	0.7230		0–7.5	0.7630		0–7.5	0.8087		0–7.5	0.8087
			7.5–22.5	1.0000		7.5–22.5	0.9980		7.5–22.5	1.0540		7.5–22.5	1.1121		7.5–22.5	1.1121
	Aterca	1.01	22.5–37.5	1.8050	1.03	22.5–37.5	1.8100	1.07	22.5–37.5	1.9110	1.13	22.5–37.5	2.0255	1.13	22.5–37.5	2.0255
			>37.5	2.5520		>37.5	2.7400		>37.5	2.8930		>37.5	3.0663		>37.5	3.0663
		2011			2012			2013			2014			2015		
		Fixed charge (€/UE)	Variable charge per UE		Fixed charge (€/UE)	Variable charge per UE		Fixed charge (€/UE)	Variable charge per UE		Fixed charge (€/UE)	Variable charge per UE		Fixed charge (€/UE)	Variable charge per UE	
			Blocks (m^3)	Fee (€/m^3)		Blocks (m^3)	Fee (€/m^3)		Blocks (m^3)	Fee (€/m^3)		Blocks (m^3)	Fee (€/m^3)		Blocks (m^3)	Fee (€/m^3)
			0–20	1.0500		0–20	1.0500		0–20	1.0500		0–20	1.0500		0–20	1.0500
Ses Salines (Bimonthly)		6.00	20–40	1.2000	6.00	20–40	1.2000	9.00	20–40	1.2000	9.00	20–40	1.2000	9.00	20–40	1.2000
			40–100	1.4000		40–100	1.4000		40–100	1.4000		40–100	1.4000		40–100	1.4000
			100–200	1.6000		100–200	1.6000		100–200	1.6000		100–200	1.6000		100–200	1.6000
			>200	1.9000		>200	1.9000		>200	1.9000		>200	1.9000		>200	1.9000
		2011			2012			2013			2014			2015		
		Fixed charge (€/bed)	Variable charge		Fixed charge (€/bed)	Variable charge		Fixed charge (€/bed)	Variable charge		Fixed charge (€/bed)	Variable charge		Fixed charge (€/bed)	Variable charge	
Santa Margalida			(€/m^3)			(€/m^3)			(€/m^3)			(€/m^3)			(€/m^3)	
(Monthly)		0.85	0.3713		0.85	0.3713		0.85	0.3713		0.85	0.3713		0.85	0.3713	

Notes: UE: Equivalent units (1 UE is equal to 4 beds). In Calvià, the distribution of freshwater is provided by two private operators: Aterca S.A., in the area of Santa Ponça, and Hidrobal S.A., in the rest of the municipality.

Table 2. Sewage tariff per municipality and year.

<table>
<tr><th rowspan="3"></th><th colspan="3">2011–2015 (Monthly)</th></tr>
<tr><th rowspan="2">Fixed Charge (€/Bed)</th><th colspan="2">Variable Charge Per UE</th></tr>
<tr><th>Blocks (m³)</th><th>Fee (€/m³)</th></tr>
<tr><td rowspan="4">Calvià</td><td rowspan="4">0.46389</td><td>0–7.5</td><td>0.150764</td></tr>
<tr><td>7.5–22.5</td><td>0.197152</td></tr>
<tr><td>22.5–37.5</td><td>0.278334</td></tr>
<tr><td>>37.5</td><td>0.359514</td></tr>
<tr><td rowspan="3">Ses Salines</td><td>2011–2012 (Annually)</td><td colspan="2">2013–2015 (Bimonthly)</td></tr>
<tr><td>Fee (€/Room)</td><td colspan="2">Fee (€/Room)</td></tr>
<tr><td>7.93</td><td colspan="2">2.06</td></tr>
<tr><td rowspan="3">Santa Margalida</td><td colspan="3">2011–2015 (Annually)</td></tr>
<tr><td colspan="3">Fee (€/Bed)</td></tr>
<tr><td colspan="3">3.00</td></tr>
</table>

Nevertheless, the sanitation fee, fixed by the regional government, is homogeneous for all municipalities, and it presents a binomial structure (with a fixed and a variable part), with a monthly billing period. Initially, the fixed part was a constant charge determined by the number of stars and beds of hotels, while the variable part was a flat rate per cubic meter (m^3) consumed per bed. During the period from 1992 to 2012, both increased according to the inflation rate. However, in December 2012, the regional government of the Balearic Islands decided to substantially modify the sanitation fee structure to reduce water consumption levels, encourage water savings, and recover (at least partially) the environmental costs of water. The reform consisted in moving the variable part of the sanitation fee from a flat rate to an increasing block rate, and it raised both the fixed and the variable charges of the fee (Table 3).

It is important to note that the new sanitation fee structure introduced in 2013 was applied equally both for residential and hotel water consumption. While in the case of residential use there is some previous evidence that concludes that the introduction of an increasing block rates system leads to lower levels of water consumption [22,29–31], no such evidence is found in the case of the hotel sector consumption. This study will therefore try to provide new evidence about the effectiveness of a change in water tariff to promote a more conservative use of the resource in the hotel sector.

Table 3. Monthly sanitation fee per year.

2011			**2012**			**2013**				**2014**				**2015**			
Stars	Fixed charge (€/bed)	Variable charge	Stars	Fixed charge (€/bed)	Variable charge	Stars	Fixed charge (€/bed)	Variable charge		Stars	Fixed charge (€/bed)	Variable charge		Stars	Fixed charge (€/bed)	Variable charge	
		Fee (€/m^3)			Fee (€/m^3)			Blocks (m^3)	Fee (€/m^3)			Blocks (m^3)	Fee (€/m^3)			Blocks (m^3)	Fee (€/m^3)
1	0.848967		1	0.881228		1	0.9694	0–6	0.27787	1	0.997462	0–6	0.285924	1	0.997462	0–6	0.285924
2	1.277279	0.267694	2	1.325816	0.277866	2	1.458398	6–10	0.41675	2	1.500692	6–10	0.428835	2	1.500692	6–10	0.428835
3	1.705588		3	1.770400		3	1.94744	10–20	0.55573	3	2.003916	10–20	0.571848	3	2.003916	10–20	0.571848
4	2.546905		4	2.643687		4	2.908056	20–40	1.11146	4	2.992390	20–40	1.143696	4	2.992390	20–40	1.143696
5	3.403525		5	3.532859		5	3.886145	>40	1.6662	5	3.998843	>40	1.714516	5	3.998843	>40	1.714516

4. Methodology

The study applies a quantile regression within-artificial blocks transformation on panel data to solve the key concern of the endogeneity problem that is present when evaluating the price effect on hotel water consumption. This problem is inherent to an increasing block tariff system, since a higher consumption will lead to a higher marginal price when the consumption reaches a new block. Accordingly, the tariff system introduces an endogeneity problem, since the price is determined by the total amount of water consumed. The tariff system implies a positive correlation of water consumption and the marginal price, due to the increase in price for higher blocks. This implies that the use of the ordinary least squares (OLS) method, without tackling the endogeneity problem, is not capable of identifying the price elasticity.

Several possibilities have been proposed by previous literature to solve this problem: (i) the introduction of instrumental variables in the OLS models in various stages (2SLS, 3SLS) [12,15,32–35]; (ii) the application of maximum likelihood estimation methodologies [36–39]; and (iii) the use of OLS with Nordin's difference variable, which is sufficient to address this issue [40]. Nordin's difference variable is defined as the difference between the total bill and the cost if all units were charged at the marginal price, and it captures the impact of changes in intra-marginal prices on consumers' income. Nordin's difference variable has also been used by several studies to estimate water demand models [12,34,36–38,41,42]. According to [43,44], this methodology allows the collection of the effect of the fixed fee that is usually charged in the water bill for connection to the water and sanitation network. Nevertheless, the authors conclude that the specific characteristics of the study and the available data will finally determine the existence of endogeneity problems, and the most suitable specific econometric technique for use in such cases.

This study applies the methodology of within-artificial blocks transformation to only take advantage of the variation free from endogeneity. A first step is to specify all block limits for the study period. Water consumption that varies within such blocks is unrelated to the increasing block tariff, but it could still be related to price changes that occur over time. Thus, for each observation, the average water consumption for each hotel and the same two-month period was deducted, with the additional restriction that only observations in the same artificial block (*ab*) are used, according to Equation (1):

$$\widetilde{y}_{ikt} = y_{ikt} - \overline{y}^{*}_{i\bullet}, \text{ where, } \overline{y}^{*}_{i\bullet} = \frac{1}{J}\sum_{j=1}^{J} y_{ij} \big| ab_j = ab_t \tag{1}$$

where the variables (y_{ikt}) and ($\widetilde{y}_{ikt}$) are the observed and the transformed water consumption (respectively) for hotel i, in year k and two-month period t (t = 1, ... , 6). The average water consumption ($\overline{y}_{i\bullet}$) is computed for each artificial block (*ab*), and J is the number of cases that water consumption was in the same artificial block (*ab*) as in year k and two-month period t (i.e., only the same two-month period is considered, but all of the years are taken into account). The restriction to base the average only on data from the same two-month periods implies a fixed-effect model, where only the variation within the period for the same hotel is used to identify the coefficients. Hence, neither cross-sectional variation, variation due to seasonal difference within a year nor variations over different blocks are used. This within-block transformation is also performed for all explanatory variables.

An additional concern consists in the fact that, since water price includes a fixed part, higher consumption decreases the average price, until a situation occurs in which consumption reaches a block with a marginal price that is higher than the average price. Any consumption beyond that point will increase the average price. Including Nordin's difference variable, which uses both the marginal price and the average price, would also introduce an automatic relation with the dependent variable. To deal with this, the average consumption within the artificial block is calculated following the methodology described above. The average consumption was used to find the average price for each two-month period. Since water consumption that does not vary for the same two-month period for different years is used, the only source of variation in the corresponding average price is therefore due to changes in the tariff system.

The model includes Nordin's difference variable to take into account the fact that, despite the similar marginal price, the pricing structure employed to reach that marginal price could be different, and hence also has an effect on water consumption. The model uses the alternative definition of the difference variable (D_{alt} = AP − MP), with an average price, as explained above, that only varies over time due to changes in the price system.

Hence, the dependent variable of our model is water consumption per bed for two-month periods, thus involving six observations per year from 2011 to 2015. The regression model includes a logarithmic transformation because a price change is expected to imply a percentage change in water consumption, rather than an equally sized reduction in water consumption measured in m^3/bed place for all hotels.

The model includes three explanatory variables: logarithm of marginal price, an inverse hyperbolic sine transformation of Nordin's difference variable, and occupancy rate expressed as a percentage. The within-transformation ensures that the coefficients of the model are not affected by seasonal differences or unobserved hotel-specific factors that are constant over time. Thus, those variables that do not change over time (i.e., pool and garden areas) are not included in the model. Regarding the climatological variables, the evolution of monthly average precipitation and monthly average temperature during the study period is analyzed. Neither of the variables present significant differences across the study period and are therefore not included it in the estimated regression model.

The estimated conditional quantile regression estimator [45] minimizes (over $\boldsymbol{\beta}_q$):

$$Q_N\left(\boldsymbol{\beta}_q\right) = \sum_{i:\widetilde{y}_i \geq \widetilde{x}_i\prime\beta}^{N} q\left|\widetilde{y}_i - \widetilde{x}_i\prime\boldsymbol{\beta}_q\right| + \sum_{i:\widetilde{y}_i < \widetilde{x}_i\prime\beta} (1-q)\left|\widetilde{y}_i - \widetilde{x}_i\prime\boldsymbol{\beta}_q\right|, \quad (2)$$

where ($\widetilde{y}_i$) and ($\widetilde{x}_i$) are, respectively, the within-artificial blocks transformation for water consumption and the explanatory variables for hotel (*i*). Explanatory variables included are the logarithm of marginal price, an inverse hyperbolic sine transformation of Nordin's difference variable, and occupancy rate. The model is estimated for $q = (0.25;\ 0.5;\ 0.75)$. The reason for not using only $q = 0.5$ for the estimation, or applying OLS on transformed variables, is that if many artificial blocks have a very small width, observations are restricted to small variations within these blocks. Evaluating more quantiles ensures that these observations are not exerting too much influence on the estimated coefficients.

Data Description

The sample database includes 67 hotels from the three selected tourist municipalities (Calvià, Ses Salines, and Santa Margalida), which represent 40.85% of the total hotel plant in the three municipalities.

The database covers the period from 2011 to 2015 (the year of the reform, 2013, and two years before and after), following the methodology applied in similar previous studies [30,34]. Data related to water consumption were provided by the water companies. Water prices were obtained from several official data sources, such as the Official Bulletin of the Autonomous Government (BOIB), and the tax regulations of the municipalities. Finally, hotel occupation rates were obtained directly from hotel managers during interviews conducted by professionals.

The descriptive statistics of dependent variables and explanatory variables are shown in Tables 4 and 5. Table 4 includes the median for each year, while Table 5 includes the median for each two-month period. The median water consumption is about 10 m^3 per bed place and per two-month period for all years. The lowest median is found in 2014, while the highest is in 2015. Both the median of the average price and the median of the marginal price increase over the period studied.

Table 4. Median of key variables per year.

	Water Consumption	Marginal Price	Average Price	Average Price *	Occupancy Rate
2011	10.033	1.444	2.072	2.079	85%
2012	10.107	1.454	2.109	2.107	83%
2013	10.054	1.454	2.154	2.171	85%
2014	9.935	1.462	2.206	2.224	83.5%
2015	10.12	1.462	2.213	2.224	83%

Notes: Water consumption is measured per bed place for two-month periods (in cubic meters). Average price * is the average price that the hotel would have paid if consumption were at the average level. The average is calculated within two-month periods and within-artificial block.

Table 5. Median of key variables for different two-month periods.

	Water Consumption	Marginal Price	Average Price	Average Price *	Occupancy Rate	Number of Cases
January, February	1.3	0.653	7.531	7.298	20%	54
March, April	4.244	1.328	2.973	2.862	48.5%	129
May, June	9.38	1.454	2.106	2.121	85%	235
July, August	13.45	1.678	2.101	2.095	95%	223
September, October	12.306	1.686	2.104	2.108	82.5%	231
November, December	8.377	1.462	2.381	2.400	39.5%	41

* is the average price that the hotel would have paid if consumption is on average level.

Table 6 includes all artificial blocks and the absolute and relative frequency as a percentage in each of the intervals. The column amplitude of each interval is included to clarify that there is sufficient room for variation in consumption without moving to another artificial block. While there is sufficient variation within blocks, it is also interesting to evaluate whether the variation that is discarded contains a particular pattern. This is performed in the following way: the most important price change for the period was the change from a flat tariff to an increasing block structure for the sanitation fee. The blocks are the same for all hotels and are separated at 12, 20, 40, and 80 m^3/bed place, thus yielding five intervals. A value of one is assigned for consumption in the first block and increases until five in the last block, and then the average block ordering in 2011–2012 and in 2013–2015 is calculated. Table 7 includes the proportion of cases where this average was lower, equal, or higher after the introduction of the increasing block structure.

Table 6. Artificial blocks.

	$\mathbf{Amplitude_i}$	$\mathbf{n_i}$	%
(0–3333)	3.333	159	17.42
(3333–375)	0.417	9	0.99
(375–6667)	2.917	82	8.98
(6667–1125)	4.583	282	30.89
(1125–12)	0.75	31	3.40
(12–16,667)	4.667	191	20.92
(16,667–1875)	2083	44	4.82
(1875–20)	1.25	9	0.99
(20–33,333)	13.333	88	9.64
(33,333–40)	6.667	0	0.00
(40–80)	40	14	1.53
(80–)	–	4	0.44

Table 7. Changes in average block ordering for blocks of the sanitation fee (before and after 2012).

	January, February	March, April	May, June	July, August	September, October	November, December
Lower	2.99%	13.43%	19.4%	29.85%	17.91%	2.99%
Equal	77.61%	71.64%	62.69%	32.84%	52.24%	74.63%
Higher	19.4%	14.93%	17.91%	37.31%	29.85%	22.38%

Note: The block ordering goes from the lowest (1) to the highest (5) block of the sanitation fee, where the number indicates in which block the hotel was consuming.

This overview includes all cases and not only those used in the final model. There is no tendency to adjust to lower blocks and it appears that the movements are merely due to fluctuation around the interval limits. Regardless of whether the average ordering is higher or lower, observations are not necessarily discarded because the average could be higher or lower due to a departure from the block in a single period, i.e., only that observation would be excluded.

5. Results and Discussion

The results of the coefficient estimations for quantile regression on percentiles 25, 50, and 75 are presented in Table 8. Calculations excluded those observations corresponding to the period where the hotels were closed (usually in the low season that refers to the period from November to February). This is the reason for the reduced number of observations for the period November to February. Those observations in which the within transformation for water consumption was zero were also discarded. This happens in 233 cases when the water consumption for a hotel was in a specific artificial block only once for a specific two-month period. Keeping these observations does not produce any qualitative change in the results. The pseudo-coefficient of determination is very low for all models, but this is natural since only variation within hotels in the same artificial blocks and the same two months are modeled.

Table 8. Quantile regressions estimates.

	p25		p50		p75	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Constant term	−0.050	0.005	0.002	0.003	0.055	0.006
Marginal price	0.070	0.154	−0.026	0.094	0.141	0.172
Nordin's variable	0.260 ***	0.077	0.200 ***	0.047	0.150 *	0.086
Occupancy rate	0.004 **	0.002	0.003 ***	0.001	0.002	0.002
Pseudo R^2	0.015		0.013		0.007	

Notes: The sample size for all models is 913. Notation: *** significant at 1%, ** significant at 5%, * significant at 10%.

Before the analysis of our key interest (that is, evaluation of the effects of the price change), it is interesting to evaluate the effect of a change in the occupancy rate, based on the exponent of its coefficient. Accordingly, an increase in the occupancy rate by one percentage point is expected to require an increased water consumption of 0.3% for it to remain at the median. It is important to underline that this effect does not include any change in occupancy rate due to seasonal differences. Hence, the within-difference only includes an average based on the same two-month periods, in order to avoid confusing the effect of occupancy rate with an effect of different seasons (where both occupancy rate and water consumption are higher in the high season). This effect is much smaller than 1% because a share of the hotel's water consumption is unrelated to the occupancy rate. This result is interesting and provides evidence of the considerable water "lock in" at hotels, due to the water-intensive facilities (i.e., filling the pool, garden irrigation, spa facilities, etc.) that do not depend on occupancy levels and entail a fixed water consumption [46–48].

Regarding the effect of price variables, the coefficients of the price variables cannot be interpreted separately because any change in price will affect both the marginal price and Nordin's difference variable. Thus, the model develops three different scenarios to evaluate the effects of any hypothetical price changes in the tariff system (Table 9).

Table 9. Complete effect of price changes in different scenarios.

		p25	p50	p75
		% Change	% Change	% Change
Scenario A	Average	−0.011	−0.077	0.080
All	Median	0.018	−0.065	0.100
Scenario B	Average	0.077	0.035	0.075
First block	Median	0.070	0.032	0.068
Scenario C	Average	−0.052	−0.075	0.013
Last block	Median	0.013	−0.005	0.025

First, in scenario A, the study evaluates the effect of a 1% increase in price in all of the blocks. This scenario is intended to evaluate the price elasticity. Scenario B includes a 1% increase only in the first block. This means that hotels consuming in higher blocks will not experience the change in marginal price, but the average price will change due to different prices for the initial units consumed. Finally, scenario C implies a 1% increase only in the last block. In this case, only hotels that consume in that block are affected, and the evaluated effect is restricted to this particular subsample.

The change in the average price is measured to evaluate the effect of the price change on Nordin's difference variable. This difference was added to the average price that was previously calculated based on the within-artificial block average consumption. Finally, the new Nordin's difference variable was calculated (with an inverse-hyperbolic-sine transformation) using the new marginal price and the adapted average price. For 232 cases, this change was negative, and for 681 it meant an increase in the variable. Accordingly, it is difficult to know how the sign of the coefficient would matter for water consumption, and this underlines the importance of using scenarios to interpret the overall effect of a change in prices. The study uses the coefficients generated from the models to obtain a predicted dependent variable, to which the within-artificial block mean is added (which was previously deducted in the within-transformation procedure). The quantiles have the property of equivariance to monotonic transformations, and it is possible to simply back-transform the fitted value to its original scale using the exponent.

The first scenario (A) suggests that a 1% increase in all prices in all blocks is decreasing the median water consumption by an average 0.077% or, using the median, a reduction of 0.065%. Conversely, the same policy would increase the water consumption by an average of 0.080%, so that water consumption would remain at the percentile 75. Accordingly, the point estimates are very small and even of different signs, and the overall conclusion is that the price changes had a negligible effect on the water consumption of the hotels for the period included in this study. Therefore, the tariff reform did not have any relevant effect on the water consumption of the hotels.

The evidence obtained by previous literature [2,9,19,49] concludes that only significant increments in water prices encourage the adoption of water saving measures in the hotel sector. Thus, a natural question to ask is, of course, whether the price reform was too small to generate a relevant effect on hotel water consumption. In this sense, results reveal that the interquartile range for the marginal price (in logarithm) is only 0.017, while Nordin's difference variable, as defined above, has an interquartile range of 0.061. The interquartile range of the water consumption is 0.11.

Although the modification of the sanitation fee might have resulted in an important increase in the water bill for those stakeholders with large consumptions (since the tariff of the latest block is multiplied by five), this increase did not really happen. The average variation in the total water costs of the hotels studied accounted for 7%, with increases ranging from 3% to 16%. There are two main reasons that explain this moderate increase in the bill. First, the new sanitation fee includes a fixed component that represents an important part of the total fee (approximately 70% of the total), and it does not depend on the water consumption but instead on the total number of tourist places of the hotel. In this respect, the increase in this fixed part of the sanitation charge was 14%. Second, the excessive amplitude of the blocks of consumption of the new sanitation fee means that most of the observations, in particular during the low season, are located in the first block (61.68%), in which the increase is less important (2.9%). The second block, where the marginal price increased by 50%, includes 26.7% of the observations, and only 9.6% were in the third block, with an increased marginal price of 100%. Regarding higher blocks, only 1.5% of the observations were in the second highest block (where the marginal price increased by 300%) and, finally, only 0.4% consumed in the highest block (with a marginal price increased by about 500%). Even in these cases, the high weight of the fixed part of the sanitation fee made the increase in the total bill somewhat unclear, and it was insufficient to encourage a reduction in hotel water consumption.

The results obtained are similar to those obtained by previous studies. For example, [50] concluded that Spanish urban water tariffs do not encourage water saving for three main reasons: the fixed fee is usually excessively high, the variable fee is not sufficiently progressive, and the marginal prices are too low. Similarly, [31], analyzing the residential water price reform in a group of cities in China (from uniform to increasing block tariff), conclude that the oversized initial block and the reduced price differentiation between blocks may prevent the reform from being effective as a way to improve water use efficiency and resource conservation.

6. Conclusions

This study analyzes the short-term effects of a water price reform (from a linear to an increasing block rate), introduced by the regional government in 2013, on hotel water consumption in Mallorca. The role of the hotel sector is crucial to guarantee the sustainability of the water resources of the destination, since hotels are the most popular accommodation option among tourists and those with the highest water consumptions. The reform engendered a substantial modification of the sanitation fee, one of the components of the water-pricing tariff, both in terms of quantity and structure. Its purpose was to penalize high water consumption, promote a more efficient use of the resource, encourage water savings, and recover the environmental costs of the water cycle. The study applies an econometric technique to deal with two important problems that usually arise in these demand regression models: the endogeneity problem and the effects of the fixed charge on the average price.

Although the reform was clearly aimed at saving water, the study concludes that this objective was not achieved in the hotel sector. During the period studied, the reform did not generate sufficient incentives to reduce water consumption due to an inappropriate design. Specifically, the potential key issues were the disproportionate fixed component of the water tariff and the oversized initial block of the sanitation fee. The exacerbated seasonal component of tourism on the island implies that most of the observations are situated in the first block. During the high season (from May to September), and only in some hotels, there is a relevant increase in the marginal price of water.

The idea of moving from linear to increasing block rates has gained a lot of interest among water utilities and regulators as a means to promote water conservation and efficiency, thereby ensuring equity. Nevertheless, our research concludes that this is not always true, and the design of the block structure plays a crucial role. Hence, if policymakers want to implement an effective water price policy, it will be necessary to develop a rigorous ex-ante analysis of the hotel water demand. The characteristics of this sector and the shortage of literature on the subject call for further empirical studies with new evidence on this relationship, to design an optimal water-tariff structure that promotes sustainable water consumption in the hotel sector. More specifically, the study recommends that the water tariff should include a reduction of the weight of the fixed part, an increase in the prices of the variable part, and a reduction of the block size in increasing block tariffs. The reduction of fixed costs, which could jeopardize the recovery of all costs of water, could be offset by an increase in the rates of the first blocks.

It is very important to keep in mind that increasing block rates designed for domestic water use are not necessarily suitable for commercial and industrial sectors. It is, of course, a political issue whether keeping a low rate in the first block is also a priority for private businesses. In this sense, the analysis and evaluation of water tariffs should distinguish between domestic, and commercial and industrial water use. Another important difference is that seasonality patterns can differ, which could also affect how effective the policy is in achieving its goals.

In the specific case of the hotel sector, a better design of the water tariff structure should consider two important aspects. First, the size and the number of the blocks have to be designed on the basis of a previous benchmarking of the most efficient hotels for each category. Second, water tariffs have to recover the full costs of water services, and the discrete price shifts among blocks have to promote saving water.

The evaluation of the short-term impact of changing from linear to increasing block rates for the hotel water demand in Mallorca provided disappointing results. Possible flaws in the design are identified, but it is, of course, uncertain whether correcting these issues would be enough to achieve important water savings in the hotel sector.

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