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SAVING NATURAL RESOURCES: THE EXEMPLE OF BALEARIC INDUSTRY/ AHORRO DE RECURSOS NATURALES: EL EJEMPLO DE LA INDUSTRIA BALEAR

L. Vizcaíno Pérez[1]

[1]*National Distance Education University, UNED, Spain*

ABSTRACT

Tourism is the most important industry in the Balearic Islands. This article develops a method to set mathematical models that relate water consumption with occupation. The method is tested in a set of hotels from Majorca, although it is perfectly applicable anywhere in the world. Every model is validated by the square of the Pearson correlation coefficient. The methodology displayed is acceptable in the examples analyzed, as Pearson coefficient values obteined are above 0.69, opening a new field for further research. Finally, it is studied the effect of adding new hotels to the model of the group of hotels, obtained previously.

Keywords: Consumption model, Natural resources, Hotel chain, Water control, Balearic islands, Pearson correlation coefficient.

1. INTRODUCTION

The effect of the tourism on local economies is well known. However, tourist industry does not only impact economy, but also enviroment.

Consumption of local natural resources, as water and energy, are the second most important cost input in hospitality. Aside from cost savings, efficient water management brings value in terms of reputation and market positioning. Reduction of water consumption is key element of continuous improvement process of any hotel Enviromental Management System.

In tourist locations in the Balearic Islands, population increases dramatically in summer season. This increment entails an increase of natural resources consumption. For example, in Capdepera, the population is 11.000 inhabitants in winter but it reaches 40.000 inhabitants during the summer season. It seems clear that the consumption of local natural resources in Capdepera village multiply by four.

So, it has been taken as an example data monthly water consumption of three star hotels sunny beach in Majorca Island, Spain, then add another hotel of another chain and check effects on the dynamic model developed, just to prove that the method is completely reproducible.

The need to improve competitiveness in the hospitality industry has been widely treated in the literature, as the article «Analysis of the role of international financial institutions in the financing of tourism» (Pulido, 2011). Therefore, attempts to control overhead costs of a hotel are perfectly developed using programs of enterprise resource planning (ERP), such as Navision Financials, Navihotel, Verial or Prestige. An ERP system is a software application that allows you to manage all business processes of a company in an integrated manner, as defined the article «Methodology for selection of ERP systems» (Chiesa, 2004). In the hospitality module of ERP there is the same information from several departments, spending results in both personal and incidents, and materials. Management of water consumption is too coarse, simply because ERP is not especific designed for this work. The ERP allow the introduction of daily meter data and analysis monthly consumption per person, but do not calculate the mathematical model of consumption of the hotel itself, much less the model of water consumption target of every hotel chain or in particularly in terms of water consumption per occupied room.

The attempt to create models of water consumption in the industry is not new. Much more is to obtain models of consumption in natural resources, and especially in water. Some authors have tried to obtain consumption patterns. Even, «Energy Rationalization in hotel facilities: technical analysis for a new project based on the cogeneration» (Rivero, 1998), optimizes curves thermal and electrical demands inclusive of hot water services, cold, sea water desalination and electricity of a "type hotel ." Schedule energy curves describes his studies , and based upon a model of hotel , defining different energy consumption by formulas basic consumer segments as swimming pool, rooms…

The article «Obtaining the demand curve for water tour Acapulco» , Guerrero (Cruz Vicente, 2011) develops a mathematical model based on the economic theory of demand for two areas of Acapulco. This model relates number of rooms occupied with liters consumed and depends on logarithmic variables, but does not discuss the influence of other variables such as height or age of the building, or the membership of the hotel to a chain.

The next step was a multiple regression analysis, which studied the differents variables that affect consumprion of the natural resource water in a hotel in Hong Kong (Shi-Ming and Burnett, 2002). The article «Energy simulation accommodations mathematical model: analysis in the Canary Islands» (Trujillo Armas *et al.*, 1996), proposes a mathematical model for heat and power consumption, segregated for each subsystem, operating time and load variation . For this, the author set the variables affecting consumption schedules, getting daily consumption by a computer program data storage , obtaining an admissible error of + -12 %.

It is amazing how the rest of the industry analyzes energy and water consumption, and the models develop exponentially. Thus, energy modelling of electrical systems in industrial processes is widely reported in the literature: patterns of energy supply (Samoulidis, 1980), the linear programming model of the U.S. electricity industry (Hillsman *et al.*, 1988), models that

allow analysis of a single plant from an industry models (Pilati and Sparrow, 1980), the analysis model developed energy resources for the gas industry US ((Limaye and Sharko, 1974), the dynamic linear programming model for energy resources (Rapoport, 1975) or energy modeling (Jebaraj and Iniyan, 2006).

Engineering models (bottom- up) , getting to represent an energy system in detail , considering it as a set of technologies for production, distribution and final energy demand competing (González, 2005)

Finally, note metaborder models, such as those already used to measure efficiencies between different groups of hotels, but only in terms of environmental variables and technological. Thus in contrast to what happens in the rest of the industry, there are no models in catering to appraise accurately the efficiency of a hotel regarding their optimal consumption, much less models to assess this efficiency for a group of hotels. Everything is based on the intuition that comes from experience manager over the years, especially in mansions but also in large chains, but intuition cannot necessarily be translated into a vague and not entirely objective assessments.

Finally, the article Water consumption model for three star hotels in Majorca (Escalera Izquierdo *et al.*, 2013), develops no a model but a method to study water consumption, from historical data from hotels, using linear regressions validated by the Pearson correlation coefficient.

Among the multitude of existing hotel establishments, some homogeneous enough to be comparable hotels have been chosen. Studied hotels have similar characteristics: they are sun and sand establishments, their type of construction is the same, their age is similar and they belong to the same hotel chain: Hotetur. Thus, a particular segment of the hotel industry is well defined. The typical establishment studied is a three star (or three keys) hotel or apartment in Balearic Islands; that is, sun and sand hotel, similar in structure built of reinforced concrete, concrete block and sandstone, belonging to a Spanish hotel chain, and twenty years old at least.

In this paper, a model for control of natural resources to a number of hotels in Majorca is proposed and checked what happens, experimentally, when another hotel is added to the series. The input chosen for this paper is water, as essential for the hospitality industry anywhere in the world, because reducing water consumption leads to social and environmental benefits.

2. STATE OF SCIENCE

This article studies the effect of adding data of new hotels to the chain analyzed previously by Escalera Izquierdo, G in 2013.

It is interesting that the consumptions were measured in litres per person per day, while the total ones are measured in litres. The data analysis was divided into two broad categories: water consumption for each hotel and consumption for the hotel group. Both analyses have different objectives and use different mathematical tools. The first one characterized the water

consumption of each hotel, allowing, in principle, to predict or assess their own consumption, and facilitates comparisons between different hotels. The analysis of the second category homogenize and group data from all hotels of the same type, and then find empirical relationships that provide an overview of water consumption in the studied hotel group.

Table-1. General data of premises

	Linda	Leo	Belsana	Bellevue Club	Vistanova	Lagomonte
Type	Hotel	Hotel	Hotel and apartments	Apartments	Hotel	Hotel
Location (Majorca)	Can Pastilla	Can Pastilla	Porto Colom	Alcudia	Punta Ballena	Alcudia
Hotel chain	Hotetur-Roc	Hotetur-Roc	Hotetur-Bluebay	Hotetur-Bluebay	Hotetur-Bluebay	Hotetur-Bluebay
Stars/Keys	3	3	3	3	3	3
Year of construction	1971	1968	1986	1982	1969	1970
Building type	Several floors	Several floors	Several floors	Several floors	Several floors	Several floors
Number of buildings	1	1	2	18	1	1
Number of floors	5	5	5	8	8	6
Number of rooms	189	285	100	1474	198	272
Number of double rooms	189	275	63	1474	172	245
Personnel rooms	4	0	4	25	0	0
Total capacity pax/month	11,250	18,000	7,500	139,050	12,300	25,500
Garden surface (m2)	600	200	0	250,000	300	1,600
Specific garden surface (m2/room)	3.17	0.70	0.00	169.61	1.52	5.88
Swimming pool surface (m2)	180	350	250	2450	220	450
Specific swimming pool surface (m2/room)	0.95	1.23	2.50	1.66	1.11	1.65
Spa	No	No	Yes	No	No	No
Distance to beach (m)	250	150	500	800	50	1200
Electronic drive for water pumping	Yes	No	No	No	Yes	No
Pipe type	Reticulated polypropylene (RPP)	RPP	RPP	Iron and RPP	Reticulated polyethylene	Reticulated polyethylene
Air conditioning	Yes	Yes	Yes	No	Yes	Yes
Hot water fuel	Diesel	Natural gas	Propane	Propane	Propane	Diesel
Hot water accumulation volume (m3)	12	12	10	64	12	18
Working laundry	No	No	No	No	Yes	Yes
Study time range	2003-2008	2003-2008	2003-2012	2003-2012	2003-2012	2003-2012

Source: Water consumption model for three star hotels in Majorca (Escalera Izquierdo *et al.*, 2013)

All empirical relations are obtained for both normal and optimal consumptions. The normal consumption analysis included all consumptions that have passed the aforementioned filters.

2.1. Water Consumption for a Group of Hotels

The analysis of the first category started by checking the apparent linear relationship between monthly water consumption and the number of overnight stays. In this case, the author concluded that the water consumption could be expressed by a straight line as indicated in equation:

Equation-1. Monthly water consumption versus overnight stays

$$A = m^A \cdot P + A^F$$

- m^A: slope of the empirical straight obtained for each hotel, which is the average per person water consumption for a specific hotel (L / pax).
- A: gross monthly water consumption (L / month).
- P: number of overnight stays in a month (pax / month).

- A^F: fixed water consumption in one month, independent of individual use (L/month).

Differences between hotels would depend on different consumption rates per person at the individual hotels as well as A^F. Every straight line is obtained by a simple linear regression analysis, based on empirical data. Its validity was checked by means of the Pearson's correlation coefficient, r, between both variables under consideration. The closer to one the coefficient is, the greater the validity of the straight line as a model is. Criterion to rate correlation between the two variables (Suárez Ibujes, 2011), is shown in Table 2:

Table-2. Pearson coefficient: the rate correlation

Value	Meaning
-1	Negative perfect correlation
-0.9 a -0.99	Very high negative correlation
-0.7 a -0.89	High negative correlation
-0.4 a -0.69	Moderate negative correlation
-0.2 a -0.39	Low negative correlation
-0.01 a -0.19	Very low negative correlation
0	Non-existing correlation
0.01 a 0.19	Very low positive correlation
0.2 a 0.39	Low positive correlation
0.4 a 0.69	Moderate positive correlation
0.7 a 0.89	High positive correlation
0.9 a 0.99	Very high positive correlation
1	Perfect positive correlation

Source: Suárez Ibujes. Article: Karl Pearson's correlation coefficient

After verifying the existence of a linear relationship with at least a moderate positive correlation between both variables, monthly water consumption and the number of overnight stays, in affirmative case, the specific consumption, "a", can be easily calculated by the Equation 3, which is a parabola with a horizontal asymptote a=mA.

Equation-2. Water consumption for a hotel, in litres per person per day, versus overnight stays

$$a = A/P = m^A + A^F/P$$

The first analysis involves calculating the parameters of the monthly water consumption versus overnight stays straight line, which are also parameters of the water specific consumption curve.

The second category analysis involves representing specific consumption versus the occupancy percentage for all hotels. Only specific consumptions and occupancy percentages can be analysed together. From all these data, several models were tested by means of linear regression analysis. The empirical equation that has the higher correlation coefficient were chosen. Finally, the author made a change of variable, such that the average occupancy rate p(%) in a month:

p(%)=(P/maximum capacity)*100 and then:

Equation-3. Linear equation of specific water consumption in hotels

$$a=m^A+ (A^F/(p(\%)*\text{maximum capacity}/100))$$

Normal consumption data were studied in the same way as water consumption was studied for each hotel, but author studied the effect of using data of a group of hotels as if it were a single hotel. Table 3 shows the result of the coefficients of normal water consumption in summer season of the group of hotels analized.

Table-3. Water consumption for a whole year parameters of the overal analysis. 2003-2013 period

Parameter	Majorca 3*
Specific consumption yearly average (L/pax·month)	226
R	0,99
m^A	234
A^F	84.420
Capacity	205.726

So, finally it results, by simply the same change of variable:

Equation-4. Linear equation of specific water consumption of overall analysis. 2003-2013 period

$$a= 84.420*100/p*205.726$$

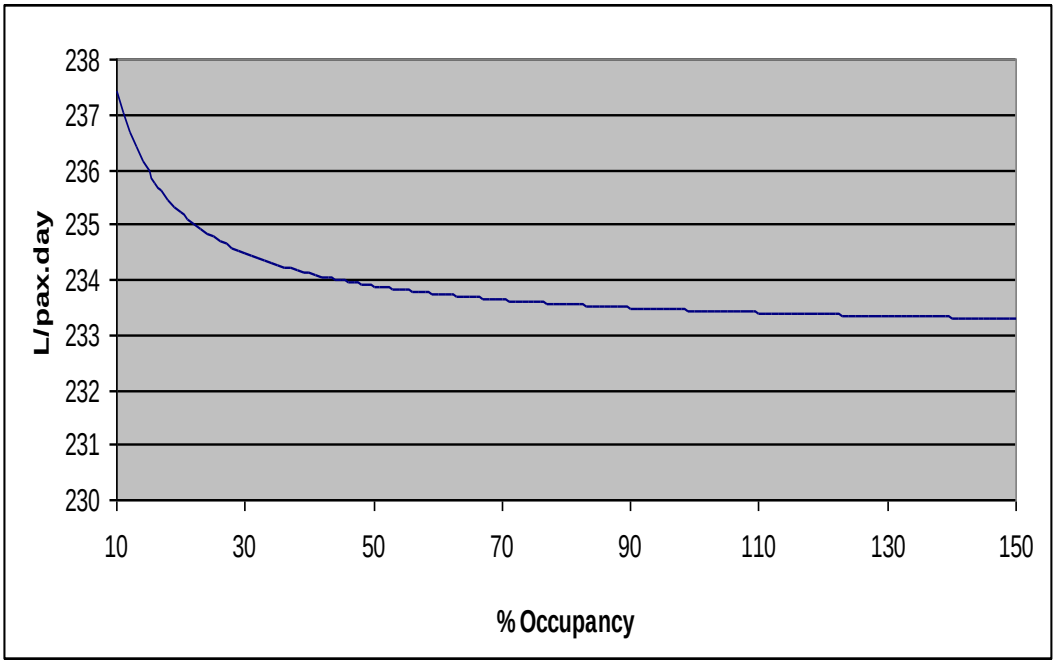

Figure-1. Overal analysis: global water consumption curve. Studied period 2003-2013

2.2. Effect of adding new Hotels to the Model Group

In this case, the effect of adding a new hotel is analized.

The data of the new hotel are shown in the table 4.

Table-4. General data of the apartamentos Lagoplaya

	Lagoplaya
Type	Apartamentos
Location (Majorca)	Capdepera
Hotel chain	Hotetur
Stars/Keys	3
Year of construction	1971
Building type	Multitude of bbuildings
Number of buildings	8
Number of floors	3
Number of rooms	100
Number of double rooms	100
Personnel rooms	0
Total capacity pax/month	25.500
Spa	Si
Distance to beach (m)	50
Electronic drive for water pumping	No
Pipe type	Reticulated polypropylene (RPP)
Air conditioning	Yes
Hot water fuel	Diesel
Hot water accumulation volume (m3)	9
Working laundry	No
Study time range	2003-2008

This article follows the method described in the article by Escalera Izquierdo, G. for the group of hotels. First of all, the hotel Lagoplaya is studied individually. The table 5 shows the result of applying the method of the hotel.

Table-5. Water consumption for the Lagoplaya hotel individually

Parameter	**Majorca 3***
Specific consumption yearly average (L/pax·month)	374
R	0,692
m^A	297
A^F	752.264
Capacity	25.500

So, finally it results, by simply the same change of variable:

Equation-5. Linear equation of specific water consumption of Lagoplaya hotel a= 752.264*100/p*25.500

The next step is simply to add the hotel to all hotels Lagoplaya previously studied, and reapply the method developed by Escalera Izquierdo, G. as table 6 shows.

Table-6. Water consumption of the group including Lagoplaya

Parameter	Majorca 3*
Specific consumption yearly average (L/pax·month)	252
R	0,99
m^A	233
A^F	178.079
Capacity	231.226

As can be seen, the effect does not change the coefficient of Pearson, which implies that the fact of adding this hotel to previously studied group of hotels will not negatively affect its linearity form.

3. CONCLUSION

Annual water consumption curve has been obtained for a sample of hotels from a well-defined segment of hotel industry. This group or curves refer not only to normal, but also optimal consumption.

The method used to model this hotel industry segment could be used to model any other segment of this industry.

Since models have been calculated by means of statistical methods, the bigger the sample is, the more reliable are the models obtained because of the consistency in the models applied.

The developed method leads to conduct new experiments in other hotels with similar characteristics to each other, but completely different from those studied here; as hotels in other destinations such as the Caribbean or even city hotels, or even other industries. The method to obtain the corresponding model can thus be tested in the same manner as in the case studied by other accommodation.Validity of the models can be measured by the Pearson coefficients, in the same way as in the study presented here.

The method is fully reproducible and can discern whether a hotel is part of a group of hotels or not.

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