A NEW APPROACH FOR ESTIMATING TOURISM - INDUCED ELECTRICITY CONSUMPTION

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Abstract: Environmental impacts of tourism and related sectors have become perceptible in many regions of the word and have been quantified by a large number of studies. However, because of the no presence of the tourist sector in traditional economic classifications, the environmental costs that can be ascribed to the tourist industry have been neglected in the literature. In this paper the contribution of the tourism activity to the electricity consumption is investigated using the case study of the Balearic Islands. On the basis of a daily traditional model, and using the daily stocks of the population (residents and non-residents), it is shown how tourist load influence the electricity consumption in the Balearic Islands.

Keywords: Electricity demand, tourism industry, sustainable tourism, daily data.

JEL codes: L83, O13, Q41.

1. INTRODUCTION

International tourism is considered nowadays one of the most important industries in the world, with an annual volume of 900 million arrivals (UNWTO, 2008) and a projection that this number will continue growing to 1.6 billion worldwide by 2020. In terms of economic importance, the Tourism Satellite Accounts elaborated by the World Travel & Tourism Council estimates the contribution of travel and tourism to World Gross Domestic Product at 9.9% in 2008, a percentage that is expected to continue growing to 10.5% by 2018 (WTTC, 2008).

In addition to its economic significance, the sector is a major source of environmental impacts and resource consumption. It has been recognized that to be able to assess and improve sustainable development, accounting for a sector's performance should not only address the economic contribution but also environmental and social dimensions (Gray and Bebbington, 1993). In response to this recognition, additional methods for auditing performance have evolved, including lifecycle assessment (Hernández and León, 2007; Becken and Simmons, 2008) and ecological footprinting (Gössling et al., 2002; Patterson et al. 2007).

However, although the contribution of tourism has been recognized as potentially considerable (Gössling, 2002), only very recently, literature have started to study energy consumption by tourist activities and the resulting greenhouse gas emissions that contribute to the anthropogenic component of global warming (Cárdenas and Rosselló, 2008). Thus, it is being fueled by a great recognition that tourism industry is also one of the largest consumers of energy, particularly it is needed to facilitate transportation of travelers, as well as to provide amenities and supporting facilities at the destinations visited (Becken, 2002; Becken & Simmons, 2002, Becken et al., 2001, 2003; Gossling, 2000; Gossling et al., 2002; Tabatchnaia-Tamirisa et al., 1997).

The use of energy and the contribution to greenhouse gas (GHG) emissions has benefit from a special attention in the case to the use of air transport. Price & Probert (1995) discussed environment impacts for air travel for a more general perspective but without particular reference to tourism. Penner et al. (1999) pointed out the difficulty to quantify the contribution of the greenhouse gases to global warming. However, some recent works examined the environmental impact of air travel. In particular, energy use and GHG emissions have been discussed by Gössling (2000), Gossling *et al.* (2005) and Peeters and Schouten (2006) by giving a figure of 60–95% of the contribution of an average trip involving air transport to global warming. A comprehensive discussion of the externalities of aviation, such as air pollution, noise, accidents, and congestion, is provided by Janic (1999). Becken (2002a) revealed that the energy use of up to 27.8 PJ is resulting from international air travel to New Zealand.

Accommodation sector and other complementary industries have also been analyzed in the context of tourism energy use. Some pioneer studies have focused on a relationship between energy intensity and building characteristics highlighting the variety of the energy used by the different establishments, as well as the environment impact of their production (Becken et al., 2001; Deng and Burnett, 2000; Simmons and Lewis, 2001). Thus, Becken et al (2001) found that hotels are energy intensive and the average consumption per bed night range at 130MJ in the case of New Zealand. However the scientific data limitation in this area of research, makes it difficult to allocate a certain amounts of energy use for different accommodation establishments, and therefore a degree of uncertainty should considered.

However all these studies have considered sub-sectors of the tourist industry in order to accomplish to the calculation of the contribution of tourism to energy consumption. The reason for this desegregation can be found in the fact that tourism is not recognized as an economic sector in the traditional economic classification and their full consideration constitutes a problem because of the mixture nature of some of the sub-sectors that can be included in the tourists' product.[1] Nevertheless, it is important to ascribe an environmental responsibility to tourism activities in the sense that they can be regionally relevant for promoting or discouraging tourism development policies. Thus, to derive national and global estimates of that contribution it is necessary to develop methodologies for efficiently assessing tourism's contribution to greenhouse gas emissions, as well as key areas within tourism that should be targeted for mitigation strategies.

Consequently, the main objective of this paper is to evaluate the contribution of the tourism to electricity energy consumption by estimating an electricity demand model that introduces the stock of tourists that contributes to this demand. Thus, using the isolated and highly tourist destination of the Balearic Islands (Spain), the daily electricity demand is modeled mainly as an explanation of the meteorological conditions of the archipelago, a set of labor calendar variables that controls the working and non-working days and the stock of tourism that are present in the islands during a day.

The paper is structured as follows. Section 2 reviews the literature on electricity demand modeling providing the methodological underpinnings for the study. Section 3 provides major details about data with special emphasis on the calculation of the daily stock of tourists. Section 4 presents the results and the discussions. Finally, Section 5 concludes.

2. MODELING ELECTRICITY CONSUMPTION

Modeling electricity consumption has received considerable attention over the past fifty years. Houthakker (1951) analyzed electricity demand on domestic two-part tariffs for 42 provincial towns in the UK and found that average annual electricity consumption per consumer was a function of the average income per household, marginal price of

[1] For instance, restaurants and some specific commercial activities can have both a local and a tourist component that is often difficult to isolate.

elasticity and marginal price of competing forms of energy, such as gas. He also reported that the electricity consumption of families had a strong seasonal variation, depending on average temperature and average hours of daylight per day for each month. Foss (1963) studied the utilization of capital equipment and suggested that electricity consumption was an indicator of capital usage, especially in an industrial country such as the United States (US). Foss's idea was adopted by Jorgensen and Griliches (1976) and Heathfield (1972) to measure capital usage using electricity consumption data. Mount et al. (1973) analyzed both the short- and long-run demand for electricity for three classes of consumers, namely residential, commercial and industrial. They demonstrated that long-run electricity demand was generally price elastic and becomes increasingly elastic as prices rose. In contrast, demand was general inelastic with respect to income, especially for residential and industrial classes that approached zero as income increased. Afterward, Kraft and Kraft (1978) examined the relationship between electricity consumption and economic growth in the US using data over the 1947–1974 periods. They found evidence of a unidirectional causality running from gross national product to electricity consumption.

During the eighties, more sophisticated time series models started to be implemented and they were the basis works of modeling electricity consumption. After the liberalization of the electricity market in the nineties, an increasing interest was raised in predicting energy demand and the development of new approaches for energy price forecasting. To understand the different types of models that have been undertaken, it is essential to be conscious about the behavior of electricity consumption, which demonstrates high fluctuations, whether recorded daily, hourly, half-hourly or minute-by-minute. Generally, much of this variation is due to historical consumption and the relationship of this consumption to other relevant variables, such as economic, demographic, climatic and energy price.

Thus, in the context of energy consumption and economic activity, Glasure and Lee (1997) presented a bidirectional causality relationship between energy consumption and gross of domestic production (GDP) for South Korea and Singapore using the cointegration and error-correction models. Shiu and Lam (2004) found that there is a unidirectional relationship running from electricity consumption to real GDP for China using error-correction model too. Soytas and Sari (2003) examines the causal relationship between GDP and energy consumption in the top 10 emerging markets and the G-7 countries while Yang (2000) found bidirectional causality between energy consumption and GDP for Taiwan. Murray and Nan (1996), Wolde-Rufael (2006) and Yoo (2006) found that there are diverse causality between electricity consumption and economic growth in different countries. Flores et al. (2004) and Ozturk and Ceylon (2005) studied the annual electricity consumption in industrial sector. They found that industrial-related parameters such as the number of establishments, fuel costs, import and export values, etc. affected electricity consumption

When higher frequency data are investigated, no the causality is extended to other factors that have been incorporated in models leading to a number of stylized facts in regards to energy consumption. These include some degree of trend; several dummy seasonal variables for hourly, daily and monthly periodicities; complex calendar effects including weekends, holidays, vacation periods and other special days; and a non-linear dependence on meteorological variables, which could change depending on the day of the week, the season of the year or consumer habits.

Weather variables have been used for the prediction of load, and a great variety of modeling approaches has been made up to capture the weather effects. Yan (1998) studied electricity in residential sector using climate factors as explanatory variables. Ranjan and Jain (1999) categorized electricity in Delhi into four seasons and derived empirical models based on population and weather conditions. Moreover, Egelioglu et al. (2001) found that the model using the number of customers, the number of tourists, and the electricity prices as regressors has very strong predictive ability for Northern Cyprus. Additionally Nasr et al. (2002) studied electricity in Lebanon and found that it depended on degree days and total imports.

Finally, in the context of electricity demand modelling, it should be pointed out a special set of works proposed and implemented with the main aim of producing forecasting. Thus, from linear regression (Bodger and Mohamed, 2005) to artificial neural networks techniques (Darbellay and Slama, 2000), through simple autoregressive terms (Saab et al, 2001; Fatai et al.,2003), smooth transition autoregressive (Amaral et al., 2008), and ARIMA modelling (Cancelo et al. 2008) have appeared in the literature with the objective of get good results in terms of the forecasting accuracy.

3. DATA ANALYSIS

The proposed electricity models developed in this paper takes the case study of daily data consumption of the isolated electricity system of the Balearic Islands (Spain). The power system in Balearic Islands is responsible for supplying electricity to 1 million of residents and 13 of tourists annually according to the official statistics. In reference to the tourist population it is important to highlight that the average length of stay of a tourist is about 9 days, and the fact that the climate conditions of the archipelago explain the high level of seasonality that characterize tourism in the islands that accounts for 60% of total arrivals from June to September.

3.1. Electricity data

Data of electricity consumption for each one of the Balearic Islands (BAL), Mallorca (MALL), Menorca(MEN) and Eivissa and Formentera (IBI) was provided by Red Electrica Española, the Spanish System Operator, and ranges from January 1995 to September 2007. The data set used comprises daily electricity demand (E) in MW h for the entire period under consideration. The daily demand data are the total of all sectors of economic activity (industrial, commercial, residential, and agriculture), as sector disaggregated data were not available for this time frequency, and can be seen in Figure 1.

[*Insert Figure 1 about here*]

It is clearly observed that a strong long-term trend do exist in the daily electricity demand. This trend has been often observed. More precisely Cancelo and Espasa (1996), for the Spanish case, shows a positive trend for the period 1983-1988 that was attributed to social, economic, and demographic factors. Previous tests and papers have shown also a significant seasonal daily and monthly components in the electricity load series (Valor et al., 2001). In order to capture them, different dummy variables can be introduced. Anomalous events related to holidays, or special days, have also to be considered in order to capture the different electricity patterns shown traditionally by population in this special days. Thus, it is expected that the electricity consumption, mainly in the industrial sector, decreases considerably during holidays as well as in weekend.

3.2. Weather data

Historical weather data required by the proposed models for the period were supplied by the *Centre de Recerca Econòmica* and comes from the Balearics meteorological center. The experience of many utilities indicates that the weather elements, which influence electricity demand, consist of temperature, humidity, wind and precipitation in a decreasing order of importance (Engle et al. 1992). However, the influence of a considerable number of meteorological parameters on electricity demand of Spain was analyzed by Cancelo y Espasa (1996) affirming that primary temperature and secondary humidity are the most significant of them.

As literature has traditionally considered and as clearly depicted in Figure 1 the non-linear influence of temperature on electricity demand suggests the use of two temperature derived functions, the heating degree-days (HDD) and the cooling degree-days (CDD), thus separating the winter and summer data. In dealing with the non-linearity of the temperature effect, the most frequent posture in the literature is to segment temperature in terms of the HDD and CDD that can be defined as:

$$HDD_t = Max\ (T_{ref} - T_{t,}\ 0) \quad [1]$$

$$CDD_t = Max\ (T_t - T_{ref},\ 0) \quad [2]$$

T_t is the weighted average temperature for the day t and T_{ref} is a reference temperature that should be adequately selected to separate the heat and cold branches of the demand-temperature relationship. These functions reflect in combination the number of days on which the temperature stands below or above the thresholds of cold and heat, and by how many degrees. Since there is no strict quantification of the values of the "threshold" temperatures, there can be many different versions of the functions HDD and CDD. In the context of this study the reference temperature has been selected to be equal to 17 °C for high temperatures and 12 °C for low temperatures, which is the interval of temperature at which, as shown in Figure 2, the influence of temperature is minimized and electricity demand is inelastic to temperature changes.

[*Insert Figure 2 about here*]

Additionally, because of the special high degree of humidity that characterize the Balearic Islands that, the Heat index (HI) was introduced as an alternative of the use of the simple mean temperature variable. Thus, the HI combine the mean daily outdoor temperature and the mean daily relative humidity in order to fairly accurate the human feeling of heat and cold. Thus, when temperature is high and the relative humidity is high the HI collects the higher heat sensation that people often perceives. Alternatively, when temperature is low and the relative humidity is high, the HI collects the higher cold sensation that people often perceives. The explanation of this distortion is found in the fact that the human body normally cools itself by perspiration, or sweating, which evaporates and carries heat away from the body. However, when the relative humidity is high, the evaporation rate is reduced, so heat is removed from the body at a lower rate causing it to retain more heat than it would in dry air.

Measurements have been taken based on subjective descriptions of how hot subjects feel for a given temperature and humidity, allowing an index to be made which corresponds a temperature and humidity combination to a higher temperature in dry air. Whatever the case, the most used formulation of the HI was proposed by Steadman (1979) and is also adopted in this study.[2] Otherwise, for the measurement of the Balearic index the population weighted temperature index has been constructed from the mean daily temperatures measured at the different islands separately. The reason why the population has been selected as a weighting factor is that climate influences the electric consumption through the response to people to weather; the people will increase or decrease the use of electricity appliances or air conditioners. Thus the higher the population, the higher the influence of weather conditions in electricity demand.

Thus, Figure 3 presents daily electricity consumption in Balearics versus HDD and CDD build on the basis of the HI (HTEMPHI and LTEMPHI, respectively). It is clear that the two seasonal branches are separated into two functions, the first one for high temperatures and the second for low temperatures.

[*Insert Figure 3about here*]

3.3. The daily population stock

The annually demographic load that can be present in an area or region could be largely different from the data collected by the census office. Mainly, this divergence is due to the high frequent movement of the people to destinations outside the places where they normally live and it includes movements for all purposes, family, studies, work or leisure. The Balearic Islands, with its high specialization in tourism industry, are considered one of the regions with this special pattern. In fact, tourist movements in the Balearics Islands are very important and can double the amount of resident in some days of the year.

In this context, Mateu and Riera (2007) developed a measure IDPH[3] the stock of people, at a daily level, that were on each one of the Balearic Islands based on the resident population data and the arrivals and departures at airports and ports. The

[2] Then, $HI = -42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783 \cdot 10^{-3}T^2 - 5.481717 10^{-2}R^2 + 1.22874 \cdot 10^{-3}T^2R + 8.5282 \cdot 10^{-4}TR^2 - 1.99 \cdot 10^{-6}T^2R^2$, with T = ambient dry bulb temperature degrees in Fahrenheit and R = relative humidity.

[3] Indicador de pressió Humana (Human pressure indicator).

IDPH has proven an accurate approximation to measure the demographic pressure in Balearic Islands and could be expressed as follow:

$$\mathrm{IDPHD} = \mathrm{PR0} + \sum_{d=1}^{D}(Ed - Sd) + \sum_{d=1}^{D}(Vd) \qquad [3]$$

Where PR0 is the resident population on the first day of each year based on the official statistics; *Ed-Sd* is the difference between the entry and exit quantities of individuals, derived from airports and ports registrations; and *Vd* stands for the natural growth of the population as consequence of births and deaths. IDPH variable for the three islands and for the whole archipelago can be shown in Figure 4.

In this work the IDPH is separated into the daily stock of the resident population (IDPH_RES) and the daily stock of the tourist population (IDPH_NORES) in order to isolate the effect of the tourist sector on electricity consumption. This separation was based on the *Familitur* data from where it is possible to estimate how many residents are on tourism monthly. In any case, data from Familitur is only available at the Balearic Islands level being not possible to separate the two groups for each one of the islands. For the case of the Balearic Islands the separation of the IDPH into residents and non-residents can be shown in Figure 5.

[*Insert Figure 4 about here*]

[*Insert Figure 5 about here*]

4. RESULTS AND DISCUSSIONS

Following considerations mentioned above two equations for the estimation of the daily electricity demand were considered. For the case of the Balearic Islands:

$$Ln(E_t)=c+\alpha t+k_1*HTempHI_t+k_2*HTempHI_t*t+k_3*HTempHI_t^2+k_4*HTempHI_t^2*t+l_1*LTempHI_t+l_2*LTempHI_t*t+l_3*LTempHI_t^2+l_4*LTempHI_t^2*t+\sum_{i=2}^{7}(di*Dit)+\sum_{j=2}^{12}(fj*Mjt)+\sum_{k=1}^{16}e_k*SD_{kt}+p_1*IDPH_{RES}+p_2*IDPH_{NORES}+e_t \qquad [4]$$

For the cases of the Mallorca, Menorca and Ibiza and Formentera:

$$Ln(E_t)=c+\alpha t+k_1*HTempHI_t+k_2*HTempHI_t*t+k_3*HTempHI_t^2+k_4*HTempHI_t^2*t+l_1*LTempHI_t+l_2*LTempHI_t*t+l_3*LTempHI_t^2+l_4*LTempHI_t^2*t+\sum_{i=2}^{7}(di*Dit)+\sum_{j=2}^{12}(fj*Mjt)+\sum_{k=1}^{16}e_k*SD_{kt}+p_1*IDPH+e_t \qquad [5]$$

It should be noted how the electricity demand variable (E) is taken in natural logarithm; D_{it} and M_{jt} are dummy variables that control for the day of the week (*i*) and the moth of the year (*j*); SD_k are dummy variables that controls the non-labor and special holidays days; c, α, k_1, k_2, k_3, k_4, l_1, l_2, l_3, l_4, d_i (i from 2 to 7), f_j (j from 2 to 12), e_k (k from1 to 16) $p_1$and p_2 are the coefficients to be estimated from the regression analysis and e_t is the residual term distributed normally and independently.

The results of the models are reported in Table1. The adjusted R^2, the Akaike Info Criterion (AIC) and the Schwarz Criterion (SC) were used to select the best model that fit our data, in addition to F-test for overall significance of the model and a t-test for testing the strength of each of its individual coefficients. The main results obtained with the introduction of the dynamic structure are presented in Table 1, where it can be shown how different autoregressive terms (AR for simple autoregressive terms, and SAR for seasonal autoregresive terms) as well as moving average terms have been introduced in order to account for the strong autocorrelation and partial autocorrelation of the daily time series. Thus, the Breusch–Godfrey Serial Correlation LM Test rejected the null hypothesis for no serial correlation in the residuals.

The adjusted Rsquared of all the estimated models can be qualified as good being higher that 0.96 in all the cases. For the Balearics model a subset of the variables is tested for statistical significance to examine if they can be omitted. Each of the insignificant variables is deleted sequentially from the general dynamic model, while the significant parameters at 1%; 5% and 10% levels are retained.

[*Insert Table 1 about here*]

For weather parameters, high temperature heating index and low temperature heating index are both significant at 1% level, in addition the square of these parameters were added to the model of the Balearic Islands in order to capture non–linear relationships and reveal 5% significance for high temperatures and 1% significance level for low temperatures. Population stock variables are also significant at 1% level in all the cases and with an expected positive estimated parameter. However, because of the special interest of this work the case of the Balearic Islands with the distinction between residents and tourists population the efforts are centred in this model.

Thus, because of the non-linear relationship between electricity consumption and temperature, the obtained relationship between this two variables in investigated using the concept of elasticity, a standard measure to evaluate the sensibility of electricity load to temperature changes (Valor et al, 2001), that for this case study can be defined as:

$$\epsilon_{HTHI} = \frac{HTHI}{E_{HTHI}} * f'\,(\mathrm{HTEMHI}) \qquad [6]$$

$$\epsilon_{LTHI} = \frac{LTHI}{E_{LTHI}} * g'\,(\mathrm{LTEMHI}) \qquad [7]$$

Where ϵ_{HTHI} and ϵ_{LTHI} are the elasticities for the high and low temperatures using the heat index; f'(HTHI) and g'(LTHI) are the first derivatives of the electricity demand function with respect to HTEMHI and LTEMHI, respectively.

Figure 6 and 7 depicts the elasticity estimations for high and low temperature heating index, for Balearics Islands from 1994 to 2006. The maximum elasticities are observed in years 2003 and 2005 for high and low temperatures heating index respectively, then descended gradually till 2006. In addition, the mean of annual elasticity of the high temperatures heating index is higher than for low temperatures heating index, except for the year 2005 when low temperatures were recorded, and annual elasticity for low temperatures reached 2.6% versus 2.3% in high temperatures. This gap of elasticity values is clearly noticeable in 2003 when high temperature reached historical record and elasticities are 3.7% and 1.6% for high and low temperatures respectively (Figure 7). These features show a relatively higher sensitivity of the electricity demand function in summer than the one in winter.

[*Insert Figure 6 about here*]

[*Insert Figure 7 about here*]

For the population stock variable, different simulation about the effect that various rises in the two population stocks (residents and non-residents) are analyzed in Table 2. As there is an increasing gap between the two populations during the period set of our study, simulations were done for two different years, 1999 and 2006 and for different increase percentages.

[*Insert Table 2 about here*]

Results show how an increase in population stock for respectively residents and non residents is associated with an increase of electricity consumption, with relatively high annual rates for residents in the three scenarios and in the both years, 1999 and 2006. In addition to the fact that maximums of electricity consumption of non residents are depicted in summer period of respectively years 1999 and 2006, the deference between the maximums of the couple (resident; nonresident) in the Table 2 is increasing when we pass from year 1999 to year 2006 (0.4% for year 1999 and 0.7% for year 2006). This issue is explained by the fact that the proportion of resident nonresident is increasing and it is relatively higher in year 1999 (97%) compared to 85% of year 2006. This result triggers other questions like, what would happen if the population of resident increased by a fixed amount? Has electricity consumption the same effect if this amount was increased in February instead of August?

Different simulations were processed as intent to answer the questions set above. Thus, in Table 3, a simulation of an increase of the Balearics' resident and nonresident population separately, by adding a 3%, 5% and 10% of the resident and nonresident average population respectively, is depicted. The results show a higher sensitivity of electricity demand in case of resident than nonresident; the means of electricity demand growth rates reached 53.7%, 50.7% and 49.5% for 10%, 5% and 3% increases respectively of resident population mean, compared to 13.1%, 12.5% and 12.2% for the case of nonresident population.

[*Insert Table 3 about here*]

High electricity consumptions are observed in summer, either for residents or nonresidents models, whereas low rates are depicted in autumn and winter. Furthermore, a sensitivity analysis of electricity consumption is done for the months February, March, April, August and November. Minimum rates of electricity growth for both residents and nonresidents are obtained in April and November, as in a simulation of a 10% increase in absolute value of nonresident's population of Balearics; the electricity growth is 33% higher in August than in April or November.

This result is for a considerable importance for tourism planners, to mitigate the effect of high energy consumption on the environment. Such a result can be used as a basis for measures to regulate, or otherwise maintain a control on visitor flows in congested places, or to guide planning decisions about the number of population stock that may be acceptable in an area in peak season.

5. CONCLUSIONS

Tourism is regarded as an economic activity which brings about several benefits for destination countries. However, it is important to evaluate its net benefits by considering the associated costs as well. Thus, tourism activities should be analyzed considering not only of the level of tourist expenditures and the direct costs of providing tourist services, but other environmental costs as well. However, literature review reveals how the no-recognition of the tourists sector by the traditional public economic accounts has derived in sectorial studies when tourism associated costs have been evaluated.

This works considers an alternative modeling procedure though the consideration of the tourist population stock that could improve the efficiency of the models applied so far in this area, and that could be useful for estimating the relative effects of energy use and its concomitant GHG emissions in tourism destinations. Using the case study of the Balearic Islands the relationship between electricity load and population stock factor has been estimated showing a high level of significance of both resident and nonresident population stocks when determining electricity demand.

The analysis has revealed that the sensitivity of electricity load to population stock variable has increased along time for residents and nonresidents, with higher sensitivity for resident case. Furthermore, a simulation study has been undertaken through a hypothesized increase of 3%, 5% and 10% of the resident and nonresident average population respectively. The main results of the simulation show high growth rates of electricity demand for both residents and nonresidents in the summer, in addition to a relative insensitivity of electric demand between resident and nonresident during summertime.

The fact that a simulation of an increase of nonresident population in February or November is associated with a relatively low growth rate of electricity consumption, can be for a great help to planners in the context of monitoring sustainability and reducing the impact of tourism to environment.

Future research will have to deal with de possibility to evaluate the tourism responsibility in determining electricity load in each one of the Balearic Islands by considering the variability within the year of the total population stock, assuming that the main fluctuation of the variable is caused by the tourist population. These results should be compared with those obtained in this work in order to validate them.

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Figure 1. Daily electricity consumption in the Balearic Islands

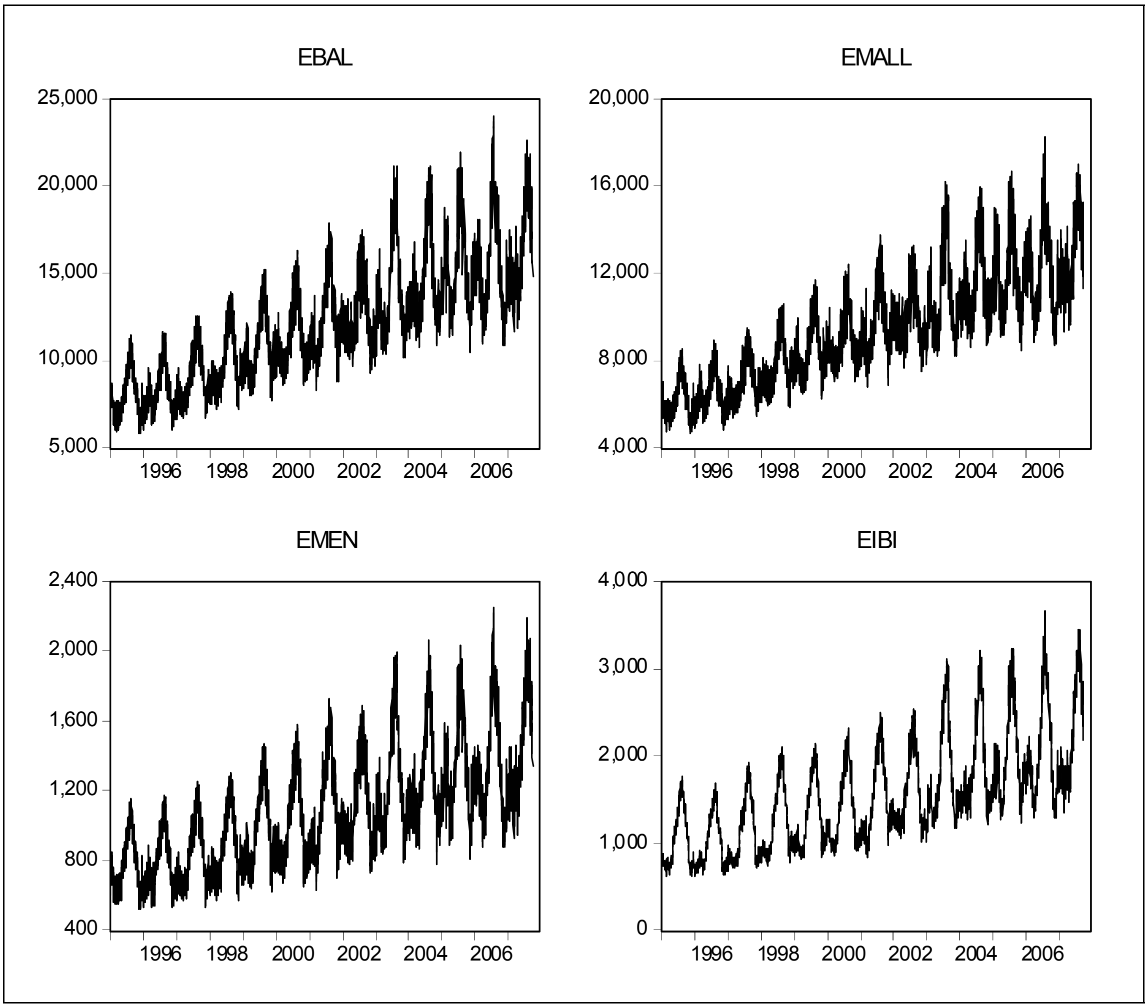


Fig.2 Daily Load and mean temperature

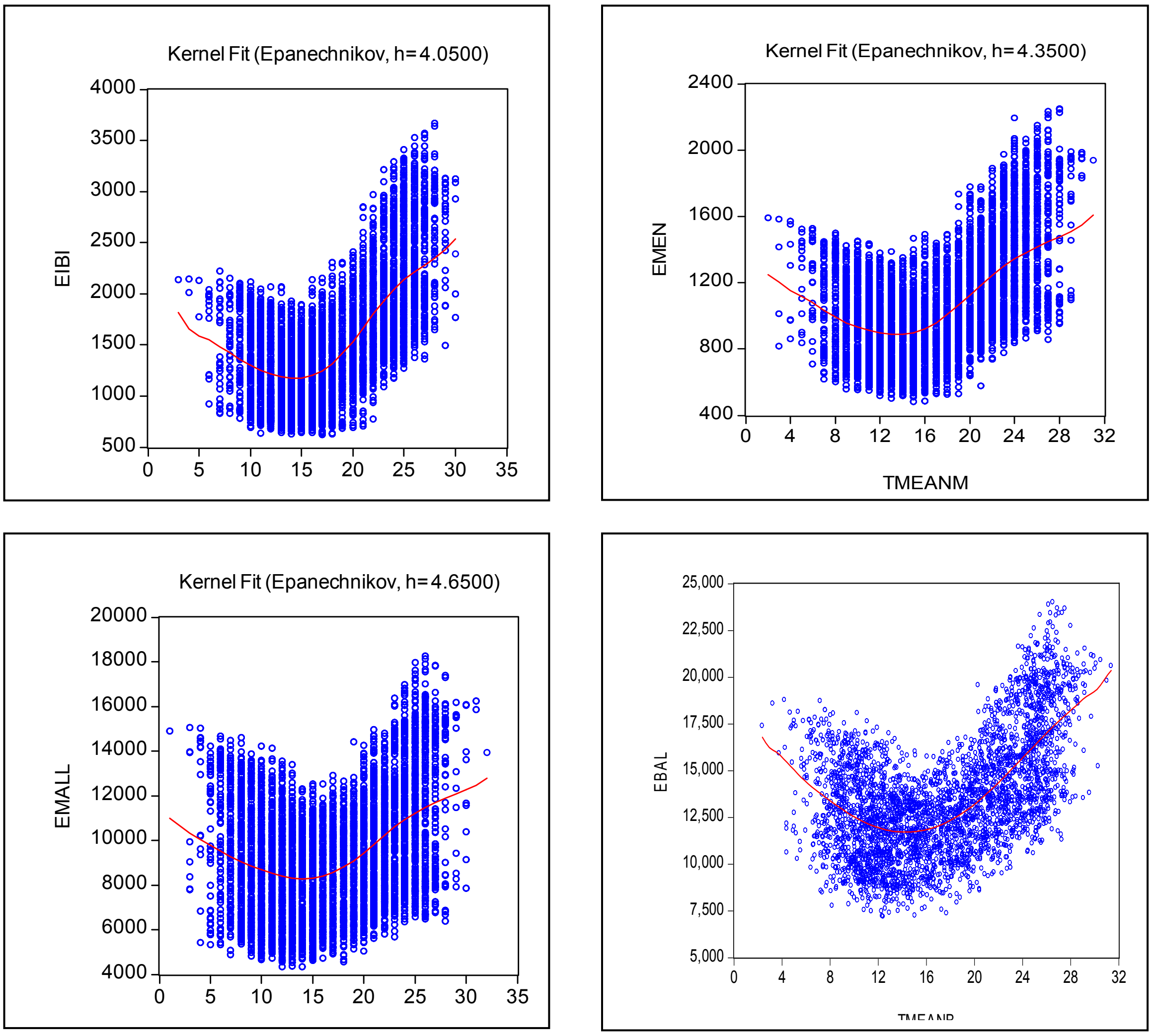


Fig.3. Daily electricity consumption & HDD and CDD in Balearics

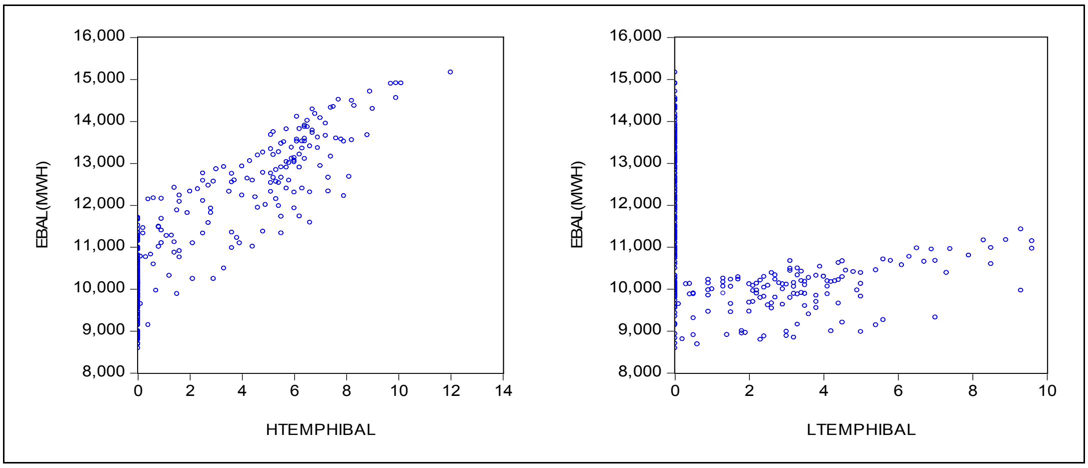
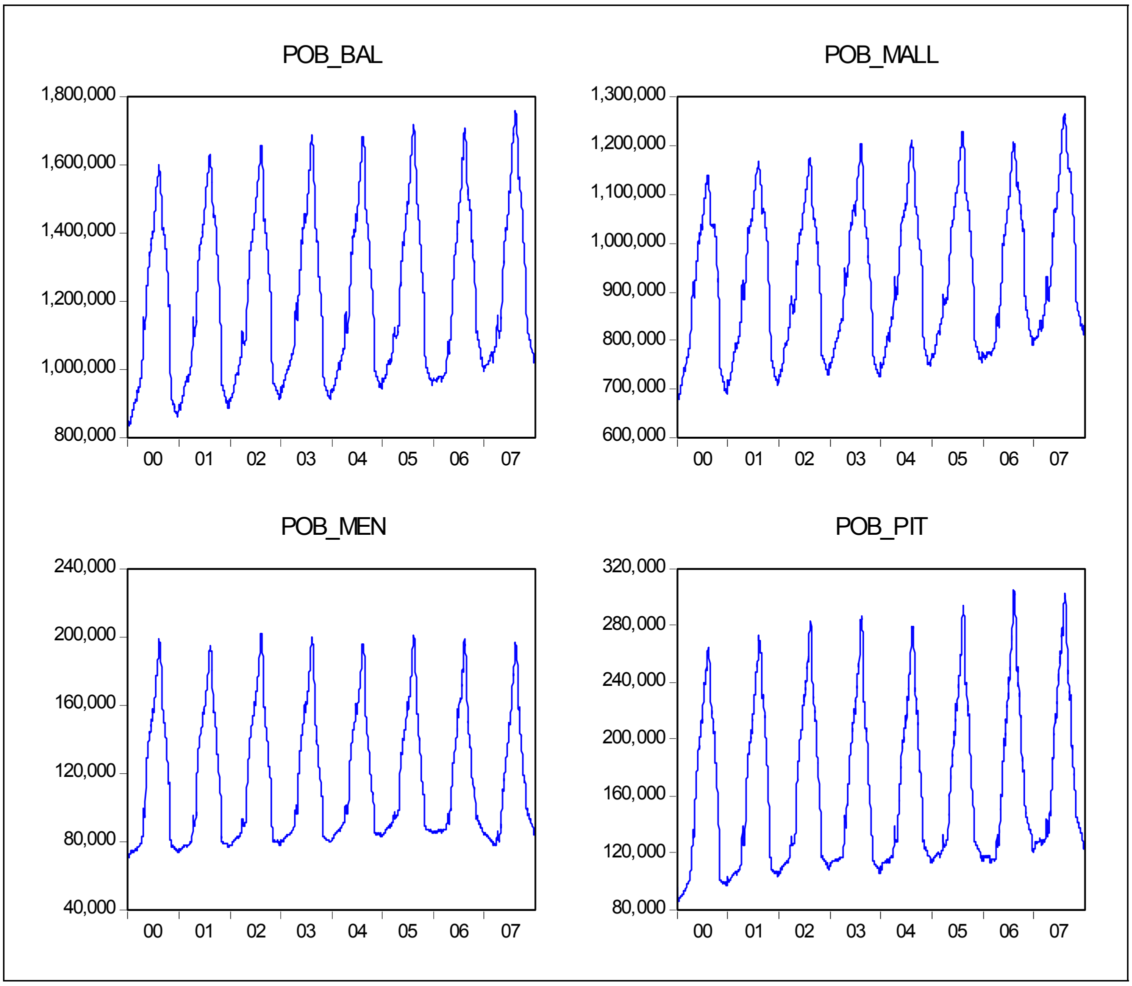


Figure 4. IDPH in the Balearics Islands.



Note: POB_BAL, POB_MALL, POB_MEN and POB_PIT stands for the IDPH in the Balearic Islands, Mallorca, Menorca and Pitiuses (Eivissa and Formentera). The Balearic one is computed as the sum of the other ones.

Figure 5. IDPH for the residents and for the tourists in the Balearics

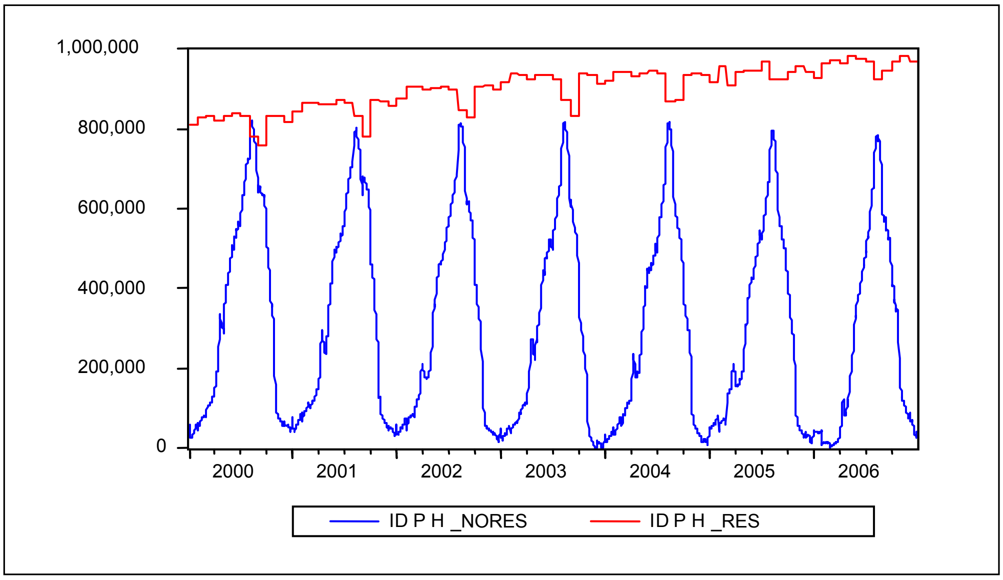


Table 1. Estimated models for electricity consumption in the Balearics

	Mallorca	Menorca	Ibiza&Formentera	Balearics
@TREND	0.000127***	0.000125***	0.000140***	0.000121***
SD05_1	-0.076714***	-0.095080***	-0.057749***	-0.084873***
SD06_1	-0.036096***	-0.059927***	-0.026091***	-0.016502
SD16_1	-0.027869**	-0.129835***	-0.018137**	-0.034970***
SD20_1	-0.026715***	-0.020524*	-0.013432*	-0.017176*
SD28_2	-0.082633***	-0.104918***	-0.061911***	-0.080794***
SD01_3	0.016676	0.013428	0.027495***	0.012277
SD30_4	-0.066764***	-0.041709***	-0.024391**	-0.074209***
SD14_8	-0.085388***	-0.067912***	-0.034242***	-0.090787***
SD11_10	-0.095919***	-0.106356***	-0.060462***	-0.093382***
SD12_10	-0.048970***	-0.042953***	-0.024114***	-0.034739***
SD31_10	-0.154956***	-0.213954***	-0.143242***	-0.161923***
SD01_11	-0.032179***	-0.034211***	-0.010716	-0.030237***
SD05_12	-0.108537***	-0.108125***	-0.068630***	-0.108315***
SD06_12	-0.033793***	-0.060950***	-0.007897	-0.045012***
SD07_12	-0.076988***	-0.103847***	-0.056949***	-0.089030***
SD09_12	0.030624**	0.041290***	0.023680**	0.028125**
SD24_12	-0.087572***	-0.103496***	-0.067089***	-0.112713***
SD25_12	-0.086077***	-0.095875***	-0.072438***	-0.093491***
SD31_12	-0.062316***	-0.062612***	-0.035323***	-0.078890***
SDJVS_ST	-0.072965***	-0.089714***	-0.043922***	-0.069747***
HTEMPHIP	0.004349***	0.012129***	0.005785***	0.010488***
HTEMPHIP^2	0.000169*	-0.000273**	-0.000154**	0.000278**
LTEMPHIP	0.004190***	0.009171***	0.008591***	0.007386***
LTEMPHIP^2	0.000342***	0.000445***	0.000153	0.000537***
C	8.379606***	6.209016***	6.317974***	8.480177***
IDPH	5.34E-07***	3.99E-06***	3.89E-06***	-
IDPH_RES	-	-	-	4.34E-07***
IDPH_NORES	-	-	-	3.71E-07***
AR(1)	0.530607***	0.115697***	0.154783***	0.458179***
AR(2)	0.154419***	0.255424***	0.452174***	0.128453***
AR(3)	-	-	0.112326***	0.125815***
AR(4)	0.073508***	0.090580***	-	0.095278***
AR(5)	0.036845**	0.077891***	-	-
AR(6)	-	0.081215***	0.041135***	-
AR(7)	-0.245973***	-0.377213***	-0.285512***	-0.256688***
SAR(7)	0.753823***	0.781130***	0.737799***	0.694744***
MA(1)	-	0.381395***	0.554410***	-
Equation Statistics				
Adjusted R-Squared	0.965062	0.974239	0.990281	0.971475
Log likelihood	6496.125	6299.866	7151.687	6154.008
Durbin-Watson stat	1.905434	2.030176	1.946184	1.893018
AIC	-3.641255	-3.530531	-4.011107	-3.840886
SC	-3.568116	-3.457392	-3.937968	-3.751251
F-statistic	2388.608	3270.005	8808.062	2354.644
Proba(F-Statistic)	0.000000	0.000000	0.000000	0.000000

Note: *** significant at 1%, ** significant at 5%, * significant at 10%

Figure 6. Daily elasticity estimations from the electricity demand function

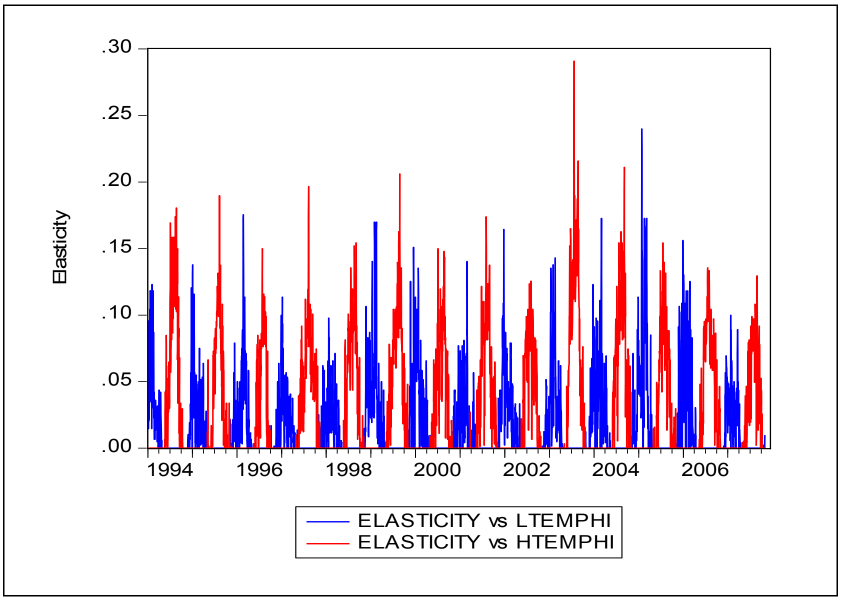


Figure 7. Yearly elasticity estimations from the electricity demand function

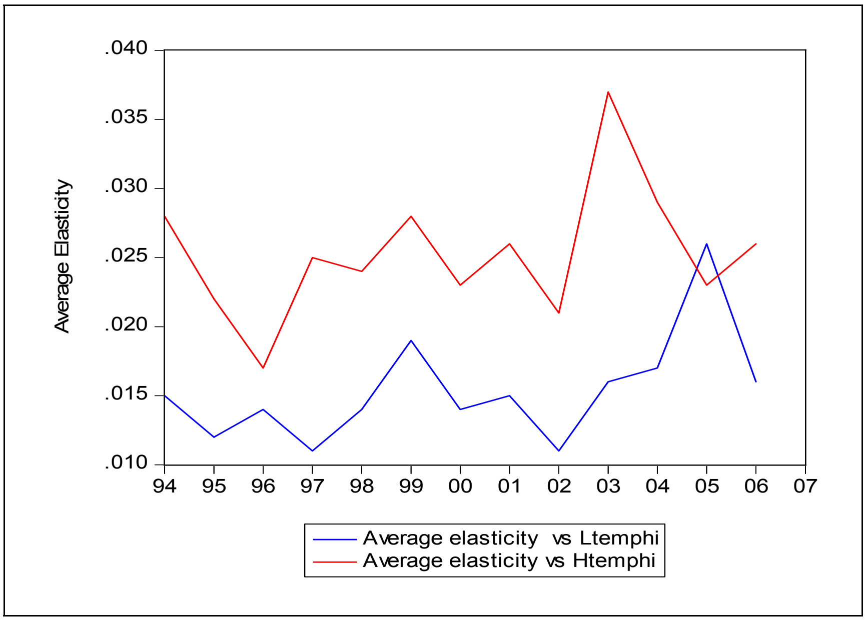


Table 2: A simulation for electricity consumption growth of Balearics

		5% increase		8% increase		10% increase	
		resident	non resident	resident	non resident	resident	non resident
Max	1999	1.8%	1.4%	2.9%	2.3%	3.6%	2.9%
Mean	1999	1.7%	0.6%	2.8%	1.0%	3.5%	1.2%
Max	2006	2.2%	1.5%	3.6%	2.4%	4.5%	3.0%
Mean	2006	2.1%	0.5%	3.4%	0.8%	4.3%	1.0%

Table 3: Simulation from tourist and residents population growth

	3% increase		5% increase		10% increase	
	resident	non resident	resident	non resident	resident	non resident
Mean	49.5%	12.2%	50.7%	12.5%	53.7%	13.1%