Economía Agraria y Recursos Naturales. ISSN: 1578-0732. e-ISSN: 2174-7350. Vol. 13, 1. (2013). pp. 69-93

Municipal solid waste generation in mature destinations: An IPAT-type model for Mallorca

Italo Arbulú[a], Javier Lozano[a] and Javier Rey-Maquieira[a]

ABSTRACT: Several studies examined the relationship between environmental degradation and population growth. However, most of them don't take into account the difference between local population and tourist arrivals. This paper contributes to the literature by separating these two groups within the framework of IPAT-based models to measure the impact of tourist arrivals in terms of municipal solid waste generation for Mallorca. The model leads to a stochastic differential equations system, which showed that this mature tourist destinations have higher population elasticity than industrial economies. Moreover, the model allowed us to measure the elasticity of substitution between lower-income and higher-income tourists.

KEYWORDS: IPAT Model, municipal solid waste, tourism growth.

JEL classification: C32, D62, L83, Q01, Q53.

DOI: 10.7201/earn.2013.01.04.

Generación de residuos sólidos municipales en destinos maduros: un modelo tipo IPAT para Mallorca

RESUMEN: Varios estudios examinaron la relación entre la degradación ambiental y el crecimiento demográfico. Sin embargo, la mayoría de estos no consideran la diferencia entre población local y turística. Este trabajo contribuye a la literatura mediante la separación de estos grupos en el modelo IPAT para cuantificar el impacto del turismo en la generación de residuos sólidos urbanos en Mallorca. Éste conduce a un sistema estocástico de ecuaciones diferenciales que muestra que destinos maduros tienen mayor elasticidad de población que las economías industriales. Además, el modelo permite medir la elasticidad de sustitución entre turistas de bajos ingresos y de mayores ingresos.

PALABRAS CLAVES: Modelo IPAT, residuos sólidos municipales, crecimiento turístico.

Clasificación JEL: C32, D62, L83, Q01, Q53.

DOI: 10.7201/earn.2013.01.04.

[a] Departamento de Economía Aplicada. Universidad de las Islas Baleares.

Acknowledgement: The authors would like to mention our gratefulness to TIRME S.A. for their trust, financial support and data source.

Dirigir correspondencia a: Italo Arbulú. E-mail: italo.arbulu@uib.es.

Recibido en agosto de 2012. Aceptado en mayo de 2013.

1. Introduction

Tourism is an industry with a product based on environmental consumption, both natural and man-made. The continued growth in tourism has led many nations, as well as tourism companies, to recognize the need to conserve valuable tourism resources in order to continue with the growth trends in the future. Thus, it will be possible to extend the benefits of tourism activities to future generations as well (Archer, 1996; Butler, 1993; Guthunz and von Krosigk, 1996; Filho, 1996; Gossling, 2003; Hampton and Christensen, 2007; Liu and Var, 1986; Saleem, 1996; Sheldon *et al*., 2005; Wilkinson, 1997; Wilson, 1996). Therefore, an integrated approach to tourism planning and management is now required to achieve sustainable development in tourism.

With regard to tourism, the competitiveness of a given destination is related to the experience that tourists have. Although the measurement of the "experience" concept can be difficult to achieve, there is a considerable consensus among researchers that part of the tourist experience is associated with the quality of the destination attributes. Thus, it should be understood that environmental quality is one of the main inputs of tourism competitiveness (Bramwell, 2004; Bardolet and Sheldon, 2008).

The tourism industry has special characteristics in production given that to the consumption of the "tourism product" is performed at the destination. This reveals that tourism growth is related to the increase in tourist arrivals, which are equal to have a nomad population in the destination.

Every population, nomad or local have a pattern of consumption that certainly generates a waste flow that eventually must be dealt with in order to maintain the environmental quality (which is an asset of the tourist sector) of the destination. However, waste disposal collection and treatment that avoid (or at least reduce) environmental impacts on local landscape involve costs usually paid by local population. Thus, waste treatment could be considered as an externality generated by the tourism sector.

Although the relationship between environmental degradation and economic growth has been the subject of increasing attention in recent years due to obvious negative impacts on human economic activities and life quality, almost the entire set of studies has focus on economic production, particularly in industrial countries (Stern, 2004).

The relationship between population growth and environmental impacts still need further research; therefore, this paper stems from the need to improve the environmental impact modeling and comprehension of the consequences of different population trends on environmental disruption.

The main objective of this paper is to assess the environmental impact of tourism growth on municipal solid waste (MSW) generation by an IPAT-type model based on stochastic differential equations for a mature tourist destination as Mallorca (Balearic Islands). This formulation seeks to get better results than those obtained by previous studies as it allows dealing with the presence of stochastic regressors (population and affluence).

Mallorca is one of the most popular tourist destinations in Spain and one of the most visited "sun and sand" destinations in Europe. Located in the Mediterranean north-east coast of Spain, the island is easily reached from most European countries in no more than four hours from the most distant countries as noted by Garín-Muñoz and Montero-Martín (2007). As these authors suggest, Mallorca has usually been considered in the literature as a typical example of a second generation European mass tourist resort (Knowles and Curtis, 1999).

Therefore, the important contribution of natural resources and environmental services in the productive structure of the island and its rapid development as high-density tourist destination are the main reasons why this island is one of the most interesting locations to analyze the potential impact of tourist arrivals on environmental quality (measured by municipal solid waste generation).

Previous studies have attempted to measure the impact of population growth on the environment following the seminal idea of Ehrlich and Holdren (1971). These studies focused their attention on local population; however, little attention was given on the performance of the regions which have specialized in tourism activities where human pressure does not correspond directly to the local population (Shi, 2003).

The paper is organized as follows: Section 1 of this paper briefly explains the relationship between tourism and municipal solid waste generation; Section 2 gives a brief introduction to waste disposal management in Mallorca; Section 3 summarizes the theory behind the IPAT Model; Section 4 introduces the stochastic system of equations according to the STIRPAT model. Section 5 and 6 are devoted to explain the methodology and the data set used and finally, Section 7 and Section 8 show the main empirical results and conclusions.

2. Tourism and municipal solid waste generation

Tourism is not only one of the fastest-growing industries in the world, but also can be considered as one of the most remarkable socio-economic phenomena of the post-World War II period (WTO, 2001). This industry has become a major source of income, employment and wealth in many destinations (Archer, 1976; Archer, 1982; Archer and Fletcher, 1988; Fletcher and Archer, 1991). However, its rapid expansion has also had negative environmental impacts, which should be considered in the economic analysis (Palmer and Riera, 2003).

The natural resource's depletion and environmental degradation related with tourism became a serious challenge to many tourism-based economies. The fact that most tourists who chose to maintain their relatively high consumption patterns (and waste generation) when they reach their destination can be a particularly severe problem if destinations do not have the means to protect their local ecosystems from the pressures of mass tourism (Mathieson and Wall, 1982; Briassoulis and van der Straaten, 1992; WTO, 1999). It is also important to recognize that environmental degradation, at the same time, face a serious threat to future tourism activities by discouraging tourists from visiting some "dirty" destinations (Rey-Maquieira *et al.*, 2005; Alegre and Cladera, 2006).

As Abrate and Ferraris (2010) argued, post-consumption environmental impacts have become an important issue all over the world. Municipal solid waste volumes are predicted to continue rising unless actions are taken in order to keep down the problem. Moreover, untreated MSW disposal has contributed to reduce environmental quality of destinations. Therefore, the fast growth of tourism has exacerbated this problem in recent years. In fact, new trends in tourism are related to improving the enforcement of their environmental protection targets.

The concept of sustainable tourism, as developed by the World Tourism Organization (UNWTO) in the context of the United Nations sustainable development process, refers to tourist activities as "leading to management of all resources in such a way that economic, social and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity and life support systems" (UN, 2001).

Similarly, in the academic literature, as well as tourism-related forums, there is growing interest in the evolution of destinations considered as "mature". Changes in tourist values, lifestyles and greater concern about environmental impacts of human activities are considered as part of the new features of tourists (Poon, 1993; Urry, 1995; Vanhove, 2005; Montero and Oreja, 2005).

As some authors noted (Cooper, 1990; Aguiló and Juaneda, 2000; Aguiló *et al.*, 2005; Vera and Baños, 2010), in order to compete, "mature destinations" have to innovate through research and development of new features and elements that can distinguish them as attractive compared to the supply of other destinations. This creates a competitive environment which is increasingly dynamic (Butler, 1980; Agarwal, 1997; Priestley and Mundet, 1998). Therefore, the innovation process in these mature destinations seeks to increase the value of the destination. In this sense, the growing world interest about environmental causes makes environmental innovations highly relevant to improve the tourist destination's competitiveness (Vera, 1992; Poon, 1993; Cooper, 2002).

However, increases in tourist arrivals and value of the destination should lead to increases in income and consumption, which lead to increase the amount of municipal solid waste generation. The change in consumption patterns has resulted in shortening the lifespan of products and hence bringing about the early elimination of recyclable products, such as furniture, home electronics, and other household items (Hitchens *et al*., 2000).

As Ku *et al*. (2009) noted; the increase in overall consumption, the use of disposable products and excessive packaging are creating increasing challenges for waste management authorities. Therefore, waste has become a serious social problem and a threat to the environment. In addition, the search for efficient alternatives to reduce municipal solid waste has become very important and the problems associated with waste generation and management cannot be solved without efforts to reduce the growing amount of waste.

One of the major environmental challenges for tourist destination planning is related to proper waste management, since MSW generation is higher in tourist areas than in residential areas. There is a need to take appropriate policies in order to reduce the amount of waste generation. Moreover, in the last three decades, MSW collection and disposal industry have been affected by the increasing volume of waste leading to landfill collapses and other negative impacts over environmental quality (Nicolli *et al.*, 2010). Furthermore, fixed landfill capacity and the rising real costs of MWS disposal have made it even more difficult to offer a good service in some areas.

The attention over landfill's capacity and recycling policies greatly increased over the last years, encouraging households to sort waste and creating a bigger market of recycled materials (an example, many countries established a 'per bag' price policy). As a result, some economists started to pay attention to this sector, especially in tourism destinations where recycling policies have been applied to local population but there are few incentives for tourists to take care of the environmental quality of the destination (Radwan *et al.*, 2010; Gidarakos *et al.*, 2006).

Tourism economic growth benefits can be measured in terms of employment and income; however, this process also involves costs that could affect some value drivers of the tourism economy. Municipal solid waste generation is an externality that received little attention in tourism studies; therefore, one of the main goals of researches in environmental innovation on tourist destinations must go through the analysis of the determinants of MSW generation.

3. Waste disposal treatment in Mallorca

Current trends in urban solid waste treatment are directed to (i) the introduction of incentives to reduce volumes of waste generation, (ii) recovery (reuse) of a current amount of MSW and (iii) disposal in an environmentally friendly way of unrecoverable fractions. Therefore, the first element of the list is related to long-term policy while the latter two points have to do with medium-term policies.

The implementation of efficient and environmentally advanced systems for proper MSW management is still one of the main challenges of the XXI century. This requires not only a customized solution, but also consensus at all levels: political, economic and social (TIRME, 2010).

As Aguiló and Juaneda (2000) noted, "the process of modernization of the tourism product, and the reshaping of Balearic Island's image has been remarkable. While it is true that both modernization and image-reshaping have received a great deal of criticism, the islands have developed a policy aimed at the conservation of natural spaces and the improvement of tourism resorts, which has proven less erroneous than that of competitors in this region".

The first step of this strategy was taken by the Balearic Government which developed a set of rules, which became the origin of this process. The plan included efforts to modernize tourist accommodation in 1990, the legislation for natural areas in

1991, and the plan to control accommodation supply in 1995 (Blasco, 1996; Blasco and Segura, 1994).

It is in this way, that tackling the problem of proper municipal solid waste management as an environmental externality, the Balearic Government in 1992 gave the grant of public service waste management in Mallorca to a private project, whose operations have been marked by the three waste plans that establish the guidelines of the MSW management model on the island.

Before the project began, Mallorca was one of the "dirtiest" destinations in Europe generating a large amount of waste per capita[1]. Because of these problems, Balearic Islands authorities developed the Master Plan for Solid Waste in Balearic Islands (*Plan Director de Residuos Sólidos Urbanos*, PDRSU) that looked forward to helping the region to take care for its environmental assets in a better way.

The PDRSU focused on recycling and hereby leads for reuse of resources in other sectors (in contrast to the landfill where these are dumped and stocked). Therefore, part of the MSW disposal is used efficiently for electric generation while another is devoted to the production of organic fertilizers, building materials and other alternative uses.

Nowadays, Mallorca's waste treatment plant has a capacity of 30.000 tons, and it is considered as an example of environmental efficiency by leveraging virtually all waste received in the island (TIRME, 2010). However, waste management currently faces technical challenges, given the increasing volumes of MSW generated as a result of tourism and population growth in Mallorca. In this sense, despite the great achievements of the government in waste management, the need to increase efficiency in management should be considered as a primary target for the solution of environmental externalities.

4. The IPAT Model

One of the essential steps towards an efficiently MSW management is to know and be able to predict the magnitude of the contribution of tourist's growth to the generation of municipal solid waste. In this regard, one of the main objectives of this research focuses on the development of an accurate analysis of the problem of waste generation in Mallorca in order to identify its leading determinants. This research also looks forward to giving public authorities a set of quantitative tools that could help them propose policies that would reduce these effects.

Although there is a consensus among researchers about the main determinants of environmental impact, such as population growth and economic development, there is still a strong debate on the importance of these determinants on the environmental system in which they interact.

[1] In Balearic Islands approximately 2,4 kg of waste disposal per habitant per day were generated, while the mean value of Spain was 1,8 kg of waste disposal per habitant per day in 1992.

Usually in theoretical models the environment is considered as a sink of waste, which is indirectly determined by the population. However, the amount and type of environmental impact are furthermore determined by production technologies and consumption patterns (Gans and Jöst, 2005). Therefore, even a growing population does not necessarily lead to increase environmental deterioration *per-se* if this population can substitute goods of high polluting character for those that cause lower environmental impact. In addition, technical progress might reduce the amount of pollutants produced per unit of output.

As we can see, the main difference between these models is the importance that those determinants have as long-term effects. Some examples of theoretical models which base their explanation on consumption patterns are the Environmental Kuznets Curve (EKC) and the Green Solow Model. On the other hand, one of the main models which support the idea that population growth is a major determinant of environmental impact is IPAT-model, developed by Ehrlich and Holdren (1971), which is widespread in ecological economics.

Even though these models are widely spread in academic literature, researchers focused their attention on industrialized countries or developing countries to assess and quantify environmental impacts (usually through greenhouse gases). However, little attention has been given to the study of these models in tourist economies.

Mature tourist destinations are characterized by a significant number of tourist's arrivals each year, where repetition of the destination is a usual behavior between them, and that tend to be related with a stable behavior in tourist expenditure too. Given these characteristics of mature destination's tourist arrivals could be considered as a major determinant of environmental impacts, even more important than tourist expenditure.

The role of population growth on environmental quality can be traced back to the debate on the relationship between population and natural resources made by Malthus (1798) in "An Essay on the Principle of Population" who was initially concerned by the trend of population, which would increase pressure on limited resources (land). However, some of the critics to Malthus forecast were related to the omission of the possibility of technological innovation in agriculture, which, in fact, made the increase in yields possible and allowed the natural environment to support a large population without harming their welfare.

As Fischer-Kowalski and Amann (2001) mention, the Malthusian concern returned again during the 60s when some researchers as Ayres and Kneese (1968) attempted to conceptualize the economic system into a thermodynamic framework, taking into account the law of conservation of mass. This attempt should be seen as one of the early stage of the important contributions such as those made by Boulding (1966) with his "Cowboy economy on a spaceship earth" and Meadow's "Limits to Growth" model (Meadows *et al.*, 1972) which suggested to take into account the earth's carrying capacity in an economic growth process.

Although the author and those belonging to the Malthusian framework were not specifically concerned about the environment but more related to natural resource for production, their positions have been well taken in recent environmental debates. However, as Shi (2003) noted, there are still some researchers that have attained to test the ability of the environment to absorb wastes generated by mankind's activities and didn't find any relationship with population growth (Commoner, 1972; Cropper and Griffiths, 1994; Myers, 1993[2]).

Our starting point in the theoretical framework used in this paper is the debate that took place in the seventies, which led to the formulation of the so-called IPAT equation that reserved a prominent role in explaining demographic environmental impacts. Ehrlich and Holdren described the environmental impact of an economic system by the following

$$I \equiv P \cdot A \cdot T \qquad [1]$$

In this expression *I* denotes the environmental impact; *P* represents population size; *A* stands for affluence; and *T* for the state of technology. Ehrlich & Holdren's original arguments were close to Malthus position, considering that population growth caused "disproportionate negative impact" on the environment.

As Jöst and Quaas (2006) explain, in empirical research, the use of an observable variable for the environmental impact is usually related greenhouse gasses emissions (however, the concept of the theoretical model applies to all environmental variables), the affluence is measured by per-capita gross domestic product (*Y/P*), and the state of technology is approximated by the amount of pollutants per unit of gross domestic product.

If we take the logarithm of the previous equation and the derivatives with respect to time to get the mean relative change of the environmental impact, we would find that it is equal to the sum of the average change of pollutant per unit of gross domestic product, the average change of per-capita gross domestic product, and the average change in population size, respectively.

$$\frac{\dot{I}(t)}{I(t)} = \frac{\dot{P}(t)}{P(t)} + \frac{\dot{\left(Y/_P\right)}(t)}{\left(Y/_P\right)(t)} + \frac{\dot{\left(I/_Y\right)}(t)}{\left(I/_Y\right)(t)} \qquad [2]$$

This identity has been applied quite frequently at different levels of aggregation (nations, regions or districts; see Scholz, 2006). However, as the IPAT is treated as an accounting equation, this formulation is simply a tautology which leads to strong critics to empirical estimations of these models. Moreover, the IPAT equation is not

2 Some of these papers are based on the idea proposed by Simon (1981) who argued that the larger the population, the more vigorous the development of science and technology, and the better mankind's ability to provide technological solutions to environmental problems.

prepared to test hypotheses given that it assumes that (i) the effect of each driven force is proportional, and (ii) the sum of these forces was equal to one.

This is exactly the starting point of the work developed by Dietz and Rosa (1994; 1997) about twenty years after Ehrlich and Holdren's original publication. These authors proposed that IPAT identity would be reformulated into a stochastic equation in order to allow random errors in the estimation of parameters. Thus, they IPAT equation was reformulated as STIRPAT, meaning "Stochastic Impacts by Regression on Population, Affluence and Technology". These authors consider the following formulation:

$$I = aP^b A^c T^d e \qquad [3]$$

Where *a*, *b*, *c* and *d* are the parameters to be estimated and *e* is an error term. This functional form allows the presence of non-linear relationships between theoretical forces of human-driven actions and environmental impact. Taking the logarithmic transformation of the above expression we obtain an easy way to calculate the elasticity of the environmental impact with respect to each of the anthropogenic factors:

$$\ln(I) = \ln(a) + b * \ln(P) + c * \ln(A) + d * \ln(T) + \ln(e) \qquad [4]$$

As York *et al.* (2002; 2003) noted, the STIRPAT model meant a radical reformulation of the IPAT environmental accounting equation into a stochastic form which can be estimated using common econometric techniques in social sciences. This formulation keeps the ecological foundation and the multiplicative logic of the original IPAT model, however, reformulated it to allow estimation of the net effect of each anthropogenic driver on the environmental impact breaking the implicit assumptions that the effect of each driven force was proportional and that their sum equal to one.

Some advantages of the STIRPAT model, as Knight (2009) noted, are related to the analysis of the population-environment relationship in a theoretical framework, but also to the possibility to include relevant control variables to the model as Dietz *et al.* (2007), Knight (2008), Schulze (2002) and others did (for further references see Lin *et al.*, 2009). The STIRPAT model, therefore, allows the incorporation of greater complexity in the analysis of between environmental variables and other factors that could determine the negative impact.

In terms of public policy issues, the main advantage of the STIRPAT model is to identify key drivers of environmental impacts and their relative importance. This model can be useful to policymakers who look forward to assessing environmental degradation caused by human-driven forces or to forecast environmental impacts of economic growth.

5. A stochastic model of environmental of tourism impact based on the IPAT equation

Our work stems from the contributions of Dietz and Rosa (1994) and aims at deepening the STIRPAT approach concerning municipal solid waste generation in Mallorca, which is considered as a mature destination.

Since our initial hypothesis is that STIRPAT model regressors are not deterministic over time, our starting point is the same as the one considered by Zagheni and Billari (2007) in which the environmental impact (expressed in terms of MSW generation), evolves over time as a function of P (population size), A (affluence) and T (technology efficiency):

$$I(t) = f\{P(t); A(t); T(t)\} \quad [5]$$

Therefore, if we take the derivate with respect to time, it holds that:

$$\frac{dI/dt}{I(t)} = \frac{dI/I}{dP/P}\frac{dP/dt}{P(t)} + \frac{dI/I}{dA/A}\frac{dA/dt}{A(t)} + \frac{dI/I}{dT/T}\frac{dT/dt}{T(t)} \quad [6]$$

This above expression can be written in terms of growth rates as:

$$\frac{dI/dt}{I(t)} = \frac{\dot{I(t)}}{I(t)} = \varepsilon_{I,P}\frac{\dot{P(t)}}{P(t)} + \varepsilon_{I,A}\frac{\dot{A}(t)}{A(t)} + \varepsilon_{I,T}\frac{\dot{T}(t)}{T(t)} \quad [7]$$

Where $\varepsilon_{I,P}$, $\varepsilon_{I,A}$, $\varepsilon_{I,T}$ represent the elasticity of municipal solid waste generation (our environmental variable) with respect to the human-driving forces: Population (*P*), affluence (*A*) and technology (*T*), respectively. Furthermore, it is also possible to decompose the variables *A* and *T* as:

$$A = E/P \quad [8]$$

and

$$T = I/E \quad [9]$$

where *E* represent the level of expenditure. It is important to highlight that previous studies on IPAT and STIRPAT models usually include GDP rather than the level of expenditure (*E*). However, it is significant to note that these studies focused on this variable as a proxy of income and, therefore, as a proxy of consumption, which is the main theoretical reason why human actions impact on the environment. Thereby, by subtraction, we can get the following expression:

$$\frac{\dot{A}}{A} = \frac{d(^{E}/_{P})/dt}{^{E}/_{P}} = \frac{\dot{E}}{E} - \frac{\dot{P}}{P} \qquad [10]$$

and

$$\frac{\dot{T}}{T} = \frac{d(^{I}/_{E})/dt}{^{I}/_{E}} = \frac{\dot{I}}{I} - \frac{\dot{E}}{E} \qquad [11]$$

Consequently, we can rearrange the STIRPAT equation as:

$$\frac{^{dI}/_{dt}}{I(t)} = \frac{I(\dot{t})}{I(t)} = \varepsilon_{I,P}\ \frac{P(\dot{t})}{P(t)} + \varepsilon_{I,A}\ \left[\frac{\dot{E}(t)}{E(t)} - \frac{\dot{P}(t)}{P(t)}\right] + \varepsilon_{I,T}\ \left[\frac{\dot{I}(t)}{I(t)} - \frac{\dot{E}(t)}{E(t)}\right] \qquad [12]$$

According to this formulation, when data on growth rates of *I*, *P*, *A*, *E* are available; it is possible to estimate the elasticities, however, we can rewrite the whole expression and simplify it as:

$$\frac{I(\dot{t})}{I(t)} = \left(\frac{\varepsilon_{I,P} - \varepsilon_{I,A}}{1 - \varepsilon_{I,T}}\right)\left[\frac{P(\dot{t})}{P(t)}\right] + \left(\frac{\varepsilon_{I,A} - \varepsilon_{I,T}}{1 - \varepsilon_{I,T}}\right)\left[\frac{\dot{E}(t)}{E(t)}\right] \qquad [13]$$

In the equation written above the parameters may be estimated by means of the following stochastic formulation:

$$\frac{I(\dot{t})}{I(t)} = \beta_1 \left[\frac{P(\dot{t})}{P(t)}\right] + \beta_2 \left[\frac{\dot{E}(t)}{E(t)}\right] + \omega_t \qquad [14]$$

where ω_t is a zero mean error term which behaves according to a normal distribution and with the property of no serial correlation. Therefore, this equation represents an IPAT-based stochastic model of environmental impact. Under the assumptions that the elasticities remain constant over the time period we analyze, the equation may be expressed as:

$$dI = \left\{\beta_1 \left[\frac{P(\dot{t})}{P(t)}\right] + \beta_2 \left[\frac{\dot{E}(t)}{E(t)}\right]\right\} I\,dt + \omega_t + I\,dt \qquad [15]$$

As Zagheni and Billari argued, equation [15] may be expressed in stochastic terms basically for two reasons: the first one is related to the possibility that other factors than those included in the model might intervene in the explanation of environmental impact, and the second reason is related to the possibility that population and income growth rates do not evolve in a deterministically way, this meaning that their trend might show a random component.

Furthermore, we if we assume that population and income evolve as a stochastic process, then, we can say that:

$$dP = \beta_3 P\, dt + \upsilon_t P\, dt \tag{16}$$

and

$$dE = \beta_4 E\, dt + \psi_t E\, dt \tag{17}$$

where υ_{t_t} and ψ_{t_t} are zero mean error term which follow a normal distribution. Starting from these assumptions, we can rewrite equation [15] as a system of three stochastic differential equations:

$$\begin{cases} dI = \left\{ \beta_1 \left[\dfrac{d(P)/dt}{P(t)} \right] + \beta_2 \left[\dfrac{d(E)/dt}{E(t)} \right] \right\} I\, dt + \omega_t I\, dt & [18] \\ dP = \beta_3 P\, dt + \upsilon_t P\, dt & [19] \\ dE = \beta_4 E\, dt + \psi_t E\, dt & [20] \end{cases}$$

As it can be derived, OLS estimation of the STIRPAT model in the presence of stochastic regressors would have important impacts on the properties of the estimators[3]. One of the best and most popular methods to overcome the problems generated by stochastic regressors is the use of instrumental variables. This technique attempts to replace the explanatory variable with one, which is not correlated with the disturbance term.

In applied econometric analysis, the use of a suitable instrument can be regarded as a difficult task. However, as the purpose of this research is not the explanation of the determinants of population growth or the expenditure trend, we can get an appropriate instrument by using the estimated value of the explanatory variables through time-series analysis.

This methodology implies that, in order to solve the system, the estimation should be based on two stages. In the first stage, the fitted values of the explanatory variables are obtained by Box-Jenkins methodology. Once the estimated values of the series are calculated, the second step involves the use of them into the STIRPAT equation an estimate the coefficients by OLS regression.

[3] For further references about this topic see Greene (2002).

However, if this model is applied to mature tourist destinations which can be characterized by the presence of two different types of populations: local (P_L) and nomad population (P_T) which is formed by tourists, then we can express the variable P as:

$$P = P_L + P_T \quad [21]$$

Therefore, it holds that:

$$\frac{dP}{dt} = \frac{dP_L}{dt} + \frac{dP_T}{dt} \quad [22]$$

Moreover, if we consider that the expenditure in the economic system is conformed not only by locals but also by nomad population (tourists), then it should hold that:

$$E = E_L + E_T \quad [23]$$

where E_L and E_T represent the local expenditure and tourist expenditure, respectively. Therefore, it is also true that:

$$\frac{dE}{dt} = \frac{dE_L}{dt} + \frac{dE_T}{dt} \quad [24]$$

It is important to note that if we consider that the population and level of expenditure follow a stochastic process in their formulation, this would also hold for the two populations (local and nomad) separately. This means that the use of instruments by Box-Jenkins methodology should be applied to all the four series[4] in the tourist destination.

6. Methodology

The main goal of this research is to measure the participation of total population (local and tourists) on waste disposal generation. In Mallorca municipal solid waste treatment is charged directly to municipalities, which finally get the resources through taxes on local population and therefore, the amount of garbage generated by tourists could be considered as an externality of production of the tourism sector.

The selection of an appropriated econometric technique would be required to assess the relationship between tourist arrivals and their externality in the most accurate way. Several empirical studies based on IPAT models used traditional econometric methodology on time-series data to measure, among other factors, the relationship between population growth and environmental degradation[5]. However, these models implicitly assumed that explanatory variables were completely exogenous (orthogonal) in these models, neglecting the possibility of stochastic variables in these models.

4 Local population, local expenditure, tourist population and tourist expenditures.
5 The initial empirical studies on IPAT model used this type of econometric analysis.

This paper works with a system of stochastic equations following standard approaches in the existing IPAT model literature, but as explained in the previous section, the presence of stochastic regressors implies a problem to direct OLS estimation; therefore, the model should be estimated in two stages. In order to compare results, the methodology proposed involves the estimation of three models:

- **Basic model**: This specification enables the estimation of the IPAT in its traditional form regardless of the presence of stochastic regressors.
- **Stochastic model n° 1**: This model assumes that only one explanatory variable (population) could be considered as stochastic in order to assess the effect on the IPAT model of a non-exogenous variable (population, both local and nomad).
- **Stochastic model n° 2**: This model includes the possibility of treat all explanatory variables in the IPAT model as stochastic regressors in order to assess the impact on the estimators.

7. Data

The dependent variable considered is municipal solid municipal waste disposal (RSU) (measured in kilograms). The dataset of RSU series is composed by the total amount of urban solid waste disposal generate in Mallorca between the years 2004 to 2010 regardless recycled elements[6].

The following table shows the list of variables included in the estimation, as well as its definition, a technical explanation and the sources from where the data was taken.

[6] Recycled elements are classified by TIRME and are plastic packages, paper and glass.

TABLE 1

Data source and description

Variable	Description	Source
RSU	Municipal solid wasted generation in Mallorca (in kg). The series does not include recycled disposals.	TIRME SA
IPH_MALL	Human Pressure Index for Mallorca Island: This indicator measures the demographic burden (in number of persons) of Mallorca. It intends to complement the information gleaned from official population figures. In this sense, it estimates the actual demographic burden that supports a territory in a given period.	IBESTAT
POB_MALL	Local population in Mallorca: Includes the number of defunctions, births and registered migration.	IBESTAT
GAST_TUR	Tourist expenditure in Mallorca (in Euros) taken from the EGATUR which is a monthly border operation survey that takes place in major road crossings, airports and seaports. The surveying is done by personal interview nonresident visitors to the output of Spain.	EGATUR
GAST_LOCAL	Local expenditure in Mallorca (in Euros) - Monthly estimation according to quarterly data taken from the Household Budget Survey (EPF).	INE / IBESTAT

Source: Own elaboration.

By means of this data set, the explanatory variables for the estimation of the three models proposed in the methodology were included in the following table.

TABLE 2

Variables

Variable	Description
POP	IPH_MALL + POB_MALL
EXP	GAST_TUR + GAST_LOCAL
IPH_MALLF	Fitted value for estimation of IPH_MALL by Box-Jenkins methodology
POB_MALLF	Fitted value for estimation of POB_MALL by Box-Jenkins methodology
GAST_TURF	Fitted value for estimation of GAST_TUR by Box-Jenkins methodology
GAST_LOCALF	Fitted value for estimation of GAST_LOCAL by Box-Jenkins methodology
POPF	IPH_MALLF + POB_MALLF
EXPF	GAST_TURF + GAST_LOCALF

Source: Own elaboration.

8. Empirical finding

This section makes use of the models presented above to analyze the environmental impact, expressed in terms of MSW generation by tourist arrivals through three different models.

The estimation of the so called "Basic Model" which results from regressing the perceptual change of RSU (our environmental variable) on the perceptual change of population (POP) and the perceptual change of the level of expenditure (EXP). This specification allows the estimation of the STIRPAT model in its traditional formulation. The Basic Model estimation results gave the expected signs and statistical significance of both coefficients which led to confirm the IPAT hypothesis.

For the Stochastic Model two different versions were estimated: (i) "Stochastic Model nº 1" will include the basic model formulation including the fitted value of the population (POPF) as an instrument to avoid the problem of an stochastic regressor but the variable EXP is considered as non-stochastic; (ii) "Stochastic Model nº 2" includes the formulation of the basic model but including instruments for both regressors (POPF and EXPF). The following table shows the estimation results for the three models.

TABLE 3

Econometric results

Coefficients	Basic model	Stochastic model n° 1	Stochastic model n° 2
POPULATION GROWTH	2.993453* (12.44235)	3.193025* (11.78547)	2.832025* (8.438347)
EXPENDITURE GROWTH	0.091984** (2.037676)	0.058514 (1.152927)	0.16241** (2.027464)
R^2	**0.878794**	**0.883673**	**0.89759**

Note: Values in parenthesis are related to t-statistic. * Significance at 1%; ** Significance at 5%.

Source: Own elaboration.

However, it is important to note that the coefficients for the explanatory variables were as expected by theory. The coefficient of population growth (local and nomad) confirms the idea that population is the main determinant of MSW generation in mature tourist destinations. Moreover, the expected sign of expenditure growth (local and nomad) also confirms the idea that affluence does have a positive impact over the pollution growth rate.

Furthermore, it is essential to notice that only in the Stochastic Model n° 1 the expenditure growth rate didn't show a statistical significance of the coefficient. However, for the three models tested the statistical significance of population growth led to confirm that there is no statistical evidence to accept the null hypothesis of non significance of this variable in waste generation.

It is important to highlight that due to the theoretical construction of the model, the explanatory variables cannot be considered directly as elasticities *per-se*, but rather the coefficients are a combination of them:

$$Coef_1 = \left(\frac{\varepsilon_{I,P} - \varepsilon_{I,A}}{1 - \varepsilon_{I,T}}\right) \quad [25]$$

and

$$Coef_2 = \left(\frac{\varepsilon_{I,A} - \varepsilon_{I,T}}{1 - \varepsilon_{I,T}}\right) \quad [26]$$

Regarding to this, the results allow us to face a situation of two equations and three variables. Therefore, in order to solve this, we need to introduce some additional information in order to reach a final value for the elastiticities.

Even though there are no studies on the elasticity of population or affluence in tourist economies, it could be considered that the best variable to be introduced as additional information may be related to the elasticity of technology. Few studies attempted to calculate this elasticity, but we can find some like the one made by Alfranca (2009) in which he calculates this elasticity with a value of 17.6% or the one of Jaffre and Palmer (1997) with a similar value of 15%. However, as the study made by Alfranca was related to Spanish performance it should be taken as a more accurate value. The following table shows the results from the simulation.

TABLE 4

Simulated elasticities

Elasticity	Basic model	Stochastic model n° 1	Stochastic model n° 2
Population	2.214810	2.406837	2.023763
Affluence	0.251795	0.224216	0.309826
Technology	0.176	0.176	0.176

Source: Own elaboration.

The first main result to note is that the lowest value of the population elasticity and the highest value of affluence elasticity are related to the Stochastic Model n° 2. This could mean that if the existence of stochastic regressors is not taken into account on the STIRPAT formulation, there is a high probability of overestimation on the population elasticity and an underestimation of the affluence elasticity.

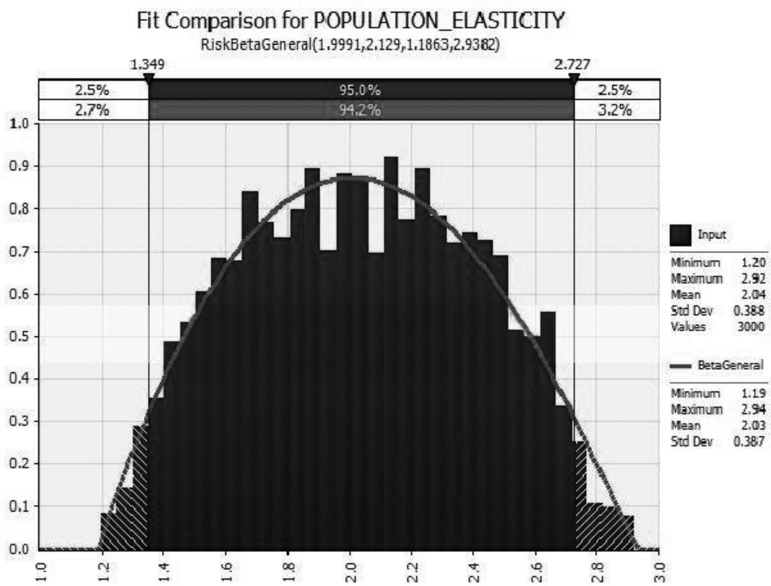
If we consider that local population growth rate does not change, then an increase of 1% on nomad population (tourist arrivals) would produce an increase in waste disposal generation of 2.024%. Furthermore, if Destination Management Offices (DMO) seeks to increase tourist expenditure by 1% on the destination, subsequently the increase of waste disposal generation would be of 0.31%. It is central to take into account that both concepts are important to measure the impact of tourism growth on the environment.

Taking into account that the results belong to a punctual estimation, given by the value of the technology elasticity and the values of the coefficients estimated in the model, the assumption of a T-distribution for this estimates was applied in order to make a Montecarlo Analysis which would generate an empirical distribution for the elasticity of population and the elasticity of affluence[7].

Montecarlo Analysis considers the mean value of each distribution as the probable value of the variable under analysis. Therefore, the population elasticity would have an expected value of 2.04 and the expected value of the affluence elasticity would be 0.31. The results are shown in the following graphs.

GRAPH 1

Empirical distribution of the population elasticity

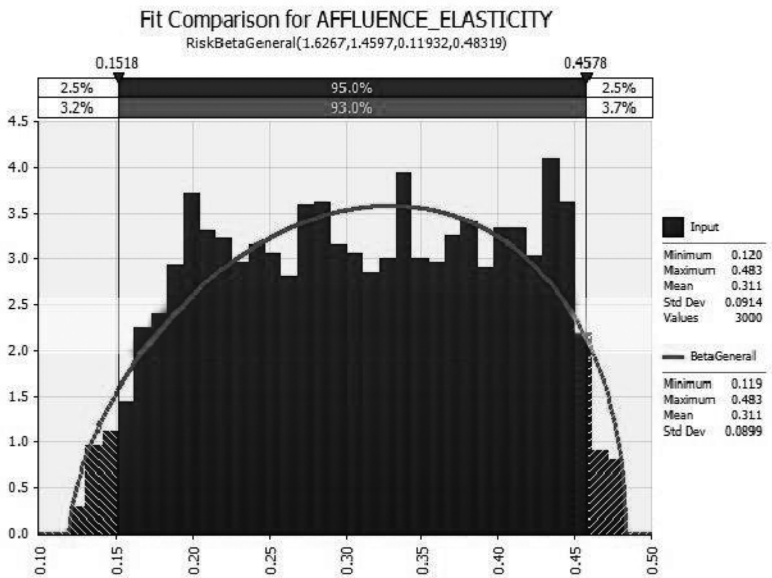


Source: Own elaboration.

[7] The empirical distributions were generated in 3,000 simulations of possible scenarios.

GRAPH 2

Empirical distribution of the affluence elasticity



Source: Own elaboration.

Finally, the impact of public policies on environmental quality should not only be considered by the amount of laws or directives issued, but also by the way in which governments make this regulation accomplish its goals. In mature tourist destinations one of the main challenges for public authorities is to promote tourism growth minimizing the environmental impact.

As new tourist destinations are trying to increase tourist arrivals, mature tourist destinations are looking to increasing (or at least keep constant) the level of tourist income. Therefore, some DMOs are trying to increase the receipts generated by tourist sector, even if it means a reduction in the number of tourist arrivals.

If we take into consideration that:

$$\frac{\Delta\,\%RSU}{\Delta\,\%POPULATION} = \varepsilon_{I,P} \qquad [27]$$

and

$$\frac{\Delta\,\%RSU}{\Delta\,\%AFFLUENCE} = \varepsilon_{I,A} \qquad [28]$$

If the tourist destination would like to keep the MSW growth rate constant, then the threshold should be:

$$\frac{\Delta\,\%AFFLUENCE}{\Delta\,\%POPULATION} = \frac{\varepsilon_{I,P}}{\varepsilon_{I,A}} = \frac{2.0355}{0.3107} \qquad [29]$$

Therefore, if DMO's in Mallorca would like to increase their environmental quality by reducing the amount of visitors to the destinations in 1%, it should be necessary that the increase in tourist expenditure (and local expenditure) generated by this policy should not exceed 6.55%.

9. Conclusions

As worldwide environmental quality degenerates over time, many countries began to worry about the determinants of environmental degradation. However, although the tourist sector grew in importance as an economic activity, little attention has been paid to the externalities created by this activity through municipal solid waste generation.

It is important to recognize as the UNWTO does, that more and more efforts should focus in the tourist sector in order to make it a sustainable activity which could benefit not only the local population but also to tourists who value natural attributes of the destinations.

However, in order to perform efficient environmental public policies, it is necessary to identify first the main determinants of environmental damage and measure their impact over a given environmental indicator. In academic literature, the STIRPAT model had attempted to measure the effect of population growth on a given environmental variable.

The aim of this research is to assess the impact of population growth on environmental outcome, measured by the amount of municipal solid waste. The results, obtained by means of three econometric models, supported the IPAT hypothesis for this environmental variable in a mature tourist destination such as Mallorca. This paper looks forward to helping public authorities to understand the relationship between tourist growth and waste disposal generation and contribute to accurate policymaking in mature tourist destinations.

The final model selected (Stochastic Model nº 2) was considered as the most appropriate to explain the IPAT theory though the STIRPAT formulation, since it corrected the problem of stochastic explanatory variables. The main contribution of this research is related to the inclusion of the idea of nomad population (tourists) into the STIRPAT model which attempts to measure the importance of population growth on environmental outcome (municipal solid waste). Traditionally, STIRPAT models tested environmental impacts in industrial regions and focused on greenhouse gasses emissions; however, the theoretical background of the model makes it useful to analyze other kinds of economies like mature tourist destinations.

The results showed that nomad and local population do have statistical significance and, therefore, should be taken into account to explain the relationship between tourism growth and municipal solid waste generation. Moreover, the estimations also showed the potential relevance of improvement in environmental outcome without harming tourist revenues by means of elasticity of substitution (trade-off) between low income tourists and higher-income tourists.

Furthermore, it is interesting that the results also showed that mature tourist destinations tend to have higher population elasticity than industrial populations (tested in previous STIRPAT models), the causes of this mature tourist destination characteristic should be analyzed in future researches.

References

Abrate, G. and Ferraris, M. (2010). "The environmental Kuznets curve in the municipal solid waste sector*". HERMES Working Paper*, 01.

Agarwal, S. (1997). "The resort cycle and seaside tourism: An assessment of its applicability and validity". *Tourism Management*, 18(2): 65-73. http://doi.org/c7457m.

Aguiló, E. and Juaneda, C. (2000). "Tourist expenditure for mass tourism markets". *Annals of Tourism Research*, 27(3): 624-637. http://doi.org/cwz3d9.

Aguiló, E., Alegre, J. and Sard, M. (2005). "The persistence of the sun and sand tourism model". *Tourism Management*, 26: 219-231. http://doi.org/fgsxss.

Alegre, J. and Cladera, M. (2006). "Repeat visitation in mature sun and sand holiday destinations". *Journal of Travel Research,* 44(2): 288-297. http://doi.org/fjbs9t.

Alfranca, O. (2009). "Regulación ambiental e innovación". *Clm. Economía,* 15: 33-50.

Archer, B. (1976). "The anatomy of multiplier". *Regional Studies,* 10: 71-77. http://doi.org/b35spr.

Archer, B. (1982). "The value of multipliers and their policy implications". *Tourism Management*, 3(2): 236-241. http://doi.org/d97w5m.

Archer, B. and Fletcher, J.E. (1988). "The tourist multiplier". *Teoros*, 7(3): 6-9.

Archer, B. (1996). "Sustainable tourism: An economist's viewpoint". In Briguglio, L., Archer, B., Jafari, J. and Wall, G. (Eds.): *Sustainable tourism in islands and small states*. Pinter, London.

Ayres, R.U. and Kneese, A.V. (1968). *Environmental pollution*. Federal Programs for the Development of Human Resources, Washington D.C.

Bardolet, E. and Sheldon, J. (2008). "Tourism in archipelagos: Hawai'i and the Balearics". *Annals of Tourism Research*, 35(4): 900-923. http://doi.org/c2cskn.

Blasco, A. (1996). *Legislació d'ordenación del territori i urbanisme de les Illes Balears*. Universitat de les Illes Balears, Palma de Mallorca.

Blasco, A. and Segura, F. (1994). *Legislació turística estatal i balear*. Universitat de les Illes Balears y Federación Empresarial Hotelera de Mallorca, Palma de Mallorca.

Boulding, K. (1966). "The Economics of the coming spaceship Earth". In Jarrett, H. (Ed.): *Environmental Quality in a growing economy*. *Essays from the Sixth RFF Forum*. Johns Hopkins Press, Baltimore.

Bramwell, B. (2004). "Mass tourism, diversification and sustainability in Southern Europe's coastal regions". In Bramwell, B. (Ed.): *Coastal mass tourism*. Channel View Publication, Clevedon (UK).

Briassoulis, H. and van der Straaten, J. (1992). *Tourism and the environment*. Kluwer Academic Publishers, Dordrecht.

Butler, R. (1980). "The concept of a tourist area cycle of evolution: Implications for the management of resources". *Canadian Geographer,* 24(1): 5-12. http://doi.org/fbrkm2.

Butler, R. (1993). "Tourism development in small islands: Past influences and future directions". In Lockhart, D., Drakakis-Smith, D. and Schembri, J. (Eds.): *The development process in small islands*. Routledge, London.

Commoner, B. (1972). *The environmental cost of economic development*: *Population, resources and the environment*. Government Printing Office, Washington, D.C.

Cooper, C. (1990). "Il ciclo di vita delle localitá turistiche". *Politica del Turismo*, 5: 68-73.

Cooper, C. (2002). "Sustainability and tourism visions". Paper presented at the *VII Congreso Internacional del CLAD sobre la Reforma del Estado y de la Administración Pública*, Lisboa.

Cropper, M. and Griffiths, C. (1994). "The interaction of population growth and environmental quality". *American Economic Review,* 84(2): 250-254.

Dietz, T. and Rosa, E. (1994). "Rethinking the environmental impacts of population affluence and technology". *Human Ecology Review,* 1: 277-300.

Dietz, T. and Rosa, E. (1997). "Effects of population and affluence on CO2-emissions". *Protocol of the National Academy of Science*, 94(1): 175-179.

Dietz, T., Rosa, E. and York, R. (2007). "Driving the human ecological footprint". *Frontiers of Human Ecology*, 5(1): 13-18. http://doi.org/ffvs4x.

Ehrlich, P. and Holdren, J. (1971). "Impact of population growth". *Science*, 171: 1212-1217. http://doi.org/cq9zm8.

Filho, W. (1996). "Putting principles into practices: Sustainable tourism in small island states". In Briguglio, L., Archer, B., Jafari, J. and Wall, G. (Eds.): *Sustainable tourism in islands and small States: Issues and policies*. Pinter, London.

Fischer-Kowalski, M. and Amann, C. (2001). "Beyond IPAT and Kuznets Curves: Globalization as a vital factor in analyzing the environmental impact of socio-economic metabolism". *Population and Environment*, 23(1): 7-47. http://doi.org/bprvz7.

Fletcher, J.E. and Archer, B. (1991). "The development and application of multiplier analysis". In Cooper, C.P. (Ed.): *Progress in tourism, recreation and hospitality management*, Vol. 3. Belhaven, London.

Gans, O. and Jöst, F. (2005). *Decomposing the impact of population growth on environmental deterioration: Some critical comments on a widespread method in ecological economics*. Discussion Paper Series No. 422. University of Heidelberg, Heidelberg.

Garín-Muñoz, T. and Montero-Martín, L.F. (2007). "Tourism in the Balearic Islands: A dynamic model for International demand using panel data". *Tourism Management,* 28: 1224-1235. http://doi.org/dhqngg.

Gidarakos, E., Havas, G. and Ntzamilis, P. (2006). "Municipal solid waste composition determination supporting the integrated solid waste management system in the island of Crete". *Waste Management,* 26(6): 668-679. http://doi.org/d9jk38.

Gossling, S. (2003). *Tourism and development in tropical islands: Political ecology perspectives*. Elgar, London.

Greene, W. (2002). *Econometric analysis.* Pearson Education, New York.

Guthunz, U. and von Krosigk F. (1996). "Tourism development in small islands states: from Mirab to Tourab". In Briguglio, L., Archer, B., Jafari, J. and Wall, G. (Eds.): *Sustainable tourism in islands and small states: Issues and policies*. Pinter, London.

Hampton, M. and Christensen, J. (2007). "Competing industries in islands: A new tourism approach". *Annals of Tourism Research,* 34(4): 998-1020. http://doi.org/dshzm9.

Hitchens, D., Birnie, E., Thompson, W., Triebswetter, U., Bertossi, P. and Messori, L. (2000). *Environmental regulation and competitive advantage: a study of packaging waste in the European supply chain*. Edward Elgar, Cheltenham, Glos (UK).

Jöst, F. and Quaas, M. (2006). *Environmental and population externalities.* Discussion Paper Series No. 427.University of Heidelberg, Heildelberg.

Jaffre, A. and Palmer, K. (1997). "Environmental regulation and innovation: A panel data study". *Review of Economics and Statistics,* 79(4): 610-619. http://doi.org/bd658h.

Knight, K.W. (2008). *The Ecological Implications of Population Aging*. M.A. Thesis, Department of Sociology, Washington State University, Pullman (WA).

Knight, K.W. (2009). "Structural Human Ecology and STIRPAT: Theory and Method". Panel Contribution to the *Population-Environment Research Network's Cyber seminar on Theoretical and Methodological Issues in the Analysis of Population Dynamics and the Environment*.

Knowles, T. and Curtis, S. (1999). "The market viability of European mass tourist destinations. A post-stagnation life-cycle analysis". *International Journal of Tourism Research,* 1(2): 87-96. http://doi.org/fhx6h2.

Ku, S., Yoo, S. and Kwak, S. (2009). "Willingness to pay for improving the residential waste disposal system in Korea: A choice experiment study". *Environmental Management,* 44(2): 278-287. http://doi.org/fg382h.

Lin, S., Zhao, D. and Marinova, D. (2009). "Analysis of the environmental impact of China based on STIRPAT model*". Environmental Impact Assessment Review,* 29(6): 341-347. http://doi.org/ddrdd7.

Liu, J. and Var, T. (1986). "Resident attitudes to tourism impacts in Hawaii". *Annals of Tourism Research*, 13(2): 193-214. http://doi.org/b4f96b.

Malthus, T.R. (1798). *Essay on the principle of population*, 7th Ed. (1967). Dent, London.

Mathieson, A. and Wall, G. (1982). *Tourism: Economic, physical and social impacts*. Longman, London.

Meadows, D.H., Meadows, D.L. and Randers, J. (1972). *The limits to growth*. Universe Books, New York.

Montero, I. and Oreja, J.R. (2005). "La disponibilidad de los recursos tangibles de la oferta de productos de turismo cultural en las Islas Canarias. Aplicación del modelo probabilístico de RASCH". *Cuadernos de Turismo,* 16: 135-151.

Myers, N. (1993). "Population, environment and development". *Environmental Conservation,* 20(3): 205-216. http://doi.org/d5jtk3.

Nicolli, F., Mazzanti, M. and Montini, A. (2010). *Waste generation and landfill diversion dynamics: Decentralized management and spatial effects*. Working Papers, 417, Fondazione Eni Enrico Mattei, Milan.

Palmer, T. and Riera, A. (2003). "Tourism and environmental taxes: With special reference to the 'Balearic ecotax'". *Tourism Management,* 24(6): 665-674. http://doi.org/cr52h6.

Poon, A. (1993). *Tourism, technology and competitive strategies*. CAB International, Wallingford.

Priestley, G. and Mundet, L. (1998). "The post-stagnation phase of the resort cycle". *Annals of Tourism Research*, 25(1): 85-111. http://doi.org/dv76j9.

Radwan, H., Jones, E. and Minoli, D. (2010). "Managing solid waste in small hotels". *Journal of Sustainable Tourism*, 18(2): 175-190. http://doi.org/dfmqcb.

Rey-Maquieira, J., Lozano, J. and Gómez, C.M. (2005). "Land, environmental externalities and tourism development". In Lanza, A., Markandya, A. and Pigliaru, F. (Eds.): *The economics of tourism and sustainable development*. Series on Economics and the Environment. The Fondazione Eni Enrico Mattei, Milano.

Saleem, N. (1996). "A strategy for sustainable tourism in Sri Lanka". In Briguglio, L., Butler, R., Harrison, D. and Filho, W. (Eds.): *Sustainable tourism in islands and small states: Case studies*. Pinter, New York.

Scholz, S. (2006). "The POETICs of industrial carbon dioxide emissions in Japan: An urban and institutional extension of the IPAT identity". *Carbon Balance and Management*, 1:1(11). http://doi.org/b75zkf.

Schulze, P.C. (2002). "I=PBAT". *Ecological Economics*, 40(2): 149-150. http://doi.org/b29h36.

Sheldon, P., Knox, J. and Lowry, K. (2005). "Sustainability in a Mature Mass-tourism Destination: The Case of Hawaii". *Tourism Review International,* 9(1): 47-60.

Shi, A. (2003). "The impact of population pressure on global carbon dioxide emissions, 1975-1996: evidence from pooled cross-country data". *Ecological Economics,* 44(1): 29-42. http://doi.org/fwst73.

Simon, J.L. (1981). *The ultimate resource*. Princeton University Press, Princeton (NJ).

Stern, D. (2004). "Economic growth and environmental degradation: The environmental Kuznets curve and sustainable development". *World Development*, 24(7): 1151-1160. http://doi.org/fp8s3s.

TIRME S.A. (2010). *Memoria anual 2010*.

UN, United Nation. (2001). *Sustainable development of tourism*. Report of the Secretary-General. Document No. E/CN.17/2001/ PC/21. New York.

Urry, T. (1995). *Consuming places*. Routledge, London.

Vanhove, N. (2005). *The economics of tourism destinations*. Elsevier, Butterworth-Heineman.

Vera, J.F. (1992). "La dimensión ambiental de la planificación turística: Una nueva cultura para el consumo turístico". *Papeles de Geografía*, 18: 195-204.

Vera, J.F and Baños, C. (2010). "Renovación y reestructuración de los destinos turísticos consolidados del litoral: Las prácticas recreativas en la evolución del espacio turístico". *Boletín de la Asociación de Geógrafos Españoles*, 53: 329-353.

Wilkinson, P. (1997). *Tourism policy and planning: Case studies from the Commonwealth Caribbean*. Cognizant Communications, New York.

Wilson, D. (1996). "*Glimpses of Caribbean tourism and the question of sustainability in Barbados and St. Lucia*". In Briguglio, L., Butler, R., Harrison, D. and Filho, W. (Eds.): *Sustainable tourism in islands and small states: Case studies*. Pinter, New York.

WTO, World Tourism Organization (1999). *Sustainable development of tourism: An annotated bibliography*. WTO, Madrid.

WTO, World Tourism Organization (2001). *Yearbook of tourism statistics 1995-1999*. WTO, Madrid.

York, R., Dietz, T. and Rosa, E. (2002). "Bridging environmental science with environmental policy: Plasticity of population, affluence, and technology", *Social Science Quarterly,* 83(1): 18-34. http://doi.org/brbn86.

York, R., Rosa, E. and Dietz, T. (2003). "STIRPAT, IPAT and ImPACT: Analytical tools for unpacking the driving forces of environmental impacts", *Ecological Economics,* 46(3): 351-365. http://doi.org/fhv7rx.

Zagheni, E. and Billari, F. (2007). "A cost valuation model based on a stochastic representation of the IPAT equation". *Population and Environment,* 29(2): 68-82. http://doi.org/b3ts3w.