# THE ECONOMICS OF MUNICIPAL SOLID WASTE MANAGEMENT IN TOURISM DESTINATIONS: THE CASE OF MALLORCA

**Doctoral Thesis**

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# RESUMEN EN CASTELLANO

El turismo es una de los sectores que ha mostrado un destacado crecimiento a nivel mundial y uno de los fenómenos socio-económicos más notables de la era actual. El sector ha adquirido una importancia considerable en la comunidad académica que se ha enfocada en el análisis tanto de los beneficios y costos sociales del desarrollo de esta actividad en los últimos años.

En relación con el estudio de los impactos negativos del turismo, la investigación sobre las externalidades ambientales ha sido objeto de gran interés por la literatura académica en el campo del turismo, sin embargo la relación entre la actividad turística y de los residuos sólidos municipales (RSM) no ha atendida con profundidad. Esto ha ocurrido a pesar del amplio reconocimiento en el ámbito de las políticas públicas de la grave amenaza que la inapropiada gestión de los RSM representa para el medio ambiente.

El estudio de la relación entre la actividad turística y los RSM es interesante principalmente por tres razones. En primer lugar, el sector turístico es especialmente intensivo en la generación de RSM en comparación con otros sectores como la manufactura y la agricultura. En segundo lugar, el turismo internacional es un tipo especial de exportación en el cual el consumo se lleva a cabo dentro del país exportador, por lo tanto, los flujos de turismo constituyen una fuente adicional de RSM en el destino turístico. En tercer lugar, la gestión inadecuada de los RSM puede tener impactos negativos en la capacidad de atracción del destino ya que los recursos ambientales también son insumos de producción en la creación de la experiencia turística.

Mallorca es uno de los destinos más visitados de 'sol y playa ' en Europa y es considerado en la literatura académica como un ejemplo típico de un destino turístico masivo de segunda generación. El turismo ha sido, sin duda, el motor de la generación de riqueza en las últimas décadas en Mallorca, por lo tanto, el desarrollo sostenible de esta actividad es muy importante para el bienestar de la sociedad balear a largo plazo.

Teniendo en cuenta su desarrollo como destino turístico de alta densidad en función de sus activos ambientales, su tamaño relativamente pequeño y el alto costo de oportunidad de la tierra, esta isla es uno de los lugares más interesantes que se pueden utilizar para analizar el posible impacto del turismo sobre la gestión de RSM. En las últimas décadas Mallorca ha modificado su sistema de gestión de RSM a través de cambios regulatorios que establecen los lineamientos del nuevo modelo de gestión de RSM de la isla a través de planes de gestión de residuos (PDRSUM). El objetivo principal de la política pública era cuidar los activos ambientales de la isla, esto llevó a las autoridades a migrar de una gestión basada en el uso de vertederos hacia un nuevo sistema de reciclaje y recuperación de energía que se consideran entre las tecnologías de eficiencia ambiental la mayoría de Europa.

Sin embargo, a pesar de que las instalaciones de tratamiento de Mallorca son consideradas como un ejemplo de eficiencia ambiental, la gestión de RSM en la isla todavía tiene desafíos que muestran la importancia del turismo en la generación de RSM de Mallorca. En primer lugar, la tasa de generación de RSM en la isla media es una de las más altas de España. En segundo lugar, el problema de la gestión de los RSU en Mallorca es especialmente significativo para los municipios costeros, zona con la mayor densidad poblacional y concentración de hoteles de la isla. En tercer lugar, la producción de RSM muestra un fuerte patrón estacional, vinculada a la estacionalidad del turismo, lo que genera un exceso de capacidad instalada de las plantas de tratamiento de RSM de alrededor del 30%.

Estos datos y reflexiones constituyen una base para reconocer que la relación entre la gestión de RSM y la actividad turística tiene elementos interesantes a ser investigados que han recibido poca atención en la literatura académica, ésta constituye entonces la motivación principal de la presente tesis. De esta manera, a través de un enfoque especial en el caso de Mallorca, esta tesis tiene como objetivo contribuir al conocimiento de la gestión sostenible de RSM en economías turísticas, proporcionando herramientas analíticas y empíricas útiles para el análisis de las estrategias de gestión de residuos en destinos turísticos.

Los objetivos generales de esta investigación son (i) Mejorar la comprensión de la relación entre el turismo y la gestión de residuos sólidos municipales, sobre todo en el caso de

Mallorca. (ii) Proporcionar un análisis desde la perspectiva económica del papel del turismo en la generación de residuos sólidos municipales, y (iii) Desarrollar modelos teóricos que analizan el papel de los diferentes agentes implicados en la gestión de los residuos sólidos municipales en los destinos turísticos, y de esta manera, contribuir a llenar el vacío en la literatura académica.

Con respecto a los resultados de la tesis, es importante mencionar que la investigación realiza importantes contribuciones con respecto al análisis de tres aspectos de la relación entre el turismo y la gestión de residuos sólidos municipales. En primer lugar, el análisis cuantitativo del turismo como un factor determinante de la generación de los RSM. En segundo lugar, los retos del turismo en los sistemas de gestión de RSM en los destinos turísticos, con un énfasis en Mallorca. En tercer lugar, el análisis teórico de los incentivos de las empresas turísticas para llevar a cabo la gestión de residuos ambientalmente amigable.

Finalmente, el análisis realizado en esta tesis ha abierto un camino para identificar una serie de cuestiones que deben ser exploradas en futuras investigaciones. En primer lugar, es importante trabajar en modelos y tecnologías para reducir los costos de monitoreo y medición relativas a la producción de RSM y composición. De esta manera, será posible aumentar la información pertinente para promover políticas de minimización más efectivas. En segundo lugar, es importante explorar en detalle los canales dinámicos a través de los cuales las mejoras en la gestión de los residuos pueden ser fomentadas por los agentes de la cadena de suministro del turismo y cómo estos mecanismos se desarrollan de acuerdo a las diferentes estructuras de mercado o de poder. Por último, esta tesis ha generado una mejora en el conocimiento existente sobre la relación entre la estacionalidad en el turismo y la gestión de RSM.

"*The mind can never foresee its own advance*"

— Friedrich August von Hayek

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# INTRODUCTION

Tourism is one of the fastest growing industries in the world and one of the most remarkable socio-economic phenomena of the current era. The sector has gained considerable importance in the generation of income and jobs worldwide. Therefore, the interest of the academic community in the analysis of both the social benefits and costs of the development of this activity is not surprising.

With regard to the study of the negative tourism impacts, research into environmental externalities has been the subject of great but uneven interest in tourism literature, where the relationship between tourism activity and municipal solid waste (MSW) has been largely neglected. This has happened despite the wide recognition in the non-tourism literature in the policy arena of the serious threat that MSW has become to the environment. Municipal solid waste is a natural consequence of human activities which have an impact on ecosystem services. These environmental impacts have increased pressure on the public authorities to develop policy options and other mechanisms to deal with this problem. Specifically, the need to improve municipal solid waste management (MSWM) is part of the emphasis placed upon environmental issues as openly articulated in Agenda 21, which expresses the requirement for sustainable economic activity and the need for mankind to remain in harmony with the carrying capacity of the earth.

The relationship between tourism activity and MSW is worth studying for at least three reasons. First, the tourism sector is especially intensive in MSW generation compared to other sectors as manufacturing or agriculture. Second, international tourism is a special kind of export activity where consumption is carried out in the exporting country; therefore, tourism inflows constitute an additional source of MSW in the tourism destination. Third, improper MSW management can have negative impacts on the attractiveness of the destination since environmental resources are inputs of production in the creation of the tourist experience.

New trends in tourism look forward to fostering the enforcement of environmental protection programmes for tourism destinations. Moreover, in tourism destinations both public and private agents share a common interest in achieving a better environmental quality. From a public perspective, it is well-known that destinations need to develop new features and elements that can distinguish them as attractive compared to other competitive destinations and increase the value of the destination. Thus, in a context of growing competition among destinations, environmental practices concerning better MSWM practices, for example, become highly relevant to the destinations. From the private side, the tourism sector tends to rate waste management as one of the most important concerns of tourism firms. This kind of practice has a series of benefits such as the possibility of offsetting costs or improving the image of the company by using environmentally friendly practices that could meet the expectations of their clients and stakeholders.

However, even though the need for an adequate MSWM system is shared by both the public and private sector, the implementation of efficient systems for proper MSWM is still a social and economic challenge. This is especially true for Mallorca, a tourism destination where the major problems of MSWM have not yet been properly solved.

Mallorca is one of the most visited ‘sun and sand’ destinations in Europe. It has usually been considered in the literature as a typical example of a second generation mass tourist resort. It receives approximately 10 tourists per resident per year, arrivals which are mainly concentrated between the months of May and October; thus, the peak season accounts for more than 80% of the total annual tourist arrivals in the island. Tourism has undoubtedly been the engine of the current wealth of Mallorca; therefore, the sustainable development of this activity is very important in order to continue the improvement of sustainable practices in order to enhance welfare.

Precedents for tourism development in Mallorca go back in the late nineteenth century. However, the massive tourism development of Mallorca began in the 1960s when the island’s promotion of the construction of hotels showed that it was anticipating receiving an increasing number of visitors. Thus, the tourism sector in Mallorca changed from being an unimportant area in a mainly agricultural and industrial economy to become the most important sector of the destination. As a first-order economic activity, tourism led to a strong expansion in other sectors, especially in construction and services industries, leading to increasing employment rates.

Given its development as high-density tourism destination based on its environmental assets, its relatively small size and the high cost of land, this island is one of the most interesting locations that can be used to analyze the potential impact of tourism on MSWM. In recent decades Mallorca has shown an impressive ability to change its MSWM system through innovations in treatment facilities that look forward to greening the image of the destination. In facing up to the problem of proper environmental waste management the regional government set the guidelines of the new MSWM model of the island by means of three consecutive waste management plans (PDRSUM[1]). The main strategy behind the PDRSUM was to take care of environmental assets in a better way which led public authorities to shift from landfill technology to investing in recycling and energy recovery systems which are considered to be among the most environmental efficient technologies in Europe.

Even though Mallorca's MSW treatment facilities are considered to be an example of environmental eco-efficiency, MSWM in the island still have challenges that show the importance of tourism in Mallorca's MSW generation. First, incoming tourists are an important reason for Mallorca having an average MSW generation rate of 585.78 kg./resident/year, the highest in Spain. Second, the problem of MSW management in Mallorca is especially significant for tourism coastal municipalities, which have the highest population density and the highest concentration of hotels on the island but, at the same time, the lowest recycling rate. Third, MSW generation shows a strong seasonal pattern, linked to tourism seasonality, which helps to explain an overcapacity at the MSW treatment plant of around 30%.

These data and reflections constitute a basis to recognize the relationship between MSWM and tourism activity as a potentially fertile research topic. Coupled with the lack of treatment of this topic in the academic literature, they constitute the motivation for this thesis. Thus, by

[1] Plan Director de Residuos Sólidos Urbanos de Mallorca.

placing a special focus on the case of Mallorca, this thesis aims to improve knowledge about sustainable MSWM in tourism economies and to provide useful analytical and empirical tools to analyze waste management strategies in tourism destinations. The general objectives of this research are:

1. To improve understanding of the relationship between tourism and municipal solid waste management, particularly in the case of Mallorca.

2. To provide an analysis from an economic perspective of the role of tourism in municipal solid waste generation.

3. To develop theoretical models that analyze the role of the different agents involved in municipal waste management of tourism destinations, and thus to contribute to filling the gap in the academic literature.

This thesis is structured in six chapters. It is worth mentioning that Chapters 2 to 5 were developed as four self-contained pieces of research with the structure of a publishable academic paper. Hence, each of these presents the necessary motivation, background, methodology, results and conclusions. The final chapter presents the main contributions of the thesis and a summary of the results that have been revealed in each of the preceding chapters. A brief description of the following chapters is provided below.

The cornerstone of successful MSW planning is the availability of reliable information about generation (Gidarakos et al., 2006). Most academic evidence of the determinants of MSW generation is based on microeconomic studies which often rely on case studies and small datasets which do not give enough information on tourism as a determinant of waste generation at the regional or national level. From a macroeconomic point of view, the relationship between environmental degradation and economic growth has been analyzed by means of the Environmental Kuznets Curve (EKC) in the last years. MSW, compared to other pollutants, has received little attention in the EKC literature and, as far as we know, only the paper of Mazzanti et al. (2008) tried to assess the impact of the tourism[2] on the generation of MSW on the EKC. Chapter 2 aims to contribute to the second main objective of the thesis by filling in the gaps in the tourism and EKC literature. The objectives of this chapter are: (i) to analyze the EKC relationship with MSW generation and the impact of tourism on it; (ii) to assess the relationship between tourism quality and MSW generation; (iii) to analyze the impact of tourist volume on MSW generation and; (iv) to evaluate the potential of tourism specialization on MSW generation. In order to accomplish these objectives, a sample of 32 European countries was chosen, given that tourism makes an important contribution to the productive structure of these countries and because the main directives and definitions set by the European Commission allow a homogeneous comparison between countries in this area.

Chapter 3 focuses on the analysis of the MSWM system from a sustainability framework. This chapter looks forward to contributing to the first main objective of the thesis. Many previous case studies in the academic literature concerning MSWM practices focused on big cities and only a few analyzed tourism destinations. The analysis of destinations mainly paid attention to particular issues like generation, but none of these studies attempted to assess MSWM with an integrated vision. As services provided by the tourist sector are consumed in the destination, the development of tourism destinations has a direct relationship with all the stages of MSWM (generation, collection, transport and treatment). Therefore, in formulating waste management strategies for tourism destinations it is necessary to consider the particular characteristics of the sector in its development. The objective of the chapter is to analyze the way in which tourism destinations' main characteristics challenge MSWM systems, with special attention being paid to the case of Mallorca. This chapter assesses (i) the legal and institutional framework of Mallorca's MSWM system; (ii) the main technical characteristics, how it is financially supported and the major distinctiveness of its social management; (iii) the challenges to financial sustainability; and (iv) the description of the relationship between tourism specialization and MSWM systems.

[2] By including tourist arrivals as a control variable in the model.

Another approach to the analysis of MSW generation in tourism destinations is presented in Chapter 4. The aim of this chapter is to contribute to the second main objective of the thesis by analyzing the role of tourism in MSW disposal in Mallorca. As the tourism sector has special characteristics in production (consumption of the 'tourism product' is performed at the destination), tourist growth could be conceived as the bigger presence of nomad populations in a given destination. Previous studies in the academic literature which attempted to measure the impact of population growth on the environment followed the seminal ideas of Ehrlich & Holdren (1971). However, they focused their attention on the local population and little attention was given to the performance of the regions with considerable tourism activities, where human pressure does not correspond directly to the local population. This chapter assesses the environmental impact of tourist arrivals on MSW generation by means of an IPAT-type model based on a stochastic differential equation system. This formulation seeks to get better results as it allows for dealing with the stochastic regressors in the model. Another contribution of this research is related to the inclusion of the idea of nomad population (tourists) into the STIRPAT model which traditionally focused on industrial regions. Finally, in this chapter the potential importance of improvement in environmental outcome without harming tourist revenues it is also assessed by means of the elasticity of substitution between low income tourist and higher income tourist arrivals.

In terms of supply side analysis, Chapter 5 analyzes how the tour operator (TO) can introduce efficiency in environmental management in tourism destinations. Tourism companies achieve profitability and exert pressures over environmental common pool resources (CPR), both causing and suffering external effects. Thus, a coordination failure can arise where an overexploitation of CPRs leads to a reduction of the value of environmental resources as inputs for the tourism industry. In this situation, it is often argued that government intervention (regulation) is the best answer to solve the situation. However, the academic literature identifies other means by which it is possible to reduce environmental impacts derived from tourism activities based on private interactions in which tour operators may play an important role in coordinating a shift of tourism suppliers to green management. Although the greening role of TOs is recognized in academic literature, little has so far been researched on the means by which tour operators can integrate and implement efficient sustainable practices through their position in the TSC. On the theoretical side, only Calveras & Vera-Hernández (2005) have explored the role of TOs as coordinating agents in the management of CPR in tourism destinations. However, this study has a number of shortcomings that leave room for further research. Chapter 5 looks forward to contributing to the third main objective of the thesis by setting a theoretical framework for analyzing the interaction between TOs and hotels where the former implement incentives schemes to induce investment in quality by the latter. This chapter explores (i) the role of TOs in the hotels' green management adoption in a framework of tragedy of the commons and explores how reducing the number of TOs can lead to a level of green management closer to the social optimum; (ii) the path of adoption of green management by the hotels of a tourism destination and its long run equilibrium; (iii) different assumptions on rationality of agents (TO and hotels); (iv) the determinants of the distribution of the yield from green management; and (v) the impact of government intervention by means of a subsidy that promotes green management.

Finally, Chapter 6 is devoted to the conclusions of the PhD thesis. It summarizes the issues raised in each of the chapters, and highlights the most important contributions and results.

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# CHAPTER 2: "MUNICIPAL SOLID WASTE GENERATION AND TOURISM GROWTH: ENVIRONMENTAL KUZNETS CURVE EVIDENCE FROM EUROPEAN COUNTRIES PANEL DATA"

# MUNICIPAL SOLID WASTE GENERATION AND TOURISM GROWTH: ENVIRONMENTAL KUZNETS CURVE EVIDENCE FROM EUROPEAN COUNTRIES PANEL DATA


## ABSTRACT

One of the major environmental challenges for tourist destinations is the need to reduce the amount of municipal solid waste (MSW) generated by increasing tourist inbound flows. MSW generation is an externality that received little attention in tourism research; however, given the natural impact on tourism growth on MSW generation, and since a decreasing production of MSW is the main priority of the EU waste policy, it is important to understand which role does tourism have in MSW generation since it is one of the main economic activities of Europe.

The purpose of this paper is to fill this gap in the literature by assessing the effects of tourism volume, tourist quality and tourism specialization on the Environmental Kuznets Curve (EKC) when MSW is considered as an environmental quality indicator. The study considers a panel data for 32 European economies in the 1997–2010 periods. Empirical results support the EKC hypothesis and confirm a non-linear and significant relationship between tourism arrivals and MSW generation in the region.


**KEY-WORDS:** Environmental Kuznets Curve, Municipal Solid Waste, Waste Generation, Tourism.

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## 2.1 INTRODUCTION

In the last three decades refuse collection and waste disposal industry have been affected by the growing volume of urban solid wastes, which fosters landfill collapses and negative impacts over environmental quality (Nicolli et al., 2010). Improper handling of MSW could cause serious damage to ecosystem services by increasing water, soil and air pollution (Rodríguez, 2002; Mor et al., 2006). Furthermore, it may also increase the probability of serious impacts on public health (Al-Khatib et al., 2010; Marchand, 1998) or human safety (Mor et al., 2006).

Environmental impacts of MSW generation have increased pressure on public authorities to develop policy options and other mechanisms to deal with this problem (Magrinho, 2006; Rotich, 2006; Manga et al., 2008; Shekdar, 2009). The analysis of these strategies and their impact is especially interesting in the case of tourism destinations since tourism inflows constitute an additional source of MSW and the attractiveness of a tourism destination can be affected by waste management (Mathieson & Wall, 1982; Gidarakos et al., 2006; Radwan et al., 2010). The limitation on land in some tourism destinations (Rey-Maquieira et al., 2005; Gómez et al., 2008), the increasing real costs of garbage disposal and treatment, and the need to avoid a deterioriaton of destination image have made it even more difficult to manage MSW in tourism areas. This is why one of the major environmental challenges of tourism destinations is the design of appropriate policies aimed to manage the amount of municipal solid waste (MSW) generated by increasing tourist inbound flows (Gidarakos et al., 2006; Holden, 2008; Mateu-Sbert et al. 2013).

The cornerstone of successful MSW planning is the availability of reliable information about generation (Gidarakos et al., 2006). As some authors noted, most academic evidence on the determinants of waste generation is based on microeconomic studies carried out at a community level (Karousakis, 2006; Bel, 2006; Mazzanti et al., 2006; Mazzanti et al., 2009). This approach often relies on case studies and small datasets and therefore it does not shed light on the determinants of waste generation at a regional and national level. From a macroeconomic point of view, the relationship between environmental degradation and economic growth has received increasing attention and the Environmental Kuznets Curve (EKC) hypothesis has become a centrepiece of this research. The EKC is a hypothesized relationship between environmental degradation and per capita income. The concept of EKC flourished in the early nineties to describe the time trajectory that a country's pollution would follow as a result of its economic growth (Carvalho & Almeida, 2009). The seminal paper of Grossman & Krueger (1995), and later works on the topic, found that for a number of environmental variables, the relationship between per capita income and environmental degradation takes an inverted U-shaped form, which means that environmental quality initially worsens but ultimately improves with income. This apparent empirical relationship has been called the "Environmental Kuznets Curve" because of its similarity to the relationship between per capita income and income inequality first suggested by Simon Kuznets in 1955 (Anand & Kanbur, 1993)[3].

The EKC is in fact a "reduced form" relationship in which the level of pollution is modelled as a function of per capita income without specifying the links between both of them. It is customary in the extended literature of the EKC to explain this relationship as the result of three effects, the *scale, composition and technology effects* (see for instance Stern, 2004; Carvalho & Almeida, 2009).

The scale effect implies that, for a given composition of economic activity and a given technological level, an increase in the scale of economic activity produces a worsening in environmental conditions. This effect is assumed to dominate during the first stages of economic development. However, economic development is associated with expansions and contractions of different economic sectors characterized by different environmental impact, giving place to a composition effect. If the sectors that expand have less environmental impact than those that contract, the composition effect tends to counterbalance the scale effect. This composition effect may be helped by a technological effect resulting from firms adopting less polluting technologies, either because of market driven technological change or by

[3] For surveys on the varied areas of application of the EKC hypothesis see Dasgupta et al. (2002), Dinda (2004), Stern (2004), Stern (2004b), Dinda (2005), Mazzanti et al. (2006) and Mazzanti & Zoboli (2009).

government regulation. Thus, according to Grossman & Krueger (1995), as nations experience greater prosperity, their citizens demand that more attention to the non-economic aspects of their living conditions. Therefore, richer countries would have relatively more stringent environmental standards and stricter enforcement of their environmental laws than the middle-income and poorer countries.

Then, according to this explanation, if the EKC hypothesis is satisfied, one would say that the composition and/or the technological effects eventually dominate the scale effect. Therefore, at higher levels of development, structural change of the economy coupled with increased environmental awareness, enforcement of environmental regulations, better technology and higher environmental expenditures, would lead to a gradual decline of environmental degradation as income increases. However, it is important to note that academic research based on the EKC hypothesis have shown "mixed" results since it is possible to find studies that support the EKC while other authors found no statistical evidence of it for the same environmental variable (Dinda, 2004; Stern, 2004; Jordan, 2010).

Despite the wide acceptance of the EKC hypothesis among economists, it has also received criticism, especially with regard to the estimation techniques. First of all, it is criticized that in many studies consumption and production emissions are not adequately differentiated (Agras & Chapman, 1999; Rupasingha et al., 2004). Second of all, another common topic under criticisms in the literature is related to the lack of definition of a single functional form to be used for the econometric analysis since it is possible to find several functional forms such as quadratic, log quadratic or cubic relationships, among others, between some measure of environmental degradation[4] and per capita income to test the inverted U shape of the EKC (Bruyn et al., 1998; Agras & Chapman, 1999; Dinda, 2004). Thirdly, as pointed out by several authors (Stern et al., 1996; Agras & Chapman, 1999; Damania et al., 2003; Carvalho & Almeida, 2009), neglecting the effect of changes in trade patterns associated with development on environmental quality can lead to wrong conclusions in the EKC analyses,

[4] Like concentrations of $SO_2$, per capita emissions of $CO_2$, suspended particulate matter (SPM), lack of safe water, lack of urban sanitation, annual deforestation, municipal solid waste per capita and others.

since the reduction of emissions could just be matched by an increase in the import of pollution intensive goods.

According to some authors municipal solid waste is, among the different possible environmental problems, the less investigated in the EKC literature (Mazzanti & Zoboli, 2008; Mazzanti et al., 2009; Jordan, 2010; Ichinose et al., 2011). Moreover, academic research related to the EKC hypothesis on waste shows mixed evidence since it is possible to find studies that do not support the EKC formulation and others that found some evidence of a turning point concerning MSW generation[5]. However, as far as we know, only the paper of Mazzanti et al. (2008) tried to assess the impact of the tourist sector on the generation of MSW on the EKC. There are at least two reasons to consider that tourism may be an important determinant of MSW. Firstly, international tourism is a special kind of export activity where consumption is made at the exporting country (Vanhove, 2005); therefore, the reasons for the inclusion of trade variables in the EKC regressions apply to tourism. Secondly, tourism is especially intensive in MSW generation compared to other economic sectors, like manufacturing or agriculture, more prone to produce other kind of polluting outputs (Magrinho et al., 2006; Beigl et al., 2008; Papachristou et al., 2009; Mateu-Sbert et al. 2013).

This paper tries to contribute in filling these gaps in the tourism and in the EKC literatures. With such aim, the objectives of this empirical study are: (i) to confirm the presence of an EKC relationship for municipal solid waste generation and analyze the impact of tourism in it; (ii) to assess the relationship between tourism quality and MSW generation; (iii) to analyze the impact of tourist volume on MSW generation and; (iv) to evaluate the potential of tourism specialization on MSW generation.

In order to accomplish these objectives, a sample of 32 European countries during the period 1997–2010 was chosen. This region was selected for several reasons. First of all, the important contribution of tourism to the productive structure of these countries. Second of all, in this region the main public policy directives and definitions on MSW management are set

[5] For further details on studies and results concerning to the EKC hypothesis on waste see APPENDIX N° 2.1.

by the European Commission which allows a homogeneous comparison between countries in this area. Finally, there is still a scarcity of studies on the determinants of MSW generation in the EU which are needed for the implementation of public policies that look forward to fostering the main goals set by the European Commission (European Commission, 1994; European Commission, 2004).

This paper is organized as follows: Section 2.2 reviews the methodology used for the empirical analysis; Section 2.3 presents the data sources and variables required to achieve the goals of this paper. Finally, Section 2.4 and 2.5 show the main empirical results and conclusions.

## 2.2 METHODOLOGY

Several previous empirical studies use cross-country data to measure the relationship between income and environmental degradation (Roberts & Grimes, 1997; Hilton & Levinson, 1998; Torras & Boyce, 1998; Bhattarai & Hammig, 2001; Neumayer, 2002). However, these models implicitly assume that a common structure exists across all countries at a certain period of time. This unrealistic assumption can be relaxed by applying panel data methodology, which has been facilitated by the increasing availability of statistics that combine cross-sectional data observed for a considerable time span. According to Wooldridge (2002) and Balestra & Nerlove (1966) there are three main advantages of panel data methodology compared to cross-section and time series analysis: (i) it provides more information, more variability, less collinearity among variables, higher degrees of freedom and more efficiency; (ii) panel data considers regions analyzed as heterogeneous compared to cross-sectional data, which reduces the risk of not taking into account all the information and biased parameters; (iii) it allows a more precise analysis of the dynamics of adjustment of economic variables.

For this reasons, this paper will use panel data methodology following standard approaches in the existing Environmental Kuznets Curve literature. In this paper we test the EKC hypothesis by specifying a proper reduced form as the one proposed by Stern (2004)[6]:

$$MSW_{it} = \beta_{0i} + \alpha_t + \beta_1(GDPPC_{it}) + \beta_2(GDPPC_{it})^2 + \sum_{j=1}^{k} \delta_j(X_{jt}) + e_{it} \qquad (1)$$

Where the term o the left hand side of the equation is the amount of municipal solid waste (MSW). There are two main methodological advantages for using this variable compared to other EKC studies. The first one is related to the uniform pattern of classification of MSW in Europe since other regions like Latin America or Africa do not have a uniform classification among countries which make comparisons less accurate (Bartone et al., 1991). The second methodological advantage is that the use of MSW is immune to criticism made to previous empirical research (based on emissions) regarding the lack of distinction between emissions from production and from consumption. In this case, MSW are collected mainly in the regions where it is generated so no inaccurate measures could be considered with this pollutant.

The first two terms of the right hand side are intercept parameters, which vary across countries, and years. GDPPC is the gross domestic product per capita (economic driver). Even though the countries used in the sample come from the same region (Europe), some heterogeneity across them should be expected. Therefore, the matrix X refers to other socio-economic drivers introduced in the model as control variables in the specification of the EKC regarding to municipal solid waste generation.

Under the hypothesis of no correlation between the exogenous variable and the individual effect, the panel data models can be estimated directly by ordinary least squares (OLS). However, the main problem of this method is that the model error generates a high probability

[6] Even though some studies on EKC use logarithmic specification models, as Mazzanti et al. (2006) noted "there is no clear evidence of its advantage over a non logarithmic model", therefore, the traditional EKC functional form was chosen for the analysis.

of autocorrelated and heteroskedastic behaviour, with a consequent impact on the efficiency property of the estimator (Breusch et al., 1989; Biørn, 2001).

Therefore the need for a general estimation (because the variance-covariance matrix is no longer a scalar matrix) rises. In this sense, as Arcarons & Calonge (2008) explained, White supplied a method to correct asymptotic variance estimator that was applied to the panel models by means of the econometric software (E-Views). This correction can be obtained by the following expression:

$$\widehat{\text{var}}(\hat{\beta}) = (X\,X)^{-1} \sum_{i=1}^{N} \left[x_i (e_i e_i) x_i\right] (X\,X)^{-1} \qquad (2)$$

Where $\hat{\beta}$ are the estimated coefficients; $X$ is the matrix of explanatory variables and $e_i$ represents the estimation residuals of the equation. Finally, it should be addressed that complete panels of data could not be obtained for all countries in the dataset. This is a common problem with panel data and can be corrected by using balanced panel estimation methods.

The need to control for intracluster correlation of errors in linear regression models is well known, with leading references including Kloek (1981) and Moulton (1990). This relaxes the homoskedasticity assumption of the OLS estimation and allows the error terms to be heteroskedastic and correlated within groups or so-called clusters. For the OLS estimator, estimated standard errors computed without regard to clustering can be greatly understated (Cameron & Golotvina, 2005) and more efficient estimators than OLS are possible.

Our analysis incorporates two explanatory variables to capture the effect on MSW of quantitative and qualitative characteristics of tourism and a set of dummy variables to quantify the effect of tourism specialization on MSW generation. Thus, the volume of tourism is measured with inbound tourism arrivals (TUR) and the qualitative aspect of tourism is measured by the tourism expenditure per tourist index (TUREXPIND [7]). Tourism specialization is represented by the ratio of tourism expenditure with respect to GDP (tourism expenditure / GDP). Thus, three groups were considered: (i) those countries which are within the top 25% of the sample, (ii) those which are in the bottom 25% of the sample, and (iii) countries that are between 25% and 75% of the sample. To capture the differential effects of tourist specialization, we used as a reference group those countries which belonged to the last segment and used dummy variables to capture the impact of the group with the highest degree (DX_Q1) and the lowest degree (DX_Q4) of specialization.

Some a priori reflections may suffice to justify these regressors. First of all, it seems quite clear that one should expect a positive scale effect of a quantitative measure of tourism on MSW generation, but a counterbalancing technological effect through policy pressure might also be expected on the basis of awareness of destination image. Second of all, as to the qualitative aspect of tourism, differences among tourism destinations in "tourism expenditure per tourist" reflects differences in the socioeconomic characteristics of visitors and in the quality of tourism supply that may yield different patterns of MSW generation. Finally, regarding tourism specialization, a larger weight of tourism in the productive structure may increase the weight of MSW in the set of environmental pressures in the country, but it may also increase policy awareness in solving environmental problems that negatively affect the tourism destination image.

The previous reflections suggest that a linear form for the tourism variables, as assumed in Mazzanti et al. (2008), is inadequate since similarly to the relationship between per capita income and MSW, there may be counterbalancing effects. Therefore, this study assumes a quadratic form for the variables TUR and TUREXPIND to capture possible non-linear relationships[8].

[7] This variable has been structured as an index that seeks to assess the relative importance of average tourism expenditure per tourist for a country with respect to the average tourist expenditure in each given year.
[8] The use of quadratic forms for control variables in the EKC is not new in academic literature. Lanz (2002) used quadratic explanatory variables in a panel estimation; however, none of them are related with tourism or trade.

The model also includes other variables. Following recommendations from the EKC literature (Tisdell, 2001; Cole, 2004; Chintrakarn & Millimet, 2006; Nguyen Van & Azomahou, 2007; Managi et al., 2009; Lee et al., 2010), the model includes a measure of trade (TRADE) as an explanatory variable and, as in the case of tourist variables, non-linearity is considered in the model by a quadratic form; it is important to note that, as far as we know, previous studies have only considered linear relationships of trade in EKC. The model also incorporates a set of socioeconomic variables such as the level of unemployment (UNEMP), the percentage of population with at least upper secondary school (EDU) and the percentage of total population living in rural areas (RURP). These variables try to capture particular characteristics of each society (Foo, T., 1997; Gidarakos et al., 2006; Hitchens et al., 2000; Ku et al., 2009; Nicolli et al., 2010). Furthermore, as Grossman and Krueger (1995) mentioned, proper environmental policies play a fundamental role in the inversion of the trajectory of pollutants that follow the EKC hypothesis. Therefore, it is important to include as part of the control variables an indicator of the institutional quality (Bhattarai & Hammig, 2001; Culas, 2007; Di Vita, 2007; Mazzanti & Zoboli, 2008; Mazzanti et al., 2009; Arbulú, 2012). For this purpose, the government effectiveness indicator (GOVEFF) was chosen[9].

The methodology proposed in this paper involves the estimation of four models. In all of them period fixed effect estimations are considered to capture specific macroeconomic shocks each year. :

- **MODEL N° 1**: This model is established by regressing MSW on GDP per capita and GDP per capita squared in order to test the Environmental Kuznets Curve hypothesis in its purest form.

- **MODEL N° 2**: This model extends model N°1 by including additional explanatory variables to capture cross-country differences.

[9] This reflects the statistical compilation of responses on the quality of governance given by a large number of enterprise, citizen and expert survey respondents in industrial and developing countries, as reported by a number of survey institutes, think tanks, non-governmental organizations, and international organizations.

- **MODEL N° 3**: Model Nº 2 is extended to include tourism variables TUR and TUREXPIND in order to capture the effect of quantitative and qualitative features of tourism on MSW generation.

- **MODEL N° 4**: This is the most complete model where, besides the regressors considered in previous models, a set of dummy variables is included to evaluate the effect of tourism specialization on MSW generation.

As Biørn (2001) noted, it is well established that the Generalized Least Squares (GLS) is the optimal estimator of the coefficient vector in fixed effects panel data regression models when the model is correctly specified. As one of the main concerns of this study is the efficiency, we considered a GLS estimator that takes serial correlation into account.

## 2.3 DATA

Our data sources are several international institutions such as the World Bank (WB[10]), UNWTO and EUROSTAT. The dependent variable under consideration is municipal solid waste generation (MSW) measured in kg. per capita. The dataset for MSW generation is composed of measurements for several European countries between the years 1997 to 2010. Table Nº 2.1 shows the list of countries included in the estimation and their identification codes.

[10] World Development Indicators Online Database.

**TABLE N° 2.1**

**SET OF EUROPEAN COUTRIES**

| COUNTRY | CODE | COUNTRY | CODE |
|---|---|---|---|
| AUSTRIA | AUT | LATVIA | LVA |
| BELGIUM | BEL | LITHUANIA | LTU |
| BULGARIA | BGR | LUXEMBOURG | LUX |
| CROATIA | HRV | MALTA | MLT |
| CYPRUS | CYP | NETHERLANDS | NLD |
| CZECH REPUBLIC | CZE | NORWAY | NOR |
| DENMARK | DNK | POLAND | POL |
| ESTONIA | EST | PORTUGAL | PRT |
| FINLAND | FIN | ROMANIA | ROM |
| FRANCE | FRA | SLOVAK REPUBLIC | SVK |
| GERMANY | DEU | SLOVENIA | SVN |
| GREECE | GRC | SPAIN | ESP |
| HUNGARY | HUN | SWEDEN | SWE |
| ICELAND | ISL | SWITZERLAND | CHE |
| IRELAND | IRL | TURKEY | TUR |
| ITALY | ITA | UNITED KINGDOM | GBR |

The panel includes a wide range of macro-level information on socioeconomic characteristics of countries and characteristics related to the tourism sector. The variables are shown in Table Nº 2.2 which contains the definition and explanation of those variables.

**TABLE N° 2.2**

**EXPLANATORY VARIABLES**

| COD | VARIABLE | UNIT / DESCRIPTION | SOURCE |
|---|---|---|---|
| MSW | Municipal waste generation | kg per capita | EUROSTAT |
| GDPPC | Real GDP per capita | Euro per inhabitant | EUROSTAT |
| TUR | International inbound tourists arrivas | Number of tourists who travel to a country other than the one in which they have their usual residence, but outside their (overnight million visitors). | WORLD BANK / UNWTO |
| TUREXPIND | Tourist Expenditure Index | Tourist Expenditure per Tourist of country "i" devided by the year mean of sample | UNWTO |
| TRADE | Merchandise trade | Exports and imports as % of GDP | WORLD BANK |
| DX_Q1 | Dummy Variable - Tourism Especialization | Dummy variable that is equal to 1 for the 25% of the sample with the highest Tourism Expenditure/GDP ratio | UNWTO |
| DX_Q4 | Dummy Variable - Tourism Especialization | Dummy variable that is equal to 1 for the 25% of the sample with the lowest Tourism Expenditure/GDP ratio | |
| UNEMP | Unemployment rate | % of total labor force | WORLD BANK |
| EDU | Education | % of population between 25 and 64 having completed at least upper secondary education | EUROSTAT |
| RURP | Rural population | % of total population living in rural areas | EUROSTAT |
| GOVEFF | Government Effectiveness | Index | WORLD BANK |

For the purpose of this study, Per capita Gross Domestic Product (GDPPC) is used as a proxy for the per capita income of each country.

## 2.4 EMPIRICAL FINDINGS

The results of econometric estimates on the country dataset, for the four different specifications of equation (1), are summarized in Table N° 2.3. Our empirical findings reveal an EKC relationship between per capita income and MSW generation and, as expected (Mazzanti et al., 2009), the existence of a significant effect of tourism on MSW generation.

The estimations give the expected results in terms of the sign and statistical significance of both per capita income (GDPPC) coefficients leading to confirm the quadratic formulation of the Environmental Kuznets Curve in all the formulations. However, the coefficients of the quadratic form show low values which could be related to a high turning point (see Table N° 2.4). Table N° 2.4 also shows that the elasticity of total MSW generation with respect to GDPPC is positive and lower than one. This is consistent with previous research on municipal solid waste generation in the OECD like Johnstone & Labonne (2004), Mazzanti & Zoboli (2008), Mazzanti & Zoboli (2009) and Karousakis (2006). It also shows how the inclusion of tourism variables affects key EKC's characteristics. Specifically, Models Nº 3 and Nº 4, that include tourism variables, show lower turning points than standard estimations without those variables (Models Nº1 and Nº2), whereas model Nº 4 shows higher elasticity. This leads us to think that omission of tourism variables in the EKC has produced an overestimation of these indicators in previous research.

## TABLE N° 2.3

## ECONOMETRIC RESULTS

| VARIABLE | MODEL 1 | | MODEL 2 | | MODEL 3 | | MODEL 4 | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | t-Statistic | Coefficient | t-Statistic | Coefficient | t-Statistic | Coefficient | t-Statistic |
| C | 330.157*** | 29.91 | 394.973*** | 8.22 | 387.060*** | 8.13 | 315.909*** | 6.32 |
| GDPPC (x 1000) | 11.184*** | 12.00 | 10.237*** | 5.16 | 10.411*** | 4.53 | 12.354*** | 5.21 |
| GDPPC^2 (x 1000) | -0.000107*** | -6.53 | -0.000107*** | -4.19 | -0.000116*** | -3.83 | -0.000135*** | -4.03 |
| UNEMP | | | -5.291*** | -3.30 | -6.338*** | -3.86 | -5.555*** | -3.49 |
| EDU | | | -2.242*** | -7.33 | -2.150*** | -7.12 | -1.822*** | -5.82 |
| TRADE | | | 3.299*** | 4.17 | 3.675*** | 4.66 | 4.027*** | 5.19 |
| TRADE^2 | | | -0.017*** | -4.32 | -0.019*** | -4.65 | -0.021*** | -5.34 |
| GOVEFF | | | 16.031 | 0.87 | 27.259 | 1.45 | 39.723 ** | 2.13 |
| RURP | | | 0.144 | 0.27 | 0.102 | 0.18 | 0.431 | 0.79 |
| TUR | | | | | 2.419 ** | 2.27 | 3.199 ** | 2.22 |
| TUR^2 | | | | | -0.029 ** | -2.08 | -0.039 ** | -2.03 |
| TUREXPIND | | | | | -72.128*** | -3.13 | -107.727*** | -4.28 |
| TUREXPIND^2 | | | | | 20.272*** | 3.63 | 25.255*** | 4.10 |
| DX_Q1*TUR | | | | | | | 15.918*** | 2.66 |
| DX_Q1*TUR^2 | | | | | | | -0.996*** | -3.34 |
| DX_Q4*TUR | | | | | | | 3.162 * | 1.73 |
| DX_Q4*TUR^2 | | | | | | | -0.040 | -1.54 |
| DX_Q1*TUREXPIND | | | | | | | 13.217 | 0.43 |
| DX_Q1*TUREXPIND^2 | | | | | | | -2.130 | -0.24 |
| DX_Q4*TUREXPIND | | | | | | | -169.322*** | -3.62 |
| DX_Q4*TUREXPIND^2 | | | | | | | 81.981*** | 2.80 |
| **Adjusted R-squared** | **0.4698** | | **0.5914** | | **0.5983** | | **0.6436** | |

## TABLE N° 2.4

## TURNING POINT AND INCOME ELASTICITY

| | MODEL 1 | MODEL 2 | MODEL 3 | MODEL 4 |
|---|---|---|---|---|
| **Turning Point (Euros)** | 52,262 | 47,836 | 44,875 | 45,756 |
| **Income Elasticity** | 0.3818 | 0.3412 | 0.3405 | 0.4064 |

For the estimated models with a set of control variables[11], all coefficients are significant and have values with the expected sign, except from the rural population (RURP), which turns out to be not significant. Regarding the government effectiveness index (GOVEFF), this variable is only statistically significant in Model N° 4 and it has an estimated positive influence on the MSW. This positive sign might be the resultant of two counterbalancing effects. On the one hand, it could be expected that more efficient governments would be related to better

[11] Model 2, Model 3 and Model 4.

enforcement of environmental regulations and, this way, to lower MSW generation. On the other hand, as Hitchens et al. (2000) argue, government effectiveness is related to efficiency in the allocation of resources which lead to an increase in factors productivity and production, and by this means, increases MSW. Our empirical result shows that the second effect dominates.

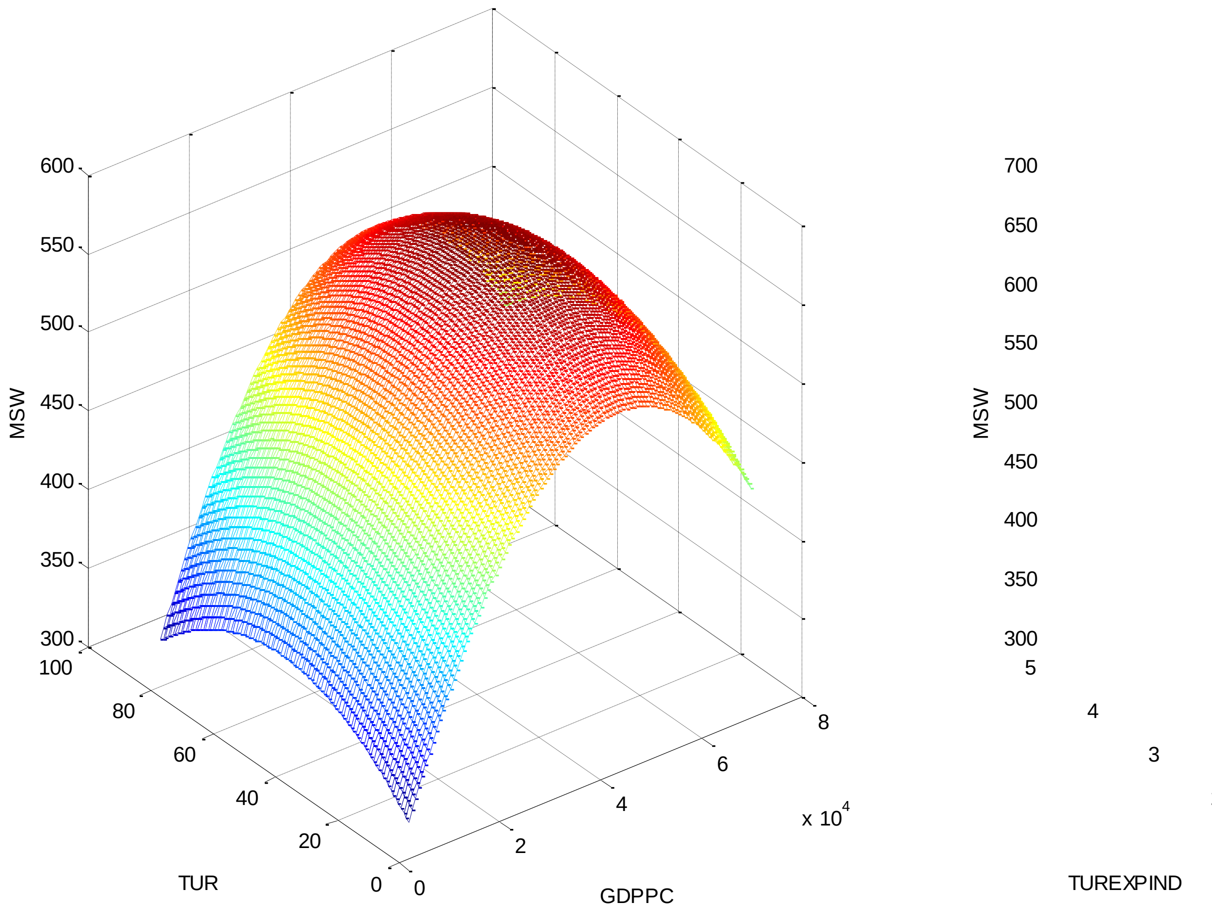
As to the socioeconomic variables such as unemployment (UNEMP) and education level (EDU), results support the significance of these variables in the same way that previous research made at microeconomic level (Foo, 1997; Gidarakos et al., 2006; Ku et al., 2009; Nicolli et al., 2010). In this way, better education level has positive effects on environmental quality by means of a "greener" behaviour or commitment (which is related to the technological effect) while the unemployment rate generates a better environmental outcome by means of the reduction in consumption capacity (impact on the scale effect).

Regarding the relevance of tourism for MSW generation, our results show that the volume of tourism, the quality of tourism and the specialization degree in tourism exert a significant influence on the volume of MSW per capita. The volume of tourism, measured by the tourism arrivals (TUR), has a positive coefficient for the linear term and a negative coefficient for the quadratic term. According to these empirical results, tourism inflows exert a significant upward pressure on MSW generation up to a turning point where more tourism arrivals contribute to lowering MSW. This non-linear effect on MSW generation (Mihalic, 2000; Mensah, 2006; Han & Kim, 2010) may be the result of two causes. On the one hand, a scale effect since more tourism inflows implies more tourists per resident and, therefore, more MSW per resident. On the other hand, a counterbalancing technological effect may come from changes in the characteristics of tourism firms; thus, as tourism arrivals increase in a destination, the internationalization of tourism firms tend to increase and tourism supply tends to be dominated by chain hotels. This has several implications favourable for environmental protection in the destination. First of all, international and chain hotel managers tend to pay more attention to environmental issues (Mensah, 2006). Second of all, although some independent hotels place a high priority on the environment, it is hard to find environmental protection programs in small and independent hotels (Cummings, 1992; Erdogan & Baris, 2007). Third of all, international hotel chains can integrate successful environmental protection programs from other destinations in a more coherent framework (Chan & Wong, 2006).

Figure Nº 2.1 shows a simulation of the combined effect of tourism arrivals (TUR) and per capita income (GDPPC) on MSW generation .The figure shows both the non-linear effect of tourism arrivals on MSW generation and how the EKC depends on the level of tourist arrivals.

**FIGURE N° 2.1**

**SIMULATION OF THE EKC ON MSW FOR DIFFENT LEVELS OF TOURIST ARRIVALS**

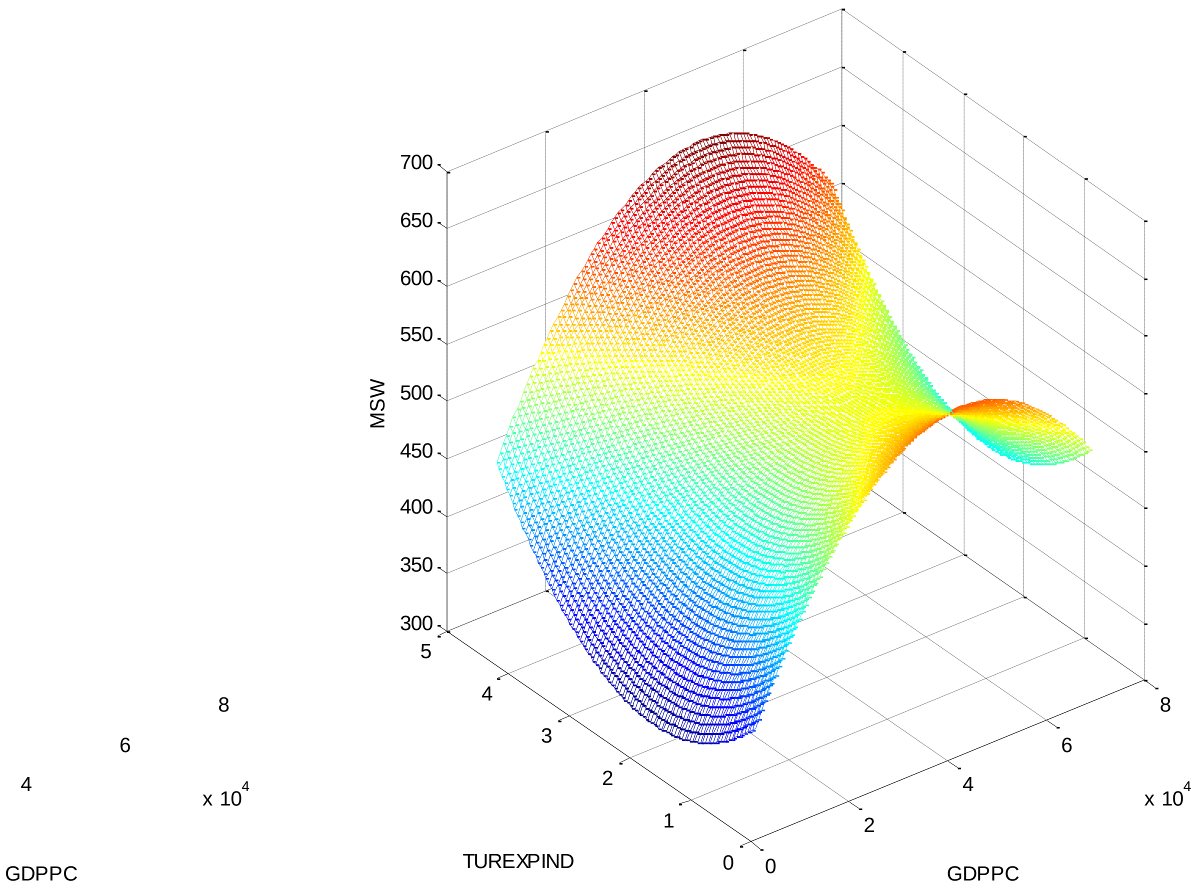


Regarding how the quality of tourism affects MSW generation, the expenditure per tourist index (TUREXPIND) shows a negative linear term and a positive quadratic term. This, as can be verified by the simulation displayed in Figure Nº 2.2, implies that higher expenditure per tourist reduces MSW generation up to a turning point beyond which MSW generation is increasing with TUREXPIND[12]. To explain this result, let us interpret the tourism expenditure per tourist as a proxy for per capita income of the floating population that constitute the tourists. Under this interpretation, the obtained result may be the outcome of counterbalancing drivers similar to those that explain the EKC. It could be argued, then, that higher expenditure per tourist implies higher material consumption per tourist and, therefore, larger amounts of MSW, but, at the same time, higher expenditure per tourist entails more sophisticated preferences and, therefore, a greener demand that stimulates the adoption of green management by tourism suppliers. It is a matter of further research as to why the interaction of these drivers gives place to a "U", instead of an inverted "U" relationship between TUREXPIND and MSW.

[12] To see this, in Figure Nº 2.2, consider the relationship between TUREXPIND and MSW for a given constant GDPPC.

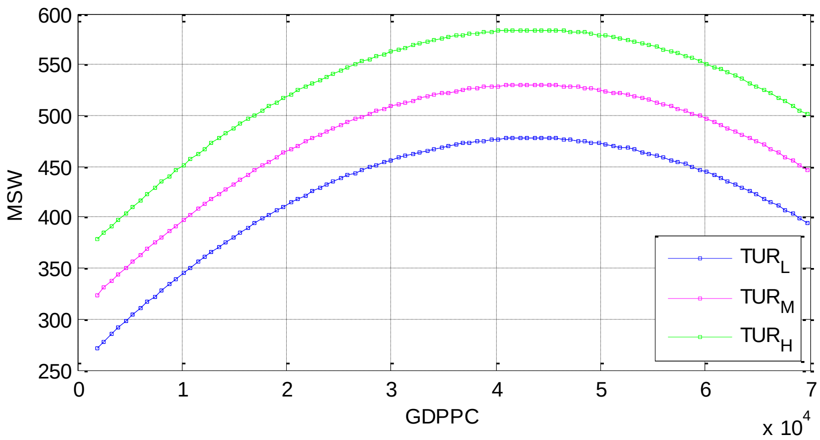
**FIGURE N° 2.2**

**SIMULATION OF THE EKC ON MSW FOR DIFFENT LEVELS OF TOURIST EXPENDITURE INDEX**




Finally, the empirical results show how relevant is the weight of tourism in total economic activity for the generation of MSW. This is done by incorporating a dummy variable (DX) in Model 04 that captures the differences in MSW generation between three groups differentiated by the size of tourism expenditure over GDP: lowest weight ($TUR_L$), intermediate weight ($TUR_M$) and highest weight ($TUR_H$). Figure Nº 2.3 shows how the EKC depends on the degree of tourism specialization. The figure reveals that for average values of the tourist variables, a greater weight of tourism on total economic activity leads to a greater intercept (greater generation of MSW). This reflects the fact that tourism tends to produce more MSW than other productive activities, such us industrial production, agriculture or transport services, whose main polluting emissions are of a different kind[13]. (Magrinho et al., 2006; Beigl et al., 2008; Papachristou et al., 2009; Mateu-Sbert et al. 2013).

**FIGURE N° 2.3**
**SIMULATION OF THE EKC ON MSW FOR DIFFENT DEGREES OF TOURIST SPECIALIZATION**




Model Nº 04 also allows us to see that the effect on MSW generation of the volume and quality of tourism may differ depending on the degree of tourism specialization. Thus, the simulation displayed in Figure Nº 2.4 reveals that for $TUR_H$ the turning point in the relationship between tourism arrivals and MSW generation is located at relatively low levels of the former variable, whereas this relationship is quasi-linearly increasing for the other two groups. As to the effect of the quality of tourism (TUREXPIND) on MSW, we only find differences between $TUR_L$ compared to $TUR_H$ and $TUR_M$ taken together. In this comparison it is now the group with low specialization in tourism that has the lowest turning point (see Figure Nº 2.5).

[13] The figure simulates the MSW generation among different values of GDPPC using the estimates of Model 4. To calculate the impact of the control and tourism variables in the model, we use average values.

**FIGURE N° 2.4**

**SIMULATION OF THE IMPACT OF TOURIST ARRIVALS ON MSW FOR DIFFENT SPETIALIZATION LEVELS**

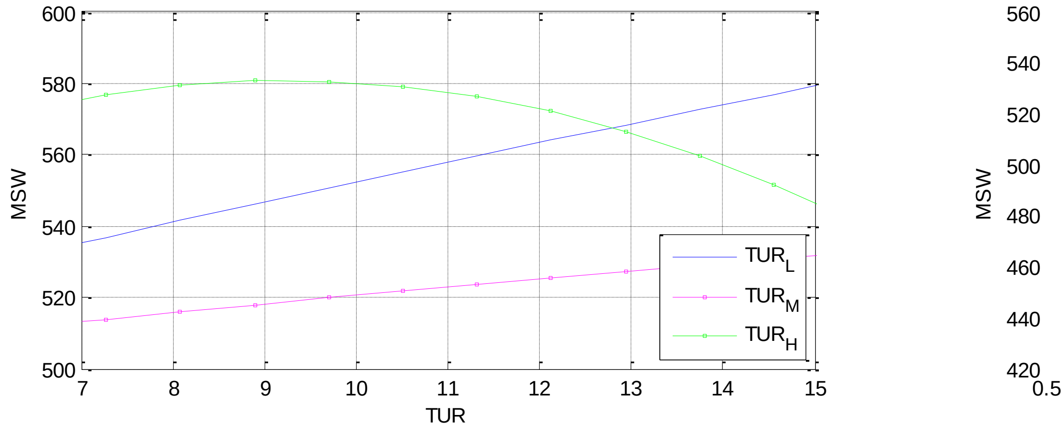
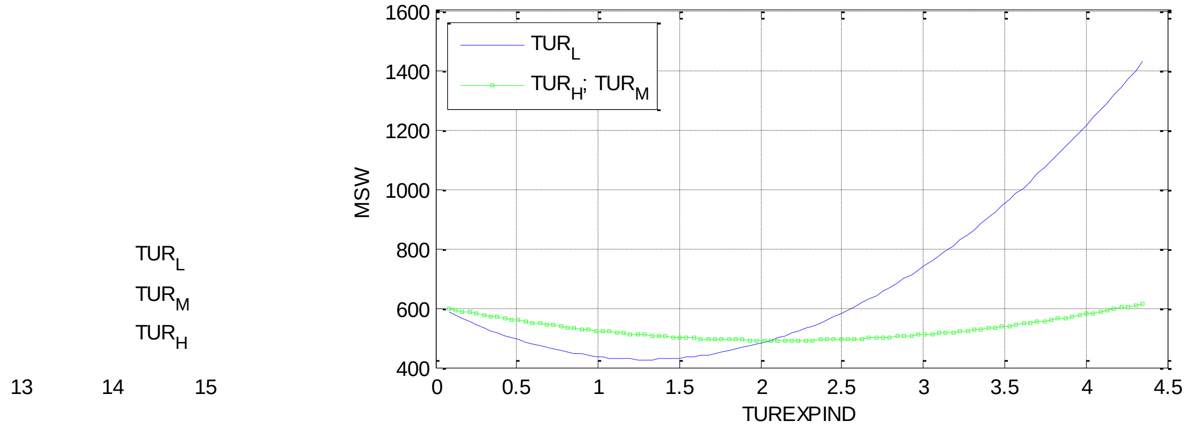



**FIGURE N° 2.5**

**SIMULATION OF THE IMPACT OF TOURIST EXPENDITURE INDEX ON MSW FOR DIFFENT SPETIALIZATION LEVELS**[14]




[14] As it is possible to see in Table N° 2.3, the coefficients of the dummy for high specialization were not statistical significant which means that the behavior of this group is equal to the one used as reference group. Therefore, the graph only shows the comparison between two different behaviors and does not consider the reference group.

## 2.5 CONCLUSIONS

Economic prosperity has been coupled with increasing consumption levels, the use of disposable products and excessive packaging. The resulting increase in MSW generation has lead to landfill collapses and negative impacts over environmental quality (Ku et al., 2009; Nicolli et al., 2010). A key question is whether this relationship is purely linear or, rather, economic growth carries the seed for mitigating the environmental impacts caused by MSW. Another key question addressed in this paper is how this MSW generation is affected by tourism. This a relevant sector that, on the one hand, is intensive in MSW generation but, on the other hand, could be a source of pressure for improvement in MSW generation and management due to the sensitivity of tourism destinations image on environmental damage.

This paper tries to answer these questions using the framework of the EKC hypothesis to analyze the relationship between MSW generation, per capita income and tourism. Results support the EKC hypothesis for a panel of 32 European countries during the period 1997-2010 and the existence of a significant effect of tourism on MSW generation. Thus, the inclusion of tourism variables affects key EKC's characteristics which lead us to think that omission of tourism variables has produced an overestimation of the impact of economic growth on MSW in previous research.

These estimations give the expected results in terms of the sign and the statistical significance of the coefficients related to per capita income (GDPPC), which leads to confirm the quadratic formulation of the Environmental Kuznets Curve. However, a high turning point is found. Furthermore, we also find that the elasticity of total MSW generation with respect to GDPPC is positive and lower than one, results that are consistent with previous research on MSW generation.

A novelty with respect to previous research is the consideration of non-linear effects of the tourism variables on MSW generation. Thus, we find that the volume of tourism has a positive coefficient for the linear term and a negative coefficient for the quadratic term. Therefore, tourism inflows exert a significant upward pressure on MSW generation up to a turning point where more tourism arrivals contribute to lowering MSW. This non-linear effect on MSW generation may be the result of two causes. On the one hand, a scale effect since more tourism inflows implies more tourists per resident and, therefore, more MSW per resident. On the other hand, a counterbalancing technological effect that may be the result of changes in the characteristics of tourism firms that comes along with the increase in tourism inflows in a destination.

Regarding to the relationship between tourism quality and MSW generation, the expenditure per tourist index (TUREXPIND) shows a negative linear term and a positive quadratic term. This implies that higher expenditure per tourist reduces MSW generation up to a turning point beyond which MSW generation is increasing with higher quality. This result may be, again, the outcome of counterbalancing drivers where higher expenditure per tourist leads to higher material consumption per tourist and, therefore, larger amounts of MSW but it also entails more sophisticated preferences and, therefore, a greener demand that stimulates the adoption of green management by tourism suppliers. Further research is needed to understand why the interaction of these drivers gives place to a “U”, instead of an inverted “U” relationship.

Finally, the empirical results show the relevance of the weight of tourism in total economic activity for the generation of MSW. The econometric evidence reveals that for average values of the tourist variables, a greater weight of tourism on total economic activity leads to a greater intercept (greater generation of MSW) in the relationship between per capita income and EKC. This reflects the fact that tourism tends to produce more MSW than other productive activities. Moreover, the effect on MSW generation of the volume and quality of tourism may differ depending on the degree of tourism specialization. Thus, for highly specialized countries, the turning point in the relationship between tourism arrivals and MSW generation is located at relatively low levels of the former variable, whereas this relationship is quasi-linearly increasing for the other countries. As to the effect of the quality of tourism on MSW, we find differences between those countries with the lowest level of tourism specialization compared to the rest of the countries, where those with low specialization show the lowest turning point.

In sum, to face the challenges that MSW generation impose over the tourist destinations, it is not only necessary to establish technological solutions to deal with MSW, but to generate a system that could align the incentives of the main stakeholders (Rotich, 2006). This explains why the creation of a MSW management system is still a complicated task (Shekdar, 2009; Magrinho, 2006) that needs, as a first step, to identify the main determinants of MSW. This research contributes to this aim by identifying the effect of tourism volume, tourism quality and tourism specialization on MSW generation. Future research should look forward to understanding the channels and dynamics through which these relationships take place.

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# 2.7 APPENDIXES

# APPENDIX N° 2.1

## LITERATURE SURVEY ON WASTE-RELATED EKC STUDIES

| Authors | Geographical Focus | Waste Typology | EKC Evidence |
|---|---|---|---|
| Abrate and Ferraris (2010) | Italy | Municipal solid waste | Yes |
| Anderson et al. (2007) | EU10 and EU15 | Waste generation | No |
| Beede and Bloom (1995) | 36 countries | Solid waste | No |
| Berrens et al. (1995) | USA | Hazardous waste | Yes |
| Cole et al. (1997) | OECD | Municipal waste | No |
| Concu (2000) | Italy | Municipal waste | Yes |
| Fischer-Kowalski & Amann (2001) | Five industrial countries | Domestic processed output | Yes (relative) |
| Gawande et al. (2000) | USA | Hazardous waste | Yes |
| Huang et al. (2012) | China | Domestic solid waste | Yes |
| Johnstone and & Labonne (2004) | OECD | Municipal solid waste | No |
| Karousakis (2006) | OECD | Municipal waste | No |
| Mazzanti & Zoboli (2008) | EU | Municipal waste | Yes (relative) |
| Mazzanti & Zoboli (2009) | EU | Municipal waste | Yes |
| Mazzanti et al. (2006) | Italy | Municipal solid waste | Yes |
| Mazzanti et al. (2008) | Italy | Municipal waste | Yes |
| Mazzanti et al. (2009) | Italy | Municipal waste | No |
| Mazzanti et al. (2009b) | Italy | Municipal waste | No |
| Raymond (2004) | International Data | Waste indicator | Yes |
| Seppala et al. (2001) | Five industrial countries | Direct material flows | No |
| Wang et al. (1998) | USA | Hazardous waste | Yes |
| Ichinose et al. (2011) | Japan | Household waste, business waste and landfill waste | Yes |

Source: Mazzanti & Zoboli (2009); Mazzanti et al. (2009); Ichinose et al. (2011) and own elaboration.

# CHAPTER 3: "MUNICIPAL SOLID WASTE MANAGEMENT CHALLENGES IN MATURE TOURIST DESTINATIONS – MALLORCA CASE STUDY"

# MUNICIPAL SOLID WASTE MANAGEMENT CHALLENGES IN MATURE TOURIST DESTINATIONS – MALLORCA CASE STUDY


## ABSTRACT

Since the European Commission placed the waste hierarchy on the agenda, many alternatives have been tested in different regions in order to improve environmental practices on municipal solid waste (MSW) management; however, little attention has been paid in the academic literature to mature tourism destinations. The interaction between tourism, MSW and sustainability should be considered in order to improve the performance of MSW management (MSWM) strategies.

This paper analyzes the influence of tourism on the MSWM system through the development of the case study of Mallorca, an internationally renowned summer seaside destination. The characteristics of this tourism destination such as seasonality, land scarcity and social support set interesting challenges to the sustainability of the system. The analysis of Mallorca's experience shows that land endowment strongly influences the choice of treatment technologies in tourism destinations. Furthermore, tourism seasonality significantly affects the management costs of those systems based on energy recovery technologies. Finally, MSWM policy still needs to adapt the tariff system to generate better economic incentives to promote waste minimization and recycling.


**KEYWORDS:** Mallorca, Sustainable Tourism, Waste Management, Mature Tourist Destination

## 3.1 INTRODUCTION

Municipal solid waste (MSW) generation is a natural consequence of human activities that influences ecosystem services (Rodríguez, 2002; Mor et al., 2006; Shekdar, 2009). Population and economic growth combined with changes in community living standards have increased the rate of MSW production in both absolute and per capita values. This has increased pressure on public authorities to develop accurate municipal solid waste management (MSWM) policies and systems to deal with this environmental problem (Foo, 1997; Marchand, 1998; Pokhrel & Viraraghavan, 2005; Magrinho, 2006; Manga et al., 2008; Shekdar, 2009; Al-Khatib et al., 2010).

Nowadays, concern about inappropriate management has led to global efforts in order to reorient MSWM systems towards sustainability (Shekdar, 2009). The concept of sustainability refers to the need to maintain these negative impacts within certain limits and, in this task, waste management plays an important role (Rodríguez, 2002). The growing MSW flows increase pressure on planners to find an environmentally friendly system that can deal with this problem given the limited resources for its funding and the need for social acceptability. To achieve these goals, it is expected that local authorities formulate a sustainable MSWM system that not only establishes technological solutions for MSW treatment, but also allows aligning the incentives of the main stakeholders (Rotich, 2006).

Many previous case studies in the academic literature concerning MSWM practices have attempted to assess several of their aspects (e.g. generation, characterization, treatment technologies, disposal, etc.) in different regions around the world[15]. These studies have created a source of state-of-the-art in MSWM by highlighting the important strengths and weaknesses of each system. However, most of these case studies focus on large cities and just few of them analyze the particular characteristics of MSWM in tourism destinations

[15] For the detailed list of countries, see APPENDIX Nº 3.1.

(Andreadakis et al., 2000; Berkun et al., 2005; Bel, 2006; Mateu-Sbert et al., 2013). This is, in our opinion, an important shortcoming since tourism is a growing sector worldwide that is intensive in MSW generation, and, as we try to show in this paper, specific challenges for MSWM are encountered in those regions specialized in tourism.

Regarding the relationship between tourism and MSW generation, the results in other sections of this thesis (see Chapter 2 and Chapter 4) show that the characteristics of tourism activities (volume, quality of tourism and specialization degree in tourism) have a significant influence on the volume of MSW. One special feature of tourism destinations is that the services provided in them are consumed by mobile customers (tourists) who visit the destination (Song, 2012); therefore, the development of tourism destinations has a direct relationship with waste generation. However, the way in which the characteristics of the sector affect MSWM has not been fully analyzed in the academic literature (Andreadakis et al., 2000; Berkun et al., 2005; Magrinho et al., 2006; Papachristou et al. 2009; Mateu-Sbert et al., 2013).

This paper analyzes the main characteristics, problems and challenges of MSWM in Mallorca (Balearic Islands), which is considered in the literature as a typical example of a second-generation mass tourist resort (Knowles & Curtis, 1999; Aguiló et al. 2005). The Balearic Islands are located in the Mediterranean Sea about 90 km east of the Spanish mainland. Nowadays, they are one of the most important tourism destinations in Spain and in the world (Urtasuna & Gutierrez, 2006). The economic system is based fundamentally on tourism with a high concentration of tourists during the peak season. This region also has the highest average amount of MSW per capita in Spain[16] (771.55 kg./resident/year). In this region, Mallorca is the main island and has an MSW generation rate of 585.78 kg./resident/year[17]. The highest generation rate of the island takes place on the coast[18], which not only tends to be the most densely populated, but also where most of the hotels are located. Furthermore, the coastal region has the lowest recovery rates of the island[19].

[16] Data for 2011. For further details, see APPENDIX Nº 3.2.
[17] Data for 2010.
[18] Data for 2010. Source: Equip tècnic d'Agenda Local 21, Departament de Medi Ambient, Consell de Mallorca.
[19] Data for 2010. Source: Equip tècnic d'Agenda Local 21, Departament de Medi Ambient, Consell de Mallorca.

Clearly, Mallorca's tourism development, which leads it to receive approximately 10 tourists per resident [20] per year, has had an impact on waste dynamics and, therefore, on the development of the MSWM system. Thus, evidence suggests that tourism plays an important role in the design of suitable policies and strategies in MSWM.

The remainder of this paper is organized as follows. Section 3.2 describes the main factors to take into account for an integrated MSWM system and sets the structure under which the analysis of the destination is carried out. In Section 3.3, the legal and institutional framework of Mallorca's MSWM system is explained. Section 3.4 describes the MSWM system in Mallorca and discusses the main technical characteristics, how it is financially supported and the major distinctiveness of its social management. The description of the relationship between tourism specialization and MSWM systems are the subject matter of Section 3.5 and, finally, Section 3.6 shows the central conclusions of the research.

## 3.2 INTEGRATED APPROACH FOR SUSTAINABLE MUNICIPAL SOLID WASTE MANAGEMENT

Nowadays, the existence of a wide variety of processes and technologies for MSW treatment has generated alternative structures and solutions for MSW disposal. However, even with such broad technological options, the optimal solution for MSW treatment has not yet been fully established (Magrinho, 2006).

Nevertheless, there is consensus about the basic principles of waste management established by the European Commission: (i) source reduction, (ii) reuse/recycling, (iii) recovery and (iv) disposal (European Commission, 1994; Lee & Sun Paik, 2011). As it is possible to note, an efficient MSWM system should aim to reduce the amount of MSW generation as its main objective, with ensuring the most efficient reuse of resources (once MSW has been generated) as a secondary goal.

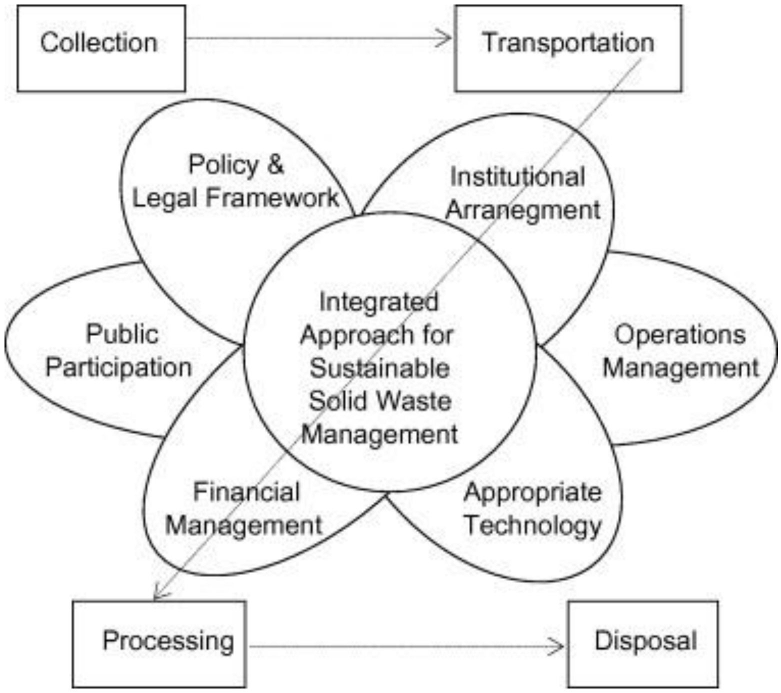
[20] See APPENDIX Nº 3.3.

In many countries, MSWM has become a complex task for public authorities not only because of the growing volume of waste and its variety (Sawell et al., 1996; Tınmaz & Demir, 2006) but also because of the increasing resources needed to operate the system (as cities grow, MSWM becomes increasingly complex [21]) and growing public concern about environmental impacts. Over recent years, many researchers have realized that in order to achieve efficient MSWM, it is necessary to design an integrated system rather than selecting individual component subsystems that may not work well together (Bovea et al., 2010; Fobila et al., 2008; Henry et al., 2006; Joos et al., 1999; Ljunggren, 1996; Rotich, 2006; Shekdar et al., 1991; Tinmaz, 2002; Wilson et al., 2006; Zhang et al., 2010). This integrated system requests from public authorities a rational planning approach that involves an integrated analysis of generation, collection, transportation, processing and disposal in order to achieve sustainability in this system (Dennison et al., 1996; Rotich, 2006; Shekdar, 2009). However, the goal of a sustainable MSWM system is not only related to the choice of an appropriate technology to handle MSW treatment and disposal (Henry et al., 2006). A sustainable MSWM system may deal with other factors such as socio-economic conditions, environmental impacts, social support and institutional coordination at different government levels (see Figure Nº 3.1).

[21] See Omuta (1987).

**FIGURE N° 3.1**

**INTEGRATED SUSTAINABLE MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM**




Source: Shekdar, 2009

The interrelationships among these factors are usually complex (Al-Khatib et al., 2010). Given these characteristics, there is no unique parameter with which to assess the effectiveness of the system; therefore, the performance of the MSWM system should consider different measures in each part of the process (collection, transportation, processing and disposal) in order to assess its performance and sustainability.

## 3.3 LEGAL FRAMEWORK AND INSTITUTIONAL ARRANGEMENTS IN MALLORCA

MSWM is becoming a complex problem for major cities where the government and local authorities are responsible for the system from the initial collection point to the final processing of MSW. During the past decade, many efforts have been made in Spain to improve MSWM with different laws, directives and plans that aimed to contribute to the goals of a sustainable economy[22]. Mallorca, as one of the main tourism destinations of the country, is no exception; thus, regional and local administrations set their main goals in terms of the handling, treatment and disposal of MSW on the island according to superior government levels.

In 1990, the Balearic Government published the Urban Solid Waste Management Master Plan (PDRSU[23]) by the Decree 87/1990. Its approval meant the adoption of a different approach to MSWM in which minimization of MSW generation, reuse and recycling was enhanced. The PDRSU established that the MSW generated in Mallorca must be treated by an energy recovery system (incineration). Moreover, the Decree sets that municipalities [24] are responsible for MSW collection and transport.

Some years later, in 2000, a new tool for the development and management of the territorial policy in Mallorca was published, namely the Urban Solid Waste Management Plan (PDSGRUM[25]). This plan, published by the Decree 21/2000, adapted the MSWM system to the recent legal framework established by the Spanish central government (Law 11/97 and Law 10/98). The PDSGRUM included a new set of treatment alternatives such as composting or anaerobic digestion for organic material and the selective classification of materials (recycling) in adequate facilities. In 2006, the PDSGRUM was revised in order to reach the long-term zero discharge goal in Mallorca. Thus, public authorities in Mallorca aimed to

[22] For more details about the European and Spanish legislation, see APPENDIX Nº 3.4.
[23] Plan Director de Residuos Sólidos Urbanos.
[24] Ayuntamientos.
[25] Plan Director Sectorial de Gestión de Residuos Urbanos de Mallorca.

reduce to zero the amount of waste discharged into landfills. The 'zero discharge' model fostered the recovery of all waste and established that MSW that could not be properly recycled should be incinerated.

It is important to note that a sustainable MSWM system not only needs a legal framework that sets the goals, it is also important to formulate the responsibilities, activities and administrative tools of each of the institutions involved in the system to let them work in the most efficient way (Shekdar, 2009; Al-Khatib et al., 2010). The legal framework in the Balearic Islands sets the main responsibilities between the different administrations:

- Municipalities are considered to be the primary managers and responsible for municipal waste management (PDSGRUM, 2006); they are responsible for the collection and disposal of MSW into the transfer stations or directly to treatment facilities (located in the area called “Son Reus”).

- The Island Council (Consell de Mallorca) has the responsibility of the treatment of MSW generated in municipalities. This means that the provincial government has administrative obligations with regard to tasks such as:
    - Transport of MSW disposal from transfer stations to treatment facilities
    - Choice of the best technological treatment method and its planning
    - Setting fees for MSW treatment
    - Inspection and control

- The Balearic Government is responsible for hazardous waste that requires specific treatment and for the revision and modification of the PDSGRUM.

Finally, it is important to note that traditionally in academic research on MSWM it was argued that the responsibility and management of MSWM facilities should exclusively rest with the public authorities (Sawell et al., 1996; Bel, 2006; Shekdar, 2009). However, in recent years several authors have suggested that in order to get efficient results, it is important to promote cooperation between the public and private sectors by allowing the former to participate in the operation[26] of the MSWM system (Bartone et al., 1991; Rotich, 2006). In Mallorca, the PDSGRUM allows an MSW collection to be operated either by the local authorities or by private companies. Furthermore, the Balearic Government approved the participation of the private sector through a concession for the operation of the facilities devoted to recovery, treatment and disposal; these operations are in charge of TIRME S.A. Through this public–private partnership, TIRME takes charge of the planning, management and supervision of all the technical operations of waste incineration facilities, while the Consell de Mallorca keeps the responsibilities of planning and supervising the whole MSWM system.

In sum, the main goal of the Mallorca waste management policy is to maximize the reduction of environmental impacts through the promotion of waste minimization, recovery and treatment in an accurate integrated system. The legislation attempts to promote strategic environmental management not only by setting the goals of the system but also by providing a scheme of incentives, which are explained in the following section.

## 3.4 MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM IN MALLORCA

In this section, we describe how Mallorca's integrated MSWM system operates in the stages of collection, transfer, processing and treatment. Subsequently, we analyze how this integrated operation faces the challenge of financial sustainability and, finally, we examine how this system, both operationally and financially, is perceived by the stakeholders of the system in order to reach social sustainability.

[26] Planning and control activities should remain with the public authorities.

### 3.4.1 TECHNOLOGICAL AND OPERATIONAL MANAGEMENT OF THE MSWM SYSTEM

The municipal solid waste collection subsystem is a pivotal component of all waste management schemes around the world (Oluwande, 1984; Dennison et al., 1996; Rotich, 2006; Shekdar, 2009). Generally, MSW collection in major cities is carried out as a two-tier system that involves primary and secondary collection[27] (Zhang, 2010). This is exactly the main MSWM system established in Mallorca, which requires citizens and companies to separate MSW into five fractions. In this way, local authorities (which are responsible for this activity) try to recover the maximum amount of valuable material contained in MSW before treatment. As waste classification cannot be fully controlled by public authorities due to the high costs of supervision, it is subject to the generator's willingness to collaborate with the program[28] (Bach et al., 2004; Fobila et al., 2008). Furthermore, this cooperative approach to MSW collection raises a problem of information since public authorities (municipalities) do not know the volume and composition of MSW by different kinds of generators. Reliable information on both the quantity and the composition of MSW is of considerable importance in the planning of waste services and infrastructure (Dennison et al., 1996; Rodriguez, 2002; Mateu-Sbert et al., 2013), even more in a framework of shifting from landfill-based to resource-based waste management systems (as in Mallorca) since increasing recycling and recovery rates are becoming more complex tasks (Burnley, 2007).

For primary collection in Mallorca, there are two types of methods: house-to-house (curbside) collection and communal collection systems. The first method has been successfully managed in small municipalities on the island, which have the highest rates of recovery (ENT Environment and Management, 2011). However, given the high cost of the first method, larger municipalities rely on communal collection systems, which involve the location of

[27] Primary collection involves the storage and transportation of the waste (sorted and non-sorted) from the generator's location to a local collection point, while secondary collection involves the storage and transportation of waste from the local collection point to the treatment facilities. In this kind of system, waste sorting by generators only takes place during primary collection.

[28] However, in Taiwan, for example, the government follows mandatory waste recycling with the possibility of fines for those residents who throw out recyclable waste with general waste (Li-The et al., 2006).

metal containers (skips) at designated sites (ENT Environment and Management, 2011) since this reduces the costs of collection by affecting the schedule of transportation vehicles according to waste generation (Tınmaz & Demir, 2006).

In Mallorca, the use of a cooperative approach to MSW collection combined with curbside and communal collection systems has led to an increase in the volume of sorted MSW. Table Nº 3.1 shows the evolution of recovered materials in recent years.

**TABLE Nº 3.1**

**RECOVERED MATERIALS IN MALLORCA**

**(In Tons)**

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|
| LIGHT PACKAGING | 3,395 | 4,376 | 5,958 | 7,639 | 8,987 | 9,953 | 10,676 |
| ORGANIC | 1,813 | 1,788 | 3,589 | 5,641 | 6,249 | 9,296 | 11,367 |
| PAPER | 8,477 | 9,473 | 10,573 | 11,381 | 11,827 | 11,654 | 11,430 |
| GLASS | 10,486 | 10,877 | 12,178 | 13,743 | 14,256 | 13,982 | 13,633 |
| **TOTAL** | **24,170** | **26,515** | **32,298** | **38,405** | **41,319** | **44,885** | **47,106** |
| ***RECOVERY RATE*** | ***5.0%*** | ***5.4%*** | ***5.7%*** | ***6.5%*** | ***7.4%*** | ***8.5%*** | ***9.3%*** |

Source: Own elaboration based on TIRME information.

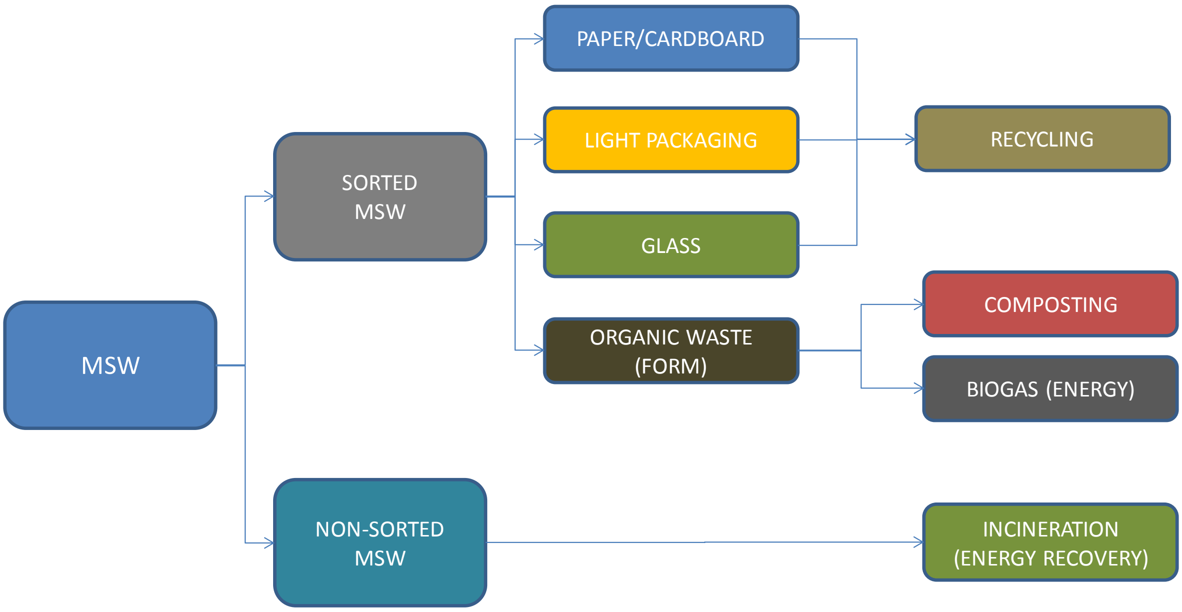
Regarding to MSW transport, Mallorca's MSWM system uses a set of transfer stations to increase efficiency. The main importance of transfer stations is not only reducing the cost for municipalities in Mallorca but also reducing the environmental impacts. Once in the transfer station, MSW is unloaded in hermetically closed containers and compacted. Transfer stations incorporate environmental considerations: there is no manual handling of MSW and no contact with the external environment once it is treated inside the station. Because of their financial[29] and environmental[30] advantages, transfer stations could be considered to be a good

[29] By combining the loads of several individual waste collection trucks into a single shipment, communities can save money on the operating costs of transporting the waste to a distant treatment facility.
[30] Transfer stations let solid waste managers separate recyclables and ensure that no hazardous waste or other undesirable materials enter the waste stream.

alternative in mature tourism destinations compared with daily transport from municipalities to treatment facilities. Waste containers, once full in transfer stations, are then transferred to treatment facilities. Figure Nº 3.2 shows graphically how MSW treatment is organized in Mallorca.

**FIGURE Nº 3.2**

**WASTE TREATMENT IN MALLORCA**




Source: Own elaboration based on TIRME information.

Once the sorted materials have been collected and sent to the Son Reus treatment facility, recovery activities begin. The academic literature has noted that recycling facilities have economic, environmental and social advantages by reducing the quantities of waste to be landfilled (Tınmaz & Demir, 2006). In Mallorca, recovery activities focus on two kinds of waste: non-organic and organic MSW.

On the one hand, even though recycling has been described as an efficient alternative to the use of raw materials[31], in the tourism sector the special characteristics of services are not intensive in the use of recovered materials; therefore, recycled resources should be sold instead of reused. Most of the valuable materials recovered from MSW in Mallorca are sold to ECOEMBES and ECOVIDRIO (packaging and glass) as part of the SIG[32] system promoted by the national government. On the other hand, the resources recovered from organic sources can be allocated to economic activities on the island since the organic material recovered is used in biological processing through bio-methanation facilities to generate biogas (through anaerobic digesters), which is a source of renewable energy in Mallorca. Furthermore, other fraction of organic material is mixed with sewage sludge from municipal wastewater treatment facilities in order to generate compost[33], which is finally sold as a supplement for the agricultural industry and gardening activities.

Finally, given Mallorca's small geographic area and high cost of land, the need to reduce waste volume has led public authorities to choose MSW incineration (energy recovery) as the best technological alternative (compared with the landfill option) to handle non-recycled waste[34]. Some authors have argued that MSW incineration has numerous advantages (such as volume reduction) that many countries are taking into account in MSWM planning (Hjelmar, 1996; Sakai et al., 1996; Li et al., 2003; Vehlow, 2006; Slagstad & Brattebø, 2012).

Even though the original goal of the MSWM system in Mallorca was to close uncontrolled landfills and establish a unique treatment that could improve environmental outcomes, an energy recovery system has an additional advantage given that the island relies on non-renewable resources (coal) for energy generation[35]. Furthermore, in many tourism

[31] Some industrialized countries such as Germany, Sweden, Japan and the United States have already achieved remarkable results by comprehensively reusing resources from solid waste management (Yuan et al., 2006).
[32] Integrated Management System. For further details, see APPENDIX Nº 3.4.
[33] Composting is considered as "the controlled decomposition of organic matter through biological processes, resulting in nutrient-rich humus" (Narayana, 2009).
[34] The energy recovery option in Mallorca has led to closing most of the landfills on the island, keeping just those located in Son Reus and Calvia.
[35] It is important to highlight that the use of waste-to-energy technology in Mallorca was chosen to reduce the volume of waste rather than to change energy sources; therefore, the use of energy from waste should be considered a complementary advantage and not the main purpose of the system.

destinations as Mallorca, natural and environmental resources can be considered sources of comparative advantage (Mihalic, 2000). Therefore, an MSWM system that focuses on incineration facilities and avoids the use of landfills fosters the conservation of natural resources and thus it should be considered the best technological option (Hjelmar, 1996; Jin et al., 2006; Joos et al., 1999). This is despite incineration usually being constrained by high costs due to the complex technology required for large-scale burning and air pollution controls[36] (Shekdar, 2009).

In sum, Mallorca's MSWM system is based on an appropriate technology given its high cost of land and high dependence on coal for energy production. However, this system has to tackle two main problems that affect its operational performance: (i) the lack of information about the volume and composition of MSW by sources (generators) and (ii) the pronounced seasonality in MSW generation, linked to tourism (as it is considered in Section 3.5 of this paper) which leads to spare capacity in the low season.

## 3.4.2 FINANCIAL MANAGEMENT OF MSWM

Every region that seeks a sustainable MSWM system should not only cover aspects such as cleanliness, public health standards and environmental quality preservation but also financing sources should be clearly developed (Shekdar, 2009). Thus, the system must adequately balance revenues with capital investment needs and operational costs in order to achieve sustainability (Rodríguez, 2002). However, the academic literature highlights that financial management is a complex task and a major challenge for MSWM systems (Karam et al., 1990; Koushki et al., 2004; Mrayyan & Hamdi, 2006; Shekdar, 2009).

As explained above, the MSWM system of Mallorca divides treatments according to two sources: sorted (recycled and organic waste) and non-sorted MSW. The use of treatment facilities for sorted MSW involves a significant increase in costs as long as the classification

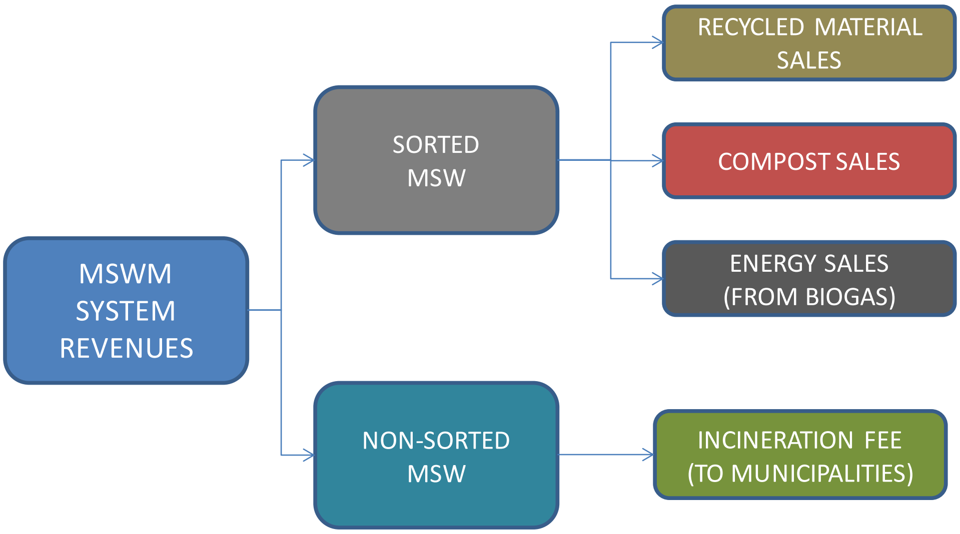
[36] For a deeper view of the environmental controls of MSW treatment, see APPENDIX Nº 3.5.

of sorted waste in the collection system is more specific (Rodríguez, 2002; Tınmaz & Demir, 2006). On the other hand, an energy recovery technology for non-sorted (mixed) MSW treatment requires not only large capital investment (Rodríguez, 2002) but also a supply of materials with high calorific value such as paper and cardboard to raise combustion levels (Murray, 1999). Thus, the financial sustainability of the system in Mallorca imposes a challenge for public authorities to structure the appropriate economic incentives since both systems, to some extent, compete for resources (higher recycling rates imply lower volumes for energy recovery).

Another characteristic of Mallorca's MSWM system is the presence of a public–private partnership in treatment provision. As some authors have argued, the involvement of the private sector in treatment provision has helped to highlight the huge costs involved in MSWM given that under public provision they are often under-priced or non-priced (Bartone, 1990; Rodriguez, 2002; Jin et al., 2006b). As a dynamic system with a high fixed capital structure, MSWM with private provision requires long-term contracts that guarantee the financial sustainability of the system (Connett & Connett, 1994). In Mallorca, the contract with TIRME seeks to update the fee in order to maintain the economic and financial balance of processing operations.

**FIGURE Nº 3.3**

**REVENUES FROM WASTE TREATMENT IN MALLORCA - TIRME**



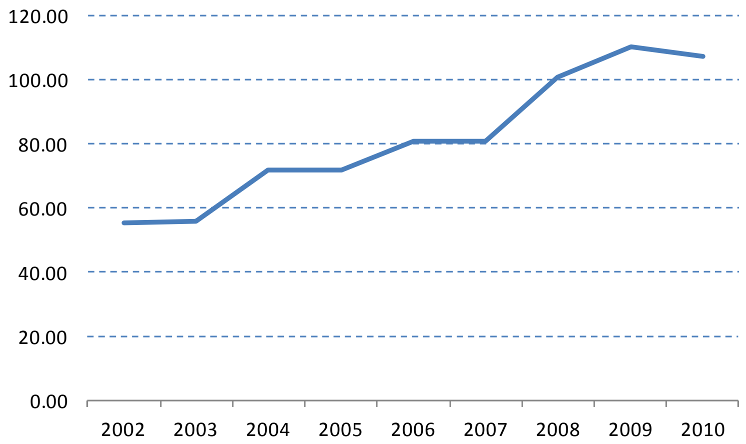

Source: Own elaboration based on TIRME information.

As Figure Nº 3.3 shows, the MSWM system in Mallorca is funded by two main sources: revenues generated by treatment facilities (derived from sorted material) and the incineration fee. The first source includes the revenues generated by sales to ECOVIDRIO and ECOEMBES, energy production from organic material and compost sales. The second source of revenue is the fee that was established in the contract with TIRME. According to this contract, all revenues derived from the first source (recovered materials) should be used to reduce the final fee that TIRME finally charges municipalities (incineration fee), which will obtain those resources by means of taxes or tariffs to residents and businesses. The evolution of this fee is shown in Figure Nº 3.4.

**FIGURE Nº 3.4**

**EVOLUTION OF THE INCINERATION FEE – TIRME**

**(IN CONSTANT EUROS OF 2002 / TONS)**




Source: Own elaboration based on TIRME information

Taking into account that MSWM involves more activities than just treatment, the economic analysis of public policy should also consider setting accurate financial incentives to reduce MSW generation and collection costs. If we adopt the polluter pays principle (PPP) as a guide for the MSWM system[37], then tariffs should be set according to the responsibility for cleaning it up (Chung & Lo, 2008; Narayana, 2009). As we can appreciate, the system shows a series of problems that should be considered challenges to the PPP in MSWM.

First, the incineration fee charged to municipalities is linked to the amount of MSW that goes to energy recovery facilities (non-sorted waste); thus, the cost of sorted treatment is included in the charges of non-sorted waste. This means an implicit subsidy on sorted MSW treatment in Mallorca. The crossed subsidy seeks to promote recycling and sorting (by providing a zero fee to municipalities). However, the main problem is the lack of information regarding the real cost of recycling and recovery to Mallorca and this leads to the erroneous idea that

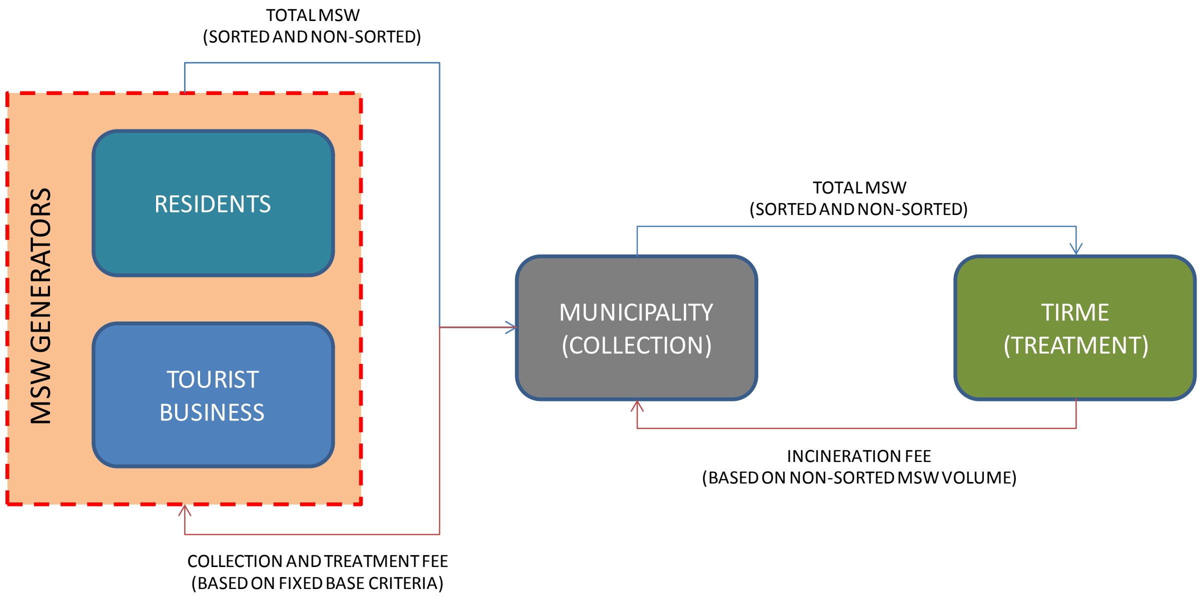
[37] As the European Commission and Spanish Law establishes.

sorting waste incurs no cost to society. Furthermore, the cross-subsidy generates a distortion in the financial structure since charges are not made according to the real cost of treatment[38].

Second, waste minimization responsibility nowadays relies on public authorities in Mallorca (municipalities). For this reason, the analysis of the fees that are finally paid by generators is important. The system established in Mallorca apparently seeks to apply the PPP by using a fee system charged according to the amount of non-sorted MSW generated by each municipality. However, for the PPP to be effectively implemented, it is important that the economic incentive could be transmitted to the generator of MSW, which are not municipalities but rather residents and businesses. Municipalities in Mallorca mainly base their tariffs on fixed payments per year; therefore, few incentives for waste reduction have been established for residents and tourism businesses (see Figure Nº 3.5).

**FIGURE Nº 3.5**

**MSWM TARIFF SYSTEM IN MALLORCA**




[38] The real cost of treatment varies according to the composition and volume of sorted waste. For details regarding financial treatment costs, see APPENDIX Nº 3.6.

The general rule of setting the tariff according to a fixed annual fee is broken for residents in some municipalities in Mallorca such as Andratx, Esporlas and Felanitx that use discounts on these fees to promote sorting and recycling[39]. In the case of tourism businesses, it is possible to find many possible bases for the tariffs such as area or a fixed amount per year; however, in the case of hotels, the base of the calculation is usually linked to the number of beds[40].

Two main options are implemented to charge the fee to hotels. On the one hand there are fixed fees such as the ones used for residents and, on the other hand, there are variable fees according to the number of beds. In the latter, there are two main alternatives: (i) charging according to the quality of the hotel (stars) or (ii) charging according to the services provided (with or without a restaurant). Thus, none of these methodologies charges according to the direct measures of MSW generation. Therefore, they do not provide incentives for better MSWM implemented by generators.

Third, the MSWM system does not give enough incentives to public authorities (municipalities) to establish different schemes that could be closer to the PPP. These may incorporate incentives for waste minimization by generators since the existing ones are much easier and cheaper to manage than charging according to MSW generation. Some studies have followed the PPP in Korea[41] (Lee & Sun Paik, 2011) and Taiwan[42] (Li-The et al., 2006), which use volume-based collection fees related to certificated garbage bags. However, even though these bag-based systems increase the separation of recyclables, they are only applied to residents and, as far as the authors know, there are no experiences concerning a volume-based collection methodology in tourism destinations.

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[39] For detailed information regarding municipal fees to residents, see APPENDIX Nº 3.7.

[40] For further details regarding municipal fees to hotels, see APPENDIX Nº 3.8.

[41] The system was implemented in 1995 and it requires that every household must purchase certified plastic bags for mixed MSW disposal, while the disposal of separated recyclables is free of charge (cross-subsidization as in Mallorca).

[42] The volume-based collection fee system in Taiwan began in 2000. This system forces waste collection fees to be paid by citizens by purchasing an authorized garbage bag for the disposal of general waste. It also established penalties for those who manufacture pirated waste bags and included possible prison sentences.

### 3.4.3 PUBLIC PARTICIPATION AND SOCIAL MANAGEMENT

Europe is one of the trendiest regions in MSWM, and one of the main factors that contributed to fostering changes in it was the attitude of society towards environmental protection (Magrinho, 2006). Thus, another key driver of sustainability in MSWM systems is the involvement of all stakeholders in order to provide social acceptability (Bartone, 1990; Charuvichaipong & Sajor, 2006; Shekdar, 2009). This task includes waste generators, waste processors (both in the formal and in the informal sectors[43]) and private initiatives such as non-governmental and community-based organizations (Baud et al., 2001; Palczynski, 2002; Read & Wilson, 2003; Ahmed & Ali, 2004; Henry et al., 2006; Kassim & Ali, 2006; Wilson et al., 2006). Therefore, in order to improve the quality and efficiency of the system, successful waste management planning must be inclusive.

The amount of MSW generated and the efficiency of sorted collection in Mallorca relies on generators' incentives to collaborate with the MSWM system; therefore, not only economic but also social conditions will influence it. The academic literature notes that social aspects of MSWM such as the suitable understanding of the recycling system affect participation rates (Metin et al., 2003). In Mallorca, the PDSGRUM of 2000 and 2006 established the need to increase public awareness through environmental education programs to help improve citizens' habits towards environmentally friendly practices[44]. The main program is called *Mallorca Recicla* and it promotes the reduction, reuse, recycling and recovery of waste in all areas of the island society. The program was created by the coordination of the Consell de Mallorca, TIRME S.A. and the Deixalles Foundation (an institution linked to social and labour integration) and it is organized into four working groups that focus their efforts on different areas of society: (i) education[45]; (ii) business[46]; (iii) local authorities[47]; and (iv) citizenship[48].

[43] There are many cases in which the informal sector is involved in recycling activities, especially in developing countries.
[44] Practices such as putting waste out at prescribed times, separating recyclables and voluntarily minimizing consumer waste.
[45] Focused on all schools on the island.
[46] Providing tools to SMEs or large businesses in Mallorca.

Mallorca's social management seeks to encourage the participation of society as a whole by promoting training activities, appraisals and educational tasks that are free of charge. The main ways to reach citizens of Mallorca is by publishing material, presentations and diffusion in communications media (radio and TV shows, newspaper articles and online). As noted in APPENDIX Nº 3.9, the number of educational visits of the program has increased considerably since 2003 and it reached approximately 20,000 visits per year between 2004 and 2006; however, these visits reduced by 50% in 2010.

Despite the increase in the recovery rate (see Table Nº 3.1) fostered by public campaigns, the expected rise in MSW generation led public authorities to increase the energy recovery facility with the PDSGRUM in 2006. From a social point of view, this has also been an important task since there are some cases of resistance to incineration facilities in the US, Europe and Japan (Narayana, 2009). A survey in Mallorca showed that 67.7% of the population considered increasing energy recovery capacity a good alternative for the destination (Fernández, 2008). For those who considered it a bad alternative, there were two main reasons for their opposition: (i) the lack of the promotion of recycling activities as an alternative (34.6%) and (ii) the environmental impact of waste combustion (15.4%). It can be noted that social acceptability in Mallorca is linked directly to environmental concerns.

Another main challenge to the social acceptability of MSWM systems is related to the increasing difficulty securing locations for MSW treatment facilities, which is known as the NIMBY (Not-In-My-Back-Yard) syndrome (den Boer et al., 2010; Lee & Sun Paik, 2011). In Mallorca, this problem has been reduced by means of three elements: (i) urban planning before the PDSGRUM; (ii) the use of technical environmental studies to certify that the chosen areas were not highly sensitive to MSW treatment facilities; and (iii) the requirement of investment[49] to mitigate environmental impacts in areas where waste disposal treatment could be developed. Despite all these strategies aimed at promoting social acceptance by

[47] Support to improving municipalities' MSWM.
[48] Target groups are associations interested in learning about any topic related to MSW.
[49] Requested by the PDSGRUM.

minimizing the NIMBY problem, in destinations such as Mallorca with land scarcity, it is impossible to fully mitigate the problem.

Finally, it is important to note that in order to achieve the goals of a sustainable MSWM system, other stakeholders besides citizens should be involved. In Mallorca, hotels and tourism-related businesses have an important impact on MSW generation and sorting; however, these organizations seem to have less importance than citizens for MSW treatment strategies[50].

In sum, in order to increase the social support of the system, it is important to (i) follow the polluter pays principle; (ii) promote training and educational activities that increase public concern about waste minimization, MSW sorting and the appropriateness of the incineration option *vis à vis* other alternatives; and (iii) include all the relevant stakeholders, specifically those related to the tourism sector, in the strategic planning of MSWM.

## 3.5 TOURISM SPECIALIZATION AND MSWM

MSW generation and characterization is considered a by-product of an economic productive structure (Rodríguez, 2002; den Boer et al., 2010). It therefore follows that Mallorca's productive structure based on providing tourism services shapes the important characteristics of the island's MSWM system. This section is devoted to those challenges of Mallorca's MSWM system that are specifically related to tourism specialization.

An important point of reference in evaluating Mallorca's MSWM system is the status of MSWM systems in other tourism destinations. Greece (Papachristou et al., 2009) and Portugal (Magrinho et al., 2006) are two cases similar to Mallorca in terms of European Union (EU) membership, the economic importance of tourism and composition of visitors; therefore, the comparison with these countries seems to be suitable. MSWM in Greece and

[50] For further details, see TIRME (2011).

Portugal has not developed as well as that in many EU-15 countries. Landfills are still the predominant MSW disposal method, with approximately 92% of MSW disposed without prior treatment[51] in Greece, whereas in Portugal, 96% of mixed waste is disposed in landfills. These countries also have lower recovery rates than Mallorca (see Table Nº 3.1); however, in both countries, public policy aims to increase materials recovery through the implementation and extension of recycling programs with source separation in all large municipalities. These policies also attempt to give priority to the gradual phasing out of non-engineered and uncontrolled dumpsites and the remediation of major ones.

The case of Turkey is representative of tourism destinations outside the EU that compete with Mallorca in the tourism market. In Turkey, until the mid-1950s waste disposal was sent to open landfills or even dumped at the sea (Berkun et al., 2005). However, public policy from the beginning of the 1990s has encompassed a full range of MSWM concerns and set the criteria for the collection, transport and final disposal of MSW including operational rules for sanitary landfills and incinerators (Berkun et al., 2005). As in the case of Mallorca, Greece and Portugal, the recommended system deals with maximizing recycling and minimizing the landfilling of MSW; moreover, it involves separation at source, collection, sorting, recycling, composting and sanitary landfilling (Tınmaz, 2002). In Turkey, the responsibility of MSWM lies with the municipality, but the public provision is inefficient given the lack of organization and planning in the MSWM system (Tınmaz & Demir, 2006). As a result, several informal recycling activities have developed in the country. This is the opposite case of Mallorca, in which the structure of the system, which lies on private provision, gives few incentives to informal recyclers to enter the market[52].

From the analysis of international experiences, it is possible to say that small destinations tend to give landfills the lowest priority for MSW disposal due to their small geographic areas and high costs of land. On the other side, destinations with large land endowments such as Mexico

[51] Of this percentage, 40% is dumped in non-engineered sites, whereas the remaining 52% is disposed in sanitary landfills.

[52] As Ecoembes and Ecovidrio only buy from an identified customer such as TIRME, and given that the former cannot buy recycled materials according to the law, there is no incentive for informal agents to become a provider of recycled materials.

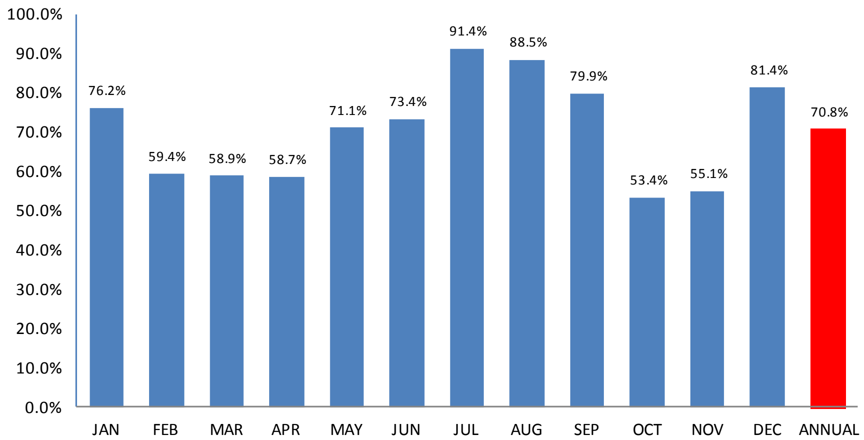
tend to rely on landfills (Bernache, 2003; Maldonado, 2006[53]) with major concerns about the implementation of sanitary landfill systems in order to minimize environmental pollution rather than shifting to other technological solutions (Shekdar, 2009). Moreover, as Sawell et al. (1996) noted, some of these countries (especially those with extensive land available) rely on landfills because waste material in a landfill can be considered to be a future energy resource through landfill gas recovery or waste mining.

MSWM systems based on energy recovery, however, face a major challenge in terms of financial sustainability when waste flows show seasonal behaviour (Canaleta & Ripoll, 2012). As Candela & Figini (2012) noted, one of the economic effects of seasonality is the definition of optimal infrastructure size, which is a crucial investment decision. Therefore, seasonality introduces additional MSWM costs since it leads to over-capacity in MSW treatment facilities (owing to the high fixed cost structure) during the low season. As shown in Figure Nº 3.6, this is exactly the situation that MSWM in Mallorca faces.

**FIGURE Nº 3.6**

**MONTHLY EVOLUTION OF USE - 2012[54]**

(% OF TOTAL CAPACITY)




Source: TIRME S.A.

[53] According to this author, MSW generation is approximately 365 kg,/per capita/year.

[54] This year, 2012, was selected as a reference because it is the latest available information and because this year showed typical behaviour in terms of waste generation and treatment compared with previous years.

Seasonality is typical in many mature tourism destinations where tourism arrivals increase in frequency in certain months of the year. In Mallorca, more than 80%[55] of annual tourist arrivals are concentrated between the months of May and October, a period that includes the months with the highest use of MSW treatment facilities. It is therefore reasonable to test the hypothesis of a link between tourism seasonality and seasonality in MSW generation, which is presented in the following paragraphs. To do this, both non-sorted and sorted waste were used as dependent variables in an econometric analysis for the period 2004–2010 (monthly data). The data needed to meet the objectives of the study came from two sources: (i) non-sorted and sorted MSW data compiled monthly by TIRME and (ii) tourism population in Mallorca provided by CAIB[56]. The variables are shown in Table Nº 3.2, which contains their definitions and an explanation.

**TABLE Nº 3.2**

**EXPLANATORY VARIABLES**

| VARIABLE | DESCRIPTION | SOURCE |
|---|---|---|
| TOURISTS | Number of tourists arriving in Mallorca | CAIB |
| SONREUS | Non-sorted MSW (in tons) treated in the Son Reus facility | TIRME |
| GLASS | Recycled glass treated in transfer Stations (in tons) | TIRME |
| PACK | Recycled light packaging treated in transfer Stations (in tons) | TIRME |
| PAPER_CB | Recycled paper and cardboard treated in transfer Stations (in tons) | TIRME |

[55] According to the CAIB database, 2011 peak season comprised 81.5% of total tourist arrivals while in 2012 this concentration represented 82.7%.

[56] Balearic Islands Autonomous Community.

Regarding the econometric process, the initial step was to obtain only the seasonal component of the series considering a multiplicative adjustment[57]. Therefore, the seasonal factor (sf) of each series is used in four models:

- MODEL 1: $SONREUS_{sf} = \beta_0 + \beta_1 TOURSIST_{sf}$
- MODEL 2: $GLASS_{sf} = \alpha_0 + \alpha_1 TOURSIST_{sf}$
- MODEL 3: $PACK_{sf} = \gamma_0 + \gamma_1 TOURSIST_{sf}$
- MODEL 4: $PAPER\_CB_{sf} = \delta_0 + \delta_1 TOURSIST_{sf}$

The results of the econometric analysis are shown in Table Nº 3.3. The estimated coefficients have the expected signs and are statistically significant; thus, the empirical findings show that there is a strong correlation between seasonality in MSW generation and seasonality in tourist arrivals for all categories (non-sorted and sorted MSW)[58].

**TABLE Nº 3.3**

**ECONOMETRIC RESULTS**

| **DEP. VAR.** / **INDEP. VAR.** | **MODEL 1 SONREUS_sf** | **MODEL 2 GLASS_sf** | **MODEL 3 PACK_sf** | **MODEL 4 PAPER_CB_sf** |
|---|---|---|---|---|
| INTERCEPT | 0.6999 * *(-111.93)* | 0.3202 * *(18.94)* | 0.7149 * *(82.23)* | 0.4832 * *(60.56)* |
| TOURIST_sf | 0.3001 * *(54.78)* | 0.6798 * *(45.89)* | 0.2845 * *(37.35)* | 0.5169 * *(18.6344)* |
| **$R^2$** | **0.97** | **0.96** | **0.94** | **0,99** |

**Note:** T-values in parentheses

* Significant at 1%

[57] In order to obtain the seasonal series, we used the Census X12 method in E-Views.

[58] For further details, see APPENDIX Nº 3.10.

According to these results, it is possible to argue that seasonality in tourism arrivals to Mallorca seems to cause seasonality in waste treatment in Son Reus. Given this characteristic of Mallorca's tourism development, the facilities needed for waste treatment face over-capacity during the low season[59].

Seasonality in MSW generation caused by a seasonal tourism pattern results in a financial cost that we estimate by using data provided by TIRME on treatment (energy recovery) costs. In the following lines, we present the details of the calculations performed and main assumptions to estimate the value of these additional costs. According to the data on total costs and variable costs per ton provided from TIRME, the total fixed costs of treatment lines 1 and 2 (L1 and L2, respectively) in 2012 were 18 million Euros, while the fixed costs of lines 3 and 4 (L3 and L4, respectively) were approximately 30.1 million Euros (see Table Nº 3.4).

**TABLE Nº 3.4**

**FIXED COSTS PER FACILITY**

| | **LINES 1 & 2** | |
|---|---|---|
| (1a) | Treated MSW (Tons) | 167,000 |
| (2a) | Variable Cost per ton (Euros) | 9.50 |
| (3a) = (1a) x (2a) | Total Variable Cost (Euros) | 1,586,500 |
| (4a) | Total Cost (Euros) | 19,674,932 |
| **(5a) = (4a) - (3a)** | **TOTAL FIXED COST (Euros)** | **18,088,432** |

| | **LINES 3 & 4** | |
|---|---|---|
| (1b) | Treated MSW (Tons) | 310,000 |
| (2b) | Variable Cost per ton (Euros) | 9.84 |
| (3b) = (1b) x (2b) | Total Variable Cost (Euros) | 3,050,400 |
| (4b) | Total Cost (Euros) | 33,126,580 |
| **(5b) = (4b) - (3b)** | **TOTAL FIXED COST (Euros)** | **30,076,180** |

Source: Own elaboration based on TIRME information.

[59] However, the case of Mallorca does not seem to be an isolated one. A similar problem was found in other tourism destinations such as Switzerland where not only seasonality but also a different political arrangement (since this country used a non-integrated MSWM system with different regions in charge of their own MSW treatment facilities) lead some regions with waste incinerators to face spare capacity (over-capacity), while in other areas large quantities of MSW end up untreated in landfill sites (Joos et al., 1999).

Thus, considering the total capacity of the facilities (723 thousand tons), it is estimated that on average each ton of capacity involves a fixed cost of 66.56 Euros (Table Nº 3.5).

**TABLE Nº 3.5**

**FIXED COSTS PER TON**

| | | |
|---|---|---|
| (6) = (5a) + (5b) | TOTAL FIXED COST (Euros) | 48,164,612 |
| (7) | TOTAL CAPACITY OF LINES (Tons) | 723,600 |
| **(8) = (6) / (7)** | **FIXED COST / TON (Euros)** | **66.56** |

Source: Own elaboration based on TIRME information.

Once the fixed cost per ton of installed capacity has been identified, the next step is to identify the capacity of the facilities that is effectively used during the year and the monthly evolution of the use of these facilities (see Figure Nº 3.6). The annual use of the facilities represents approximately 70.76% of total capacity or, put another way, the annual idle capacity represents 29.24% of total capacity. However, it is important to note from the graph above that not all installed capacity is used at the peak of the tourist season; thus, there is idle capacity in the months of highest use that must be deducted from annual idle capacity to calculate the idle capacity associated with seasonality. In 2012, the maximum use of the facilities was generated during July (91.35%), which means that the minimum value of idle capacity was 8.65%. Table Nº 3.6 shows the calculation of idle capacity associated exclusively with seasonality in MSW generation.

**TABLE Nº 3.6**

**ANNUAL IDLE CAPACITY GENERATED BY SEASONALITY**

| | | |
|---|---|---|
| (9) | ANNUAL IDLE CAPACITY (%) | 29.24% |
| (10) | MINIMUM IDLE CAPACITY (%) | 8.65% |
| (11) = (9)-(10) | IDLE CAPACITY GENERATED BY SEASONALITY (%) | 20.60% |
| **(12) = (7) x (11)** | **ANNUAL IDLE CAPACITY GENERATED BY SEASONALITY (Tons)** | **149,034** |

Source: Own elaboration based on TIRME information.

Finally, considering the fixed cost per ton of installed capacity and idle capacity resulting from seasonality in MSW generation, an amount of 9.9 million Euros per year is the estimated cost of over-capacity in treatment facilities associated with tourism seasonality. However, it is important to note that the previous analysis only considers costs associated with waste recovery treatment facilities. It does not consider other costs such as those related to over-capacity in transfer stations or transportation. Therefore, our calculations may underestimate the true cost of seasonality in MSWM.

Our analysis, so far, has shown that seasonality in MSW generation is mostly attributable to tourism activity and that it imposes high costs to the MSWM system. It remains a distributional problem of who should finance these costs. According to the PPP, most of these costs should be incurred by the tourism sector. However, the lack of information on MSW generation by generators makes it impossible to know the cross-subsidies between the tourism sector and other financial contributors to the MSWM system given the existing tariff system. This also makes it impossible to implement a tariff system based on the PPP. This, and the foreseeable social opposition by those generators whose tariffs would necessarily increase, has until now prevented this option being publicly debated.

A different proposal has been suggested to mitigate the seasonality in MSW treatment, namely "importing" MSW from outside the Balearic Islands during the low season. This option has increased environmental concerns, especially by environmentalist groups, some political parties and even the FEHM[60], which has stated that importing MSW could have negative impacts on the image of the destination and on the willingness of residents to recycle[61]. This experience shows that the need for social acceptance imposes a tight constraint on the financial management of MSW.

In sum, international experience shows that tourism destinations that have high opportunity costs of land use tend to rely on waste-to-energy technologies compared with landfills. However, in the case of destinations such as Mallorca, the existence of tourism seasonality affects waste management costs due to the existence of the high fixed capital structure of the system. In this situation, the polluter pays principle states that these additional costs should be incurred by generators, mostly in the tourism sector; however, in the case of Mallorca, the information needed to implement this principle is unavailable.

## 3.6 CONCLUSION

Research on MSWM has gained the attention of many fields in the scientific community, which has assessed MSWM systems in many regions to understand the critical environmental, economic and social problems deriving from it (Marchand, 1998). This paper presents an overview of the current MSWM system in Mallorca, which is considered one of the main mature tourist destinations. The main objective of this research is to highlight the main challenges, practices and alternative solutions to MSWM systems in these kinds of destinations, which have special features compared with traditional urban cities. Moreover, this paper provides the basis for further research on the development of suitable alternatives for sustainable MSWM in tourist destinations.

[60] Mallorca's hotels federation (Federación Hotelera de Mallorca).
[61] For further information, see http://www.diariodemallorca.es/medio-ambiente/2012/09/17/hoteleros-preocupados-importacion-residuos/794547.html.

MSWM is strongly influenced by political, legal, social, cultural, environmental and economic factors, whose interaction is usually complex (Al-Khatib et al., 2010). Given these characteristics, there is no unique parameter to assess the effectiveness of a suitable MSWM system; therefore, the performance of the system should consider many different aspects. The MSWM system in Mallorca showed a turning point in 1990 when public authorities decided to close 45 landfills on the island and shift to a system based on five transfer stations and a treatment system based on recycling facilities for sorted waste and an energy recovery system for non-sorted MSW. The MSWM established in Mallorca had as its main goal achieving so-called "zero waste dumping" in which waste is considered a valuable resource to be recovered.

One important characteristic of Mallorca's MSWM system is the presence of a public–private partnership in treatment provision. As some authors have argued, the involvement of the private sector in treatment provision has helped highlight the huge costs involved in MSWM given that under public provision they are often under-priced or non-priced (Bartone, 1990; Rodríguez, 2002; Jin et al., 2006b), which finally distorts the incentive structure.

The main goal of Mallorca's MSWM policy is to minimize environmental impacts by reducing MSW generation and setting MSW treatment through an accurate integrated system. For this task, waste recovery and recycling play a key role in the long-term strategy. Furthermore, given Mallorca's small geographic area and high cost of land, the need to reduce MSW volume has led public authorities to choose energy recovery treatment as the best technological alternative to handle non-recycled MSW. Energy recovery systems seem to be a suitable technological alternative for tourist economies such as Mallorca; however, some special characteristics of the MSWM system should be taken into account in order to assess the sustainability of the system.

First, in Mallorca, given the amount of MSW generated, its classification cannot be fully controlled by public authorities due to the high costs of supervision. The MSWM system is subject to the generator's willingness to collaborate with MSW sorting, and this raises a problem of information for municipalities, which have insufficient information about MSW volume and composition for different kinds of generators. It is also important to highlight that reliable data on the quantity and composition of MSW is crucial for MSW planning (Dennison et al., 1996; Rodriguez, 2002).

Second, regarding to recycling and energy recovery facilities, one disadvantage of the MSWM system in Mallorca is related to seasonality. This problem is typical in many tourist destinations where tourist arrivals are concentrated in certain months of the year. The economic effects of seasonality are related to optimal infrastructure size choices. In Mallorca, seasonality in tourist arrivals leads to over-capacity in MSW treatment facilities during the low season and (owing to the high fixed cost structure) this idle capacity must be afforded regardless of the amount of MSW generated, causing additional management costs for MSWM compared with the case of traditional cities.

Third, as the main objective of the MSWM system is to reduce MSW generation, the analysis of economic incentives showed that nowadays municipalities in Mallorca (which are the main authorities in charge of waste minimization) set a tariff system based on fixed payments, which does not generate enough incentives for residents and tourist businesses to reduce waste. Furthermore, the MSWM system does not seem to give enough incentives to municipalities to shift to different waste fees since current methodologies are much easier and cheaper to manage.

Finally, regarding to social acceptability, it is important to note that even when one of the main challenges of the MSW system is to increase information flow to residents in Mallorca, other stakeholders besides citizens should be involved. In a region such as Mallorca, hotels and tourist-related businesses have an important impact on MSW generation and sorting; however, these organizations seem to have less importance than citizens for MSW treatment strategies. Therefore, the leading role of public authorities should increase information flows towards increasing public concerns about MSWM goals (minimization and MSW sorting) for all relevant stakeholders in the strategic planning of MSWM.

In sum, waste minimization will continue to be one of the major challenges in tourism destinations such as Mallorca. The development of a strategic integrated MSWM plan to achieve waste minimization at the source in tourism economies should be a long-term exercise that involves suitable incentives to promote attitudinal changes in tourists, residents and businesses. Further research should focus on three main areas. First, as there are no surveys related to waste generation and composition by generators, the analysis of alternative information sources for municipalities is important since knowledge on the economic drivers of MSW generation by generator is needed to develop accurate public policies. Second, the analysis of incentives in tourist businesses is crucial for developing MSW minimization practices. Finally, the development of an alternative disposal fee system that generates economic incentives according to the PPP in tourist destinations would be beneficial.

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# 3.8 APPENDIXES

## APPENDIX Nº 3.1

## SURVEY OF MSWM CASE STUDIES IN ACADEMIC LITERATURE

- Europe
  - Austria (Bach et al., 2004)
  - England (Woodart et al., 2001; Burnley, 2007)
  - France (Defeuilley & Lupton, 1998)
  - Germany (Vehlow, 2006)
  - Greece (Andreadakis et al., 2000; Koufodimos and Samaras, 2002)
  - Ireland (Dennison et al. 1996)
  - Netherlands (van der Sloot, 1996)
  - Norway (Slagstad & Brattebø, 2012)
  - Poland (den Boer et al., 2010)
  - Southern Europe (Koufodimos & Samaras, 2002)
  - Spain (Bovea et al., 2010)
  - Sweden (Hartlén, 1996)
  - Switzerland (Joos et al., 1999).

- Asia and middle-east
  - China (Zhang et al.,2010; Yuan et al., 2006; Li et al., 2003; Chung & Lo, 2008)
  - Hong Kong (Chung & Poon, 1997)
  - India (Gupta et al., 1998; Shekdar, 2009)
  - Iran (Mahdavi Damghani & Savar, 2008)
  - Japan (Sakai, 1996; Tanaka, 1999; Yorimoto, 1990)
  - Jordania (Mrayyan & Hamdi, 2006)
  - Kuwait (Koushki et al., 2004)
  - Nepal (Pokhrel & Viraraghavan, 2005)
  - Palestina (Al-Khatib et al., 2010)
  - Phillipines (Marchand, 1998)
  - Singapore (Foo, 1997)
  - South Korea (Lee & Sun, 2011)
  - Taiwan (Li-The et al, 2006)

    - Thailand (Charuvichaipong & Sajor, 2006; Danteravanich & Siriwong, 1998)
    - Turkey (Metin et al., 2003; Berkun et al., 2005; Tınmaz & Demir, 2006)

- America
    - Argentina (Bartone et a., 1991)
    - Brasil (Bartone et a., 1991)
    - Canada (Sawell et al, 2006)
    - Chile (Bartone et a., 1991)
    - Mexico (Maldonado, 2006; Bernache, 2003; Buenrostro et al., 2001)
    - Venezuela (Bartone et a., 1991).

- Africa
    - Cameroon (Manga et al., 2008)
    - Ghana (Fobila et al. 2008)
    - Kenya (Rotich et al., 2006)
    - Nigeria (Omuta, 1987)
    - Tanzania (Kassim & Ali, 2006)

## APPENDIX Nº 3.2

## AVERAGE PER CAPITA MSW GENERATION - 2011

| | Population 2011 (Persons) | MSW 2011 (Tons) | MSW per Capita (Kg.) |
|---|---|---|---|
| ANDALUCÍA | 8,371,270 | 4,572,709 | 546.24 |
| ARAGÓN | 1,344,509 | 609,253 | 453.14 |
| ASTURIAS, PRINCIPADO DE | 1,075,183 | 57,739 | 53.70 |
| BALEARS, ILLES | 1,100,503 | 849,096 | 771.55 |
| CANARIAS | 2,082,655 | 1,388,895 | 666.89 |
| CANTABRIA | 592,542 | 341,963 | 577.11 |
| CASTILLA Y LEÓN | 2,540,188 | 1,248,937 | 491.67 |
| CASTILLA-LA MANCHA | 2,106,331 | 1,118,982 | 531.25 |
| CATALUÑA | 7,519,843 | 3,926,855 | 522.20 |
| COMUNITAT VALENCIANA | 5,009,931 | 2,221,793 | 443.48 |
| EXTREMADURA | 1,104,499 | 498,022 | 450.90 |
| GALICIA | 2,772,928 | 1,178,527 | 425.01 |
| MADRID, COMUNIDAD DE | 6,421,874 | 2,572,917 | 400.65 |
| MURCIA, REGIÓN DE | 1,462,128 | 646,344 | 442.06 |
| NAVARRA, COMUNIDAD FORAL DE | 640,129 | 311,905 | 487.25 |
| PAÍS VASCO | 2,185,393 | 1,048,759 | 479.89 |
| RIOJA, LA | 321,173 | 129,798 | 404.14 |
| **TOTAL SPAIN** | **46,815,916** | **23,281,979** | **497.31** |

Source: INE

## APPENDIX Nº 3.3

## TOURIST ARRIVALS PER RESIDENT IN MALLORCA

| | 2011 | 2012 |
|---|---|---|
| TOURIST ARRIVALS | 8.860.221 | 9.145.414 |
| POPULATION | 873.414 | 876.147 |
| **TOURIST / RESIDENT** | **10,14** | **10,44** |

Source: IBESTAT & CAIB

# APPENDIX Nº 3.4
# RELEVANT LEGISLATION CONCERNING MSW

## LEGISLATION AT THE SUPRA-NATIONAL LEVEL

The European directives had a determining influence on the development of MSWM in Spain, working as a paradigm for the guidelines of Spanish legislation as a member of the union. The first European Directive about waste appeared in 1975 (European Commission, 1975) and this defined the basic conditions for waste disposal. It is important to highlight that during those years, countries from Northern Europe were more committed to solutions that included incineration or recycling, while countries from Southern Europe preferred controlled landfills because of the lower costs.

Almost two decades later, in 1994, Directive 94/62/EC (European Commission, 1994) established guidelines for regulations concerning packaging and packaging waste management in order to reduce their environmental impacts. This directive promoted recycling, established the hierarchy of waste packaging and set targets for Member States concerning these activities.

Five years later, in 1999, Directive 99/31/EC (European Commission, 1999) defined the rules for waste landfilling in order to establish the measures, processes and guidelines that aimed to reduce the negative effects of pollution on the environment at the local (surface and underground water, soil and the atmosphere) and global levels (greenhouse gases). This directive required Member States to create strategic plans for the reduction of biodegradable MSW before going to landfills. This directive requires a reduction of 65% in biodegradable waste that is disposed in controlled landfill sites by 2016.

In 2004, the Directive 2004/12/EC (European Commission, 2004) was published in order to update the previous directive of 1994. This new directive aimed to redefine the targets for packaging and packaging waste recovery and recycling.

Finally, in 2008, the European Directive 2008/98/EC (European Commission, 2008) set the guidelines for Member States to implement new policies aimed at preventing waste generation as well as improving recycling and recovery strategies. In order to meet these objectives, action plans and targets for waste prevention are required in the near future. This directive also sets the target of a 50% weight increase in the recycling of some MSW for 2020.

**LEGISLATION AT THE NATIONAL LEVEL**

Spanish Law 42/1975 (modified later by Royal Decree 1163/1986) established the need to develop a National Municipal Solid Waste Plan (PNRSU). This plan, approved in 1992, suggests that Autonomous Communities should be responsible of the development of waste management plans within their territories.

One decade later, Spanish Law 10/1998 and its flexible complementary specific regulations (related to specific categories of waste) set a single standard for all waste generated in the country. This law aims to contribute to environmental protection through the coordination of waste policy with other economic, industrial and territorial policies. The main objectives of this law are:

- Waste production prevention: This encourages reduction at source, reuse, recycling and recovery as the main waste management system.
- Application of the PPP: The law aims to affect the cost of products in proportion to the suitable management of the waste generated by them.
- Establish responsibilities: Autonomous Communities are responsible for the development of regional waste management plans. These institutions will also have

the power to authorize, control and sanction production and management activities that could influence waste treatment systems.

- Creation of urban waste management plans: The law established that local authorities may draw up their own urban waste management plans in accordance with the waste management directives of Autonomous Communities. Local governments are responsible for urban waste management and they must provide the collection, transportation and disposal of MSW as a compulsory service.

On the other hand, Spanish Law 11/1997, related to packaging and packaging waste management approved by the Spanish Parliament and the implementation in Spain of Directive 94/62/EC, set the rules for the waste management of inorganic materials in waste disposal by forcing their selective collection. This law established the following objectives:

- Recovery of a minimum of 50% and a maximum of 65% of all packaging produced (measured by weight).

- Taking into account the objective set above, recycling activities should reach a minimum value of 25% and 45% as a maximum (measured by weight) of total packaging materials. Moreover, the minimum goal for each packaging material is 15%.

- Reduction of at least 10% (measured by weight) of all packaging waste produced.

Furthermore, Spanish Law 11/1997 also sets two possible management systems:

- SDDR[62] (deposit and return system): Through this system, packaging and packaged goods retailers must charge customers an amount of money for each package. In this

[62] Sistema de Depósito, Devolución y Retorno.

system, companies return the same amount they have charged once they receive the packages back. Packers and retailers are only forced to accept the return of the packaging that has been introduced on the market or distributed.

- SIG[63] (Integrated Management System): Through this alternative system, packaging companies pay an amount of money per package to be distinguished with a logo (green dot). This system ensures the regular collection of used packaging and packaging waste in the consumer's home or nearby.

Finally, EU legislation concerning solid waste and national environmental laws in Spain were adapted into the recently implemented National Waste Plan for 2008–2015 (Ministerio de Medio Ambiente y Medio Rural y Marino, 2009). One of the objectives of this plan is to reduce the percentage of waste sent to sanitary landfills in Spain.

[63] Sistema Integrado de Gestión.

# APPENDIX Nº 3.5
# ENVIRONMENTAL CONTROL OF MSW TREATMENT IN MALLORCA

Given the importance of energy production on the environment and commitments made at the Rio de Janeiro summit in 1992 (Agenda 21), in the Kyoto Protocol (1997) and with the EU (with the approval of the V Environment Programme), the implementation of the energy strategy should pay particular attention to the development of agreements on reducing consumption based on fossil energy sources, reducing per capita and increased progressive participation of renewable energy in electricity consumption. Incineration facilities produce energy with recovered inputs from waste, which helps replace fossil fuels that otherwise would be used in conventional power plants for energy production. These plants contribute to the reduction of $CO_2$ emissions into the atmosphere.

Environmental controls applicable to the urban waste treatment installations envisaged in the PDSGRUM are regulated through a specific Environmental Measures and Monitoring Programme (PMVA), approved by the Balearic Government (BOIB no. 59, May 17th, 2001). This extensive program identifies the main environmental aspects under study (wastewater, emissions into the atmosphere, noise, soil, air quality and by-products such as slag, cemented ash and compost), the parameters to be controlled and the frequency and type of analysis. These are applied to the possible effects on the natural surroundings and population close to treatment facilities operated by TIRME in Mallorca, with the ultimate goal of a suitable function with minimal environmental impact.

Finally, to foster controls in the PMVA, an agreement was signed between the Consell de Mallorca, the University of the Balearic Islands and TIRME, with the consultancy services of the authorities' collaborating entities and specialist laboratories and entities. To carry out control activities, automatic analyzing equipment was installed on the chimney (or the exhaust exit for combustion gases) in order to measure pollutant emissions into the atmosphere. These measurements provide quality data as well as information to be reported back to the authorities to confirm compliance to the law. Measurement data are delivered to the Consell de Mallorca and discussed by the PMVA Technical Follow-Up committee (composed of representatives of the Balearic Government, the Consell de Mallorca, TIRME and the University of the Balearic Islands). The results of the PMVA are published annually.

**APPENDIX Nº 3.6**

**MALLORCA: UNITARY COST OF SERVICES PROVIDED BY TIRME - 2006**

| Facilities | Cost (Euros / Ton) |
|---|---|
| Recycling Facility | 350 |
| Methanation Facility | 294 |
| Compost Facility Z3 | 258 |
| Compost Facility Z1 | 133 |
| Security Tanks | 64 |
| Incineration Facility | 59 |
| Landfill | 32 |
| Transfer Stations | 23 |
| Ashes and Slag Treatmen Facility | 17 |
| Other Services | 9 |

Source: TIRME S.A.

**APPENDIX Nº 3.7**

**MALLOCA: MUNICIPAL FEES TO RESIDENTS - 2010**

(IN EUROS PER HOUSEHOLD)

| MUNICIPALITY | PAYMENT SYSTEM | COLLECTION € | TREATMENT € | TOTAL € |
|---|---|---|---|---|
| Alaró | Fixed annual fee | | | 153,00 |
| Alcúdia | Fixed annual fee | | | 100,50 |
| Algaida | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Andratx | Fixed annual fee with discounts for recycling activities | 47,21 | 61,99 | 109,20 |
| Ariany | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Artà | Fixed annual fee with discounts and payment in quotas. | 135,64 | 82,34 | 217,98 |
| Banyalbufar | Fixed annual fee | | | 125,00 |
| Binissalem | Fixed annual fee with discounts | | | 140,00 |
| Búger | Fixed annual fee | | | 167,60 |
| Bunyola | Fixed annual fee | 55,71 | 66,83 | 122,54 |
| Calvià | Fixed annual fee with discounts and payment in quotas. | 80,84 | 52,70 | 133,54 |
| Campanet | Fixed annual fee | | | 278,24 |
| Campos | Fixed annual fee | 66,42 | 92,86 | 159,28 |
| Capdepera | Fixed annual fee | 52,67 | 54,62 | 107,28 |
| Consell | Fixed annual fee | | | 165,00 |
| Costix | Fixed annual fee | 59,53 | 105,08 | 164,61 |

| MUNICIPALITY | PAYMENT SYSTEM | COLLECTION € | TREATMENT € | TOTAL € |
|---|---|---|---|---|
| Deià | Fixed annual fee | | | 181,49 |
| Escorca | Fixed annual fee | | | 100,00 |
| Esporlas | Fixed annual fee with discounts to residents that purchase special garbage bags. | | | 90,00 |
| Estellencs | Fixed annual fee | | | 66,74 |
| Felanitx | Fixed annual fee with discounts for organic waste sorting and treatment | 43,28 | 110,92 | 154,20 |
| Fornalutx | Fixed annual fee with discounts and payment in quotas. | | | 126,68 |
| Inca | Fixed annual fee with discounts and payment in quotas. | 62,29 | 105,84 | 168,13 |
| Lloret de Vistalegre | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Lloseta | Fixed annual fee | | | 161,25 |
| Llubí | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Llucmajor | Fixed annual fee with discounts | 110,30 | 127 | 237,30 |
| Manacor | Fixed annual fee | | | 170,21 |
| Mancor de la Vall | Fixed annual fee | | | 164,00 |
| Maria de la Salut | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Marratxí | Fixed annual fee with discounts and payment in quotas. | 67,05 | 164 | 231,05 |
| Montuiri | Fixed annual fee | 59,53 | 105,08 | 164,61 |

| MUNICIPALITY | PAYMENT SYSTEM | COLLECTION € | TREATMENT € | TOTAL € |
|---|---|---|---|---|
| Muro | Fixed annual fee with discounts | | | 148,55 |
| Palma | Fixed annual fee with discounts and payment in quotas. | | | 119,02 |
| Petra | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Pollença | Fixed annual fee with discounts and payment in quotas. | 73,79 | 48,23 | 122,02 |
| Porreres | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Puigpunyent | Fixed annual fee with discounts | | | 142,24 |
| Sa Pobla | Fixed annual fee with discounts for recycling activities | | | 168,00 |
| Sant Joan | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Sant llorenç | Fixed annual fee | 62,00 | 55,76 | 117,76 |
| Santa Eugénia | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Santa Margalida | | | | n.d. |
| Santa Maria del Camí | Fixed annual fee | | | 120,00 |
| Santanyí | Fixed annual fee | | | 128,57 |
| Selva | Fixed annual fee | | | 170,68 |
| Sencelles | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Ses Salines | Fixed annual fee | 36,56 | 86,94 | 123,50 |
| Sineu | Fixed annual fee | 59,53 | 105,08 | 164,61 |
| Soller | Fixed annual fee with discounts | | | 244,00 |
| Son Servera | Fixed annual fee | 33,78 | 54,29 | 88,07 |

| MUNICIPALITY | PAYMENT SYSTEM | COLLECTION € | TREATMENT € | TOTAL € |
|---|---|---|---|---|
| Valldemossa | Fixed annual fee | | | 147,61 |
| Vilafranca de Bonany | Fixed annual fee | 59,53 | 105,08 | 164,61 |

Source: TIRME S.A.

**APPENDIX Nº 3.8**

**MALLOCA: MUNICIPAL FEES TO HOTELS - 2010**

(IN EUROS)

| MUNICIPALITY | PAYMENT SYSTEM |
|---|---|
| Alaró | € 72,00/BED |
| Alcúdia | € 70,56/ BED |
| Algaida | 2*/ 3* : € 52,74/ BED<br>From 4* € 88,69/ BED |
| Andratx | 2*/3*: 55,37/BED<br>From 4*: 65,27/BED |
| Ariany | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Artà | € 71,28/BED |
| Banyalbufar | € 125/BED |
| Binissalem | NO |
| Búger | NO |
| Bunyola | € 546,92 |
| Calvià | €75,74/BED |
| Campanet | N.D. |
| Campos | N.D. |
| Capdepera | € 60,50/BED |
| Consell | € 60,00/BED |
| Costix | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Deià | N.D. |
| Escorca | € 8,262 |

| MUNICIPALITY | PAYMENT SYSTEM |
|---|---|
| Esporlas | € 402.68 |
| Estellencs | N.D. |
| Felanitx | € 23,16/BED |
| Fornalutx | € 744.8 |
| Inca | With restaurant: € 60/BED<br>Without restaurant: € 30/BED |
| Lloret de Vistalegre | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Lloseta | € 1.066,83 |
| Llubí | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Llucmajor | With restaurant: € 40,00/BED<br>Without restaurant: € 25,50/BED |
| Manacor | € 91,48/BED |
| Mancor de la Vall | NO |
| Maria de la Salut | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Marratxí | NO |
| Montuiri | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Muro | € 63,80/BED |
| Palma | With restaurant: € 44,63/BED<br>Without restaurant: € 27,40/BED |
| Petra | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Pollença | € 55/BED |

| MUNICIPALITY | PAYMENT SYSTEM |
|---|---|
| Porreres | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Puigpunyent | Big hotels: € 13.340,00<br>Others: € 2.223,28 |
| Sa Pobla | € 515,00 |
| Sant Joan | 2*/ 3*: 52,74/BED<br>From 4*: € 88,69/BED |
| Sant llorenç | € 84,46/BED |
| Santa Eugénia | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Santa Margalida | € 45,00/BED |
| Santa Maria del Camí | NO |
| Santanyí | NO |
| Selva | € 548,48 |
| Sencelles | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Ses Salines | With restaurant: € 61,75/BED<br>Without restaurant: € 53,70/BED |
| Sineu | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |
| Soller | 2*: € 88,00/BED<br>From 3*: € 244,00/BED |
| Son Servera | With restaurant: € 41,43/BED<br>Without restaurant: € 24,85/BED |
| Valldemossa | N.D. |
| Vilafranca de Bonany | 2*/ 3*: € 52,74/BED<br>From 4*: € 88,69/BED |

Source: TIRME S.A.

## APPENDIX Nº 3.9

## MALLORCA: NUMBER OF EDUCATIONAL VISITS PER YEAR


Source:_TIRME (Annual Report 2010).

# APPENDIX Nº 3.10

# ECONOMETRIC RESULTS

Dependent Variable: _SONREUS_SF
Method: Least Squares
Sample: 2004M01 2010M12
Included observations: 84

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| _TOURISTS_SF | 0.300172 | 0.005479 | 54.78444 | 0.0000 |
| C | 0.699874 | 0.006253 | 111.9253 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.973405 | Mean dependent var | 0.999947 |
| Adjusted R-squared | 0.973081 | S.D. dependent var | 0.168504 |
| S.E. of regression | 0.027646 | Akaike info criterion | -4.315118 |
| Sum squared resid | 0.062675 | Schwarz criterion | -4.257241 |
| Log likelihood | 183.2350 | F-statistic | 3001.335 |
| Durbin-Watson stat | 2.182121 | Prob(F-statistic) | 0.000000 |

Dependent Variable: _GLASS_SF
Method: Least Squares
Sample: 2004M01 2010M12
Included observations: 84

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| _TOURISTS_SF | 0.679802 | 0.014815 | 45.88648 | 0.0000 |
| C | 0.320176 | 0.016907 | 18.93711 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.962515 | Mean dependent var | 0.999754 |
| Adjusted R-squared | 0.962058 | S.D. dependent var | 0.383765 |
| S.E. of regression | 0.074752 | Akaike info criterion | -2.325759 |
| Sum squared resid | 0.458205 | Schwarz criterion | -2.267882 |
| Log likelihood | 99.68186 | F-statistic | 2105.569 |
| Durbin-Watson stat | 1.516605 | Prob(F-statistic) | 0.000000 |

Dependent Variable: _PACKAGES_SF
Method: Least Squares
Sample: 2004M01 2010M12
Included observations: 84

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| _TOURISTS_SF | 0.284503 | 0.007618 | 37.34659 | 0.0000 |
| C | 0.714872 | 0.008694 | 82.22694 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.944473 | Mean dependent var | 0.999281 |
| Adjusted R-squared | 0.943796 | S.D. dependent var | 0.162136 |
| S.E. of regression | 0.038438 | Akaike info criterion | -3.656014 |
| Sum squared resid | 0.121154 | Schwarz criterion | -3.598137 |
| Log likelihood | 155.5526 | F-statistic | 1394.768 |
| Durbin-Watson stat | 2.138834 | Prob(F-statistic) | 0.000000 |

Dependent Variable: _PAPER_CB_SF
Method: Least Squares
Sample: 2004M01 2010M12
Included observations: 84

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| _TOURISTS_SF | 0.516929 | 0.006991 | 73.93971 | 0.0000 |
| C | 0.483215 | 0.007979 | 60.56324 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.985223 | Mean dependent var | 0.999974 |
| Adjusted R-squared | 0.985043 | S.D. dependent var | 0.288437 |
| S.E. of regression | 0.035276 | Akaike info criterion | -3.827707 |
| Sum squared resid | 0.102040 | Schwarz criterion | -3.769831 |
| Log likelihood | 162.7637 | F-statistic | 5467.080 |
| Durbin-Watson stat | 1.691527 | Prob(F-statistic) | 0.000000 |

# CHAPTER 4: "MUNICIPAL SOLID WASTE GENERATION IN MATURE DESTINATIONS: AN IPAT-TYPE MODEL FOR MALLORCA"

# MUNICIPAL SOLID WASTE GENERATION IN MATURE DESTINATIONS: AN IPAT-TYPE MODEL FOR MALLORCA

**ABSTRACT**

A number of studies have examined the relationship between environmental degradation and population growth. However, most do not take into account the difference between the 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 shows that the mature tourist destinations have higher population elasticity than industrial economies. Moreover, the model allows us to measure the elasticity of substitution between lower-income and higher-income tourists.

**KEY-WORDS:** IPAT Model, municipal solid waste, tourism growth.

# 4.1 INTRODUCTION

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 the growth trends in the future. Thus, it will be possible to extend the benefits of tourism activities to future generations (Archer, 1996; Butler, 1993; Guthunz & von Krosigk, 1996; Filho, 1996; Gossling, 2003; Hampton & Christensen, 2007; Liu & 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 of it. Although a measurement of the 'experience' concept can be difficult to achieve, there is a clear 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 & Sheldon, 2008).

The tourism industry has special characteristics in production given that the consumption of the 'tourism product' is performed at the destination. This reveals that tourist growth, which is related to increasing tourist arrivals, can be conceived as the larger presence of nomad populations in a given destination.

Every population, nomad or local, has a pattern of consumption that generates a waste flow which eventually must be dealt with in order to maintain the environmental quality of the destination. However, waste disposal collection and treatment that avoids (or at least reduces) the environmental impact on the local landscape involves costs which are usually met by the local population. Thus, waste generation could be considered as an externality caused by the tourism sector. In order to perform efficient environmental public policies that could correct the effects of increasing solid waste generation caused by this sector, it is necessary to first identify the main economic determinants and measure their impact.

Although the relationship between environmental degradation and economic growth has been the subject of increasing attention in recent years, due to the obvious negative impacts on human economic activities and quality of life, almost the entire set of studies has focused on economic production, particularly in industrial countries (Stern, 2004). The relationship between population growth and environmental impacts still needs further research with regard to tourist destinations. Previous studies have attempted to measure the impact of population growth on the environment by using the seminal methods of Ehrlich & Holdren (1971). These studies focused their attention on local populations. However, little attention was given to the performance of the regions which specialize in tourism activities where human pressure does not correspond directly to the local population (Shi, 2003).

This paper stems from the need to improve the environmental impact modelling and comprehension of the consequences of different population trends (local or nomad) 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 using an IPAT-type model based on a stochastic differential equation system for a mature tourist destination, Mallorca (in the Balearic Islands). This formulation seeks to get better results than those obtained by previous studies as it allows for 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 & 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 & Curtis, 1999). Therefore, the important contribution of natural resources and environmental services in the productive structure of the island and its rapid development as a 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).

The paper is organized as follows: Section 4.2 briefly explains the relationship between tourism and municipal solid waste generation; Section 4.3 gives a brief introduction to waste disposal management in Mallorca; Section 4.4 summarizes the theory behind the IPAT model; Section 4.5 introduces the stochastic system of equations according to the STIRPAT model. Sections 4.6 and 4.7 are devoted to explaining the methodology and the data set used and Section 4.8 and Section 4.9 present the main empirical results and conclusions.

## 4.2 TOURISM AND MUNICIPAL SOLID WASTE GENERATION

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

The depletion of natural resources and environmental degradation related to tourism has become a serious challenge to many tourism-based economies in recent decades. The fact that most tourists 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 & Wall, 1982; Briassoulis & van der Straaten, 1992; WTO, 1999). It is also important to recognize that environmental degradation, at the same time, constitutes a serious threat to future tourism activities by discouraging tourists from visiting certain 'dirty' destinations (Rey-Maquieira et al., 2005; Alegre & Cladera, 2006).

As Abrate & Ferraris (2010) argue, the impact of post-consumption on environments has become an important issue all over the world. Municipal solid waste volumes are predicted to continue rising unless action is taken to reduce the problem. Moreover, untreated MSW disposal has contributed to lowering the environmental quality of destinations. The fast growth of tourism has exacerbated this problem in recent years. As a result, new trends in tourism are related to improving the enforcement of 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 to be ‘mature’. Changes in tourist values, lifestyles and greater concern about environmental impacts of human activities are considered as new features of tourism (Poon, 1993; Urry, 1995; Vanhove, 2005; Montero & Oreja, 2005).

As some authors (Cooper, 1990; Aguiló & Juaneda, 2000; Aguiló et al., 2005; Vera & Baños, 2010) have noted, in order to compete, ‘mature destinations’ have to innovate through research into and the 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 & 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 in environmental causes makes environmental innovations highly relevant to improving the tourist destination’s competitiveness (Vera, 1992; Poon, 1993; Cooper, 2002).

However, increases in tourist arrivals and value of the destination should increase income and consumption, which leads to an increase in the amount of municipal solid waste generation. Furthermore, 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). This also fosters the problem of increasing MSW volumes.

As Ku et al. (2009) note, the increase in overall consumption, along with 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 launch appropriate policies in order to reduce the amount of waste generation. Moreover, in the last three decades, the MSW collection and disposal industry have been affected by the increasing volume of waste leading to landfill collapses and other negative impacts on 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 paid to landfill's capacity and recycling policies has greatly increased over the last few years, encouraging households to sort waste and creating a bigger market for recycled materials (as an example, many countries have established a 'per bag' price policy). As a result, some economists have started to pay attention to this sector, especially in tourism destinations where recycling policies have been applied to the 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).

The economic growth benefits of tourism can be measured in terms of employment and income. However, this process also involves costs that may affect some value drivers of the tourism economy. Municipal solid waste generation is a factor that has received little attention in tourism studies. Therefore, one of the main goals of research into environmental innovation on tourist destinations should be the analysis of the determinants of MSW generation.

## 4.3 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 for unrecoverable fractions. Therefore, the first element of the list is related to long-term policy while the latter two points are connected to 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 & Juaneda (2000) note “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 that became the origin of this process. The plan included efforts to modernize tourist accommodation in 1990, legislation for natural areas in 1991 and a plan to control the accommodation supply in 1995 (Blasco & Segura, 1994; Blasco, 1996).

The Balearic Government have tackled the problem of proper municipal solid waste management as an environmental externality. In 1992 it provided a grant for public service waste management in Mallorca to a private project, whose operations have been marked by the three waste disposal plans that have establish a set of guidelines for 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[64]. Because of these problems, Balearic Islands authorities developed the Master Plan for Solid Waste in the Balearic Islands (*Plan Director de Residuos Sólidos Urbanos*, PDRSU) that looked forward to helping the region to take care of its environmental assets in a better way.

The PDRSU focused on recycling and now takes the lead in the reuse of resources in other sectors (in contrast to landfill where waste is dumped and stocked up). 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 is considered as an example of environmental efficiency as it leverages virtually all the waste generated on the island (TIRME, 2010). However, waste management currently faces technical challenges, given the increasing volume 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.

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[64] In the Balearic Islands, approximately 2.4 kg of waste disposal per inhabitant per day was generated, while the mean value in Spain was 1.8 kg of waste disposal per inhabitant per day in 1992.

## 4.4 THE IPAT MODEL

One of the essential steps towards efficient MSW management is to understand and be able to predict the magnitude of the contribution of tourism's growth to the generation of municipal solid waste. In this regard, one of the main objectives of this research is the development of an accurate analysis of the problem of waste generation in Mallorca in order to identify its leading determinants. This research also hopes to provide the public authorities with 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 about the impact of these determinants on the environmental system in which they exist.

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 is also determined by production technologies and consumption patterns (Gans & Jöst, 2005). Therefore, even a growing population does not necessarily lead to increased 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. Examples of theoretical models which base their explanation on consumption patterns include the Environmental Kuznets Curve (EKC) and the Green Solow Model. On the other hand, one of the main models which supports the idea that population growth is a major determinant of environmental impact is IPAT-model, developed by Ehrlich & Holdren (1971), which is widespread in ecological economics.

Even though these models are widely spread in academic literature, researchers have focused their attention on industrialized countries or developing countries in order 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 arrivals each year, where repetition of the destination is a usual form of behaviour which tends to be related to stable behaviour in tourist expenditure. Given these characteristics of a mature destination, its tourist arrivals could be considered as a major determinant of environmental impacts, even more important than tourist expenditure.

The role of population growth in determining environmental quality can be traced back to the debate on the relationship between population and natural resources begun by Malthus (1798) in 'An Essay on the Principle of Population'. Malthus argued that that population increase would increase pressure on limited resources (including land). However, Malthus failed to foresee 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 & Amann (2001) outline, Malthusian concerns returned again during the 60s when researchers such as Ayres & Kneese (1968) attempted to conceptualize the economic system in a thermodynamic framework, taking into account the law of conservation of mass. This attempt should be seen as one of the early stages of the important contributions such as those made by Boulding (1966) with his 'Cowboy economy on a spaceship earth' and Meadows' 'Limits to Growth' model (Meadows et al., 1972) which suggested the importance of taking the earth's carrying capacity into account with regard to the process of economic growth.

Although the author and those who adhered to the Malthusian framework were not specifically concerned about the environment but more concerned about the natural resources available for production, such positions have often been taken up in recent environmental debates. However, as Shi (2003) notes, there are still some researchers who have tried to test the ability of the environment to absorb wastes generated by mankind's activities and failed to find any relationship with population growth (Commoner, 1972; Cropper & Griffiths, 1994; Myers, 1993[65]).

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 played a prominent role in explaining demographic environmental impacts. Ehrlich & Holdren described the environmental impact of an economic system by using the following equation:

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

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 & Quaas (2006) explain, in empirical research, the use of an observable variable for environmental impact is usually related to greenhouse gas emissions (although the concept of the theoretical model applies to all environmental variables). 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 use the logarithm of the previous equation and its derivatives with respect to the time required to attain the mean relative change of the environmental impact, we would find that its parts are 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.

[65] 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.

$$\frac{\dot{I(t)}}{I(t)} = \frac{\dot{P(t)}}{P(t)} + \frac{(\dot{Y/P})(t)}{(Y/P)(t)} + \frac{(\dot{I/Y})(t)}{(I/Y)(t)} \quad [2]$$

This identity has been applied quite frequently at different levels of aggregation (nations, regions or districts[66]). However, as the IPAT is treated as an accounting equation, this formulation is simply a tautology which leads to strong criticism to empirical estimations of these models. Moreover, the IPAT equation is not 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 & Rosa (1994; 1997) about twenty years after Ehrlich and Holdren's original publication. These authors proposed that IPAT's identity would be reformulated into a stochastic equation in order to allow random errors in the estimation of parameters. Thus, the IPAT equation was reformulated as STIRPAT, standing for 'Stochastic Impacts by Regression on Population, Affluence and Technology'. These authors consider the following formulation:

$$I = aP^bA^cT^de \quad [3]$$

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. Using 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:

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

[66] See Scholz (2006).

As York et al. (2002; 2003) note, 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, and reformulates it to allow estimation of the net effect of each anthropogenic driver on the environmental impact, so breaking the implicit assumptions that the effect of each driven force was proportional and that their sum was equal to one.

Some advantages of the STIRPAT model, as Knight (2009) notes, are related to the analysis of the population-environment relationship within a theoretical framework, but also to the possibility of including relevant control variables of the model, as Dietz et al. (2007), Knight (2008), Schulze (2002) and others have done[67]. The STIRPAT model, therefore, allows the incorporation of greater complexity in the analysis of environmental variables and other factors that could create a negative impact.

In terms of public policy issues, the main advantage of the STIRPAT model is that it identifies 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.

## 4.5 A STOCHASTIC MODEL OF ENVIRONMENTAL OF TOURISM IMPACT BASED ON THE IPAT EQUATION

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

[67] For further references see Lin et al. (2009).

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 & 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:

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

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*' represents 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 each elasticity. However, we can also 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 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 '$\omega_t$' is a zero mean error term which behaves according to a normal distribution and with the no properties of serial correlation. Therefore, this equation represents an IPAT-based stochastic model of environmental impact. Under the assumption that each elasticity remain constant over the time period we analyze, the equation may be expressed as:

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

As Zagheni & Billari (2007) argue, equation N° 15 may be expressed in stochastic terms for two reasons: the first is related to the possibility that factors other 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 deterministic way, so this trend might show a random component.

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

$$dP = \; \beta_3\, P\, dt + \; v_t\, P\, dt \qquad [16]$$

and

$$dE = \; \beta_4\, E\, dt + \psi_t\, E\, dt \qquad [17]$$

where $_t$ and $_t$ are zero mean error terms which follow a normal distribution. Starting from these assumptions, we can rewrite equation N° 15 as a system of three stochastic differential equations:

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

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[68]. 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.

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

$$\beta_1 = \left(\frac{\varepsilon_{I,P} - \varepsilon_{I,A}}{1 - \varepsilon_{I,T}}\right) \quad [21]$$

and

$$\beta_2 = \left(\frac{\varepsilon_{I,A} - \varepsilon_{I,T}}{1 - \varepsilon_{I,T}}\right) \quad [22]$$

Regarding this, the results let us face a situation of two equations and three variables. Therefore, in order to solve this we should introduce a different approach like the one proposed by Preston (1996) in which the estimation of the parameters is not based on

[68] For further references to this topic see Greene (2002).

perceptual rates but on the variance of the average growth rates of the environmental variable for a specific observation period[69]. On the basis of equation (14), this leads to the following formulation:

$$VAR\left[\frac{\dot{I(t)}}{I(t)}\right] = (\beta_1)^2\,VAR\left[\frac{\dot{P(t)}}{P(t)}\right] + (\beta_2)^2\,VAR\left[\frac{\dot{E}(t)}{E(t)}\right] + (\beta_3)^2\,VAR[\omega_t] + 2\beta_1\beta_2 COV\left[\frac{\dot{P(t)}}{P(t)},\frac{\dot{E}(t)}{E(t)}\right] \quad [23]$$

Since ‘$\omega_t$’, ‘ $_t$’ and ‘ $_t$’ are independent white noise process the covariance of these variables with the remaining ones are equal to zero, therefore the previous equation can be represented an IPAT-based stochastic model of environmental impact.

Under the assumptions that the elasticities remain constant over the time period we can estimate equation 23 by means of OLS as the following expression shows:

$$\sigma^2_{\dot{I}/I} = (\beta_1)^2\,\sigma^2_{\dot{P}/P} + (\beta_2)^2\,\sigma^2_{\dot{E}/E} + 2\beta_1\beta_2\sigma_{\dot{P}/P,\dot{E}/E} + \sigma^2_{\omega} + \sigma^2_{\nu} + \sigma^2_{\psi} \quad [24]$$

where $\sigma^2_{\dot{I}/I}$ represents the variance of the environmental impact growth rate, $\sigma^2_{\dot{P}/P}$ and $\sigma^2_{\dot{E}/E}$ represent the variance of the population growth rate and expenditure growth rate, respectively. $\sigma_{\dot{P}/P,\dot{E}/E}$ is the expression of the covariance of population growth rate and expenditure growth rate and $\sigma^2_{\omega}$, $\sigma^2_{\nu}$ and $\sigma^2_{\psi}$ represent the variance of $\omega_t$, $\upsilon_t$ and $\psi_t$, respectively.

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

$$P = P_L + P_T \quad [25]$$

[69] Preston’s original paper of focuses on the calculation of the variance of environmental impact based on a typical IPAT model but not on a STIRPAT model.

Therefore, it holds that:

$$\frac{dP}{dt} = \frac{dP_L}{dt} + \frac{dP_T}{dt} \quad [26]$$

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

$$E = E_L + E_T \quad [27]$$

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

$$\frac{dE}{dt} = \frac{dE_L}{dt} + \frac{dE_T}{dt} \quad [28]$$

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 in the Box-Jenkins methodology should be applied to all the four series[70] in the tourist destination.

## 4.6 METHODOLOGY

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

[70] Local population, local expenditure, tourist population and tourism expenditure.

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 have used traditional econometric methodology on time-series data to measure, among other factors, the relationship between population growth and environmental degradation[71]. However, these models have implicitly assumed that explanatory variables were completely exogenous (orthogonal) in these models, neglecting the possibility of stochastic variables.

This paper will use the formulation that Preston applied to a system of stochastic equations following standard approaches to the existing IPAT model literature. However, as explained in the previous section, the presence of stochastic regressors implies a problem with direct OLS estimation. In order to contrast the results, the methodology proposed involves the estimation of two models:

- **BASIC MODEL**: This specification enables the estimation of the IPAT in its traditional form regardless of the presence of stochastic regressors.

- **STOCHASTIC MODEL**: This model includes the possibility of treating all explanatory variables in the IPAT model as stochastic regressors.

It is important to note that, given that the model implies the use of the variance terms of the stochastic terms of the population and expenditure time series, in order to obtain these errors it is necessary to assess the methodology of estimation of the system in two stages. In the first stage, we obtain the fitted values and stochastic series of the explanatory variables by use of the Box-Jenkins methodology. Once the estimated values of the series are calculated, the second step involves the use of these new time series into the STIRPAT equation to estimate the coefficients by means of OLS regression.

[71] The initial empirical studies on IPAT model used this type of econometric analysis.

# 4.7 DATA

The dependent variable considered is municipal solid municipal waste disposal (RSU) (measured in kilograms). The dataset of the RSU series is composed by the total amount of urban solid waste disposal generated in Mallorca between 2004 and 2010 regardless of the proportion of recycled materials[72].

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

[72] Recycled materials are classified by TIRME (plastic packages, paper and glass).

**TABLE N° 4.1**

**DATA SOURCE AND DESCRIPTION**

| VARIABLE | DESCRIPTION | SOURCE |
|---|---|---|
| RSU | Municipal solid wasted generation in Mallorca (in Kg.). The series does not include recycled disposals. | TIRME S.A. |
| 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 deaths, 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 carried out by personal interviews with non-resident visitors to 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 |

By means of this data set, the explanatory variables for the estimation of the two models proposed in the methodology are described in the following table.

**TABLE N° 4.2**

**VARIABLES**

| VARIABLE | DESCRIPTION |
|---|---|
| POP | IPH_MALL + POB_MALL |
| EXP | GAST_TUR + GAST_LOCAL |
| VAR_RSU | Variance of the waste disposal growth rate. |
| VAR_POP | Variance of total population (nomad and local) growth rate. |
| VAR_EXP | Variable is the variance of total expenditure (nomad and local) growth rate |
| COV_EP | Covariance of total expenditure (nomad and local) growth rate and population (nomad and local) growth rate series. |
| SIGMA_W | Variance of error term of the STIRPAT model by direct OLS regression. |
| SIGMA_V | Variance of error term of the population (local and nomad) series obtained by Box-Jenkins methodology |
| SIGMA_T | Variance of error term of the expenditure (local and nomad) series obtained by Box-Jenkins methodology |

# 4.8 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 two different models. The estimations of the so called 'Basic Model' and the 'Stochastic Model' gave the expected signs and statistical significance of all coefficients which led to confirm the IPAT hypothesis. The following table shows the estimation results.

**TABLE N° 4.3**

**ECONOMETRIC RESULTS**

| **COEFFICIENTS** | **BASIC MODEL** | **STOCHASTIC MODEL** |
|---|---|---|
| VAR_POP | 5,904646 * *(0,4784)* | 5,918617 * *(1,146913)* |
| VAR_EXP | 0,038992 *** *(0,019956)* | 0,387770 * *(0,06608)* |
| COV_EP | 0,396677 * *(0,118863)* | -0,917733 *** *(0,540985)* |
| SIGMA_W | 1,772181 * *(0,141729)* | 2,062604 * *(0,262506)* |
| SIGMA_V | - | 0,002103 *(0,056064)* |
| SIGMA_T | - | -5,270356 *(12,36114)* |
| **R2** | **0,907948** | **0,978957** |

**Note:** Values in parenthesis are related to t-statistic

* Significance at 1%

** Significance at 5%

*** Significance at 10%

It is important to note that the coefficients of population growth (local and nomad) confirms the idea that population is the main determinant of MSW generation in mature tourist destinations. Moreover, the sign of expenditure growth (local and nomad) also confirms the hypothesis that affluence does have a positive impact over the pollution growth rate.

Given the theoretical construction of the model, the explanatory variables cannot be considered directly as elasticities *per-se*, but rather that the coefficients are a combination of them (see expression 21 and expression 22), which means that:

$$Coef_{VAR\_POP} = \left(\frac{\varepsilon_{I,P} - \varepsilon_{I,A}}{1 - \varepsilon_{I,T}}\right)^2 \quad [29]$$

and

$$Coef_{VAR\_EXP} = \left(\frac{\varepsilon_{I,A} - \varepsilon_{I,T}}{1 - \varepsilon_{I,T}}\right)^2 \quad [30]$$

and

$$Coef_{COV\_EP} = 2\left(\frac{\varepsilon_{I,P} - \varepsilon_{I,A}}{1 - \varepsilon_{I,T}}\right)\left(\frac{\varepsilon_{I,A} - \varepsilon_{I,T}}{1 - \varepsilon_{I,T}}\right) \quad [31]$$

Regarding this, the results let us face a situation of three equations and three variables. Therefore, it is possible to calculate the value of the elasticities as:

$$\varepsilon_{I,T} = 1 \pm \left(\frac{Coef_{COV\_EP}}{2 * \sqrt{Coef_{VAR\_POP} * Coef_{VAR\_EXP}}}\right) \quad [32]$$

On the other hand, affluence elasticity could take the values of:

$$\varepsilon_{I,A} = (1 - \varepsilon_{I,T})\left(\pm\sqrt{Coef_{VAR\_EXP}}\right) + \varepsilon_{I,T} \quad [33]$$

Finally, population elasticity could take the values of:

$$\varepsilon_{I,P} = (1 - \varepsilon_{I,T})\left(\pm\sqrt{Coef_{VAR\_POP}}\right) + \varepsilon_{I,A} \quad [34]$$

Therefore, given the quadratic structure of the estimators, there is a set of possible values of elasticities. The following tables show the set of alternative solutions for each model:

**TABLE N° 4.4**

**POSSIBLE VALUES OF ELASTICITIES – BASIC MODEL**

| ELASTICITY | SOLUTION 1 | SOLUTION 2 | SOLUTION 3 | SOLUTION 4 | SOLUTION 5 | SOLUTION 6 | SOLUTION 7 | SOLUTION 8 |
|---|---|---|---|---|---|---|---|---|
| Technologycal | 0.5866 | 0.5866 | 0.5866 | 0.5866 | 1.4134 | 1.4134 | 1.4134 | 1.4134 |
| Affluence | 0.6683 | 0.6683 | 0.5050 | 0.5050 | 1.3317 | 1.3317 | 1.4950 | 1.4950 |
| Population | 1.6727 | -0.3362 | 1.5095 | -0.4994 | 0.3273 | 2.3362 | 0.4905 | 2.4994 |

**TABLE N° 4.5**

**POSSIBLE VALUES OF ELASTICITIES – STOCHASTIC MODEL**

| ELASTICITY | SOLUTION 1 | SOLUTION 2 | SOLUTION 3 | SOLUTION 4 | SOLUTION 5 | SOLUTION 6 | SOLUTION 7 | SOLUTION 8 |
|---|---|---|---|---|---|---|---|---|
| Technologycal | 1.3029 | 1.3029 | 1.3029 | 1.3029 | 0.6971 | 0.6971 | 0.6971 | 0.6971 |
| Affluence | 1.1143 | 1.1143 | 1.4915 | 1.4915 | 0.8857 | 0.8857 | 0.5085 | 0.5085 |
| Population | 0.3774 | 1.8512 | 0.7546 | 2.2284 | 1.6226 | 0.1488 | 1.2454 | -0.2284 |

From the previous tables it appears to be possible to discard the possibility of solutions with the existence of negative population elasticity as these have no congruence with IPAT model theory.

Moreover, from the combination of these elasticities we can estimate a coefficient for the COV_EP variable. We can observe that some solutions give a values with different signs to the one estimated by econometric estimation. Therefore, all these solutions cannot be considered as accurate. In order to assess the remaining possible solutions, we can use some additional information from other studies to identify the accurate final value for the elasticities. Thus we can use two sets of information, the first related to previous studies of waste disposal demand and the second related to previous studies which attempted to estimate the IPAT (or STIRPAT) model.

Regarding waste disposal demand studies, we will focus on those that included an estimation of income elasticity. The main idea behind this is that, just as the STIRPAT model uses per capita income as a proxy of affluence, income elasticity is a related concept to affluence elasticity and it should be expected that both would have close values.

The following table shows a set of estimated income elasticities from a survey of papers taken by Choe & Fraser (1998), Morris (1994), Kinnaman & Fullerton (1999) and Linderhof et al. (2001).

## TABLE N° 4.6

## SURVEY OF INCOME ELASTICITY FOR WASTE DISPOSAL DEMAND

| AUTHOR | DEPENDANT VARIABLE | INCOME ELASTICITY |
|---|---|---|
| Reschovsky and Stone (1994) | Dichotonomus: Recycling or not | 0.240 |
| Jenkins (1993) | Residential waste discarded (per capita - per day ) | 0.410 |
| Richardson and Havlicek (1978) | Quantity of Kth component in pounds per household per week | 0.242 |
| Wertz (1976) | Annual pound refuse collected per capita | 0.279 |
| McFarland (1972) | Annual per capita quantity of household waste | 0.178 |
| Downing (1975) | Refuse collection | 0.390 |
| Tolley et all (1978) | Municipal solid waste | 0.3 - 0.7 |
| Eflaw and Lanen (1979) | Household solid waste | 0.2 - 0.4 |
| EPA (1973) | Municipal collection of household refusal | 0.404 |
| Beede and Bloom (1995) | Per-day garbage generation | 0.340 |
| Podolsky and Spiegel (1998) | garbage quantities | 0.550 |
| Linderhof et all (2001) | household waste in kilograms and disposable | 0.600 |

Source: Choe & Fraser (1998), Morris (1994), Kinnaman & Fullerton (1999) and Linderhof et al. (2001).

As the previous table shows, even though the methodologies of calculation and the data set sources for waste disposal demand estimation were different, the results show that a reasonable value for income elasticity should be in the range of 0.18 and 0.7. Therefore, the income elasticity of demand for waste disposal is positive and lower than 1.

According to the previous paragraph, we cannot consider as accurate all those results in which affluence elasticity have values superior to 1, since this would be near to expressing the idea that waste disposal demands are considered as a luxury good or a superior good, which is incongruent with empirical results of the survey.

On the other hand, regarding previous studies which attempted to estimate the IPAT (or STIRPAT) model, it is important to mention that even thought there are many studies related to this, none of them (as far as we know) have been applied to estimate the elasticity of population or affluence by separating local and tourist population, neither have been applied on tourist economies. Therefore, we could use these results as relative values to test the congruence of our solutions.

The following table shows a set of estimated population and affluence elasticities from IPAT models taken from a survey of papers:

**TABLE N° 4.7**

**SURVEY ON POPULATION AND AFFLUENCE ELASTICITIES FOR IPAT BASED MODELS**

| AUTHOR | REGION | DEPENDANT VARIABLE | RESULT | VALUE |
|---|---|---|---|---|
| Liddle (2011) | OECD countries | CO2 from transport | Affluence elasticity | 0.978 |
| | | Residencial electricity | Affluence elasticity | 0.771 |
| Liddle (2011) | OECD countries | CO2 from transport | Population elasticity | 1.342 |
| | | Residencial electricity | Population elasticity | 1.745 |
| Si-si & Xian-jin (2011) | China | SO2 emissions | Affluence elasticity | 0.480 |
| Si-si & Xian-jin (2011) | China | SO2 emissions | Population elasticity | 1.100 |
| York (2003) | a sample of 137 nations, which contain more than 95% of the world's population and its economic output | CO2 emissions | Affluence elasticity | 0.730 |
| York (2003) | a sample of 137 nations, which contain more than 95% of the world's population and its economic output | CO2 emissions | Population elasticity | 0.992 |
| Lin et all. (2009) | China (1978 - 2006) | Pollutant gasses from energy production | Affluence elasticity | 0.231 |
| Lin et all. (2009) | China (1978 - 2006) | Pollutant gasses from energy production | Population elasticity | 1.507 |

Source: Own elaboration.

From the results of the previous table, two main conclusions can be obtained: (i) Even though the econometric techniques, data sets and methodologies of calculation are not the same, in all the papers of the survey the affluence elasticity has a lower value than the population elasticity; moreover, (ii) in all the papers of the survey, the affluence elasticity is always lower than 1, which confirms the same idea from the comparison made with income elasticities before.

From these two main conclusions it should hold that solutions with affluence elasticity superior to population elasticity cannot be considered as accurate results.

Taking into account all the considerations taken from the model itself and from the survey of related studies, it holds that the only solutions which are consistent is SOLUTION N° 1 for BASIC MODEL and SOLUTION N° 7 for the STOCHASTIC MODEL. The following table shows the results for Mallorca:

**TABLE N° 4.8**

**SIMULATED ELASTICITIES**

| ELASTICITY | BASIC MODEL | STOCHASTIC MODEL |
|---|---|---|
| POPULATION | 1,6727 | 1,2454 |
| AFFLUENCE | 0,6683 | 0,5085 |
| TECHNOLOGY | 0,5866 | 0,6971 |

It can be concluded from the previous table that the omission of relevant theoretical variables in the basic model (the variance of the stochastic terms of population[73] and expenditure[74]) can lead to the overestimation of population and affluence elasticity while the technology elasticity is underestimated. The correction of the bias in the stochastic model will give a better estimation of the elasticities.

If we consider that local population growth rate does not change in the short term[75], then an increase of a proportion of 1% of nomad population growth rate (tourist arrivals growth) would generate an increase in waste disposal generation of 1.25%. Furthermore, if Destination Management Offices (DMO) seek to increase the expenditure growth rate by 1% for the destination, then the increase of waste disposal generation would be 0.51%. It is crucial to

[73] $\sigma_{\nu}^2$

[74] $\sigma_{\psi}^2$

[75] Under the assumption that no public policy have any impact on the demographic trends of the local population in the location.

take into account that both concepts are important to measure the impact of tourism growth on the environment.

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

While new tourist destinations are seeking to increase tourist arrivals, mature tourist destination are looking to increase (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 this means a reduction in the number of tourist arrivals.

If we take into consideration that:

$$\frac{\%RSU}{\%POPULATION} = \varepsilon_{I,P} \qquad [35]$$

and

$$\frac{\%RSU}{\%AFFLUENCE} = \varepsilon_{I,A} \qquad [36]$$

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

$$\frac{\Delta\%AFFLUENCE}{\Delta\%POPULATION} = \frac{\varepsilon_{I,P}}{\varepsilon_{I,A}} = \frac{1.2454}{0.5085} \qquad [37]$$

Therefore, if DMOs in Mallorca would like to increase their environmental quality by reducing the amount of visitors to the destinations in 1%, it should be borne in mind that the increase in tourist expenditure (and local expenditure) generated by this policy should not exceed 2.45%.

## 4.9 CONCLUSIONS

As worldwide environmental quality degenerated 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 be focused on the tourist sector in order to make tourism a sustainable activity which can benefit not only the local population but also tourists who value the natural attributes of the destinations.

However, in order to carry out efficient environmental public policies, it is necessary to first identify the main determinants of environmental damage and measure their impact over a given environmental indicator. In the 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 tourist growth on municipal solid waste generation. The results, obtained by means of two econometric models, supported the IPAT hypothesis for MSW in a mature tourist destination such as Mallorca. The STOCHASTIC MODEL was considered to be the most appropriate to explain the IPAT theory since it corrected the problem of stochastic explanatory variables. The main importance of this formulation is the correction of biased results in previous STIRPAT studies. Furthermore, another contribution of this research is related to the inclusion of the idea of nomad population (tourists) into the STIRPAT model which traditionally focused on industrial regions, even though the theoretical model makes it useful to analyze other kinds of economies like tourist destinations.

This paper looks forward to helping public authorities understand the relationship between tourist growth and waste disposal generation and to contribute to accurate policymaking in mature tourist destinations. The results have shown that nomad and local populations do have statistical significance and, therefore should be taken into account in explaining the relationship between tourism growth and waste disposal generation. The results showed that an increase of 1% in the tourist arrival growth rate can generate an increase in waste disposal generation of 1.25%. Furthermore, an increase of tourist expenditure by 1% in the destination could lead to an increase of municipal solid waste generation of 0.51%.

Furthermore, the estimations also showed the potential importance of improvement in environmental outcome without harming tourist revenues by means of the elasticity of substitution (trade-offs) between low income tourist arrivals and higher income tourists, up to a threshold of 2.45%.

# 4.10 REFERENCES

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# CHAPTER 5: "THE GREENING ROLE OF THE TOUR OPERATOR IN A DYNAMIC MODEL"

# THE GREENING ROLE OF THE TOUR OPERATOR IN A DYNAMIC MODEL

## ABSTRACT

The tourism sector is based on environmental consumption. However, because environmental assets are typically considered common pool resources, sustainable practices should be more efficient when implemented by the tourism supply chain (TSC) as a whole than by members on an individual basis. As the central player in the TSC, the tour operator can play a fundamental role and make positive contributions to ensuring environmental sustainability by helping generate accurate incentives for other members of the TSC.

In this paper, we analyse the process of environmental innovation in the tourism sector based on a dynamic model in which hotels and a tour operator cooperate to achieve a particular level of environmental quality in the destination. This paper examines the conditions under which both members of the TSC interact and explores which elements should intervene to ensure a higher level of environmental quality, given its common pool resources characteristic.

**KEY-WORDS:** Environmental quality, Environmental innovation, Tourism supply chain, Tour operators, Hotels

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# 5.1 INTRODUCTION

In recent years, environmental issues in the tourism sector have been discussed in the academic literature at both the environmental and economic levels (Bywater, 1992; Huybers & Bennet, 2000; Van Wijk & Persoon, 2006; Rey-Maquieira et al., 2005; Gómez et. al, 2008; Razumova et al., 2009). As destinations evolve in a competitive tourism market (Sheldon, 1986; Wen-Yu, 2012) and as tourists become even more sophisticated in their choice of destinations (Poon, 1993; Swarbrooke & Horner, 1999; Yaw, 2005), environmental quality is considered a main input of destination competitiveness because tourists' satisfaction depends not only on their perceptions of the quality of hotel services but on all aspects of their stay (Calveras, 2003; Bramwell, 2004; Calveras & Vera-Hernández, 2005; Pintassilgo & Silva, 2007; Bardolet & Sheldon, 2008; Arbulú et al., 2013).

Tourism companies become profitable and exert pressure on environmental common pool resources (CPR), and they both cause and suffer from external effects (Calveras, 2003; Calveras & Vera-Hernández, 2005). In this way, tourism companies may become the main actors in a Tragedy of the Commons (Hardin, 1968), in which a rational user make demands on a resource until de expected benefit of his or her actions equals the expected private costs but as each user ignores costs imposed on others, individual decisions cumulate to a tragic overuse and the potential destruction of an open-access common (Ostrom, 1999; Blanco et al., 2009b). Then, a coordination failure arises where an overexploitation of CPR leads to a reduction in the value of the environmental resources as inputs for the tourism industry (Briassoulis, 2002; Calveras & Vera-Hernandez, 2005; Pintassilgo & Silva, 2007; Blanco et al., 2009; Blanco et al., 2009b), in addition to the external costs imposed on other users of the CPR.

Under this situation, it is often argued that government intervention (regulation) is the best answer to solve this coordination problem (Forsyth, 1997; Tapper, 2001; Razumova et al., 2009). Nevertheless, the academic literature recognizes other means by which it is possible to reduce the environmental effects of tourism activities based on private interactions. On the one hand, managers and other agents at tourism destinations (especially those that are users of natural attractions, in general) have attempted to find an alternative solution by means of voluntary initiatives (Blanco et al., 2009; Blanco et al., 2009b; Blanco et al., 2009c; Lozano et al., 2010; Blanco, 2011). On the other hand, tour operators (TOs) may also play a role in coordinating the shift of tourism suppliers to green management.

Several authors highlight the interest of TOs in promoting sustainability in tourist destinations (Buhalis, 2000; Cavlek, 2002; Budeanu, 2005; Calveras & Vera-Hernández, 2005; Tapper & Font, 2005; Tepelus, 2005; Van Wijk & Persoon, 2006; Schwartz et al., 2008; Font et al., 2008; Zhang et al. 2009). Traditionally, research on the role of TOs in sustainable practices has focused on the actions within their own businesses or as sponsors of environmental protection activities at tourism locations. These actions have been considered below the true potential of tour operators in contributing to sustainable tourism (Forsyth, 1997; Budeanu, 2005). Some authors have suggested that TOs were not willing to take a long term view of destination development because of a lack of control over the environmental impacts caused by supplier firms at the destinations (Klemm & Martin-Quiros, 1996; Carey et al., 1997; Curtin & Busby, 1999; Forsyth, 1997; Miller, 2001; Tapper, 2001).

In recent years, the business agenda has included promoting activities and practices that seek to reduce the human environmental impact (Cramer, 2005), and the academic literature reveals that TOs are no exception (Van Wijk & Persoon, 2006; Font et al., 2008; Schwarts et al., 2008). The most prominent element in this new trend is the Tour Operators Initiative (TOI[76]), which encourages companies to improve and report their sustainability activities and which promotes a common commitment to foster environmental practices (Budeanu, 2000; Budeanu, 2005; Wijk & Persoon, 2006). This new trend in the market has led TOs to move from a short-term profit maximization view, as suggested by Carey et al. (1997), to new business-to-business relationships. In this new vision, chain collaboration plays a key role in fostering external capabilities and improves the competitive advantage of the tourist supply

[76] http://www.toinitiative.org/

chain (Crotts et al., 1998; Green et al., 1998; Calveras & Vera-Hernández, 2005; Zhang et al., 2009; Richey et al., 2010; Song, 2012; Ku et al., 2013). Moreover, the means through which these new strategies should ensure their success include long-term contracts and relationships because they offer a guarantee to suppliers over the return of the investment that is required to fulfil the TO's requirements (Crotts et al., 1998; Green et al., 1998; Zhang et al., 2009).

Although the greening role of TOs is recognized in the academic literature, there has been little research to date on the means by which tour operators can integrate and implement efficient sustainable practices through their position in tourism supply chain management (Zsidisin & Siferd, 2001; Calveras, 2003; Calveras & Vera-Hernández, 2005; Sigala, 2008; Font et al., 2008; Schwartz et al., 2008). On the theoretical side, only Calveras & Vera-Hernández (2005) explore the role of TOs as coordinating agents in managing CPR in tourism destinations. These authors analyse the implications of vertical relationships among hotel establishments and TOs for quality (both general quality and environmental quality) in the industry; in the Calveras & Vera-Hernández (2005) framework, the TO distributes a large share of the supply in a region and internalizes part of the externalities that arise in quality investments by hotel establishments. These authors argue further that a powerful TO could provide a solution to the tragedy of the commons and characterize the conditions under which a TO promotes quality upgrades among hotels. These authors also reveal a trade-off in the incentive structure of the TO between exploiting market power and stimulating quality upgrades among hotels.

Despite the considerable contribution made by the Calveras & Vera-Hernández (2005) study, it has several shortcomings that leave room for further research. First, their model only allows for corner solutions in which the TO requests investments in quality from all the hotels it contracts with or from none of them. Second, because it is a static model, it cannot capture the intrinsic dynamic nature of any investment decision. Third, it neglects the distributional problem of the yield of quality investments between the TO and the hotels on the one hand and —in the common case of domestic hotels and foreign TOs— between the tourism destination and the rest of the world, on the other. Fourth, it does not pay enough attention to interactions among the TO's promotion of green management and other mechanisms for mending the mismanagement of CPR, namely, government intervention. In fact, the role of public intervention is reduced to suggestions about regulation that promotes restrictions in the capacity of the destination. Finally, considering full rationality throughout, Calveras & Vera-Hernández (2005) neglect the differences in information endowments and information processing capabilities among large organisations, such as TOs, and micro and small enterprises (MSEs) like many accommodation suppliers.

Consistent with Calveras & Vera-Hernández (2005), this paper considers a vertical relationship between TOs and hotels in which the former implement incentive schemes to induce investment in quality by the latter. In our case, this investment is in environmental quality through adopting green management. Thus, our approach is different in at least the following ways. First, it explicitly shows how TOs mitigate the underprovision of green management in the hotel sector of a given tourism destination; moreover, the smaller the number of TOs operating with the destination is, the closer such TOs are to the level that maximizes overall profits. Second, the model is dynamic, which allows an analysis of the path for the adoption of green management by the hotels at a tourism destination and of its long-run equilibrium. Third, different assumptions about rationality are made for the TO and the hotels —the former are fully rational, whereas the latter are bounded rational. Fourth, we extensively analyse the determinants of the distribution of the yield from green management. Finally, a government that subsidizes hotels' green management is introduced to see how it interacts with the incentive scheme.

The paper is organized as follows. Section 5.2 presents the core assumptions of the model in which a price premium on the tourism product supplied by a tourism destination can result from hotels in the destination adopting green management practices. Section 5.3 analyses the role of TOs in the hotels' green management adoption in a framework of the tragedy of the commons; this section also explores how a reduction in the number of TOs that distribute the accommodation supply of a tourism destination can lead to a level of green management that is closer to the social optimum. Section 5.4 completes the model assumptions. Section 5.5

finds an equilibrium for the model that admits both intermediate and corner solutions. Section 5.6 performs a sensitivity analysis to identify what determines the distribution of the price premium between the TO and the hotels. Section 5.7 analyses the impact of government intervention by means of a subsidy that promotes green management. Finally, Section 5.8 concludes with a discussion of the implications of this paper. All proofs are relegated to a technical appendix.

## 5.2 THE MODEL

We develop a model for a destination with a large number of locally owned firms (hotels), $N$, in which each provides one unit of accommodation services to tourists. The price that a tourist is willing to pay for accommodation services in this destination is a function of $\phi$, a non-excludable attribute that, for short, we call environmental quality, and a vector $Z$ of other private determinants (Cerina, 2005; Gómez et al., 2008; Avila-Foucat & Eugenio-Marti, 2008; Lozano et al., 2008; Blanco et al., 2009):

$$P = P_\phi(\phi) + P_Z(Z) = \omega(\phi)^\gamma + P_Z(Z)$$

where $\omega$ is a positive parameter, $0<\gamma<1$ (Cerina, 2005; Blanco et al., 2009) and $P_\phi(\phi) \geq 0$ is an environmental quality price premium.

We further assume that environmental quality is negatively affected by the activity of hotels. Therefore, in addition to being non-excludable it is also rival and, therefore, it constitutes a CPR. Hotels can reduce their negative impact on environmental quality by adopting "green" management. Specifically, environmental quality is assumed to be proportional to the number of firms that perform green management, $N_g$, such that,

$$\phi = N_g$$

where environmental quality without green management is normalized to zero.

Finally, we assume that adopting green management entails a cost, $\alpha > 0$.

Given these assumptions, we consider the degree of adoption of green management at the destination and the resulting level of environmental quality. We first use the model to identify the problem of under-adopting green management and the potential for foreign tour operators to help mitigate this problem. Following this, we address the question of how TOs can drive hotels' green management adoption to the desired levels. Two modelling perspectives are adopted. First, we adopt a game-theoretic framework with rational perfectly-informed agents that provide no satisfactory answers. This result paves the way for a second modelling perspective in which the problem is framed as an investment decision taken by TOs.

## 5.3 TOs AND THE UNDER-ADOPTION OF GREEN MANAGEMENT

Let us now show how the problem considered here can be treated as a "tragedy of the commons" problem and how, as previously shown in Calveras & Vera-Hernández (2005), TOs can mitigate the underprovision of environmental quality. Thus, first consider a case in which the commercialisation of accommodation services in the destination is decentralized. In this case, a fully informed, fully rational profit-maximizing hotel opts for green management, when the effect of this decision on its own revenues is larger than the cost of greening its management; however, the hotel refers conventional non-green management if it does not pay to become green; thus,[77]

$$\frac{dP_\phi(\phi)}{d\phi}\frac{d\phi}{dN_g} = \gamma\omega\left(N_g\right)^{\gamma-1} > \alpha \rightarrow \text{become green}$$

[77] As a useful simplification, we consider that $N_g$ is continuous and differentiable.

$$\frac{dP_{\phi}(\phi)}{d\phi}\frac{d\phi}{dN_g} = \gamma\omega\left(N_g\right)^{\gamma-1} < \alpha \rightarrow \text{stay non-green}$$

The hotel calculates the effect on the destination's environment of becoming green in isolation and the impact of this environmental improvement on its own revenues. To make a decision, this calculation is then compared to the cost of becoming green. If we rule out corner solutions, the only possible equilibrium is reached when,

$$\gamma\omega\left(N_g\right)^{\gamma-1} = \alpha$$

$$N_g^I = \left(\frac{\gamma\omega}{\alpha}\right)^{\frac{1}{1-\gamma}}$$

This result is a Nash equilibrium in which no hotel is willing to change its management practices given other hotels' decisions. Below equilibrium, all hotels are willing to be green, whereas in the equilibrium, a non-green hotel has no incentive to become green.

It is simple to show that this equilibrium does not maximize collective profits. The number of green hotels that maximize the sum of profits results from the following maximization problem:

$$\max_{N_g} N\,\omega(\phi)^{\gamma} - N_g\alpha$$

$$N_g^C = N^{\frac{1}{1-\gamma}}\left(\frac{\gamma\omega}{\alpha}\right)^{\frac{1}{1-\gamma}}$$

It is clear that $N_g^I < N_g^C$, which is the typical common pool resources problem. Environmental quality is non-excludable because both green and non-green hotels reap the price premium from environmental quality but the costs of green management are borne only by green hotels. This effect leads to the under-adoption of green practices in the hotel sector.

We now show how TOs can mitigate this problem. Let us assume that commercialisation is made by S<N TOs, each in charge of selling to the final demand a proportional share of the total accommodation supply of the destination. Let us further assume that the TOs can impose green management on hotels (maybe because they are vertically integrated). Thus, TOs have incentives to impose green management practices among hotels to an extent determined by the following maximization problem:

$$\max_{N_{g,i}} \frac{N}{S} \omega(\phi)^{\gamma} - N_{g,i}\alpha$$

where *i*=1,…,S, and it is assumed that TOs fully reap the price premium from environmental quality and bear the cost of hotels' becoming green. The number of green hotels is then the following:

$$N_g^{TO} = \left(\frac{N}{S}\right)^{\frac{1}{1-\gamma}} \left(\frac{\gamma\omega}{\alpha}\right)^{\frac{1}{1-\gamma}}$$

It is thus easy to see that,

$$N_g^I < N_g^{TO} < N_g^C$$

Except for the case of a single TO, externalities remain between TOs that result in some under-adoption of green management. However, adopting green management in a setting with TOs is closer to the level that maximizes overall profits than in a decentralized setting. Therefore, TOs can help foster green management in a tourism destination. This general result holds without regard for the number of TOs, provided that there are fewer TOs than hotels. Therefore, we now make the simplifying assumption that there is only one TO[78].

## 5.4 SETTING INCENTIVE SCHEMES FOR THE PROMOTION OF GREEN MANAGEMENT IN A MODEL OF INVESTMENT AND BOUNDED RATIONALITY

In reality, TOs cannot impose green management, but they can set incentives for hotels to change their management practices. Specifically, by sharing the price premium for environmental quality with hotels, a TO can steer hotels to adopt green practices to a desired level. How this strategy is implemented and its results will depend on our behavioural assumptions regarding the implied economic agents. Thus, in many destinations, the accommodation supply is dominated by MSEs (Jones & Haven-Tang, 2005) that are far from being perfectly informed fully rational agents. Considering this situation, we assume that hotels in the model are bounded rational. Thus, hotels have a limited ability to process all the information that they need to make rational choices, and, as a consequence, they use rules of thumb and shortcuts to make decisions (Simon, 1957).

The case of TOs is different because they typically constitute large companies with precise information about both tourism demand and supply. Therefore, we retain the assumptions of full information and rationality for TOs. As is shown below, this new approach leads us to reinterpret the problem as an investment decision by the TO[79]. Specifically, we modify our assumptions along the following lines:

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[78] If $\left(\frac{\gamma\omega}{\alpha}\right)^{\frac{1}{1-\gamma}} \leq N$, then a corner solution is reached where $N_g^I = N_g^C = N_g^{TO} = N$.

[79] Another possible extension might be to maintain the primary assumptions on rationality and information and develop a game-theoretical bargaining model. This step would imply that the Rubinstein bargaining model (Rubinstein, 1982) should be applied to our setting. This application is not straightforward because Rubinstein's model applies to a two-player game. Some extensions of the Rubinstein bargaining model have been made for multi-player settings (see Huang, 2002), but they cannot be directly applied to the TO–hotels type of relationship that we consider in this paper.

- The first sense in which hotels are considered to be bounded rational considers that, because of information costs, hotels are not able to either calculate the marginal effect of their individual decisions on the environmental quality of the destination or determine the effect on revenues of an environmental quality improvement.

  A corollary of this interpretation stipulates that an incentive scheme based on sharing the environmental quality price premium with all (green and non-green) hotels cannot affect the behaviour of the hotels in the market in any way because they are not aware of their own capacity to increase the price premium by becoming green. In that case, hotels take the price premium as given and are thus indifferent between green or conventional management.

  Thus, a different incentive scheme that establishes a difference between the payoffs of green and non-green hotels is required to affect the behaviour of bonded rational hotels. This scheme is achieved when only green hotels receive a payment from the TO. This payment, which we call *h,* is received each period provided that the hotel undertakes green management. This payment can be interpreted as the share of the environmental quality price premium that is received by green hotels.

  Given this payment, a hotel is willing to become green if and only if the payoff from this strategy is at least as large as the payoff from continuing with non-green management.

- A second implication of the bounded rationality of hotels is the organisational inertia that (we assume) impedes green management adoption. This inertia may come from uncertainty about the consequences of adopting green management. Uncertain costs associated with green management may come, for instance, from workers' resistance to changing work habits. Revenues from green management may also be deemed to be uncertain by the hotel manager if they are conditioned on realising the resulting environmental price premium, which the hotel cannot adequately foresee, as discussed above. Therefore, because a hotel's decision to shift to green management is not governed by a fully informed calculation of pros and cons, we opt to model the entire population of hotels using linear replicator dynamics as follows instead of modelling the individual behaviour of hotels. Under this assumption, during each period, only a fraction of the hotels that undertake the lowest payoff strategy change to the highest payoff strategy[80].

- A third and final implication of the hotels' bounded rationality is that we assume that they do not act strategically and are myopic in the sense that they only care about the immediate consequences of their decision regarding green management. However, the TO is assumed to be forward-looking. We also assume that the TO is willing to bear all the costs necessary for hotels to become green, which can be justified by the existence of agency problems. If hotels take charge of the greening process, they have private information as to what extent and with what effectiveness they have greened their management. Therefore, they may have incentives to cheat the TO, which might allow them to avoid the cost of changing their management and still receive the payment from the TO. To prevent this behaviour, we assume that the TO assumes direct control of the greening process of those hotels that decide to become green.

- Finally, for purposes of public policy analysis, we assume that the government in the tourism destination is willing to promote green management by hotels. With this objective, the government provides a subsidy ($g$) to those hotels that undertake green management[81].

Given these assumptions, hotels' behaviour regarding green management is determined by the following expression:

$$\dot{S}_g = \mu * (h + g) \qquad (1)$$

[80] In the literature, a slow adjustment to profit-maximizing behaviour is commonly assumed in different settings such as evolutionary economics models (Blanco et al., 2009), natural resource management (Rondeau & Bulte, 2007) or microeconomic models of production (Howroyd & Rickard, 1981; Szidarovsky & Yen, 1995).

[81] An incentive for the local government not to leave the promotion of green management entirely in the hands of the TO is that the environmental quality may have sources of value that are not taken into account in the tourism market. These sources include the valuation of environmental quality by residents.

where $S_g=N_g/N$ is the fraction of green hotels and a dot indicates the rate of change over time. The term $h+g$ is the profit differential between green and non-green hotels and $\mu$ ($\mu > 0$) is a parameter that indicates how fast the population of hotels responds to profit differentials.

The TO is represented as a forward-looking profit-maximizing agent whose profits per unit of time are the following:

$$N\omega {S_g}^{\gamma} - NS_g h - \alpha\left(N\dot{S}_g\right)^2 \quad (2)$$

where the first term represents revenues attributable to the environmental quality of the destination. For convenience and without loss of comparability to the previous section, we have assumed that the TOs' revenues depend on the share of green firms instead of the number of green firms, that is,

$$\phi = N_g,\ P_{\phi} = \omega S_g^{\gamma} \quad (3)$$

The second term in expression (2) represents the payments made by the TO to hotels to induce them to adopt green management. As discussed above, these payments are made only to those hotels that are green. The third term is the cost of greening hotels' management practices. These costs are incurred only during those periods when a hotel changes its management practices[82]. Thus, it depends on the rate of change of $S_g$. For a given period, if only one hotel becomes green, the incurred cost is $\alpha$, as in the previous section[83]. However, the marginal costs for the TO are assumed to increase with the number of hotels that become green contemporaneously.

[82] The inclusion of period by period operational costs associated with green management would add little to our results.

[83] It can be easily shown that, for a constant $N$, $\alpha\left(N\dot{S}_g\right)^2 = \alpha\left(\dot{N}_g\right)^2$, and the cost of greening is thus $\alpha$ when $\dot{N}_g = 1$.

The TO's decision consists of choosing a stream of values for $h$ to maximize the discounted value of the sum of the TO's profits through its time horizon, which is assumed to be infinite, expressed as the following:

$$\left.\begin{array}{c} \max_h F = \int_0^{\infty} e^{-rt} \left[ N\omega({S_g}^{\gamma}) - NhS_g - \alpha * (N\dot{S}_g)^2 \right] dt \\ \text{Subject to:} \\ \dot{S}_g = \mu * (h + g) \end{array}\right\} \quad (4)$$

where $r$ is the market interest rate. As such, the problem is framed as an investment decision by the TO. In essence, the TO is investing in natural capital (environmental quality) through the indirect mechanism of inducing hotels to adopt green management. Thus, the decision variable $h$ can be interpreted as an investment rate, the state variable, $S_g$, can be interpreted as the stock of capital and, therefore, $\dot{S}_g$ can be interpreted as an investment rate. Through this lens, the last term in expression (2) represents investment costs, for which a quadratic form is assumed. The quadratic form of investment costs has been used in many previous studies (Szidarovsky & Yen, 1995; Wang & Wen, 2012; De Santis et al., 2004; Candela & Cellini, 2006) and links our model to the standard Tobin's Q investment model.

## 5.5 EQUILIBRIUM ANALYSIS

To solve the problem of the TO, we treat it as an optimal control problem. With this aim, we first show the Hamiltonian of (4):

$$H = N\omega(S_g)^{\gamma} - NhS_g - \alpha[N\mu(h+g)]^2 + q[\mu(h+g)]$$

where "q" represents the shadow value for the TO that is generated by one additional hotel deciding to be "green". This shadow value corresponds to the discounted future stream of environmental price premiums generated by this new green hotel less the discounted future stream of payments, $h$, made to this hotel by the TO.

Then, the maximum principle conditions (Chiang, 1992) are the following:

$$\frac{\partial H}{\partial h} = -NS_g - 2\,\alpha(N\mu)^2(h+g) + q\mu = 0 \qquad (5)$$

$$\frac{\partial H}{\partial S_g} = N\omega\gamma(S_g)^{\gamma-1} - Nh = rq - \dot{q} \qquad (6)$$

$$\frac{\partial H}{\partial q} = \mu(h+g) = \dot{S}g \qquad (7)$$

and the transversality condition (Chiang, 1992) is the following:

$$\lim_{t\to\infty} e^{-rt}\,S_g = 0 \qquad (8)$$

From (5), we can obtain the value of "q":

$$q = \left[\frac{1}{\mu}\right]\left[NS_g + 2\alpha(N\mu)^2(h+g)\right] \quad (5A)$$

Taking the derivative with respect to time, the expression (5A) can be expressed as the following:

$$\dot{q} = \left[\frac{1}{\mu}\right]\left[N\dot{S_g} + 2\alpha(N\mu)^2(\dot{h})\right] \quad (5B)$$

From (6) and (5A),

$$N\omega\gamma(S_g)^{\gamma-1} - Nh = \frac{rNSg}{\mu} + 2\alpha\mu rN^2(h+g) - \dot{q} \qquad (9A)$$

Rearranging the previous equation,

$$\dot{q} \;=\; -N\omega\gamma\left(S_g\right)^{\gamma-1} + Nh + \frac{rNSg}{\mu} + \; 2\alpha\mu r N^2(h+g) \qquad (9B)$$

From (9B) and (7) in (5B),

$$\dot{h} = \frac{r}{2N\alpha\mu^2}\; Sg - \; \frac{\omega\gamma}{2N\alpha\mu} S_g^{\gamma-1} + rh + \frac{2Nr\alpha\mu - 1}{2N\alpha\mu}\; g \;\; (10)$$

Finally, considering (7), (10) and the relationship between $S_g$ and $P_\phi$ implied in (3), the solution of the TO problem is the dynamic system:

$$\dot{h} = \frac{r}{2N\alpha\mu^2}\left(\frac{P_\phi}{\omega}\right)^{\frac{1}{\gamma}} - \; \frac{\omega\gamma}{2N\alpha\mu}\left(\frac{\omega}{P_\phi}\right)^{\frac{1-\gamma}{\gamma}} + rh + \frac{2Nr\alpha\mu - 1}{2N\alpha\mu}\; g \;\; (11)$$

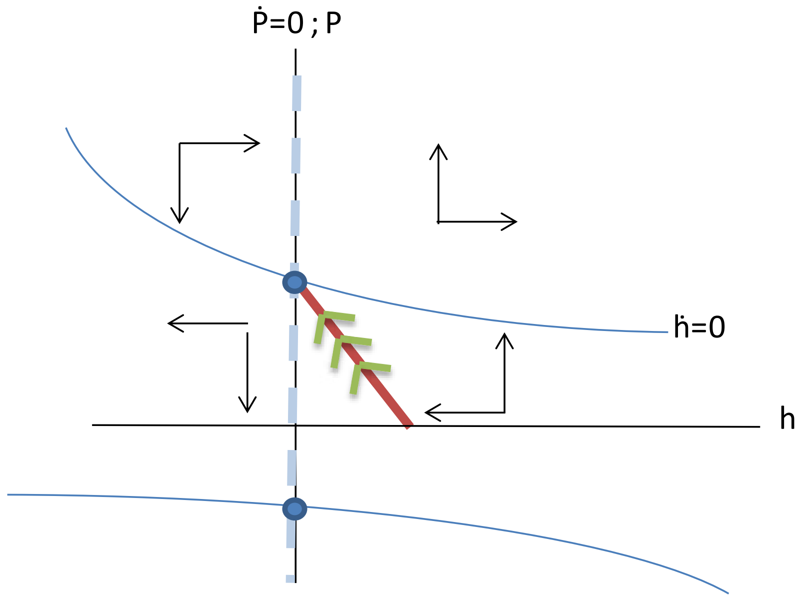
$$\dot{P_\phi} \;=\; \gamma\mu(h+g) * (\omega)^{\frac{1}{\gamma}} * \left[\frac{1}{P_\phi{}^{\left(\frac{1-\gamma}{\gamma}\right)}}\right] \qquad (12)$$

plus the transversality condition in (8).

We now consider the case in which there is no government intervention and leave the policy analysis for section 5.7. For the case when $g$ = 0, the dynamic system is represented in the following phase diagram:

**FIGURE N° 5.1**

**PHASE DIAGRAM WITHOUT PUBLIC INTERVENTION**




This phase diagram shows that most of the trajectories lead to corner equilibriums where the share of green hotels is either one (and the price premium therefore reaches $P_{\phi max}$) or zero (and the price premium is also zero). The only interior equilibrium is saddle-path stable, that is, there is only one trajectory (the stable arm) that drives the system to this equilibrium. This trajectory is the only trajectory that satisfies the transversality condition in (8), so it will be taken as the solution to the TO's problem[84].

The scenario we consider to be more interesting is that in which the TO, in an initial context without green management, implements an incentive scheme to promote green management among hotels at the destination. We are particularly interested in the trajectory that converges to the saddle-path steady state from below, taking as its initial point the location where this

[84] There are more intuitive arguments to rule out the trajectories that lead to corner solutions. For instance, the trajectories that lead to the $P\phi max$ cannot be optimal because once $P\phi max$ is reached, it is better to reduce $h$ to zero. But this alternative trajectory implies a discontinuity (a jump from $h>0$ to $h$=0) that is not consistent with the dynamic equation for $h$ and therefore cannot be optimal.

trajectory crosses the horizontal axis (the solid line with arrows in Figure N° 5.1). In the (saddle-path) steady state,

$$\dot{P}_{\phi} = 0 \rightarrow h^{*} = 0 \qquad (15)$$

$$\dot{h} = 0 \rightarrow h = \frac{\omega\gamma}{2N\alpha\mu r}\left(\frac{\omega}{P_{\phi}}\right)^{\frac{1-\gamma}{\gamma}} - \frac{1}{2N\alpha\mu^{2}}\left(\frac{P_{\phi}}{\omega}\right)^{\frac{1}{\gamma}} \quad (16)$$

Therefore, from (15) and (16),

$$P_{\phi}^{*} = \left(\frac{\gamma\mu\omega^{\frac{2}{\gamma}}}{r}\right)^{\frac{\gamma}{2-\gamma}} \rightarrow s_{g}^{*} = \phi^{*} = \left(\frac{\gamma\mu\omega}{r}\right)^{\frac{1}{2-\gamma}} \qquad (17)$$

where a star indicates the steady state level.

The interpretation of this trajectory and the corresponding steady state is as follows. To induce green management among the destination's hotels, the TO must initially share the environmental price premium with the accommodation suppliers, which means that $h$ is initially positive. An $h$ just slightly larger than zero would suffice to induce some hotels to adopt green practices. However, the speed of adoption positively depends on the size of $h$ and, given the discount factor, the TO has some interest in speeding up the process. However, this interest is counterbalanced by the increasing marginal cost function, which advises a slow pace.

As the share of green hotels increases, the size of $h$ gradually adjusts to its long-run equilibrium level. A positive $h$ is needed to induce a change to green management, but not to maintain green management practices once they have been adopted by the hotel[85]. Therefore,

[85] Notice that if we assume the existence of operative costs for green management borne by the hotels, a positive $h$ at least equal to these costs is required to avoid incentives to abandon green practices.

in the steady state, in which the share of green hotels is constant, $h$ is zero and, therefore, the TO fully appropriates the environmental quality price premium.

Environmental quality and the environmental price premium also increase in the path to the long-run equilibrium. In this equilibrium, both variables adopt a positive value, which indicates that the TO has managed to improve the environmental quality of the destination. In this way, the TO mitigates the hotel's coordination problem regarding management of the environmental CPR[86].

As shown in expression (17), this improvement negatively depends on the interest rate, which reflects the opportunity cost of the TO's "investment" in the destination's environmental quality. The improvement depends positively on the parameters of the price premium function $\omega$ and $\gamma$ because a larger value for any of these parameters reflects a higher willingness to pay for environmental quality by the tourism demand. Therefore, a larger $\omega$ or $\gamma$ makes investing in the destination's environmental quality more profitable. Finally, this improvement positively depends on $\mu$, which reflects organisational inertia in the hotel sector. Thus, the smaller that $\mu$ is, the larger the organisational inertia and the larger $h$ must be to induce a given change in managerial practices among the hotels' population. A small value of $\mu$ then makes investing in the destination's environmental quality less attractive for the TO because it requires a larger transfer of the price premium to the hotel sector.

## 5.6 SHARING THE ENVIRONMENTAL PRICE PREMIUM

In the previous section, we showed that the TO fully appropriates the environmental price premium in the long run equilibrium[87]. This appropriation occurs because once the steady

[86] Of course, there can be scenarios in which the saddle path equilibrium does not exist. In this case, the TO has no incentive to invest in the environmental quality of the destination; therefore, it will not contribute to improving CPR management.

[87] In the case where operative costs exist for green management, the TO would appropriate the environmental price premium minus the operative costs.

state is reached, the TO no longer desires further change in the share of green hotels. Therefore, the TO no longer has an incentive to produce differences in the payoffs for green and non-green hotels, and so it sets an $h$ equal to zero. Because we assume that the TO is a foreign firm whereas the hotels are locally owned, it might be said that the destination does not participate in the yield of the hotels' green management in the long run.

However, the destination does participate if we consider the entire time horizon. In fact, the TO must relinquish part of the price premium in the transition to the steady state to induce green management by the hotels. How this price premium is shared between the TO and the destination, considering the entire time horizon, is addressed in this section.

To address this question, the discounted sum of environmental price premiums (SUMP) and the discounted sum of payments by the TO to the hotels (SUMH) are calculated using a common discount factor[88], $r$. The ratio of the latter over the former (SHARE) is obtained as a measure of the participation of the destination in the tourism market value of the environmental improvements induced by the adoption of green management. That is,

$$SHARE = \frac{SUMH}{SUMP}$$

A sensitivity analysis is conducted to explore how this sharing depends on the parameter values of the model. For purposes of the simulations, we consider the following baseline scenario:

- alpha=1
- gamma=0.25
- mu=0.25
- rho=0.1

[88] For simplicity, we assume that the hotels and the tour operator have the same discount rate, but these rates may not be identical in reality.

- ω=0.5

In the following figures, from Figure N° 5.2 to Figure N° 5.5, the left-hand graph plots the total value of the discounted sum of environmental price premiums, SUMP, and the discounted sum of payments received by the hotels, SUMH. The graph in the middle shows the share of the price premium that accrues to the destination, considering the entire time horizon, SHARE. Finally, the graph on the right-hand side shows the equilibrium share of hotels with "green" management (Sg).

**FIGURE N° 5.2**

**SENSITIVITY ANALYSIS OF "*ω*"**

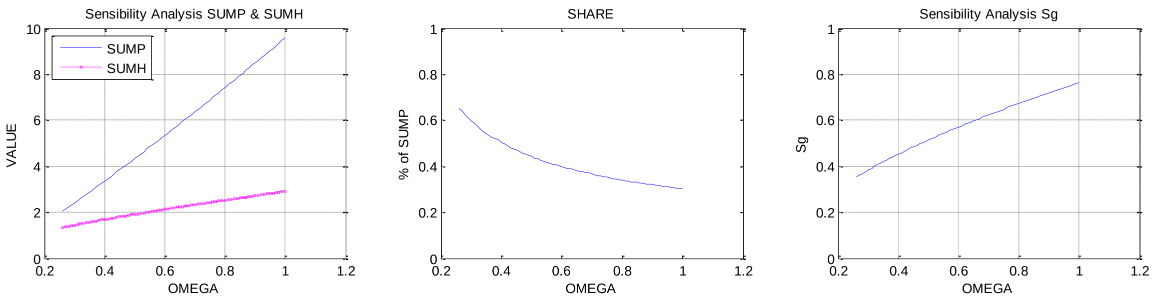
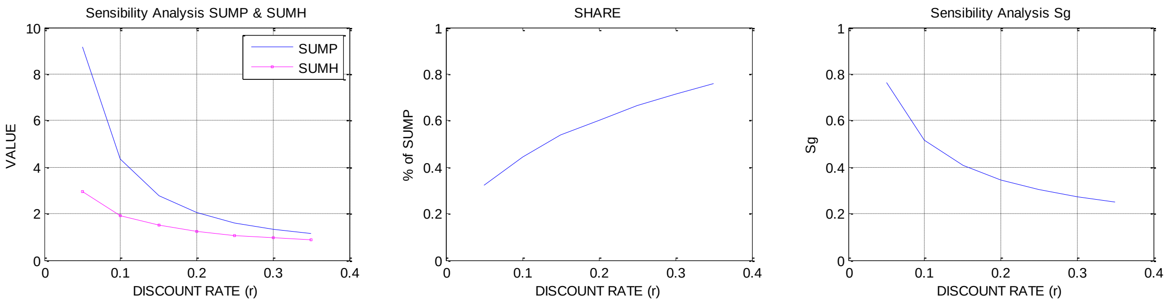



Figure N° 5.2 considers how these variables depend on the level of ω. A higher ω reflects a higher willingness to pay for environmental quality in the destination and makes the promotion of green management among the destination's hotels more attractive. Therefore, the TO is willing to offer higher financial incentives to promote green practices, and these incentives are reflected in the positive slope of SUMH. As a consequence, more hotels adopt green management (positive slope of $S_g$) and larger price premiums are produced (positive slope of SUMP). It is important to note that although SUMH increases with ω, it represents a lower share of the discounted sum of the price premium (SUMP) as ω increases.

**FIGURE N° 5.3**

**SENSITIVITY ANALYSIS OF "*r*"**



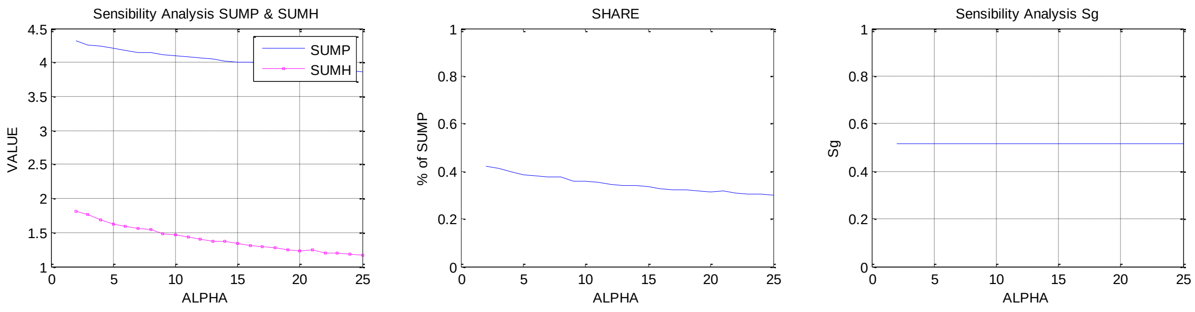

Increases in $r$ imply a larger opportunity cost from investing in the destination's environmental quality. As a consequence, the TO, as shown in Figure N° 5.3, provides lower financial incentives to adopt green management (negative slope of SUMH), which results in a smaller share of green hotels (negative slope of $S_g$) and lower price premiums (negative slope of SUMP).

However, a larger $r$ also implies that the future is more heavily discounted. Because the time profiles of $P_\phi$ and $h$ are, respectively, increasing and decreasing[89], a larger $r$ gives more weight to those periods in which $h$ is relatively large compared with $P_\phi$ (the present) and less weight to the periods when $h$ is relatively small compared with $P_\phi$ (the future). This weighting helps explain why SUMH is less sensitive to changes in $r$ than SUMP and, therefore, why SHARE is increasing in $r$.

[89] See Figure N° 5.1.

**FIGURE N° 5.4**

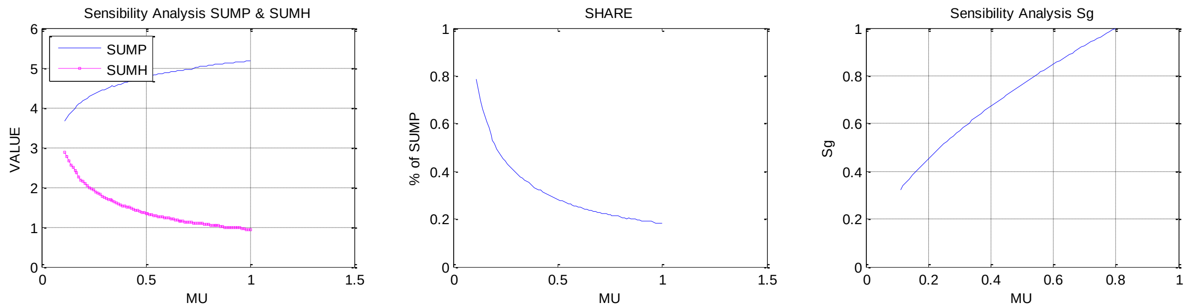
**SENSITIVITY ANALYSIS OF "$\alpha$"**




The parameter $\alpha$, which is the cost of greening a hotel's management, affects the speed of adoption of green management because this cost is increasing with the number of hotels that change management at a given moment in time. A higher $\alpha$ makes speed more costly and therefore slows down the greening of the hotel sector. As shown in the right-hand graph of Figure N° 5.4, the value of $\alpha$ does not affect the degree of adoption of green management in the long run. Therefore, a higher $\alpha$ just leads the TO to reduce the gradient of the time path of $h$ to achieve a slower convergence to an unchanged equilibrium. A higher $\alpha$ then implies lowering the early-in-time values of h and P$\phi$ and increasing the late-in-time values of h and P$\phi$, which gives way to the negative slopes of SUMH and SUMP because of discounting.

**FIGURE N° 5.5**

**SENSITIVITY ANALYSIS OF "$\mu$"**




As for parameter $\mu$, an increase in this parameter implies lower organisational inertia in the hotel sector and, therefore, greater willingness to change to green management practices as a response to the economic incentives provided by the TO. Therefore, the TO can achieve a given target in terms of green management implementation by providing lower economic incentives to hotels, which is reflected in the negative slope of SUMH in Figure N° 5.5. Simultaneously, the TO also has incentives to stimulate green management to a larger extent because this option is less costly from the TO's perspective. These incentives explain the positive slope of SUMP and the graph on the right-hand side. Both behaviours together explain why a higher value of $\mu$ results in the destination's lower participation in the environmental price premium.

## 5.7 ANALYSIS OF GOVERNMENT INTERVENTION

To consider the possible government subsidisation of hotels' adopting green management, the steady state of the model developed in section 5.4 and solved in section 5.5 is the following:

$$\dot{P}_{\phi} = 0 \rightarrow h^{*} = -g \quad (18)$$

$$\dot{h} = 0 \quad \rightarrow \quad h = \frac{1-2N\alpha\mu r}{2N\alpha\mu r}\, g + \frac{\omega\gamma}{2N\alpha\mu r}\left(\frac{\omega}{P_\phi}\right)^{\frac{1-\gamma}{\gamma}} - \frac{1}{2N\alpha\mu^2}\left(\frac{P_\phi}{\omega}\right)^{\frac{1}{\gamma}} \quad (19)$$

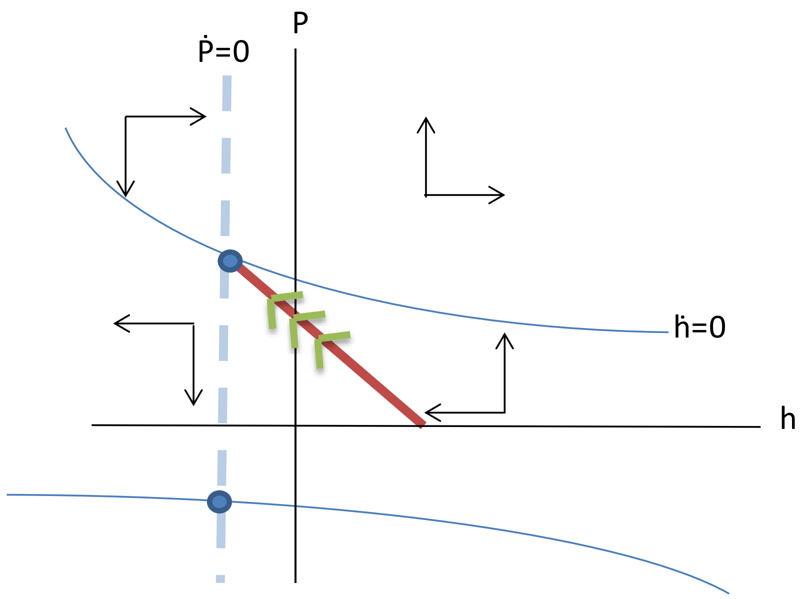
and therefore,

$$\frac{r}{\mu}\left(\frac{P_\phi^*}{\omega}\right)^{\frac{1}{\gamma}} - \frac{\gamma\,(\omega)^{\frac{1}{\gamma}}}{P_\phi{}^{*\frac{1-\gamma}{\gamma}}} = g \quad (20)$$

With a positive $g$, the phase diagram is as shown in Figure N° 5.6:

**FIGURE N° 5.6**

**PHASE DIAGRAM UNDER PUBLIC INTERVENTION**



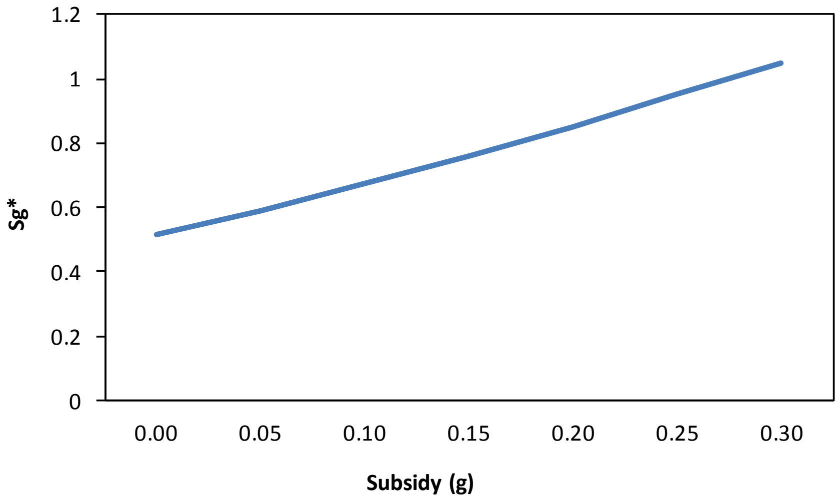

This phase diagram demonstrates that the steady state value of $h$ is negative, which indicates that the price for accommodation services received from the TO by green hotels is lower than the price earned by non-green hotels by an amount equal to $h$. Despite this result, both types of hotels receive identical revenues for accommodation services because the negative $h$ is exactly compensated for by the government's subsidy.

This finding has implications for how revenues are shared in the steady state. To address revenue sharing, we assume the perspective that a single item is to be shared, i.e., the sum of the environmental price premium ($P_{\phi}$) and the subsidy ($g$). Considering only the steady state, we obtain the same result as in the model without government intervention, with the TO reaping all the revenues (now from the market and from the government) that stem from green management in the destination. However, this result implies that the destination is making a net transfer (by means of a negative $h$) to the foreign TO that is equal to the subsidy (see expression 18). Thus, despite being paid to the hotels, the subsidy ultimately goes into the hands of the TO.

However, the picture changes when we consider the entire time horizon. To show this, we first take notice of the positive relationship between the steady state values of $g$ and $P_{\phi}$ (and, consequently, between $g$ and $S_g$), which can easily be verified in expression (20). This relationship is shown in Figure N° 5.7, where it can be seen that a government subsidy manages to foster green management.

**FIGURE N° 5.7**

**SENSITIVITY ANALYSIS OF "*G*" AND "$S_G$"**




From this relationship, it can be inferred that the TO is not willing to capture the entire amount of the subsidy during the transition but is willing to let the hotels share some of it: in this way, the hotels have more incentive to adopt green management. Put a different way, the subsidy makes the promotion of green management less costly from the point of view of the TO, and it is thus willing to allow for stronger incentives for the greening of hotels' management.

The consequences for sharing revenues that stem from green management are revealed in Figure N° 5.8 and summarized in Table N° 5.1.

First, consistent with Figure N° 5.7, the discounted value of revenues produced by green management, SUMP, increases with the subsidy. Then, because SUMH is decreasing with the government subsidy, it can be inferred that the TO benefits from a higher *g* because it obtains the difference between SUMP and SUMH.

Second, the greening of hotel management is compensated through two revenue sources, namely, *h* and *g*. The discounted value of the sum of both, SUMHG in Figure N° 5.8, is increasing, and the hotel sector thus also benefits from the subsidy.

Finally, when considering the destination as a whole, the subsidy is just a net transfer between residents and, therefore, the relevant variable for this analysis is SUMH. SUMH decreases as the subsidy increases, which implies a negative financial effect from the subsidy on the destination or, put in a different way, a net financial transfer to the TO. The extent to which this transfer is compensated for by the positive externalities of the improved environmental quality on the destination is beyond the scope of this paper.

**FIGURE N° 5.8**

**SENSITIVITY ANALYSIS OF "G" AND THE PRESENT VALUE OF "H" AND WTP**

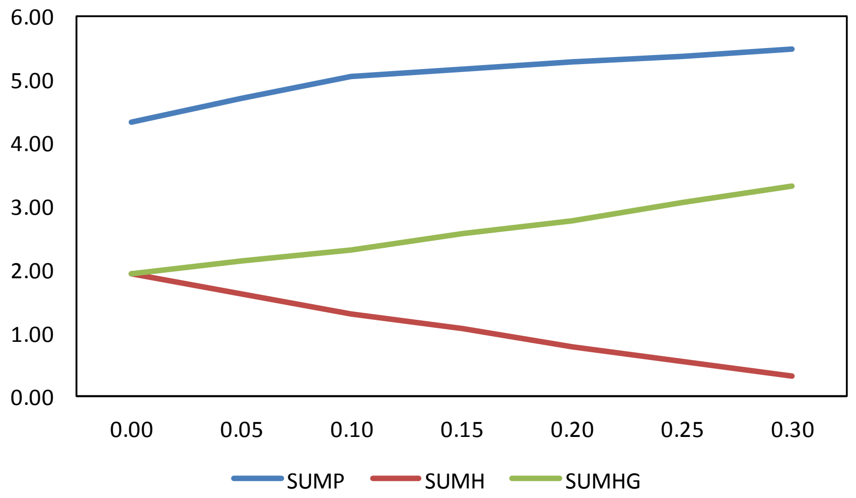


**TABLE N° 5.1**

**CONSEQUENCES OF THE GOVERNMENT SUBSIDY ON THE DISCOUNTED SUM OF REVENUES**

| FOREIGN TOUR OPERATOR | LOCAL HOTELS | DESTINATION (HOTELS+GOVERNMENT) |
|---|---|---|
| ↑ | ↑ | ↓ |

## 5.8 CONCLUSION

In a context in which sustainable practices in tourism are assuming increasing importance, an analysis of the incentives of tourism firms to "green" their management is even more necessary since this sector is distinct because of the environmental externalities that exist among producers (Calveras, 2003; Calveras & Vera-Hernández, 2005). These externalities often result from the use of common pool resources (Healy, 1994; Briassoulis, 2002; Blanco et al., 2009; Blanco, 2011).

The academic literature recognizes tour operators (TO) as one of the primary stakeholders interested in promoting sustainability in tourism destinations. Given their central position in the tourism supply chain, TOs can influence the development of sustainable practices in destinations. Although this greening role of TOs is recognized, little has been researched to date on the means by which tour operators can promote efficient sustainable practices. In fact, Calveras & Vera-Hernández (2005) have provided the only paper that addresses this issue in an economic theoretical framework.

Our paper goes beyond Calveras & Vera-Hernández (2005) in establishing the subject matter in a dynamic framework in which differences in information endowment and processing capabilities between TOs and hotels are accounted for. In a stripped-down version of the model, we first show how TOs can contribute to better CPR management in a tourism destination. We also show that the management of these CPR is closer to the social optimum when the number of TOs is lower.

The complete version of the model can characterize the dynamics of green management adoption by the hotels of a tourism destination induced by a TO by sharing the price premium resulting from green management. We show how the degree of adoption of green management in the dynamic equilibrium depends on the parameters of the model. Thus, a lower interest rate, a higher willingness to pay for environmental quality by the tourism demand and lower organisational inertia in the hotel sector will, according to our results, result in more green management in the long run.

One result of the model is that the TO fully appropriates the environmental quality price premium in the long run. However, this appropriation is not the case when the sharing of the price premium is evaluated over the entire time horizon. The TO must share the environmental price premium with the hotels to induce a shift to green management up to the desired long-run level. Through numerical simulations, we are able to analyse the sensitivity with respect to the models' parameters of the discounted sum of price premiums and its sharing between the TO and the tourism destination's hotels. It can generally be said that the share of the environmental price premium that the TO must transfer to the hotels to induce the desired level of green management is non-negligible and, in some scenarios, may be considerable.

We finally consider a local government that subsidizes green management adoption by paying hotels directly. In the long-run equilibrium, the subsidy manages to promote green management, but it is fully appropriated by the TO. A different picture is obtained when considering the entire time path though numerical simulations, in which it is revealed that the government subsidy is shared among the TO and the hotels during the transition to the steady state. In fact, this sharing is necessary for the subsidy to induce further green management. However, if we take the reasonable assumption that the TO is a foreign agent and the hotels are domestic agents (from the perspective of the tourism destination), these numerical simulations show that the government subsidy implies a transfer abroad. It is beyond the scope of this paper to analyse to what extent this transfer is compensated for by the alleviation of environmental external costs from the hotel sector suffered by other residents.

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# 5.10APPENDIXES

## APPENDIX N° 5.1
## STABILITY CONDITIONS

A steady state of the system (11), (12) is locally asymptotically stable when the determinant of the Jacobian evaluated at that equilibrium has a positive value while the trace is negative. It is locally asymptotically unstable when both the determinant and the trace are positive, whereas it is a saddle-point when the determinant is negative. Through linearization we obtain a system whose Jacobian is the following:

$$J_{11} = \frac{\partial \dot{h}}{\partial h} = r$$

$$J_{12} = \frac{\partial \dot{h}}{\partial P_{\phi}^{*}} = \frac{r}{2N\gamma\alpha\mu^{2}}\left(\frac{P_{\phi}^{*}}{\omega}\right)^{\frac{1}{\gamma}}\frac{1}{P_{\phi}^{*}} + \frac{\omega(1-\gamma)}{2N\alpha\mu}\left(\frac{\omega}{P_{\phi}^{*}}\right)^{\frac{1-\gamma}{\gamma}}\frac{1}{P_{\phi}^{*}}$$

$$J_{21} = \frac{\partial \dot{P_{\phi}}}{\partial h} = \gamma\mu\omega^{\frac{1}{\gamma}}\frac{1}{P_{\phi}^{*\frac{1-\gamma}{\gamma}}}$$

$$J_{22} = \frac{\partial \dot{P_{\phi}}}{\partial P_{\phi}} = 0$$

where a star indicates a steady state value. From mere inspection, it is clear that the determinant of the Jacobian is negative and, therefore, the steady state is saddle-path.

# CONCLUSIONS OF THE THESIS

The relationship between the tourism sector and MSW has been, up to now, the object of little research. This is puzzling, as tourism is an important contributor to MSW in tourism destinations. Also, tourism destination image and competitiveness hinge on environmental quality in general and on MSW management in particular. This thesis contributes to this scant research field with four essays that, from different angles and different methodologies, tackle the relationship between tourism and MSW.

Novel contributions are made with regard to the analysis of three aspects of this relationship. First, the quantitative analysis of the role of tourism as a determinant of MSW generation. Second, the challenges of tourism to MSWM systems in tourism destinations, with an emphasis on Mallorca. Third, the theoretical analysis of the incentives of tourism firms to carry out environmentally friendly waste management. The thesis makes empirical contributions to the understanding of the relationship between per capita income and MSW generation and methodological contributions in the econometric treatment of the STIRPAT model.

As already explained in the introduction, the thesis has been designed as four self-contained pieces of research. Hence, Chapters 2 to 5 each contain a final section devoted to the description of the conclusions and policy implications derived from its research topic. The remaining of the conclusions brings together the main findings of each chapter.

Chapter 2 uses the framework of the EKC hypothesis to analyze the relationship between MSW generation, per capita income and tourism. The results support the EKC hypothesis for a panel of 32 European countries during the period 1997-2010 and the existence of a significant effect of tourism on MSW generation. Thus, the inclusion of tourism variables affects key EKC's characteristics, which may lead us to think that the omission of tourism variables has produced an overestimation of the impact of economic growth on MSW in previous research.

The estimations give the expected results in terms of the sign and statistical significance of the coefficients related to per capita income (GDPPC), which confirms the quadratic formulation of the Environmental Kuznets Curve; however, the results showed a high turning point. Furthermore, we found that the elasticity of total MSW generation with respect to GDPPC is positive and lower than one, a result that is consistent with previous research on MSW generation.

A new aspect of this research is the consideration of the non-linear effects of the tourism variables on MSW generation. We found that the volume of tourism has a positive coefficient for the linear term and a negative coefficient for the quadratic term. Therefore, tourism inflows exert a significant upward pressure on MSW generation, up to a turning point where more tourism arrivals contribute to lowering MSW. This non-linear effect on MSW generation may have two specific causes. On the one hand, there is a scale effect since more tourism inflows implies more tourists per resident and therefore, more MSW per resident. On the other hand, a counterbalancing technological effect seems to take place that may be the result of changes in the characteristics of tourism firms that accompany the increase in tourism inflows in a destination.

With regard to the relationship between tourism quality and MSW generation, the expenditure per tourist index (TUREXPIND) shows both a negative linear term and a positive quadratic term. This implies that higher expenditure per tourist reduces MSW generation up to a turning point beyond which MSW generation increases with regard to higher quality. This result may again be the outcome of counterbalancing drivers where higher expenditure per tourist leads to higher material consumption per tourist and, therefore, larger amounts of MSW but it also entails more sophisticated preferences and, therefore, a greener demand that stimulates the adoption of green management by tourism suppliers. Further research is needed to understand why the interaction of these drivers gives place to a ‘U’, instead of an inverted ‘U’ relationship.

Finally, the empirical results show the relevance of the weight of tourism in total economic activity for the generation of MSW. The econometric evidence reveals that for the average values of the tourist variables, a greater weight of tourism on total economic activity leads to a greater intercept (greater generation of MSW) in the relationship between per capita income and EKC. This reflects the fact that tourism tends to produce more MSW than other productive activities. Moreover, the effect on MSW generation of the volume and quality of tourism may differ depending on the degree of tourism specialization. Thus, for highly specialized countries, the turning point in the relationship between tourism arrivals and MSW generation is located at relatively low levels of the former variable, whereas this relationship is increasing in a quasi-linear way for the other countries. As to the effect of the quality of tourism on MSW, we find differences between those countries with the lowest level of tourism specialization compared to the other countries, where those with low levels of specialization show the lowest turning point.

The main objective of Chapter 3 is to highlight the challenges, practices and alternative solutions for MSWM systems in tourism destinations which have special features compared to conventional urban cities. Moreover, this chapter looks forward to providing the basis for further research in the development of suitable alternatives on sustainable MSWM in tourism destinations. This is done through a case study centred on Mallorca, one of the main European tourism destinations.

The MSWM system in Mallorca reached a turning point in 1990 when public authorities decided to close 45 landfills in the island and shift to a system based on five transfer stations, a treatment system based on recycling facilities for sorted waste and an energy recovery system for non-sorted MSW. The main goal of Mallorca's current MSWM policy is to minimize environmental impacts by reducing MSW generation and setting up MSW treatment through an accurate integral system.

Even though energy recovery systems seem to be a suitable environmental alternative to tourism destinations with land scarcity like Mallorca, some particular characteristics of the

MSWM system should be taken into account in order to assess the sustainability of the system:

- As MSW sorting cannot be fully controlled by public authorities in Mallorca due to the high costs of supervision, municipalities do not have enough information about MSW volume and composition by different kinds of generators, which is important knowledge for MSW planning.

- Tourism seasonality generates a big challenge for MSW management in the destination since the size of MSW treatment facilities must be adapted to absorb MSW generation during the high season, implying over-capacity during the low season. We estimate that the financial cost of over-capacity amounts to 9,9 millions of Euros per year.

- As the main objective of the MSWM system is to reduce MSW generation, the analysis of economic incentives shows that nowadays municipalities in Mallorca do not generate enough economic incentives for waste minimization, neither for residents nor for the tourism businesses. Furthermore, the MSWM system does not seem to give enough incentives to the municipalities to change their behaviour since current methodologies are much easier and cheaper to manage.

- In a region such as Mallorca, hotels and tourism related business have an important impact on MSW generation and sorting. However, business organizations seem to have less importance than citizens for MSW treatment strategies. Therefore, MSW minimization strategies need to involve an assessment of the importance of tourism businesses as relevant stakeholders in strategic actions.

Thus, waste minimization will continue to be one of the major challenges for tourism destinations such as Mallorca. The development of a strategic integrated MSWM plan to achieve waste minimization at the source in tourism economies should be a long-term exercise that involves proper incentives to promote attitudinal changes in tourists, residents and business. Further research should focus on three main areas: (i) as there are no surveys related to waste generation and composition by generators, the analysis of alternative information sources for municipalities is important since knowledge regarding economic drivers of MSW generation by generator is needed to develop accurate public policies; (ii) the analysis of incentives in tourism businesses to develop MSW minimization practices; and (iii) the development of an alternative disposal fee system that generates incentives according to the 'polluter pays principle' (PPP) in tourist destinations.

As has been highlighted in the previous paragraph, the case study of Mallorca reveals the need for information about the drivers of MSW generation in tourism destinations. This motivates Chapter 4, which uses the STIRPAT model to assess the role of tourism inflows to Mallorca on MSW generation. This chapter also complements Chapter 2 in its broader aim to empirically account for the effect of tourism on MSW generation.

In the academic literature, the STIRPAT model has attempted to measure the effect of population growth on a given environmental variable. STIRPAT models traditionally focus on industrial regions. However, we show their usefulness in analyzing regions that specialize in tourism. Thus, one contribution of this research is the inclusion of the non-resident population (tourists) in this model. Another contribution is the use of a stochastic system of equations based on the STIRPAT. This formulation corrects a problem of stochastic explanatory variables, and by this means, the biased results of some previous STIRPAT studies are avoided.

The results support the IPAT hypothesis for Mallorca and show that tourism and local population do have statistical significance in the explanation of MSW generation. Specifically, it shows that an increase of 1% on tourist arrivals would generate a 1.25% increase in MSW generation. Moreover, an increase of tourism expenditure by 1% in the destination would lead to an increase of MSW generation of 0.51%. Furthermore, the estimations also show the potential of the improvement of environmental outcomes without harming tourism revenues by means of the elasticity of substitution (trade-off) between low and high income tourists until reaching a threshold of 2.45%.

Following the recommendations from the case study in Chapter 3, Chapter 5 uses a theoretical perspective to analyze the incentives for tourism firms to develop MSW minimization practices. Specifically, it tackles the neglected topic of the role of TOs in providing the adequate incentives for the implementation of green practices in a tourism destination.

Thus, Chapter 5 develops a model where the typical tragedy of the commons arises among hotels in a tourism destination due to the use of a common pool resource. It is assumed that there are differences in information endowment and processing capabilities between TOs and hotels. The model shows how the TOs can contribute to a better management of CPRs in a tourism destination. It also shows that the management of these CPRs is closer to the social optimum when there are a lower number of TOs.

The model is able to characterize the dynamics of green management adoption by the hotels induced by the TO through the sharing of the price premium resulting from green management. It is demonstrated that, in the long run, the TO fully appropriates the environmental quality price premium. However, this is not the case when the sharing of the price premium is evaluated for the whole time horizon, since TO needs to share the environmental price premium with the hotels to achieve the desired long run level.

Another important result from the model is the analysis of public intervention which is made by the local government through a subsidy for the adoption of green management by hotels. The results show that in the long run equilibrium, the subsidy induces further green management but is fully appropriated by the TO. However, considering the whole time path, during the transition to the steady state, the government subsidy is shared between the TO and the hotels. Nevertheless, if we make the reasonable assumption that, from the perspective of the tourism destination, the TO is a foreign agent and the hotels are domestic agents, the existence of a government subsidy implies a transfer of resources abroad.

In conclusion, the analysis in this thesis has opened a path to identify a number of issues that should be explored in future research. First, it is important to work on models and technologies to reduce the costs of monitoring and measurement regarding MSW generation and composition. In this way, it will be possible to increase relevant information to promote minimization policies. Second, it is important to explore in detail the dynamic channels through which improvements in waste management can be fostered by agents in the tourism supply chain and how these mechanisms evolve according to different market or power structures. Finally, it is important to improve knowledge about the relationship between seasonality in tourism and MSWM.