DOI: http://dx.doi.org/10.11606/issn.1984-4867.v26i1p4-20

The Use of Tourism Demand Models in the Estimation of the Impact of Climate Change on Tourism

La Utilización de Modelos de Demanda Turística en la Estimación de los Impactos del Cambio Climático en el Turismo

O Uso de Modelos de Demanda Turística na Estimação dos Impactos da Mudança Climática sobre o Turismo

Jaume Rosselló[1]
Aon Waqas[2]

Abstract

With the increasing interest in evaluating the consequences of climate change on tourism, part of the literature on tourism demand modelling has tried to integrate climate and weather factors into the estimation of tourism demand models. This study analyses how the effects of climate change on tourism flows have been evaluated using these models by discussing the theoretical background behind each one of the three perspectives considered in the literature: time series, choice models and aggregated models. Despite the differences in methodological considerations, results suggest a similar map on major affected destinations.

Keywords*:* climate change; tourism demand models; choice models; time series; aggregated models.

Resumo

Com o crescente interesse em avaliar as consequências da mudança climática no turismo, parte da literatura tem tentado integrar fatores climáticos à estimação de modelos de demanda turística. Este estudo analisa como os efeitos da mudança climática sobre os fluxos turísticos têm sido avaliados utilizando modelos de demanda turística, discutindo os fundamentos teóricos por trás de cada uma das três perspectivas consideradas na literatura: séries temporais, modelos de escolha e modelos agregados. Apesar das diferenças metodológicas, os resultados sugerem um panorama similar entre os destinos mais afetados.

Palavras-chave: *mudança climática; modelagem da demanda turística; modelos de escolha; séries temporais; modelos agregados.*

[1] Associate Professor in the Departmentof Applied Economics at the Universitat de les Illes Balears. Phd in Economics. Spain. E-mail: jrossello@uib.es
[2] Departament of Management Sciences of the Institute of Management Sciences of Peshawar, Pakistan. Phd candidate at the Universitat de les IllesBalears. Spain. E-mail: aon_waqas@yahoo.com

Resumen

Con el creciente interés en la evaluación de las consecuencias del cambio climático sobre el turismo, parte de la literatura ha tratado de integrar factores de clima en la estimación de modelos de demanda de turismo. Este estudio analiza de qué manera los efectos del cambio climático en los flujos turísticos se han evaluado a partir de modelos de demanda de turismo, discutiéndose los fundamentos teóricos detrás de cada uno de los tres puntos de vista considerados en la literatura: series de tiempo, modelos de elección y modelos agregados. Apesar de las diferencias metodológicas, los resultados sugieren un panorama similar entre los destinos más afectados.

Palabras-clave: *cambio climático; modelaje de la demanda turística; modelos de elección; series de tiempo; modelos agregados.*

1. Introduction

Climate on Earth will change in unexpected manners over the 21st century (SOLOMON et al., 2007). Direct effects of this change include rise in temperature, change in precipitation regime, among others; while indirect effects include loss of snow cover, rise in sea level, changes in natural resources availability and many others. It is expected that both direct and indirect effects will affect tourism patterns. Tourist destinations are giving much importance to the consequences of global warming. They are cautious not only about forecasting tourism demand, but also to the measures to tackle these effects (MAGNAN et al., 2013).

Literature have gradually compensated for the relatively limited attention that climate change impact research paid to tourism during the 1990s. During the last years, different approaches projecting future trends of tourism in scenarios of global warming have been developed (CÁRDENAS, ROSSELLÓ, 2008; ROSSELLÓ-NADAL, 2014). On the one hand, it is possible to focus attention on measuring destination's attractiveness for tourists from a physical point of view by analyzing, for instance, snow coverage (SCOTT et al., 2006) or evaluating suitable tourism climate conditions through the use of Tourism Climate Indexes (AMELUNG, NICHOLLS, VINER, 2007). Although both alternatives can provide a quick, easy and objective view about the relationship between climate conditions and tourism attractiveness, they cannot provide a quantitative measure of climate change's impact on tourism in what regards economy or tourist flows.

On the other hand, there are tourism demand models constructed for statistical analysis of tourist behavior as a function of climate. Within this approach, it is possible to show the relationship between climate conditions and tourist movements from three points of view: time series, choice models and aggregated models. Gössling et al. (2012) recently highlights the difficulty of analyzing tourist perceptions and reactions to the impacts of climate change for anticipating the growth or decline of a specific tourism market and the seasonal shift in tourism demand. They argue that tourism is distinguished with a large adaptive ability and also that this ability needs a combination with other uncertainties concerning the implementation of future mitigation policies. Moreover, climate change consequences hits transportation system seriously and, as a consequence, the tourism activity of a certain area might be affected badly. So, all these types of consequences have a big impact on society and also on economic development.

Bigano, Hamilton and Tol (2006) argue that tourism demand is uncertain since determinants such as disposable income, time budget for holidays and travel costs are difficult to project in the long run. This problem is intrinsic in all predictions. Smaller scale studies that examine demand from a single country could be extended to include such aspects, if data were available. Then it would be possible to develop scenarios that examine changes in disposable income, leisure time or in increases in the costs of mobility. According to Gössling and Hall (2006), tourism demand models do not capture a wide range of aspects that are likely to influence results in the context of evaluating climate change impacts on tourism flows. For instance, databases used for modeling do not differentiate between business and leisure tourists or those tourists travelling to visit friends and relatives, with each of these groups having substantially different travel behaviors and elasticity of demand. There is also uncertainty about the role of other weather parameters such as rain, storms, air pollution or humidity, the effects of weather extremes, the information process in decision-making, perceptions of other non-climatic parameters (e.g. perceived travel risks), fuzzy variables, and the complexity of travel behavior.

Regardless of the debate over the flaws of statistical models in forecasting visitor flows in the context of climate change (GÖSSLING, HALL, 2006), outcomes of this literature should be contextualized under the *ceteris paribus* clause. In economics and other sciences, the *ceteris paribus* clause means to analyze the variable that one wishes to study as all other variables remain constant. This expression is not used clearly in other sciences; however essential methods or formalisms are often used. For example, when partial derivatives are considered, the rate of changes of one variable regarding another one is estimated, that's why the *ceteris* *paribus* clause is implicit whereas it is assumed that the remaining variables stay unaffected. Analysis is simplified because it is almost impossible to examine the impact on each and every variable included in the whole system. By repeating this method again and again, differentiating each variable clearly and also examining one variable at a time will simplify the whole process, allowing the understanding of complex phenomena. The method also allows for the examination of difficult phenomena as well as for its description.

The problem arising from the application of the clause is relevant to interpretations of the result. Meanwhile, in the short-run, the estimation of a tourism demand model along with the assessment of one single shock can create direct forecasts of the tourism demand variable (i.e. the evaluation of the monetary disaster on tourism flow). However, the case is totally different when long-term variables, such as climate, are taken into consideration. The forecast using this type of variable will have a totally different interpretation; moreover, it is taken as general projection more willingly than real forecast.

The disregard of tourism in the literature of climate change highlighted the exclusion of climate determinants inside tourism demand models since the turn of the century (GOH, 2012). In the revision of Crouch (1994), only a few papers had included climate or weather as determining variables, and, on many occasions, with limited success. A feasible justification for this exclusion would be connected to the interest of researchers and planners in income elasticity and/or price elasticity with the intention of forecasting tourism demand in an accurate way – the main concern for services industry through comparatively high fix cost – or, otherwise, with the purpose of evaluating the consequences of tax or exchange-rate policy. This shows why tourism demand literature has been dominated by time series model as well as commonly related to forecasting issues (SONG, LI, 2008). Therefore, because climate is a comparatively stable determinant, climate variables does not have the required variability, moreover, it is not correlated by the determining variable, so no bias in estimated elasticity is expected.

In spite of this, there is need for looking forward toward the consequences of climate change on future tourism demand, because this will help not only in planning strategic infrastructure but also in identifying business opportunities most effectively. Therefore, a number of studies on tourism demand modeling evaluated climate change effects on tourism quantitatively over the last years. This study aims to comprehend all these studies and come up with a consistent model, well established and most generally recognized. For this reason, most of the statistical methods used in the previous studies are summarized and assessed. The paper, thus, aims to show how each of the previous studies solves the problem and what its conclusions are. Moreover, because many of these studies are analyzed for the first time, there is space for revealing limitations and advantages related to each statistical method.

This paper is organized as follows. Section two presents the theoretical background of tourism demand models, common for different perspectives. Section 3 analyses the use of time series models. Section 4 presents the use of discrete choice models in evaluating climate change impact on tourism. Section 5 evaluates the application of aggregated tourism demand models with emphasis in cross section data. Finally, in Section 6 the conclusions are presented.

2. Tourism Demand Models: underpinnings

One of the most popular adaptations of the consumer theory for tourism demand is presented in Morley (1992). From this adaptation, and in the context of climate change, it can be assumed that a tourist derives individual utility from visits to different destinations as well as from the consumption of a vector of other goods. Analytically, the utility function can be represented as

$$U_{iJt} = f\left(N_{iJt}, Q_{it}, ZO_i, ZD_J, X_{IJt}\right) \tag{1}$$

where U_{iJt} is the utility of an individual from the origin *i* visiting a destination *J* during period *t*; N_{iJt} is the number of visits by an individual from origin *i* to destination *J* during *t*; Q_{it} is a vector of consumption of other non-tourist goods; ZO_i and ZD_J are vectors of site qualities referred to the origin and destination, respectively; and X_{IJt} is a vector of other variables referred to the origin and to the destination during period *t*. The constraint attached to the choices of a particular destination can be expressed as

$$p_{iJt} N_{iJt} + ®_{it} Q_{it} \leq M_{it} \tag{2}$$

where p_{iJt} represents the cost of visiting destination *J* for a potential tourist from origin *i*during *t*; $®_{it}$ is the price vector of the consumption of non-tourist goods; and M_{it} is the personal income of the potential tourists. The utility's constrained maximization can be solved to find optimum levels of other goods' consumption and the number of trips between any specific origins *i* to any specific destination *J*. Analytically, the problem can be written as:

$$\underset{Q_{it},N_{iJt}}{Max}\, U_{iJt} = f\left(N_{iJt}, Q_{it}, ZO_{it}, ZD_J, X_{IJ}\right)$$

$$subj.\ to \qquad p_{iJt}N_{iJt} + \circledR_{it}Q_{it} = M_{it} \qquad (3)$$

$$N_{iJt} \geq 0,\ Q_{it} \geq 0$$

The problem's solution provides the optimum levels of other goods' consumption (Q^*) and number of trips between any specific origin to any specific destination (N^*) for each potential tourist:

$$\begin{aligned} N^*_{11t} &= n\left(\circledR_{11t}, p_{11t}, M_{1t}, ZO_1, ZD_1, X_{IJt}\right) \\ N^*_{12t} &= n\left(\circledR_{12t}, p_{12t}, M_{1t}, ZO_1, ZD_2, X_{IJt}\right) \\ &\vdots \\ N^*_{KKt} &= n\left(\circledR_{Kt}, p_{K(K-1)t}, M_{Kt}, ZO_K, ZD_K, X_{IJt}\right) \\ Q^*_{it} &= q\left(\circledR_{it}, p_{iJt}, M_{it}, ZO_i, ZD_J, X_{IJt}\right) \end{aligned} \qquad (4)$$

From this solution it is possible to get the indirect utility function for a certain destination *J* from

$$U^{'}_{iJt} = F\left(N^*_{iJt}, Q^*_{it}, ZO^{s'}_i, ZD^{p'}_J, X_{IJt}\right) \qquad (5)$$

However, because of the possibility of corner solutions, utility from equation 5 should be compared with the obtained from not taking the trip to *J* (U^0_{it}). Consequently, the higher utility that a certain potential tourist can get (U^*_{iJt}) comes from the expression:

$$U^*_{iJt} = Max\left[U^{'}_{iJt}, U^0_{it}\right] \qquad (6)$$

Whatever the case, once the individual demands have been determined, it is possible to obtain the aggregated demand through the consideration of all the residents of a particular origin *I* visiting a particular destination *J*.

$$N_{IJt} = \sum_{i \in I} N^{*}_{iJt} \tag{7}$$

Despite the problems related to the aggregation of individual demands (MORLEY, 1995), in line with previous assumptions about the determination of the number of trips for an individual, the number of trips between origin country *I* to destination country *J* during time *t* can be written as:

$$N_{IJt} = F\left(®_{It}, p_{IJt}, M_{It}, ZO_{I}, ZD_{J}, X_{IJt}\right) \tag{8}$$

At this point it is important to highlight how expression (8) is equivalent to the formula used by Li, Song and Witt (2005) when representing the aggregated demand function for tourism. The key point is that this expression can be explored in different ways according to the objectives, as explained over the next sections.

3. Time Series Analysis

Frequently, because of data availability or specific managerial objectives, most econometric analysis of tourism demand have used single equation models referring to a particular destination (or origin) (LIM, 1999). In terms of equation (8), this circumstance entails the loss of dimension *I* (*J* in caseof particular origin), and, frequently, the reduction of the variability of dimension *J* (*I* in caseof a particular origin). In other words, if a significant number of origin-destination pairs is not available, only one dimension can be explored and those variables not affected by this dimension cannot be considered. Thus, as climate conditions at the destination and at the origin are represented in ZO_i and ZD_J, respectively, the consideration of single equation models cannot incorporate the climate conditions as determinants of temporal variability of tourism flows.

However, when time series analysis is concerned, weather (short-term atmosphere condition) can be used as proxy to climate (the mean atmosphere condition of a region). The reason behind this is the possibility to find any short term relationship of tourism demand with an extreme weather event. Thus, Subak et al. (2000) studied extreme weather from November

1994 to October 1995 in UK, and its impact on tourism. They showed that there exist a clear difference in tourism sector in response to winter and summer anomalies. Agnew and Palutikof (2006) further elaborated weather conditions impact on tourism by using monthly data for domestic tourism, as well as annual data for trips abroad and came up with the finding that outbound flows of tourists are sensitive to the preceding year weather variability. However, the domestic tourism flow is sensitive to variability within the year of travel. So, the impact of climate change on tourism is shown clearly by using the anomalously warm year of 1995 in the UK. The warmer the weather in the UK, the larger will be the domestic tourism and duller-than-average conditions (weather) in the year previous to travel seemed to increase trips abroad.

Generally, monthly time series models can capture the long term relationship by using an ARIMA model (ROSSELLÓ-NADAL, RIERA-FONT, CÁRDENAS, 2011), even considering prices and other economic determining variables (ÁLVAREZ-DÍAZ, ROSSELLÓ-NADAL, 2010; ROSSELLÓ, 2011). After capturing the long term relationship, the residual term remains, so the hypothesis is whether short-term extreme weather episodes are related to this residual term. Analytically, the problem can be summarized in terms of a Transfer Function Model:

$$\text{¤}_p(L)N_t = \text{¯}_p(L)a_t + \text{¨}_b(L)X_t \qquad (9)$$

where Nt is the number of tourists at month t; at is the innovation or moving average term; Xt is a set of determinants including weather variables that could influence the number of tourists; $\text{¤}_p(L)$ and $\text{¯}_p(L)$ are the lag operator polynomials for both Nt and at, respectively capturing the cyclical-trend component (the long-term component) of Nt, as is common practice in ARIMA modelling; and $\text{¨}_b(L)$ are the lag operator polynomial (or transfer function) for the weather determining variables, thus assuming that some lag between the observation of weather variables and tourist flows data occur.

The equation above estimates the prediction within sample values that are compared with simulated predictions by means of a scenario of global warming, accordingly affecting the Xt variables. Likewise, Rosselló-Nadal, Riera-Font and Cárdenas (2011) evaluated the British tourist flow with a weather variable and found that different weather variables like temperature, heat waves, air frost days and sunshine duration significantly affects the tourist flow. This study used transfer function methodology; using different simulations they found that 1oC increase in UK average temperature causes a decrease of 1.73% on British outbound flows. That change was not constant during the whole year because at winter time that impact is higher, but there exist non-linear relationships between temperature and tourist flows.

Recent literature has considered a more complex structure. Kulendran and Dwyer (2012) autoregressive conditional heteroskedasticity modelling approach applied to holiday tourism from the U.S., UK, Japan and New Zealand to Australia identified the relationship between climate variables, such as maximum temperature, relative humidity and sunshine hours, and seasonal variations defined as the repetitive movement in demand for holiday tourism around the trend line. It has been shown that considering climate change has definitely improved forecasting. However, the Australian seasonal variation cannot be generalized. On the other hand, Goh (2012) built a tourism model that corrects errors in the previous model, because there was absence of structural change in the estimation using a Tourist Climatic Index as a determining variable. He shows how the climate index is found to have a significant relationship in favor of all analyzed tourism demand series.

In summary, despite the recent success of time series models linking tourism behavior and meteorological data, it should be noted that climate is a long term factor while time series models can only capture short term relationships. Consequently, the ability to project future scenarios in the context of global warming would be limited with the use of these models.

4. Discrete Choice Modelling

Random Utility Models (RUM) can be defined as probabilistic models based on the maximization principle developed in order to analyses the choices of individuals under a set of alternatives. Because true utilities are non-observable data, they are considered random variables and, consequently, the probability for an alternative to be chosen can be defined like the higher utility within a choice set (BEN-AKIVA, LERMAN, 1985). Different RUM can be used in the context of tourism choices. From a methodological point of view, for simplicity not considering the temporal dimension and assuming linear functional form, equation 5 can be transformed in

$$U_{iJ} = \beta_d Y_{iJ}^d + \varepsilon_{iJ} \quad (10)$$

Where β Y_{iJ}^d represents the deterministic portion of the utility received if destination J is visited. Therefore, Y_{iJ}^d is the set of variables containing $N_{iJt}^*, Q_{it}^*, ZO_i^{s'}, ZD_J^{p'}$ and X_{IJt} or, in other words, the observed attributes characterizing the alternatives available to tourists; and βd is the vector of estimated coefficients representing his/her tastes. Finally, the error term εiJ captures the variation in preferences among tourists in the population. As the individual is assumed to visit the destination yielding the greatest utility, the probability PiJ of choosing the J-th alternative is:

$$P_{iJ} = \Pr\left({}_d Y_{iJ}^d + £_{iJ} > {}_d Y_{iK}^d + £_{iK} \right) \forall J \neq K \quad (11)$$

Therefore, households having same socioeconomic and demographic conditions may choose different tourist destinations. On the other hand, besides the issues regarding the utility theory, by using the random utility model it has been commonly known that tourists have diverse tastes and that choosing the final destination is not an independent decision, but the final decision of a set of choices. Likewise, once tourists have determined to go on holiday along the budget and the mode of transport, they decide the destination depending upon their preference as well as the attributes describing the alternatives in the choice set (EUGENIO-MARTIN, 2003).

Tourism stakeholders and marketing analysts have become curious about tourism demand from a microeconomic dimension; hence it is eligible to spot the determinants of target tourism decisions. Nevertheless, electing a destination is known to be the most important step in tourists' decision making, including a large number of variables that have an effect on these decisions (MARCUSSEN, 2011).

Regarding climate change and tourism relationship, Eugenio-Martin and Campos-Soria (2010) studied the relationship between target area's climate and the selection of holidays in that particular area or abroad. The analysis was conducted with the help of a discrete choice model for European households. They showed that the climate in the target area is a significant determinant of holiday destination choices and that the better the climate conditions in the target area, the larger the domestic tourism and vice versa.

By estimating the coefficients of equation (10), they revealed the relationship between climate change and travel decision making, further elaborating the probability of travel abroad and/or domestically. A weak relationship of global warming was found when considering both domestic and foreign travel. A positive relationship exists between the raising of temperature in a specific area and travelling domestically. However, the relationship with travelling abroad is the inverse.

Likewise, Bujosa and Rosselló (2013) studied the impact of climate change on destination choice decisions with reference to seasonal and summer coastal tourism in Spain by using the same methodology explained above. Destinations were categorized by considering travel cost and coastal 'attractors' (temperature and beach-related attributes). The observed pattern of interprovincial domestic trips was modelled, revealing the substitution between temperature and attractiveness in the possibility of a certain area being selected. Using A1FI and B1 climate change scenarios (INTERGOVERNAMENTAL PANEL ON CLIMATE CHANGE, 2000), it has been shown that raise in temperature will clearly benefit the northern part of Spain by mean of frequency of trips; however there will be decrease in southern provinces. During the analysis, the important thing to highlight is that they used a squared term of temperature in order to provide an estimation of highest or lowest ideal temperatures, moreover proving the non-linear linkage between tourism and climate.

5. Aggregated Tourism Demand Models

Recent reviews on tourism demand modelling (LI, SONG, WITT, 2005; LIM, 1999; PENG, SONG, CROUCH, 2014; SONG, LI, 2008) show that most of the studies in tourism demand estimation and forecasting are based on the time series analysis. Time series models include variables with significant short term variability, like prices and income. However, they neglect structural determinants, such as climate, which are expected to be captured by the constant term. The use of time series models by tourism planners can be justified if preference is given to income elasticity and/or price elasticity for forecasting tourism demand in a perfect approach (the main concern for services industry within comparatively high fixed cost) or, instead, for evaluating the consequences of tax or exchange rate policies.

However, if a large set of alternatives is considered, cross sectional aggregated models can be estimated, and the role of structural determinants like climate can be evaluated. The pioneering study of Maddison (2001) used traditional price determinants of tourism demand along with climate variables for modelling choice destination of British tourists. The model allowed measuring the substitution between climate and holiday-expenditure and identifying the 'optimal' climate for generating British tourism due to the introduction of non-linear effects (though a 4th order polynomial). Finally, the results are used to estimate the effects of different climate variables on the various destinations. Likewise, Lise and Tol (2002) find the most favorable temperature for various tourists at destinations by using aggregated data and regression analysis. They showed that OECD tourists have a preference, on average, for the hottest month of the year's temperature, 21oC. If due to climate change the temperature increases, tourists will spend their holidays in other places than they currently do.

With a global perspective, Hamilton, Maddison and Tol (2005a) and Hamilton, Maddison and Tol (2005b) set out what is known as the Hamburg Tourism Model (HTM), consisting of the estimation of two equations for international tourist departures and arrivals for a specific year. Analytically:

$$ln\, A_d = \sim_0 + \sim_1 G_d + \sim_2 T_d + \sim_3 T_d^2 + \sim_4 C_d + \sim_5 \, ln\, Y_d \qquad (12)$$

$$ln \frac{D_o}{P_o} = {}_0 + {}_1 T_o + {}_2 T_o^2 + {}_3 B_o + {}_4 Y_o + {}_5 \, ln\, G_o \qquad (13)$$

where A refers to the total number of arrivals in a country d; D the total number of departures from country O; P the population in thousands; G the area in squared kilometers; T the country's mean yearly temperature for the period 1961-1990 in degrees centigrade; C the length of the coastline in kilometers; Y the country's per capita income; B the number of countries bordering a particular country; and αi and βj parameters to be estimated.

Hamilton, Maddison and Tol (2005a) and Hamilton, Maddison and Tol (2005b) evaluated how climate variables change the comparative appeal of countries by using HTM. They studied the redistribution of tourist arrivals as well as departures as a function of changes in population, per capita income and climate. They came up with the conclusion that in the

ISSN 1984-4867

medium and long term perspectives tourism will grow in absolute terms. However, this growth will be higher in cold countries as compared to warmer ones. This increase will be lower than population and income growth and not evenly distributed. Climate change might also imply that the presently prevailing cluster of international tourists (sun-and-beach lovers from Western Europe) would stay closer to home, leading to a comparatively small drop in total international tourist numbers along with a decrease of total distance travelled. The authors draw attention to that changes due to climate change are expected to be much smaller than those resulting from population and economic growth.

The HTM aggregated model has been criticized in many ways. For overcoming the deficiencies it has been extended by various means. However, these improvements in the model have frequently implied a loss of generalization. Thus, Bigano, Hamilton and Tol (2006) enlarged the HTM by means of considering exchange among domestic and international tourism, at the same time also analyzing tourist expenditure. But tackling these two issues involves the drawback of restricting the sample of countries to be incorporated in the model due to data limitations. For this reason only 45 origin countries travelling to 200 destination countries were considered. Hamilton and Tol (2007) evaluated the impact of climate change on tourism from a local perspective in Germany, the UK and Ireland, derived from various scenarios of climate change regarding the regions under analysis. The study proposed that uneven changes in weather inside countries could lead to locally dissimilar tourist behavior patterns, indicating the need for developing HTM methods on a lower scale than a national one.

Following this need, recent studies of Rosselló and Santana-Gallego (2014) and Tol and Walsh (2012) updated the HTM. They used bilateral tourism flows along with considering the nature of the data dynamics for testing the change in tourism preferences in reference to climate conditions. Despite the complexity in the specifications and estimations, by means of specific projected climatic, population and economic data related to A2, B1 and B2 scenarios, Rosselló and Santana-Gallego (2014) forecasted tourist arrivals for 2080. The results were consistent and similar with their previous study. Accordingly, the study provides more evidence of climate change implications, indicating that the currently dominant international tourism flows from North to South would be weaker.

6. Conclusions

Climate change effect on tourist destinations is a hot issue nowadays. Destinations are willing to analyses what these effects would be, since consequences on tourist demand are important. In spite of the doubts and complexities in assessing expected tourism demand response to global warming, the literature have been trying to solve this problem by taking into consideration the difficulties of controlling the complex nature of tourism demand decisions by turning to the ceteris paribus clause. This study analyses the most relevant statistical models existing in the literature that evaluate quantitatively the effect of climate change on tourism. They are summarized in three categories: time series analysis, microeconomics models and aggregate tourism modelling.

Whatever methodology is used, it is known that global warming is bad news for warmer destinations. Since the search for favorable climate is one of the important issues determining global tourism flows, climate change is not only a threat for warmer destinations, but also for the winter resorts that might lose some of their snow cover. However, it appears that global warming would boost domestic trips, mainly in colder countries. According to revealed preference methods, it can also be good news for seasonality. Moreover, this could be a chance in favor of the industry toward capturing the increase in short breaks travel during non-summer seasons. In any case, further research is encouraged. An additional finding revealed by various approaches is the non-linear relationship between tourism and climate. Specifically, an inverted u-shaped relationship among temperature and tourism demand has been found by means of various perspectives. Therefore, there are optimal climatic conditions for the practice of tourism.

On the other hand, some questions remain. The inverted u-shape can be explained by both the existence of a turning point (destination will be too hot) or by the increase of competitors. Consequently it is not clear if some destinations are too hot or simply they have more substitute destinations. It remains also unknown which are the most climate change sensitive segments and which will be the induced effects of climate change on biodiversity loss, dry episodes, beach transformations, etc.. These appear to be clear gaps in these particular areas of study, showing the need for more research.

Due to the aim of this study, the research findings were limited to quantitative evidences of the relationship between tourism and temperature warming. On the other hand, non-empirical studies could also be applicable because they present appropriate theories, contributing to a broader understanding of future tourism reaction to global warming. This study does not attempt to incorporate the outcomes of all the relevant empirical studies, especially because there might be a number of unpublished studies. However, the studies that are included in this review paper are examined and described comprehensively, resulting in a large set of findings that are fairly comprehensive. The study also provides a useful guide for other researchers and practitioners interested in carrying out similar studies investigating the effects of climate change on tourism. It also answers many questions, like which is the most suitable approach according to the circumstances and objectives of the research being planned. It would be wrong to blindly adopt any approach without first judging its limitations and assumptions. In this regard, this work provides a convenient reference.

References

AGNEW, M. D.; PALUTIKOF, J. P. Impacts of short-term climate variability in the UK on demand for domestic and international tourism. *Climate Research*, v. 31, n. 1, p. 109-120, 2006.

ÁLVAREZ-DÍAZ, M.; ROSSELLÓ-NADAL, J. Forecasting British tourist arrivals in the Balearic Islands using meteorological variables. *Tourism Economics*, v. 16, n. 1, p. 153-168, 2010.

AMELUNG, B.; NICHOLLS, S.; VINER, D. Implications of Global Climate Change for Tourism Flows and Seasonality. *Journal of Travel Research*, v. 45, n. 3, p. 285-296, 2007.

BEN-AKIVA, M.; LERMAN, S. R. *Discrete choice analysis:* theory and application to travel demand. Cambridge, MA: MIT Press, 1985.

BIGANO, A.; HAMILTON, J.; TOL, R. J. The impact of climate on holiday destination choice. *Climatic Change*, v. 76, n. 3-4, p. 389-406, 2006.

BUJOSA, A.; ROSSELLÓ, J. Climate change and summer mass tourism: the case of Spanish domestic tourism. *Climatic Change*, v. 117, n. 1-2, p. 363-375, 2013.

CÁRDENAS, V.; ROSSELLÓ, J. Análisis económico de los impactos del cambio climático en el turismo: estado de la cuestión. *Ekonomiaz*, v. 67, p. 262-283, 2008.

CROUCH, G. I. The study of international tourism demand: a survey of practice. *Journal of Travel Research*, v. 32, n. 4, p. 41-55, 1994.

EUGENIO-MARTIN, J. L. Modelling determinants of tourism demand as a five-stage process: a discrete choice methodological approach. *Tourism and Hospitality Research*, v. 4, n. 4, p. 341-354, 2003.

EUGENIO-MARTIN, J. L.; CAMPOS-SORIA, J. A. Climate in the region of origin and destination choice in outbound tourism demand. *Tourism Management*, v. 31, n. 6, p. 744-753, 2010.

GOH, C. Exploring impact of climate on tourism demand. *Annals of Tourism Research*, v. 39, n. 4, p. 1859-1883, 2012.

GÖSSLING, S.; HALL, C. M. Uncertainties in predicting tourist flows under scenarios of climate change. *Climatic Change*, v. 79, n. 3-4, p. 163-173, 2006.

GÖSSLING, S. et al. Consumer behaviour and demand response of tourists to climate change. *Annals of Tourism Research*, v. 39, n. 1, p. 36-58, 2012.

HAMILTON, J.; TOL, R. J. The impact of climate change on tourism in Germany, the UK and Ireland: a simulation study. *Regional Environmental Change*, v. 7, n. 3, p. 161-172, 2007.

HAMILTON, J. M.; MADDISON, D. J.; TOL, R. S. J. Climate change and international tourism: A simulation study. *Global Environmental Change*, v. 15, n. 3, p. 253-266, 2005a.

HAMILTON, J. M.; MADDISON, D. J.; TOL, R. S. J. Effects of climate change on international tourism. *Climate Research*, v. 29, n. 3, p. 245-254, 2005b.

INTERGOVERNAMENTAL PANEL ON CLIMATE CHANGE. *Special report on emissions scenarios*: a special report of working group III of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2000.

KULENDRAN, N.; DWYER, L. Modeling seasonal variation in tourism flows with climate variables. *Tourism Analysis*, v. 17, n. 2, p. 121-137, 2012.

LI, G.; SONG, H.; WITT, S. F. Recent developments in econometric modeling and forecasting. *Journal of Travel Research*, v. 44, n. 1, p. 82-99, 2005.

LIM, C. A meta-analytic review of international tourism demand. *Journal of Travel Research*, v. 37, n. 3, p. 273-284, 1999.

LISE, W.; TOL, R. J. Impact of climate on tourist demand. *Climatic Change*, v. 55, n. 4, p. 429-449, 2002.

MADDISON, D. In search of warmer climates? The impact of climate change on flows of British tourists. *Climatic Change*, v. 49, n. 1-2, p. 193-208, 2001.

MAGNAN, A. et al. Mediterranean tourism and climate change: Identifying future demand and assessing destinations' vulnerability. In: NAVARRA, A.; TUBIANA, L. (Orgs.). *Regional assessment of climate change in the Mediterranean*. Netherlands: Springer, 2013.

MARCUSSEN, C. H. Understanding destination choices of German travelers. *Tourism Analysis*, v. 16, n. 6, p. 649-662, 2011.

MORLEY, C. L. A microeconomic theory of international tourism demand. *Annals of Tourism Research*, v. 19, n. 2, p. 250-267, 1992.

MORLEY, C. L. Tourism demand: characteristics, segmentation and aggregation. *Tourism Economics*, v. 1, n. 4, p. 315-328, 1995.

PENG, B.; SONG, H.; CROUCH, G. I. A meta-analysis of international tourism demand forecasting and implications for practice. *Tourism Management*, v. 45, p. 181-193, 2014.

ROSSELLÓ-NADAL, J. How to evaluate the effects of climate change on tourism. *Tourism Management*, v. 42, p. 334-340, 2014.

ROSSELLÓ-NADAL, J.; RIERA-FONT, A.; CÁRDENAS, V. The impact of weather variability on British outbound flows. *Climatic Change*, v. 105, n. 1-2, p. 281-292, 2011.

ROSSELLÓ, J. The impact of the NAO index on european airline transit. *Transportation Research Part D: Transport and Environment*, v. 16, p. 183-187, 2011.

ROSSELLÓ, J.; SANTANA-GALLEGO, M. Recent trends in international tourist climate preferences: a revised picture for climatic change scenarios. *Climatic Change*, v. 124, n. 1-2, p. 119-132, 2014.

SCOTT, D. et al. Climate change and the sustainability of ski-based tourism in eastern North America:

a reassessment. *Journal of Sustainable Tourism*, v. 14, n. 4, p. 376-398, 2006.

SOLOMON, S. et al. *Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change*. Cambridge: Cambridge University Press, 2007.

SONG, H.; LI, G. Tourism demand modelling and forecasting: a review of recent research. *Tourism Management*, v. 29, n. 2, p. 203-220, 2008.

SUBAK, S. et al. The impact of the anomalous weather of 1995 on the U.K. economy. *Climatic Change*, v. 44, n. 1-2, p. 1-26, 2000.

TOL, R. S. J.; WALSH, S. The impact of climate on tourist destination choice. *Economic and Social Research Institute (ERSI)*, v. Working paper, n. 423, 2012.

Recebido em: 19/08/2014

Aprovado em: 08/09/2014