Research Paper

Climate change and tourism seasonality

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Abstract: *This study proposes a decomposition-based time series method to assess the relation between tourism seasonality and climate. When applied to two geographically contrasting locations, the results suggest that climate plays a dominant role in shaping the seasonal patterns of visitation, and that the impact of climate variations on visitation varies across seasons and locations. Beyond the methodological contribution of developing a procedure which facilitates the incorporation of the seasonality of the explanatory variable, the findings underscore the importance of a localized approach. The variation across regions indicates that such localized approach could provide more precise and accurate estimates in support of tourism planning, forecasting and decision-making.*

Keywords: Climate change, visitation, seasonality, decomposition

Introduction

Climate change is one of the major environmental issues facing the world today as evidence shows that the global climate has changed compared to the pre-industrial era. According to the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change, 2001; Intergovernmental Panel on Climate Change, 2007), the global average surface temperature has increased by about 1 $^\circ F$ in the past century, with accelerated warming during the past few decades. This warming trend is expected to continue into the 21st century and beyond.

The impact of climate change on tourism is widely recognized (Breiling & Charamza, 1999; Martin, 2005; deFreitas, 2003; Hale & Altalo, 2002) as studies suggest that climate change can influence tourists' destination selection (Hamilton & Lau, 2005; Bigano, Hamilton & Tol, 2006), tourism supply (Amelung, Nicholls & Viner, 2007), and tourism demand (Amelung & Viner, 2006; Scott, Jonesa & Konopeka, 2007). Research shows that a substantive spatial and temporal redistribution of climate resources for tourism is possible as a result of projected climate change in the 21st century. For example, Amelung et al. (2007) found that the seasonal pattern in the Mediterranean is likely to shift from the current summer peak to a two shoulders pattern, while Lise & Tol's 2002 study implies that global warming has the potential to cause the relocation of tourists towards higher latitudes and altitudes.

One challenge for studies that aim at examining the relationship between climate and tourism demand is the lack of an appropriate methodology. Recent attempts to explore the relationship between climate and tourism demand have been limited by methodologies that failed to properly account for climate seasonal patterns. For example, consider Scott et al. (2007) who proposed statistical models of monthly visitation and climate (monthly maximum, minimum, mean temperature, and precipitation) to examine the direct impact of climate change on park visitation using monthly data from 1996-2003. They found a weak relationship between monthly minimum temperature and visitation in the summer peak season (July and August) and a strong relationship in the shoulder season (September to June). However, the strong relationship identified may be biased because it could have been caused by the similar seasonality pattern of climate and tourists visitation.

Similarly, the lack of consideration for the seasonality of the explanatory variables in econometric tourism demand models makes them inapplicable to studies of the impact of climate change. Usually, econometric tourism demand studies apply multivariate analysis methods to model the role of factors such as income, price, and foreign exchange rates (*e.g.*, Song & Witt, 2003; Croes & Vanegas, 2005), adding seasonal indicator variables when demand data exhibit seasonality (Ismail, Iverson & Cai., 2000; Kulendran & Witt, 2003). A major limitation of these models is that their inherent assumption about the constant seasonal pattern of demand is often unsubstantiated. The dynamic nature of the seasonal pattern of both tourism demand and climate conditions is very important and should not be ignored when assessing the impact of climate change on tourism demand.

In their recent attempts to improve the accuracy of forecasting tourism demand, Greenidge (2000), and Witt & Turner (2002), advocated the use of a structural time series model in which time-varying components, including trend, cycle, and seasonality, are decomposed from demand time series, and are then incorporated into an econometric model along with other explanatory variables. While this approach considers the dynamic nature of tourism demand, its major drawback is that it does not accommodate the seasonal patterns of the independent variable(s). This is a considerable weakness when studying the impact of a changing climate because, unlike the traditional economic factors of the tourism demand models, tourism climate resources most often exhibit strong seasonality.

The purpose of this study is therefore to develop a more robust statistical procedure to assess the relation between climate on tourism in destinations where both visitation and climate exhibit unambiguous seasonal patterns. The method is tested using data from two destinations where tourism demand exhibits different seasonal patterns.

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This paper proposes and tests a method to handle multiple seasonal patterns simultaneously. In this section we outline the decomposition procedure we propose, the manner in which the outcome of the decomposition procedure can be used to assess the impact of climate on visitation patterns, and the data used in this study.

Study methods

Our approach is based on the notion that both tourism demand and climate factors can be decomposed into different time varying components (*e.g.,* trend and seasonal) according to the nature of the time series. The relationship between demand and climate is then estimated by using monthly corresponding components. Thus, for monthly data, 12 coefficients are estimated. The use of seasonal components has several advantages. First it allows for the examination of the climate/demand relationship in different seasons. Second, it distinguishes climate impact from the impact of other factors such as income and price. These economic factors don't usually exhibit seasonality and their effects are contained in the trend component. Lastly, the decomposed seasonal components are used to measure how similar the seasonal patterns of tourism demand and climate factors are. The more similar the two patterns, the more significant the climate impact.

The proposed method follows three consecutive stages as follows:

(1) Decomposition of the demand and climate factor series into a stochastic time trend and a stochastic seasonal component. This phase follows Harvey (1989; 1995) as outlined below.

$$y_t = \mu_t + \gamma_t + \varepsilon_t \quad \varepsilon_t \sim i.i.d.N(0,\sigma_\varepsilon^2) \tag{1}$$

where y_t is the original time series. μ_t is the trend component, and γ_t is the seasonal component. ε_t is an identical independent normal distributed variable with a mean of 0 and variance of σ_ε^2. The trend component μ_t is modeled as:

$$Level: \mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \qquad \eta_t \sim i.i.d.N(0,\sigma_\eta^2) \tag{2}$$

$$Slope: \beta_t = \beta_{t-1} + \xi_t \qquad \xi_t \sim i.i.d.N(0,\sigma_\xi^2) \tag{3}$$

Where η_t and ξ_t are the level and slope disturbances respectively, and are uncorrelated. The seasonal component γ_t is modeled as:

$$\gamma_t = \gamma_{t-1} + \ldots + \gamma_{t-s+1} + \omega_t \qquad \omega_t \sim i.i.d.N(0,\sigma_\omega^2) \tag{4}$$

$$\gamma_t = \sum_{j=1}^{[s/2]} \gamma_{j,t} \tag{5}$$

where each $\gamma_{j,t}$ is generated by

$$\gamma_{j,t} = \gamma_{j,t-1} \cos\lambda_j + \gamma^*_{j,t-1} \sin\lambda_j + \omega_{j,t} \tag{6}$$

$$\gamma^*_{j,t} = -\gamma_{j,t-1} \sin\lambda_j + \gamma^*_{j,t-1} \cos\lambda_j + \omega^*_{jt} \quad \text{for } j=1,\ldots,[s/2] \tag{7}$$

where ω_{jt} and ω_{jt}^* are zero mean white-noise processes with a common variance for j=1,…,[s/2]. ω_{jt} is uncorrelated with ω_{jt}.

(2) Assessment of the impact of climate on tourism demand seasonality. We propose that the contribution of climate to visitation seasonality can be assessed by comparing the shape of the climate pattern to that of the visitation seasonal component's pattern. Similar patterns indicate a larger role of climate in shaping the seasonal characteristic of the visitation. Since the two patterns have different units, the seasonal components of visitation and the climate factor must be first standardized.

The similarity of the two patterns is assessed using a Euclidean distance as follows:

$$D = \sqrt{\frac{1}{12}\sum_{i=1}^{12}(\gamma(DEMAND\_SD)_i - \gamma(CLIMATE\_SD)_i)^2} \tag{8}$$

where γ *(DEMAND _SD)* denotes the average standardized decomposed seasonal components of tourism demand; γ *(CLIMATE _SD)* denotes the average standardized decomposed seasonal components of the climate factor; i denotes the month (i=1,…, 12); and *D* denotes the distance between the two time series.

(3) Estimation of the seasonal relationship between climate and tourism demand with seasonal components using univariate regression analysis.

$$\gamma_{in}(DEMAND) = \rho_i \gamma_{in}(CLIMATE) + o_{it} \qquad i=1,\ldots,12;\ n=1,\ldots,N \qquad (8)$$

where γ_{in} denotes the i_{th} month component of year n. N is the number of years in the sample. v_t and o_{jt} are zero mean white-noise processes.

The magnitude and sign of ρ_j gauge the sensitivity of tourism demand to climate variation across the seasons: The higher ρ_j, the larger the impact of climate on tourism demand in month i.

Data

Twenty-seven years (1979-2006) of hourly weather observation data as well as monthly visitation statistics were used in this study to assess the impact of climate change on visitation to two U.S. National Parks: Denali in Alaska, and the Everglades in Florida. Park visitation data were published by the Public Use Statistic Office of the National Park Service (Public Use Statistic Office, 2007). The two national parks, Denali and the Everglades, are popular tourist detonations. In 2008, 432,309 tourists visited Denali and 822,118 visited the Everglades (Public Use Statistic Office, 2009).

Hourly weather observation data were obtained from the National Climate Data Center (National Climate Data Center, 2007). Following the procedure demonstrated in Yu, Schwartz & Walsh (2009), a modified climate index for tourism was constructed. This modified index (MCIT) was designed to integrate multiple weather elements, elements that determine the quality and suitability of weather conditions for pre-defined outdoor tourism activities and it introduced several improvements over previously suggested indices. First the MCIT altered the tourism related climate elements that were used to construct a tourism climate index by adding visibility and significant weather elements such as rain, lightning, hail, and snow, while removing other such as sunshine and clouds. In addition, instead of using a 7 point scale this modified index has employed three categories of unsuitable, marginal and ideal (0, 1, and 2 respectively) conditions, describing each of the sub-indices and the aggregated index. Finally, it used hourly data as oppose to the daily averages used before. It aggregates four sub-indices which use perceived temperature (temperature, relative humidity and wind), visibility, and significant weather data. The use of the 0, 1, 2 scale allows for a more realistic representation of the conditions as it reflects the overriding nature of these weather elements. The aggregated index is set to 0 (that is, unsuitable condition) when any of the four sub-indices shows unsuitable weather condition, and it is set to ideal condition (2) only when all sub-indices are at the ideal level.

Accordingly, this study uses the index to characterize the tourism weather conditions (in terms of suitability for outdoor activities) in the two destinations during the investigated period of 27 years. Given the nature of these two destinations, the index parameters were set to reflect suitability for outdoor sightseeing. In other words, the index combines hourly observations of multiple weather and climate factors to construct an aggregated (across time and factors) measure: the monthly frequencies of ideal conditions for sightseeing by tourists to these two destinations. Data were extracted and aggregated, and the indices were generated according to the rules outlined in Yu et al., (2009) using computer code written in C. The structural time series decomposition was conducted using SAS/ETS 9.1.3 (PROC UCM).

Results

Significance tests of the decomposed components (Table 1) suggest that park visitation in both Denali and the Everglades display strong seasonality. The seasonal component (along with the trend component) plays a significant role in explaining visitation in both parks. The chi-squared value of 335.25 with 11 *df* and a *p* value of 0.00 for Denali indicates that the seasonal component is significant.

The analysis of the stochastic nature of the individual components suggests that Denali's visitation differs from that of the Everglades (Table 1). The estimates of the parameters and their significance levels indicate that the seasonal pattern for Denali is stochastic, since the disturbance variance for the seasonal component is significant at the

Table 1: Decomposition Statistics for Denali AK and Everglades FL National Park Visitation

	Component	**Parameter**	**Estimate**	**Chi-Square**	**R-square**
AK	Level	σ_η^2	901341	122.78**	0.927
	Slope	σ_ξ^2	545	0.11	
	Season	σ_ω^2	1202588**	335.25**	
	Irregular	σ_τ^2	57611437**	0.01	
FL	Level	σ_η^2	59313218**	103.48**	0.775
	Slope	σ_ξ^2	0.06933	13.48	
	Season	σ_ω^2	11547	554.8	
	Irregular	σ_τ^2	122792481**	0.70	

(**) significant at .01 level

0.05% level. The trend component, however, appears to be non-stochastic. In the case of the Everglades, the trend component is stochastic but the seasonal pattern is non-stochastic.

Figures 1 shows the distribution of monthly visitation from Jan 1979 to Dec 2006 along with the decomposed components (trend, seasonal and irregular) for Denali AK. The charts for the individual components confirm the analysis conclusion above that the trend component of Denali's visitation and the seasonal component of the Everglades' visitation are non stochastic and that conversely, the seasonal component of Denali and the trend component of the Everglades are stochastic.

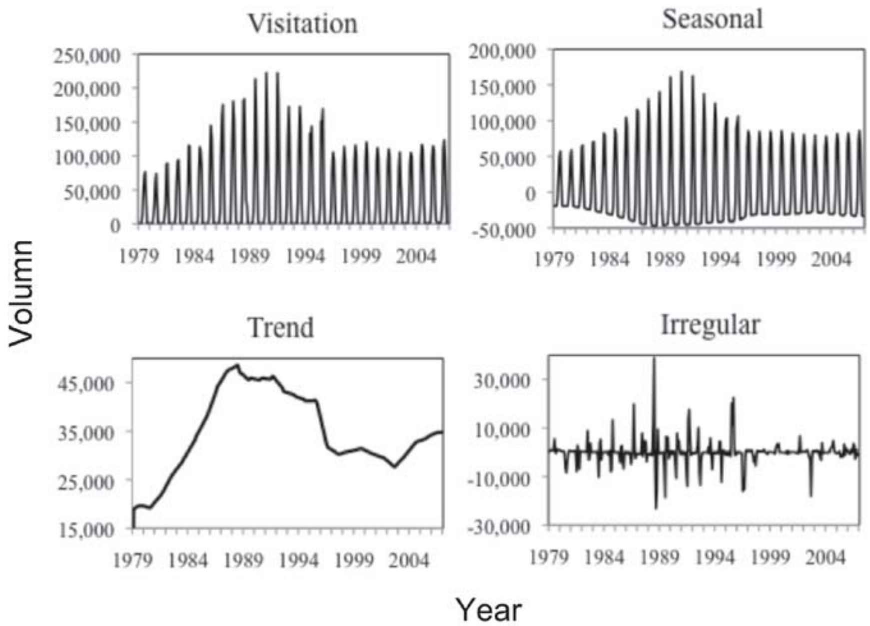

Fig 1. Decomposed Trend, Seasonal, and Irregular Components of Denali AK National Park Visitation.

The decomposition of the climate factor (the frequency of ideal climate conditions for tourism) indicates that similarly to the visitation data, the role of the seasonal component is significant. The seasonal component of the climate factor is non stochastic with *p* value of 0.359 in Denali, but is stochastic in the Everglades with a *p* value of 0.0021. In addition, Denali data exhibit an increasing trend, while the trend component for the Everglades is non-stochastic is decreasing over time.

The Impact of Climate on the Seasonal Patterns of Visitation

Using standardized monthly averages, the seasonal patterns of visitation and the climate factor for Denali and the Everglades are shown in Figure 2. In both destinations, the seasonal visitation patterns are very similar to the climate seasonal patterns. However, the shape of Denali's seasonal visitation pattern is a mirror image of that of the Everglades. Denali's visitation and climate condition patterns both peak in the summer. Conversely, the seasonal pattern for visitation and climate conditions in the Everglades appears to have a summer valley and a winter peak.

The match between Denali's visitation and climate patterns is stronger than that of the Everglades. As shown in Fig. 2, Denali's visitation and climate peak in the summer (June through August) and valley between November and March. In the Everglades there is a slight timing difference between the peaks, but the valleys match very well. The peak for climate conditions in the Everglades is between November and January, while the peak for visitation appears to be around February and March. A Euclidean distance (Equation 8 where zero denotes a perfect match) was used to measure the similarity between the two standardized patterns. The Euclidean distance between the seasonal patterns of visitation and climate is 0.48 for Denali and 0.71 for the Everglades, confirming that visitation and climate seasonal patterns match well in both Denali and the Everglades with Denali scoring slightly better (i.e., a stronger pattern match).

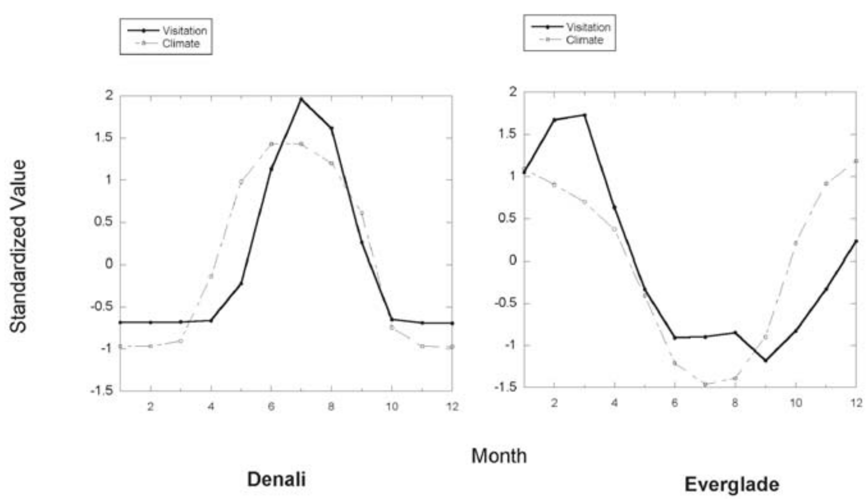

Fig 2. Seasonal Patterns of Park Visitation and Climate Conditions (Standardized Seasonal.

In summary, the findings indicate that climate conditions play a significant role in shaping the seasonality of visitation to both Denali and the Everglades, two national parks that are located in areas that are very different form each other in terms of their climate. The study's finding that the decomposed seasonal patterns of visitation and climate are more similar in Denali than in the Everglades suggests that the impact of climate seasonality on visitation might be larger in northern regions such as Alaska than in southern regions such as Florida.

Seasonal Differences in the Impact of Climate on Park Visitation

Does the impact of climate on park visitation vary across the seasons? Univariate regression analysis is used to answer this question, where the decomposed seasonal component of monthly visitation is the dependent variable, and the decomposed seasonal components of monthly frequencies of ideal climate conditions are the independent variable. The set of regression coefficients, ρ_1, are reported in Table 2. In addition, the coefficients of the univariate regression were estimated with the pre-decomposition data. These coefficient estimates are reported in Table 2 as ρ_2. Note that the interpretation of ρ_1 is somewhat different from ρ_2. Since ρ_2 reflects the relationship between park visitation and climate conditions, it is interpreted in the traditional way: An increase (or decrease if the coefficient is negative) in park visitation due to a 1% improvement in tourism related ideal weather conditions. However, the decomposed seasonal components coefficients do not represent actual visitation figures but rather a relative position in a seasonal cycle. As such, the sign and statistical significance levels are more meaningful than the magnitude.

At Denali National Park, the impact of climate on park visitation varies by season. The variation of ρ_2, the pre-decomposition coefficients relating park visitation and climate condition, across seasons show a clear pattern: the improvement of climate condition for sightseeing increases park visitation during most of the summer season (May through July), but decreases park visitation in the winter. The variation of ρ_1, the vector of coefficients of the decomposed elements, displays a similar pattern: high values in the summer season (June through July) and low value or a negative sign in other seasons. While the relations and patterns, revealed by using the decomposed coefficients, are similar to those shown by the pre-decomposition fitted models, more of the former are statistically significant. This underscores the notion that assessing the relationship between visitation and climate using seasonal decomposed components is more efficient than using the original data.

Table 2 Coefficients of Regression Analysis models: park visitation and climate

	Denali		Everglade	
Month	ρ_1	ρ_2	ρ_1	ρ_2
1	6244	-7	76	-246
2	1989	-217	147 (**)	-315
3	-199	-47	44	-98
4	-4247 (*)	-4	96 (**)	-111
5	4172 (*)	200	-106 (**)	-734 (**)
6	10873 (**)	1155	-78 (*)	-989 (*)
7	134879 (**)	1385	-80 (*)	-1421 (**)
8	4588	73	-251 (**)	494
9	-5944 (*)	47	-21 (**)	176
10	9379 (*)	-21	-2	149
11	4438	-296	276 (**)	833
12	-186	0	-592 (*)	-205

Note:
ρ_1 are the regression coefficients of the decomposed seasonal visitation and climate components model
ρ_2 are the regression coefficients of the actual visitation and climate factor model
(*) significant at .05 level
(**) significant at .01 level

Interpreting the negative relationship (between favorable climate conditions and visitation) is not easy. The plots show that the standardized visitation components fluctuate much more than the climate factor components over time. The climate factor appears to be stable with an increasing trend in all months while the visitation components appear to have different trends in different months. For example, the visitation components exhibit an overall increasing trend in June but a decreasing trend in September. This suggests that in addition to climate, there might be other important factors that affect park visitation patterns, and consequently that the coefficients estimates might be biased. The visitation components in September appear to follow an overall decreasing trend while the frequency of ideal climate conditions exhibits an increasing trend. The omission of important factors that might explain the overall decreasing trend is likely to result in biased estimates. For example, the extremely severe September snowstorm in 1992 might have had a carry-over effect into subsequent Septembers, as tourists were “scared away” from planning

September trips to Denali. It is therefore very likely that the negative coefficient in September is biased.

Finally, the observed impact of climate on visitation in early summer is considerably larger and more significant. It is difficult to detect the impact of a single factor if the data contains effects of other known or unknown factors. A comparison of the plots of the decomposed standardized visitation and climate factors to the pre- decomposition figures in June, indicates that the pre-decomposition data fluctuates more (Fig. 3).

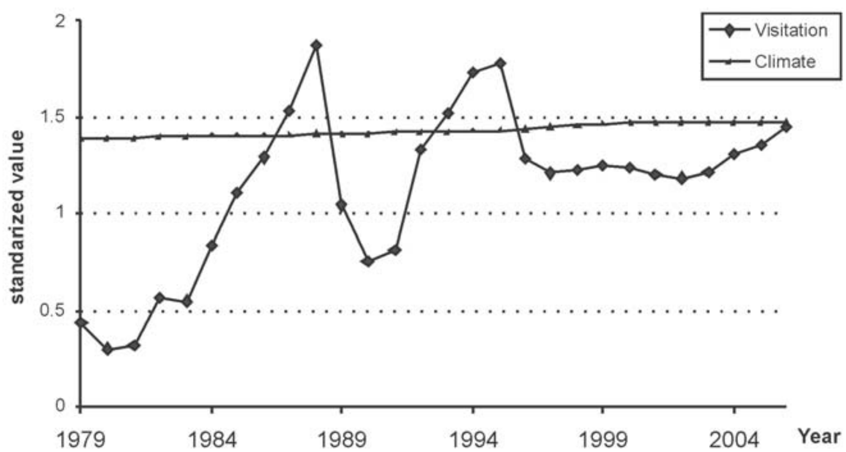

Fig 3. Standardized Visitation and Climate Seasonal Component for June in Denali.

As for the Everglades data, the analysis indicates that the impact of climate on visitation is smaller as the coefficients (positive and negative) are of lesser magnitude. Though the coefficients are significant in most months, compared to a monthly average visitation of 75,593, a change in visitation of around 100 a month has no practical significance. In addition, the variation in (standardized) visitation is very small compared to the variation of climate, implying that visitation is almost constant as it does not change much over time. It indicates while statistically significant the impact of climate and other factors on visitation is small.

Conclusion

This study proposed an innovative method to assess the relationship between tourism demand and climate, both of which display strong seasonality. This new method is based on the notion that both tourism demand and climate factors can be decomposed into different time varying components. Examination of the patterns with decomposed seasonal components facilitates a more efficient separation of climate impact from the impact of other factors.

Application of the proposed methods to two geographically contrasting national parks, Denali and the Everglades, shows that climate plays a dominant role in shaping the visitation seasonal pattern for both destinations. However, there is a difference between these two parks in terms of the impact of climate variations. The seasonal component of park visitation in Denali is stochastic and the correlation between visitation and climate varies with season. The climate impact is only significant in the late spring and early summer season with the largest impact in July. However, the seasonal component of park visitation in the Everglades is non-stochastic, implying no obvious change over time. Thus, the impact of climate on seasonal visitation in the Everglades is small even though the coefficients of the regression analysis are statistically significant in several months.

Our findings suggest that the application of time series decomposition techniques facilitates a more efficient examination of seasonal climate impact on tourism demand by filtering out "noise", and consequently better understanding of the nature of patterns of tourism demand and climate conditions. An analysis of the decomposed trend and seasonal components provides specific information on the change trend and seasonal patterns.

Decomposition of Denali's visitation patterns also shows that the trend component is non stochastic (a cycle pattern) while the seasonal component is stochastic. Given that the seasonal component of the climate pattern is a non-stochastic, monotonic increasing trend, is it likely that there are additional important factors which influence seasonal visitation.

The Everglades visitation trend component is stochastic while the seasonal component is non stochastic. Given the nature of the visitation seasonal pattern, the impact of climate on the seasonal component appears to be negligible. The non stochastic nature of the trend components implies that there are possibly mixed multi-cycles in the trend component and this calls for further exploration. Identification and understanding of the nature of these components can assist in properly assessing the impact of climate on visitation and in forecasting future park visitation.

The contribution of this study is both theoretical and practical. The study pioneers a three stage statistical procedure to assess the impact of climate on tourism demand, a procedure which accounts for both climate and demand seasonality. As such, the study extends the existing tourism demand literature by offering an innovative way to accommodate the unique characteristics of climate/tourism demand relationships where both the dependent and independent variable patterns might have a seasonal component. This timely contribution is of great importance as the scientific community attempts to assess climate change trends and their likely impact on global economic activities.

On the practical side, the study shows that the impact of climate change on tourism demand will be diverse and wide-ranging and will depend upon location. Our analysis of the data from Denali and the Everglades shows that global warming has significant impact on park visitation in May, June and July but its impact on park visitation in the Everglades is inconsequential. Region-specific knowledge about global warming and its relation to visitation could lead to better understanding of who is likely to gain and who is likely to lose because of climate change. This could assist tourism managers to develop adaptation plans in advance so as to minimize the cost or maximize the benefits. Information gleaned in this study, and by applying its methods to other destinations in future studies, could provide valuable support for climate sensitive tourism planning, forecasting and decision-making.

Although tested with only two destinations, the proposed method showed encouraging results. Plans for future research, include extending this analysis to data from additional locations with more diverse climate characteristics and visitation patterns. The long term relationship between tourism demand and climate change will be examined as data become available. More research is needed to explain the puzzling relationship (the negative sign in the univariate regression model) between park visitation and climate in some months. The ultimate goal is to incorporate this better undesrtasind of the relation between climate and tourism demand in tourism forecasts. In other words, plans for future research include using the identified relationship between climate and tourism demand to produce more accurate tourism demand forecasts, especially in regions where drastic climate changes are expected and where tourism demand is likely to be affected.

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