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Weather Variability and the Tourism Industry: A Panel Data Analysis

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ABSTRACT

Increasing weather variability around the world has led to many researchers examining the impacts of weather variability on vulnerable industries. For example, the tourism industry can make up a large portion of an economy's growth, with some of the most dependent countries relying on tourism for over 40% of GDP (World Travel & Tourism Council 2014). In an attempt to better understand the relationship between weather variability and the tourism industry at the country level, this study employs a series of fixed effects panel regression models to analyze the impact of rainfall and temperature on tourism levels and growth rates among 194 countries. Variations of the model allow for the exploration of the differential impacts sustained by island and non-island countries to help determine whether island countries are more vulnerable to weather variations due to the large contribution of tourism to their economies (Uyarra et al. 2005). Results suggest that using a yearly average measure of the temperature and rainfall data does not yield useful results, while using seasonal temperature and seasonal rainfall averages appears to explain the different impacts across island and non-island countries with more consistency.

INTRODUCTION

Tourism is a large and growing economic sector throughout the world (World Tourism Organization UNWTO). It is recognized as a source of employment (Archer 1995; Durbarry 2002), economic growth (Kim et al. 2006; Chou 2013), and income (Dissertation Planet). For some countries, tourism can contribute as much as 22.2% of total employment (Uyarra et al. 2005). It is also closely related to economic growth, with studies showing that the two reinforce one another (Kim et al. 2006; Chou 2013).

As one of the largest and fastest growing economic sectors, tourism often makes significant contributions to a country's GDP. In advanced and developed economies, this contribution ranges from about 2-12% of GDP. In developing economies, tourism contribution averages 40% of GDP. There are also cases, in island countries, where this contribution is as great as 70% of a country's GDP (Ashely et al. 2007). It is this large contribution, relative to a country's size and economic standing, which can categorize a country as being "tourism dependent." Within this paper, tourism dependency is defining cases where tourism makes up a significant portion of a country's GDP. Although there are no distinct estimates for this dependency, it will be assumed that a significant portion of GDP is about 40% or more. In more extreme cases, this contribution could average 70% or more of a country's GDP.

Typically, these tourism dependent countries are island countries, with nine out of ten of the most tourism dependent countries being islands (World Travel & Tourism Council 2014). The Maldives was listed as the second country to be most reliant on tourism. While the Maldives does have a large tourism contribution, the tourism industry is only valued at about $1.03 billion. This can be compared to countries such as China, with a tourism industry valued at $263 billion and the United States with a tourism industry valued at $485 billion. In these advanced economies, however, the large tourism value is paired with a low tourism contribution. This is because the value of the tourism industry is relative to the size of the country's GDP. For larger economies, other industries may generate more wealth, leaving tourism relatively undervalued.

This relative value becomes important as the tourism industry continues to grow globally creating larger contributions and more dependency. As that value increases, it is important to understand which factors may stimulate or depress the industry. Among the many factors that may influence tourism, weather variability is one that has grown increasing attention in the media. Weather variability is commonly measured using patterns of rainfall and temperature, (Business Dictionary). Over the past century, there has been an increase in the annual average global temperature. As the mean has been increasing, variability within these years has also continued to fluctuate, leading to extreme weather events (Davies 2014). At the same time, there has been in increase in the global mean of the number of record-breaking daily rainfall events, meaning more floods and droughts at both extremes. This increase in variability with rainfall is consistent with the rising global temperatures (Lehmann et al. 2015).

When looking at weather variability in the context of the tourism industry, it becomes apparent that weather variability has an important role to play (United Nations Environment Programme). This is likely because often times, tourism activities are directly related to a country's weather conditions (United Nations Environment Programme; Schapiro 1997). For example, island countries tend to showcase warm weather and beaches, which attract a specific group of tourists. Presumably, many tourists would be unwilling to return to these locations, at the same prices, if their weather conditions changed greatly (Uyarra et al. 2005).

There is also the potential for weather variability to help stimulate the tourism industry (Uyarra et al). Haiti is an example that has gained public attention in recent years due a number of disastrous weather events. In 2012, the Government of Haiti created a Strategic Plan for the Development for Haiti which highlighted the potential for the tourism industry to rebuild the economy. In 1995, Haiti had a recorded 145,000 international inbounded tourist arrivals. Over the years this number has more than doubled, reaching 349,000 in 2012 and 465,000 in 2014. Examples such as this show the need to understand the different responses that the tourism industry will have to weather variability over a period of time.

This study will use a series of regression models to study rainfall and temperature patterns throughout the world to understand the impacts that they have on tourism industries. The research also looks into the impact of weather variability on countries that are identified as "island countries", which are likely more tourism dependent (World Travel & Tourism Council 2014).

LITERATURE REVIEW

There has been a large amount of research conducted on the impact of varying weather and climate patterns on different industries. The research has varied in approach and produced a number of results which are relatively inconsistent. This may be due to the varying aspects of tourism studied, looking either short term or long term. The studies have also varied in scope, looking into single industries, countries, or in regions. Researches have also used different combinations of weather variants to measure the changes in weather.

Aylen et al. (2014), takes the narrow approach by examining the effect of daily weather on visits to the Chester Zoo, in Northwest England. These authors examine whether varying weather may have more of an influence on the decision making for short day trips, which often take little pre-planning, as opposed to long trips, which require more planning ahead. Aylen et al. (2014) collect observations of daily admissions of visitors for 32 years, from 1978 to 2010. The weather data is comprised of temperature and rainfall taken from the local UK Met office weather stations at Hawarden and Ness Gardens. Though there are no statistically significant findings, the research does suggest that there is a need to study the short-term and long-term effects of weather variability (Aylen et al. 2014).

While Aylen et al. (2014) don't find any impacts of weather variability, another narrow approach is taken by Beaudin and Huang (2014) who focus their research on the United States and find results which suggest both direct and indirect impacts of weather on the probability of a ski area closing. These authors looking study the ways in which changing weather conditions in New England impact the ski industry, using average daily snow fall and average daily temperature, with winter being defined as November through February. The empirical model is set up with the binary dependent variable being the probability of a ski area closing during a specific year, (1 if closed in year *t*, 0 of it remains open in year *t*). The results from Beaudin and Huang (2014) indicate that an increase in snowfall decreases the probability of a ski area closing, with the indication that the size of a ski resort may also play a significant role.

Shih et al. (2009) study the impact of weather and environmental conditions on the ski industry using maximum temperature, minimum temperature, snowfall, snow depth and wind chill as independent weather variables. The authors observe two ski resorts in northwestern Michigan with the number of daily lift tickets sold per day being used as the dependent variable. Findings suggest, with significance, that as temperatures increase, lift ticket sales decline. Of the weather variables, snow depth is found to be statistically significant in all four regressions that were run. These study and the study conducted by Aylen et al (2014) on the Chester Zoo, both suggest that it is important to look further into the effects of weather variability on different industries, one of which is tourism.

The tourism industry is further explored by Surugiu (2012), who studies the impact of weather variability on the number of domestic tourists in seaside resorts, on the Romanian Black Sea Coast. The variables used to measure changing weather are mean monthly temperature, sunshine hours, and precipitation, observed during the summer season (May-September) from 2002-2007. Surugiu also includes tourist services as a percent of services exports, tourist services as a percent of service imports, consumption price index (2005=100) and Households final consumption expenditure per capita (constant 2000 US$). Results find mean air temperature and sunshine duration to be statistically significant at the 1% and 10% levels, respectively, suggesting that an increase in either mean air temperature or sunshine duration will result in an increase in the domestic tourism demand in seaside resorts, (Surugiu 2012).

The impacts of weather variability on the tourism industry are also examined Goh (2012) by who uses an error correction model to study tourism demand in Hong-Kong, with data ranging from 1987 to 2011. Like Surugiu (2012), Goh (2012) uses temperature, precipitation, and sun to measure weather variability. The dependent variable in the number of tourism arrivals in Hong Kong, from a given origin. The four origins included in this study are China, Japan, United Kingdom, and the United States. These were chosen intentionally so that the dataset would include two “short-haul” markets and two “short-haul” markets. Goh derives a tourism climatic index (TCI) using measurements of precipitation, sunshine duration, wind speed, daily temperature, and daily humidity.

When the TCI is calculated, Goh (2012) uses this as an independent variable for the empirical analysis which measures the impact of an industrial production index, relative cost of living in Hong Kong, relative cost of living in substitute destinations, volume of trade between Hong Kong and origin market, population in origin market and climate (TCI). The study finds a positive and statistically significant relationship between the TCI and tourism arrivals in Hong Kong, for all four origin countries, suggesting that an increase in the TCI results in an increase in the number of tourism arrivals from all origin countries. The significance is relatively higher for tourists originating from the United States, which Goh believes is due to the fact that traveling from the United States to Hong Kong would be considered a long-haul as compared to the short-haul from locations such as Japan and China, (Goh 2012).

Taylor and Ortiz (2013), conduct research using temperature, precipitation, and sun hours a measurement of weather variability, as well. Taking a less narrow approach, they hope to better understand what role weather plays in the determination of Holiday destination and timing, at the regional level. Taylor and Ortiz (2013), conduct a panel data estimation on the UK, using data from the summer of 2003. The study includes data on income levels, accessibility of tourist destination, relative price levels, the exchange rate, tourism expenditures and number of bed nights and trips, from the years 1998 to 2004. 10 regions are examined in England, excluding data from Wales and Scotland, which was not available.

Taylor and Ortiz run a linear statistic model with trips as the dependent variable and find that temperature, sun days and exchange rate are significant, suggesting that a decrease in temperature or the number of sun days would lead to a decrease in the number of trips taken.

With the number of bed nights as the dependent variable, similar results are found, suggesting with some significance that an increase in temperature and sunshine hours would increase the number of overnight stays.

Similarly, Falk (2014), looks into the impact of temperature, rainfall and sunshine on the number of domestic and foreign overnight stays in Austria. The data for these weather variables is collected from 59 weather stations from the HISTALP dataset from the years 1960-2008 and from the ZAMG yearbook for the years 2008-2012. Falk uses weather data for the summer season, July to August. 12 countries are used to collect data on the number of foreign overnight stays at a given time (Austria, Belgium, Denmark, France, Germany, Italy, Hungary, Netherlands, Sweden, Switzerland, United Kingdom and United States).

Falk estimates static regression models using the weather variables and other economic health measures such as consumer price indices, exchange rates, and GDP as independent variables. Results indicate statistical significance of average temperatures in summer months, suggesting that as they increase, the number of domestic overnight stays in Austria also increase. Falk also estimates a squared term of temperature which is found to be statistically significant implying a non-linear relationship between average temperature and the number of domestic overnight stays in Austria. Results also indicate that precipitation has a negative impact on the number of domestic overnight stays. These results did not remain consistent when foreign overnight stays was used as the dependent variable. Instead, results suggest that the impact of weather on overnight stays is insignificant, and that visitors are more likely to be impacted by relative prices and real income. Falk estimates the model in the long run using a lag of each variable and finds similar results indicating that there is a relationship between tourism demand and real income in the long run (Falk 2014).

Colacito et al. (2014) also looks into country level impacts of weather variability. Using historical daily temperature, rainfall and snowfall data from 135 weather stations in the United States, Colacito et al. (2014) studies the effects of variations in seasonal temperature on economic growth. The weather station data is used to construct state and country-level weather data. As a measure of economic health, the authors use gross state product (GSP) from 1957-1962, taken from the U.S. Census Bureau Bicentennial Edition Bureau and the U.S. Department of Commerce's Bureau of Economic Analysis. The empirical analysis uses the average temperature for a state as an independent variable, with a GSP lag used as the independent variable. Additional models in the paper also include specifications for region (i.e. North, South, Midwest, and West) and for season (i.e. winter, spring, summer, fall). Results suggest that during the summer, an increase in temperature depresses growth while, in the fall, an increase in temperature increases growth. These results were found to be strongest in the South (Colacito et. al 2014).

Lanzafame (2012) examines the relationship between weather and economic growth, focusing on less developed countries in Africa. The primary weather variables considered are average yearly temperature and rainfall, weighted by population. The variables used to measure economic growth real GDP per capita and real GDP per worker (a measure of labor productivity). Using a standard MG estimation, initial results suggest a strong positive relationship between rainfall and per-Capita growth. The impact of temperature was not found to be significant, although, the relationship was suggested to be negative. Lanzafame (2012) also estimates the model for countries that identified as "Sub-Saharan" due to the fact that this is a common trend in previous literature. Similar results were found, with rainfall and per-capita growth having a significant positive relationship.

Using a common correlated effects approach to estimate the model, Lanzafame finds results that indicate a significant inverse relationship between temperature and per capita GDP growth in countries of Africa. These results are not consistent with those initially found in the MG model which didn't find temperature to be significant and found rainfall to have a strong impact. Lanzafame (2012) also uses an augmented mean group approach to estimate the model, which offers results consistent with the common correlated effects model.

Schumann (2013) studies the impacts of six recorded hurricane disasters on the relationship between a tourist's perception of a destination and the social vulnerability of local residents, local economic dependence on tourism, and pre storm destination popularity. Like Beaudin and Huang (2014) and Shih et al. (2009), Schumann (2013) investigates the impact of weather in the United States, however, this author looks into Southeastern coastal counties. Two metrics are used to estimate tourism recovery, the payroll recovery rate (PRR) and the establishment recovery rate (ERR), which describe the local economic landscape in terms of expansion, consolidation, shrinkage, or regeneration of the tourism economy, relative to pre-disaster levels. . Results suggest that nearly two-thirds of Southeastern counties show tourism expansion after disaster, while nearly one-third shows consolidation. Further results indicate that the more tourism dependent locations are negatively correlated to social vulnerability. As components of the tourism destinations decline, it is likely that consumers' preferences and experiences will be affected (Uristoe-Stone et al. 2016).

Hamilton et al. (2005), conduct a study on the relationship between international tourism, (measuring the changes in arrivals and departures) and changes in population, income and climate. The study also includes the length of the country's coastline and the total land area, which helps to provide information on how smaller, possibly island, countries can be affected differently by changes in population, income and climate. This dataset included 207 countries, however, due to data availability, several observations had to be filled with a statistical model derived by the authors. The results suggest that population growth is related to a proportional increase in departures (Hamilton et. al 2005).

The study conducted by Hamilton et al. (2005) uses annual average temperature as a measurement of climate variability, which has in the past, been viewed as sufficient (Rosello-Nadal 2014). This has been seen as a limitation by other authors who find that the inclusion of both annual precipitation and temperature offers more reliable results. Day et al. (2013) look into the relationship between economic performance in the tourism industry and climate change, measured using historical data for precipitation and temperature. Specifically, five cities in the United States are examined, (Chicago, Las Vegas, Miami, San Diego, Vail), to see whether variability in the weather has short-term or medium-term (weekly) impacts on economic performance. Day et al. (2013) measure economic performance using the number of establishments, annual payroll, first quarter payroll, and number of employees. The findings suggest a significant and positive correlation between total precipitation and all four economic variables used.

Uyarra et al. 2005, examine two Caribbean Islands (Bonaire and Barbados) and popular tourist destinations. Using survey data collected from 654 participants, Uyarra et al. 2005 find that as climate changes affect environmental components of these destinations, tourism will likely decline. This information is also found in a review conducted by Lashley (2013), who studies Caribbean island states. In this economic review, Lashley (2013) finds that economic losses increase due to weather-and-climate related disasters, with total losses being higher in developing countries, (as a proportion of GDP). Small states, which include small island countries, are generally more vulnerable to weather changes and climate-related disasters (Lashley 2013). Lashley (2013) discusses how the degradation of coral reef ecosystems, which may be caused by climate change, will then negatively impact the communities in those areas, which depend on those reefs for coastal protection, subsistence fisheries, and tourism.

From this literature, there are two key takeaways. The first is that there does appear to be a difference in the way that seasonal tourism industries are affected by weather variability. For example, the winter-activity related studies found that increasing temperatures and decreasing amounts of snowfall were hurting ski industries (Shih et al. 2009; Beaudin and Huang 2014). Surugiu (2012) focused on summer-related tourism activity and found that increasing temperatures and sun duration increased domestic tourism demand in seaside resorts. This results, along with the research conducted by Colacito et al. (2014), suggest the need to study seasonal impacts of weather variability on tourism.

The second takeaway is that there may be different implications for island countries, versus non-island countries. As was noted by Uyarra et al. (2005) and Lashley (2013), who studied island countries. Small states and island countries appear to be more vulnerable to weather activities, with these countries experiencing higher economic losses due to weather related disasters. With these takeaways in mind, this research looks to understand how increasing weather variability has impacted tourism industries throughout the world, focusing on the effect of island countries and non-island countries, while accounting for seasonality in rainfall and temperature patterns.

DATA AND METHODOLOGY

A series of regression analyses are run on the data in order to understand the relationship between tourism expenditures and the changes in weather, as measured by rainfall and temperature. Data are collected for 194 from the World Bank. The full list of countries used in this dataset can be found in Appendix A. Due to data limitations, the information spans across the years 1995-2012. The countries are categorized as either Island or Non-Island. The independent weather variables are downloaded from the World Bank Climate Change Knowledge Portal.

Variable Descriptions

The variable descriptions table shows the descriptions of the dependent variable, primary independent variables and the controls, (Appendix B, Table B1). From this table, it can be seen that the dependent variable is labeled as ExpenditureGDP which is measured as the total tourism expenditure for each country, in each year, as a percentage of GDP. Both independent weather variables are downloaded as monthly units. Rainfall is downloaded as monthly rainfall in millimeters and temperature is downloaded as the monthly temperature in degrees Celsius. These monthly units are inconsistent with the yearly observations for *ExpenditureGDP*, *Agriculture, Population, ExchangeRate*, and *Unemployment.* For this reason, a yearly aggregate of both variables must be calculated, as well as additional variable transformations that will help to create more dynamic models.

Independent Weather Variable Transformations

Yearly Average: The yearly average is calculated by taking the mean of the twelve monthly observations for each country in each year.

30 Year Rolling Average: The 30 year rolling average is calculated by taking the mean of the previous 30 yearly averages for each country in each year.

Seasonal Yearly Averages: Based on results found within the literature, (Colacito et al. 2014), this study uses seasonal independent weather variables. In order to transform these variables, each country was categorized with a dummy variable for the Northern Hemisphere. Where Northern Hemisphere = 1 if the country was located there or Northern Hemisphere = 0 if the country was located in the Southern Hemisphere. Seasons were then determined based on the hemisphere.

Northern Hemisphere = 1	
Spring	March, April, May
Fall	September, October, November
Summer	June, July, August
Winter	December, January, February

Northern Hemisphere = 0	
Spring	September, October, November
Fall	March, April, May
Summer	December, January, February
Winter	June, July, August

After determining the hemisphere and the season, the seasonal yearly averages were calculated by finding the mean of the three monthly observations for each country, in each year, based on the appropriate hemisphere and season.

Growth Averages: The final model uses growth averages for rainfall and temperature, found by calculating the % growth of rainfall or temperature from one year to the next.

<u>Summary Statistics</u>

After calculating the yearly averages for rainfall and temperature, the summary statistics were calculated for all variables. Table B1, found in Appendix B, displays these statistics, showing the mean and standard deviation for each variable. The summary statistics are calculated for the full sample, and are also calculated by separating the countries into island and non-island countries. The total number of observations used in the models, for the full sample, is 856.

This is largely due to data limitations, resulting in a number of observations being omitted from the dataset. When broken up by island and non-island countries, island countries have 172 observations and island countries have 684 observations.

From the summary statistics, it can be seen that island countries, on average, experience more tourism expenditures as a percentage of GDP. This is also the case for average yearly rainfall, where island countries experience 131.04 mm on average, and non-island countries experience 83.11 mm. It is important to note here that the standard deviations for these rainfall averages are very large. For island countries the standard deviation is 69.44 and for non-island countries it is 62.05, indicating that there is high variability with the amount of rainfall that all countries receive, and that it is higher for island countries.

Island countries are also experiencing higher temperatures on average with a mean of 19.59 degrees Celsius, compared to non-island countries with a mean of 14.55 degrees Celsius. For both types of countries, there are large standard deviations, indicating that there is high variability with temperature, as well as rainfall.

EMPIRICAL ANALYSIS

A series of fixed effects panel regression models are run in order to analyze the data thoroughly and assess the consistency of results. The analyses are divided up into four types of models, which become progressively more dynamic. The first model measures the impact of rainfall on tourism expenditure and the second model measures the impact of temperature on tourism expenditure.

Model 1

$$ExpenditureGDP_{it} = \alpha + \beta_1 AveYrRain_{it} + \sum_{k=1}^{K} \beta_k X_{kit} + \tau_t + \gamma_i + \varepsilon_{it}$$

$$ExpenditureGDP_{it} = \alpha + \beta_1 AveYrTemp_{it} + \sum_{k=1}^{K} \beta_k X_{kit} + \tau_t + \gamma_i + \varepsilon_{it}$$

The primary independent variable in the first model is *AveYrRain*, or average yearly rainfall in millimeters. After the model is run for the full sample, it is run with only island countries and only non-island countries. This is to account for the effect of country type on the impact that weather variability has on each country's tourism industry. In this model, X represents all control variables, described in the previous section of this paper. The results for the independent controls are not shown within the results tables. Time effects, the unmeasurable impacts that result from the change in one year to the next, are accounted for and represented by τ, *Tau*. The model also counts for country effects, which are the unmeasurable impacts that occur from differences in countries, denoted within the model by γ, *Gamma*.

AveYrRain is then removed from the model and replaced with *AveSprRain, AveSumRain, AveFalRain, AveWinRain,* which are the four seasonal averages used to account for seasonal impacts of weather variability on tourism expenditures. This version of the model is run for the full sample and then for only island countries and only non-island countries. The second model with *AveYrTemp* or average yearly temperature in degrees Celsius, follows the same variations as the model described above for *AveYrRain*.

The results for model 1 can be found in Appendix C, table C1. The results from models with the full year, *AvgYrRain* and *AvgYrTemp*, do not show any results to be significant. This could be because the yearly averages aggregate the weather data and mask the effects of different seasons. This could also be because the model analyzes the impact of the current year's weather on the current year's tourism. This isn't taking into account any possible lag effects of weather or tourism.

The first hypothesis is tested when the original model is run using seasonal weather variables as opposed to the yearly aggregate. As can be seen in table C1, there still aren't any significant results with these model variations. However, the signs of the coefficients begin to vary across seasons, which suggests that seasonal differences are occurring and are likely being masked by the yearly aggregate. The second hypothesis is tested for within the following models, which each become increasingly dynamic.

Model 2

The second set of models becomes more dynamic by using the 30 year rolling averages of rainfall and temperature instead of the yearly averages. This begins to account for some of the lagged effects of weather variation and creates a more robust model. Again, the following models include X, τ, and γ to represent the control variables, time effects and country effects.

$$ExpenditureGDP_{it} = \alpha + \beta_1 Avg30Rain_{it} + \sum_{k=1}^{K} \beta_k X_{kit} + \tau_t + \gamma_i + \varepsilon_{it}$$

$$ExpenditureGDP_{it} = \alpha + \beta_1 Avg30Temp_{it} + \sum_{k=1}^{K} \beta_k X_{kit} + \tau_t + \gamma_i + \varepsilon_{it}$$

The results for model 2 can be found in Appendix C, table C2. There continues to be very little significance with the exception of the impact of summer temperatures on tourism for the full sample. The model would suggest that an increase in temperature by 1 degree Celsius in the summer would increase tourism expenditures by .4216% in all countries. However, there are still very little information told by this model, which suggests the need for a more dynamic approach to be explored.

Model 3

The third set of models uses the one year lag of the 30 year rolling averages that were used in model 2. This analyzes the impact of the previous year's 30 year rolling averages of rainfall or temperature on the current year's tourism, for each country. Like the previous models, X, τ, and γ are included to represent the control variables, time effects and country effects.

$$ExpenditureGDP_{it} = \alpha + \beta_1 Avg30Rain_{it-1} + \sum_{k=1}^{K} \beta_k X_{kit} + \tau_t + \gamma_i + \varepsilon_{it}$$

$$ExpenditureGDP_{it} = \alpha + \beta_1 Avg30Temp_{it-1} + \sum_{k=1}^{K} \beta_k X_{kit} + \tau_t + \gamma_i + \varepsilon_{it}$$

As can be seen in Appendix C, table C3, there begins to be more significance with model 3. The results suggest that rainfall has an impact on tourism in island countries, with variations across seasons. The positive coefficient for rainfall, *L.Ave30Rain*, suggests that as rain increases in the summer, tourism expenditure increases, in island countries. This is offset by a negative coefficient for the rainfall in the fall, suggesting that an increase in rainfall would decrease tourism expenditure. The varying signs of these coefficients likely cancelled each other out in the yearly aggregate, *L.Ave30Rain*, and is the reason that island countries don't appear to be impacted by the full year's rainfall. This points to the importance of studying seasonal impacts of weather variability, as was noted by Colacito et al. (2014).

The results of model 3 also suggest that temperature has an impact on tourism expenditure. Results indicate that an increase in summer temperature would increase tourism for non-island countries. These results are further explored in the next model which continues to become more dynamic in the hopes of finding consistency with the results, which reflect information gained from the literature.

Model 4

The final set of models uses a growth average approach. Instead of using *ExpenditureGDP*, (tourism expenditures as a percentage of GDP) as the dependent variable, the models use *TourismGrowth*. This variable measures the percent change in tourism expenditure from one year to the next, for each country. Once more, X, τ, and γ are included within the models to represent the control variables, time effects and country effects.

$$TourismGrowth_{it} = \alpha + \beta_1 TourismGrowth_{it-1} + \beta_2 GrowthAvgYrRain_{it-1} + \sum_{k=1}^{K} \beta_k X_{kit} + \tau_t + \gamma_i + \varepsilon_{it}$$

$$TourismGrowth_{it} = \alpha + \beta_1 TourismGrowth_{it-1} + \beta_2 GrowthAvgYrTemp_{it-1} + \sum_{k=1}^{K} \beta_k X_{kit} + \tau_t + \gamma_i + \varepsilon_{it}$$

The first independent variable of the model is a one year lag of *TourismGrowth*, which controls for the impact that the previous year's tourism growth has on the current year's tourism growth. The independent weather variables are also growth variables, which analyze the percent growth in rainfall and temperature from one year to the next.

The results for model 4 are found in Appendix C, table C4. With the growth average of rainfall being used as the weather independent variable, the results suggest that growth in summer rain has a positive impact on the growth of tourism in island countries. The results also suggest that the growth of temperature has an impact on the growth of tourism, specifically for island countries. It would appear that as temperature grows in the summer and winter, tourism grows for island countries but not for non-island countries. This may be true for island countries and not for non-island countries because island countries do not experience a true winter and are therefore aren't harmed from increasing winter temperatures the way that non-island countries would be. For example, a ski industry would likely suffer from increasing temperatures in the winter, (Beaudin and Huang 2014; Shih et al. 2009).

CONCLUSION

The results from the four sets of models do not offer much consistency from which to draw conclusions and make policy recommendations. However, the results do show that as the models become increasingly more dynamic, the impacts of weather variability become more apparent and more consistent.

Results suggest that island countries and non-island countries are impacted different by weather variability. For example, in the third set of models, rain positively impacted island countries in the spring and negatively impacted island countries in the fall, while non-island countries were not impacted at all. There are also differences in the way that seasons impact tourism industries in each country. This is noticeable in the first model, when the coefficients for seasonal weather variables begin to show different signs. It becomes more apparent as the models become more dynamic, with coefficients beginning to show statistical significance. For example, the final set of growth models show that increasing temperature in the summer and winter significantly impact tourism growth for island countries.

While the results from this study are not very consistent, they do point towards the future of this area of research. This study was limited by the data availability, which allowed for only 17 years of usable data. Future research would benefit from a larger number of observations, allowing for weather variability to be analyzed over a longer time span. With more data available, the models would be able to become more complex and dynamic, which would likely yield results that are more consistent across models and more consistent with findings from the literature.

APPENDICES

Appendix A: List of Countries

Afghanistan
Albania
Algeria
Andorra
Angola
Antigua and Barbuda
Argentina
Armenia
Australia
Austria
Azerbaijan
Bahamas, The
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Belize
Benin
Bhutan
Bolivia
Bosnia and Herzegovina
Botswana
Brazil
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi
Cabo Verde
Cambodia
Cameroon
Canada
Central African Republic
Chad
Chile
China
Colombia
Comoros
Congo, Dem. Rep.
Congo, Rep.
Costa Rica
Cote d'Ivoire
Croatia
Cuba
Cyprus
Czech Republic
Denmark
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt, Arab Rep.
El Salvador
Equatorial Guinea
Eritrea
Estonia
Ethiopia
Fiji
Finland
France
Gabon
Gambia, The
Georgia
Germany
Ghana
Greece
Grenada
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hungary
Iceland
India
Indonesia
Iran, Islamic Rep.
Iraq
Ireland
Israel
Italy
Jamaica
Japan

Jordan
Kazakhstan
Kenya
Kiribati
Korea, Dem. People's Rep.
Korea, Rep.
Kosovo
Kuwait
Kyrgyz Republic
Lao PDR
Latvia
Lebanon
Lesotho
Liberia
Libya
Liechtenstein
Lithuania
Luxembourg
Macedonia, FYR
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Marshall Islands
Mauritania
Mauritius
Mexico
Micronesia, Fed. Sts.
Moldova
Monaco
Mongolia
Montenegro
Morocco
Mozambique
Myanmar
Namibia
Nauru
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
Norway
Oman
Pakistan
Palau
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Romania
Russian Federation
Rwanda
Samoa
San Marino
Sao Tome and Principe
Saudi Arabia
Senegal
Serbia
Seychelles
Sierra Leone
Singapore
Slovak Republic
Slovenia
Solomon Islands
Somalia
South Africa
South Sudan
Spain
Sri Lanka
St. Kitts and Nevis
St. Lucia
St. Vincent and the Grenadines
Sudan
Suriname
Swaziland
Sweden
Switzerland
Syrian Arab Republic
Tajikistan
Tanzania

Thailand
Timor-Leste
Togo
Tonga
Trinidad and Tobago
Tunisia
Turkey
Turkmenistan
Tuvalu
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States
Uruguay
Uzbekistan
Vanuatu
Venezuela, RB
Vietnam
Yemen, Rep.
Zambia
Zimbabwe

Appendix B: Descriptive Statistics

Table B1: Variable Descriptions

Variable	**Description**
ExpenditureGDP	Tourism Expenditure as % of GDP
Average Monthly Rain	Measured in (mm)
Average Monthly Temperature	Measured in degrees Celsius
Agriculture	% of total land area
Population	Total Population
ExchangeRate	Real effective exchange rate index (2010=100)
Unemployment	% of labor force

Table B2: Summary Statistics

	Full Sample	**Islands**	**Non Islands**
Variable	Mean [Std.]	Mean [Std.]	Mean [Std.]
ExpenditureGDP	2.42 [1.50]	2.98 [1.86]	2.28 [1.36]
AveYrRain	92.74 [66.40]	131.04 [69.44]	83.11 [62.05]
AveYrTemp	15.57 [8.40]	19.59 [8.37]	14.55 [8.10]
Agriculture	41.71 [21.65]	30.85 [20.47]	44.44 [21.08]
Population	228.64 [799.44]	761.26 [1676.63]	94.71 [82.72]
ExchangeRate	96.67 [14.26]	98.54 [16.50]	96.19 [13.61]
Unemployment	9.97 [6.33]	7.69 [4.74]	10.55 [6.55]
Observations	856	172	684

Appendix C: Empirical Results

Table C1: Model 1

Independent Weather Variable: Average Yearly Rain					
	Full Year	Spring	Summer	Fall	Winter
Full Sample	0.005 [0.0010]	-0.0004 [0.0013]	0.0005 [0.0009]	0.0007 [0.0007]	-0.0006 [0.0014]
Island Country	0.0018 [0.0020]	-0.0026 [0.0030]	0.0000 [0.0015]	0.0023 [0.0022]	0.0022 [0.0017]
Non-Island	0.0001 [0.0017]	-0.0001 [0.0015]	0.0008 [0.0010]	0.0005 [0.0008]	-0.0016 [0.0019]
Independent Weather Variable: Average Yearly Temperature					
	Full Year	Spring	Summer	Fall	Winter
Full Sample	0.0097 [0.0638]	-0.0089 [0.0174]	0.0023 [0.0148]	0.0106 [0.0160]	0.0039 [0.0136]
Island Country	-0.0070 [0.1637]	-0.0658 [0.0518]	-0.0203 [0.0446]	0.0097 [0.0376]	-0.0356 [0.0410]
Non-Island	0.0337 [0.0568]	-0.0011 [0.0157]	0.0106 [0.0132]	0.0156 [0.0143]	0.0104 [0.0124]

Standard errors in brackets, results shown only for independent weather variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C2: Model 2

Independent Weather Variable: 30 year average Rain					
	Full Year	Spring	Summer	Fall	Winter
Full Sample	0.0144 [0.0366]	0.0135 [0.0362]	-0.0194 [0.0228]	-0.0058 [0.0136]	0.0317 [0.0255]
Island Country	0.0875 [0.0762]	0.0638 [0.0510]	-0.0221 [0.0406]	-0.0391 [0.0237]	0.0576 [0.0421]
Non-Island	-0.0395 [0.0338]	-0.0357 [0.0441]	0.0126 [0.0253]	0.0012 [0.0205]	0.0261 [0.0364]
Independent Weather Variable: 30 year average Temperature					
	Full Year	Spring	Summer	Fall	Winter
Full Sample	0.4463 [0.6807]	0.0694 [0.2070]	0.4216* [0.2184]	0.0683 [0.2312]	0.1344 [0.2365]
Island Country	2.1108 [2.1689]	0.4733 [0.7927]	0.5374 [0.6887]	0.5418 [0.7419]	0.5520 [0.4594]
Non-Island	0.2791 [0.7153]	0.0105 [0.2238]	0.3412 [0.2123]	0.0118 [0.2315]	0.1098 [0.2506]

Standard errors in brackets, results shown only for independent weather variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C3: Model 3

Independent Weather Variable: 30 year average Rain, One year lag					
	Full Year	Spring	Summer	Fall	Winter
Full Sample	-0.0062 [0.0327]	0.0106 [0.0358]	-0.0168 [0.0257]	-0.0128 [0.0132]	0.0186 [0.0259]
Island Country	0.0587 [0.0643]	0.0927* [0.0448]	-0.0291 [0.0472]	-0.0441* [0.0233]	-0.0009 [0.0482]
Non-Island	-0.0518 [0.0339]	-0.0412 [0.0417]	-0.0102 [0.0283]	-0.0061 [0.0202]	0.0221 [0.0336]
Independent Weather Variable: 30 year average Temperature, One year lag					
	Full Year	Spring	Summer	Fall	Winter
Full Sample	0.4464 [0.6873]	0.1003 [0.2070]	0.4425** [0.2047]	0.1169 [0.2224]	0.0602 [0.2576]
Island Country	2.2360 [2.2502]	0.5600 [0.8812]	0.1501 [0.6885]	0.7021 [0.7068]	0.5261 [0.4590]
Non-Island	0.3157 [0.7210]	0.0476 [0.2195]	0.3851* [0.2033]	0.0766 [0.2327]	0.0344 [0.2822]

Standard errors in brackets, results shown only for independent weather variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C4:Model 4

Independent Weather Variable: Growth Average Rain					
	Full Year	Spring	Summer	Fall	Winter
Full Sample	0.0641* [0.0362]	0.0144 [0.0100]	0.0375** [0.0178]	0.0026 [0.0078]	0.0083 [0.0155]
Island Country	0.0800 [0.0942]	0.0260 [0.0212]	0.1031** [0.0421]	0.0114 [0.0280]	-0.0233 [0.0329]
Non-Island	0.0583 [0.0368]	0.0106 [0.0118]	0.0203 [0.0185]	0.0028 [0.0077]	0.0123 [0.0175]
Independent Weather Variable: Growth Average Temperature					
	Full Year	Spring	Summer	Fall	Winter
Full Sample	-0.0093 [0.0002]	-0.000005** [0.0000]	-0.0002 [0.0006]	0.0023 [0.0034]	0.0035* [0.0019]
Island Country	0.0311 [0.0835]	-0.0019 [0.0036]	0.0139*** [0.0049]	0.0080 [0.0070]	0.0053*** [0.0017]
Non-Island	-0.0003 [0.0002]	-0.000005** [0.0000]	-0.0004 [0.0006]	0.0020 [0.0034]	0.0011 [0.0029]

Standard errors in brackets, results shown only for independent weather variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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