The Impact of Sargassum Seaweed in the Caribbean Region on Tourism

Kaylyn Silva

The College of New Jersey

ECO 495: Senior Thesis in Economics

Professor Michele Naples

June 7, 2022

Abstract

This study will observe the impact sargassum seaweed has on tourism in the Caribbean region. The dependent variable is tourism volume per population, while the explanatory variables include sargassum areal coverage, real GDP per capita, freedom rating, homicide rate, unemployment rate, and natural disasters. I hypothesize that an increase in real GDP per capita and a higher degree of freedom would show an increase in tourism volume per population. I also expect that an increase in sargassum areal coverage, homicide rate, unemployment rate, and natural disasters would contribute to a decrease in tourism volume per population. My sample size includes 48 countries over the period from 2000 to 2019. Countries were selected based on offering beach destinations that either have no, minimal, or an abundance of sargassum. The main goal of this study is to show how sargassum affects tourism while controlling for other factors. Stata was used to conduct panel regression analysis, and the results reveal that sargassum seaweed in the Caribbean region does not impact tourism.

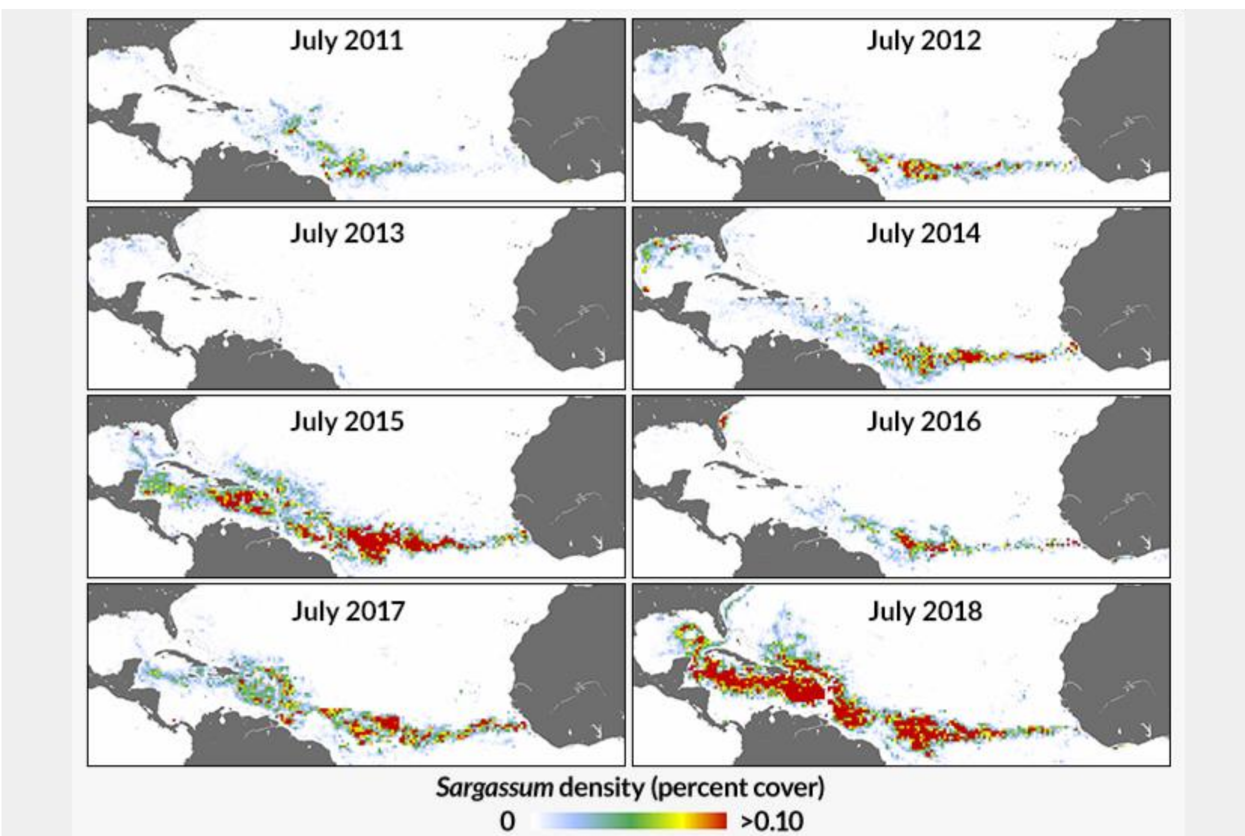
Contents

Introduction

The Caribbean region is known for its stunning scenery of crystal-clear waters and white-sand beaches, attracting a great number of tourists each year for a perfect vacation spot. Recently, the region has been struggling with an environmental issue that turns its blue waters brown and covers its beaches with enormous piles of seaweed. This seaweed, identified as sargassum, is a brown macroalgae that floats on the surface of the ocean. It originated in the Sargasso Sea, which has always been considered the principal source (Louime et al., 2017). However, a recent abundance of sargassum has generated an enormous belt extending from West Africa to the Caribbean Sea and Gulf of Mexico since 2011 as seen in Figure 1. See Appendix A for images of sargassum.

Figure 1

Visual of Sargassum Density and Areal Coverage from 2011 to 2018 in the Atlantic Ocean



Note. A sargassum bloom started in 2011 and has occurred every year since then, except in 2013. From “The Great Atlantic Sargassum Belt,” by M. Wang, C. Hu, B. B. Barnes, G. Mitchum, B. Lapointe, and J.P. Montoya, 2019, *Science, 365*(6448), pp. 83-87 (https://www.science.org/doi/10.1126/science.aaw7912).

As someone who cares deeply about the environment and economic well-being of those living in less developed countries and territories, the purpose of choosing this topic is to spread awareness about the issue as many individuals do not seem to know what has been going on in the Caribbean region since 2011. I visited Martinique in 2017 where I first witnessed the severity of the sargassum issue on the island. I then returned in 2019 and was surprised to notice that the amount of sargassum substantially increased over the past two years. With the help of personal experience and gathered research, this thesis will primarily focus on the impact sargassum has on tourism in the Caribbean region.

In June 2018, the 8850-kilometer-long sargassum belt contained more than 20 million tons of sargassum biomass (Wang et al., 2019). There are several predictions made by scientists that may explain the cause of the 2011 sargassum bloom, but the most reasonable scenario relates to the “high flow of nutrients from South America's Amazon and Orinoco Rivers mixing with warmer ocean temperatures” (Louime et al., 2017). Therefore, the initial conditions of the sargassum invasion were produced by “nutrient accumulations from 2009 due to stronger upwelling in the eastern Atlantic and excessive Amazon River discharge in the western Atlantic, while high temperature and low salinity in 2010 delayed the bloom until 2011” (Wang et al., 2019).

Although the abundance of sargassum affects the coasts of Caribbean countries and territories the most, there are other locations where the issue also exists. The coasts of Mexico, Florida in the United States, and other countries in Central and South America are dealing with the sargassum crisis as well. As a result, these areas have suffered from significant ecological and socio-economic impacts. For example, the tourism industry has taken a detrimental hit from the sargassum bloom. Due to health risks, the unappealing appearance, and rotten smell, sargassum continues to push tourists away from these areas. Since the Caribbean region heavily relies on tourism for economic stability, this provides an ideal opportunity to observe the relationship between sargassum and tourism over time.

Literature Review

Since the issue of sargassum is fairly recent and ongoing, there has not been an overwhelming amount of literature on the topic as new information is constantly being discovered. Most research focuses on the overall causes, impacts, challenges, opportunities, management, recommendations, and mitigation efforts of the sargassum invasion from 2011 to 2021. Other research discussed throughout this paper will also consist of the determinants of tourism.

Although the exact reason for the sargassum phenomenon remains inconclusive, long-term satellite data, numerical models, and field measurements suggest that the main cause connects to nutrient enrichments from the Amazon River and climatic variations (Wang et al., 2019). However, other hypotheses have been proposed, such as the lack of cyclones in the region during the last decade, the deviation of the Gulf Stream to the south, and the increased intake of nutrient-rich Sahara dust (Louime et al., 2017). All of these probable causes may ultimately link “to human modification and biogeochemical cycles” (Chavez et al., 2020).

As previously mentioned, affected areas have encountered significant ecological and socio-economic impacts. Regarding ecological impacts, the abundance of sargassum harms coasts and fauna but seems to benefit ecosystems and biodiversity. Sargassum negatively affects coasts by contributing to beach erosion, creating coastal dead zones due to biomass decomposition and beach fouling, the killing of mangrove and seagrass seedlings, eutrophication, changes in the species composition of the benthic community and seagrass loss, toxic leachate production, the risk of environmental contamination by heavy metals, and changes in the food webs. Sargassum also negatively affects fauna as there are recent changes in the behavior of nesting sea turtles, decreases in nesting success, and existing lethal temperatures for the embryos. There has been an increase of dead fish, turtles, and other marine wildlife overall as the sargassum impairs the traditional food-search strategies and blocks sunlight, inhibiting other plant growth (Chavez et al., 2020; Robledo et al., 2021; United Nations Environmental Programme [UNEP], 2018).

However, sargassum positively affects ecosystems and biodiversity in other ways. Floating biomass provides habitat and refuge for diverse species. The introduction of nutrients to the marine-terrestrial ecotone represents a natural fertilizer that favors the growth of vegetation on some beaches and dunes, and carbon sequestration removes carbon dioxide and mitigates climate change (Chavez et al., 2020; Robledo et al., 2021; UNEP, 2018).

Regarding socio-economic impacts, the abundance of sargassum harms fisheries, human health, and tourism. Sargassum affects fisheries by interrupting fishing operations, reducing access to fishing and catches, and increasing the mortality of fish and other marine life. Sargassum additionally affects human health as decomposition produces toxic gases, such as hydrogen sulfide and anhydrous ammonia, which may cause irritation to the upper airways, headaches, nausea, confusion, and other extreme damages under chronic exposure (Chavez et al. 2020; Robledo et al., 2021).

Last, the Caribbean region has witnessed a large decline in tourism, such as a 35% drop during the first semester of 2018 in Mexico, mainly due to the massive amount of sargassum on beaches (UNEP, 2018). Sargassum disrupts tourists from enjoying the beauty of the beaches as piles of seaweed on shore and mats in the ocean completely occupy most of the area. Sargassum also produces an unpleasant odor, as mentioned above, that most tourists do not want to smell constantly while they are on vacation. As a result, “sargassum poses serious threats to the tourism sector” due to the “lack of beach access, increased cost for consistent removal, and inability to operate tours and ocean-based activities near the beach shores and coastlines” (Caribbean Alliance for Sustainable Tourism [CAST], 2015). In severe situations, “vacation cancellations and beachfront room closures have occurred, leading to staff layoffs and reduced economic gain for the sector and communities” (CAST, 2015). Therefore, the sargassum invasion “has harmed the tourist industry, which is the main driver of the economy in the Caribbean region” (Chavez et al., 2020).

The ecological and socio-economic impacts create multiple challenges for the countries and territories in the Caribbean region, but the costs for sargassum clean-up, removal, and disposal are extremely difficult to keep up with and afford as well. The total estimated expenditure for clean-up, removal, and disposal in 2018 ranged between $445,000 to $7 million USD per country, which depended on the extent of the accumulation and the distance to the disposal site (Caribbean Regional Fisheries Mechanism [CRFC], 2019). The essential types of equipment, such as front-end loaders, backhoes, and excavators, are not readily available to the public sector, so the equipment has to be provided by the private sector most of the time. “Rental or purchase of these types of equipment are considered to be an expensive investment for governments, especially when there is no budget specifically allocated to clean-up sargassum" (CRFC, 2019). Additionally, unsupervised beach clean-ups are an issue since the equipment used to remove sargassum also picks up sand, which then causes beach erosion.

For disposal, sargassum is either taken to a landfill or dumped on private property. The amounts arriving at a landfill could reach up to 1,000 tons per day during peak influx periods, so this disposal method is unsustainable as many landfills do not have the space to accommodate these amounts. Some landfills do not take sargassum due to the odor and possible fire hazard, which leads to illegal dumping contaminating soil and fresh water (CRFC, 2019). There are many other challenges, including the limited funding for taskforces and committees to function properly, but the impacts and the removal of sargassum are the major obstacles focused on in the literature.

There are several opportunities for affected areas to recycle and reuse sargassum for different purposes. The Caribbean region has explored potential uses of sargassum for fertilizer and compost, sodium alginate in food, textile, and pharmaceutical products, construction blocks, manually produced paper, beauty care products, crop and livestock production, bioplastics, biogas production, and biosorption (Chavez et al., 2020). The excessive supply of sargassum provides these areas with an economic opportunity. As an example:

> Algas Organics, the first indigenous biotech company of the Caribbean, developed a technique to make a plant bio-stimulant out of sargassum in 2015. The product can replace energy-intensive, polluting synthetic fertilizers, with a quality similar to top fertilizer brands. The demand for the plant tonic has been on the rise in the St. Lucian agricultural market and is reaching other islands, such as Barbados. After building

> partnerships and receiving support from international organizations and the government, the company has built the first Sargassum processing facility of the Caribbean, which now plans to expand their production, create more jobs in the community, and invest in research to improve their Sargassum-based products (UNEP, 2018).

Individuals from these countries and territories have been using sargassum for their local benefit and capitalizing on the profitable, freely available resource (UNEP, 2018).

Other literature contains information and studies about the determinants of tourism. There are many factors that seem to increase or decrease tourism in specific areas. Assaf and Josiassen (2012) explain that the tourism industry is suffering from the effects of a weaker world economy. In order to improve the performance of the industry, the determinants of tourism must be identified and ranked. The drivers of tourism performance observed in Assaf and Josiassen's study include (1) tourism and related infrastructure; (2) economic conditions; (3) security, safety, and health; (4) tourism price levels; (5) government policies; (6) environmental sustainability; (7) labor skills and training; and (8) natural and cultural resources (2012).

Strong infrastructure within a country or territory attracts tourism, while areas with poor infrastructure generally have low-quality tourism and might be unable to meet the demand during high seasons. This driver is an important determinant of tourism performance since "the ease of tourist movement is affected by the quality of roads, railroads, ports, and airports" (Assaf & Josiassen, 2012).

Tourism is sensitive to economic growth and stability as these conditions also determine the success of the industry. Many studies have found that there are significant differences in tourism development between developing and developed economies as "a strong economy can encourage more foreign investments in the industry," enabling more government support (Assaf & Josiassen, 2012).

Security, safety, and health conditions additionally influence the tourism industry. Tourists are less likely to visit or return to dangerous areas that may have security or safety issues, such as high crime rates. According to Assaf and Josiassen (2012), "the ease or difficulty of access to improved health and hygiene resources can also impact tourism demand." Overall, most tourists do not feel comfortable traveling to places with security, safety, and health concerns that can potentially cause harm.

Assaf and Josiassen (2012) argue that:

> the number of tourists is strongly affected by the price competitiveness of a particular destination. When selecting a destination, tourists consider the price to get to the destination and the cost of living at the origin relative to substitute destinations. The intention to return to a destination can also be affected by the prices experienced by tourists in their previous visits.

This driver is an important determinant as exchange rates, fuel prices, ticket prices, hotel prices, etc. all affect a tourist's decision when selecting a particular destination. Culiuc (2014) also identifies that "tourism flows respond strongly to changes in the destination country's real exchange rate."

Furthermore, environmental sustainability correlates with positive tourism performance. Countries or territories that prioritize sustainable development strategies and techniques seem to gain more tourists. This driver is also critical to conserve the natural environment and improve the overall image of a certain area.

Labor skills and training both play an important role within the tourism industry as well. Most tourists value high quality service, which makes their experience more enjoyable and stress free. As a result, “tourists are more likely to return to those destinations that provide a higher level of service” (Assaf & Josiassen, 2012).

In recent studies, natural and cultural resources are considered significant determinants of tourism. More tourists are attracted to specific locations with natural and cultural resources that cannot be found in other areas. If a certain destination has an exclusive activity or landmark, tourists have no other option but to visit that area (Assaf & Josiassen).

As previously mentioned, Assaf and Josiassen (2012) identified and ranked the determinants of tourism performance using data on 120 countries from 2005 to 2008 by using the Data Envelopment Analysis (DEA) and bootstrap truncated regression models. The results indicated that the 10 most negative determinants of tourism performance are (1) crime rate; (2) fuel price level; (3) hotel price index; (4) CO_2 emission per capita; (5) visa requirement; (6) corruption index; (7) unemployment rate; (8) ticket price; (9) HIV/AIDS; and (10) the time required to start a business. To compare, the 10 most positive determinants of tourism performance are (1) government expenditures on the tourism industry; (2) stringency of environmental regulation in the tourism industry; (3) service-mindedness of the population toward foreign visitors; (4) GDP per capita; (5) quality of airline services; (6) number of operating airlines; (7) creative industries exports; (8) number of five- and four-star hotels; (9) level of staff training; and (10) education index (Assaf & Josiassen, 2012). This study provides an extensive understanding about the determinants of tourism for those who may be unfamiliar with the topic.

Culiuc (2014) takes a similar approach to estimate "the impact of macroeconomic supply- and demand-side determinants of tourism." The study applies the gravity model to analyze the impact of several variables on tourism. The results find that there is little support for the view that tourism is a superior good, tourists do not adjust their duration of stay in response to changes in real income, tourism and trade go together, and tourism does react strongly to change in the real exchange rate (Culiuc, 2014).

The Economic Commission for Latin America and the Caribbean [ECLAC] (2009), Laframboise et al. (2014), Martin and Abraham (2017), and Hazel and George (2018) all focus on the determinants of tourism specifically within the Caribbean region. Klein and Osleeb (2010) focus on the determinants of tourism specifically within Florida beach counties. These are significant sources that relate to the thesis topic as sargassum continues to affect those observed areas.

The ECLAC (2009) analyzes the main determinants of competitiveness in the Caribbean tourism stay-over industry using panel data from 1995 to 2006 in 34 member countries of the Caribbean Tourism Organization (CTO), except Mexico. The study finds evidence that Caribbean tourism competitiveness can improve through policy measures that favor "increases in investment, private sector development, better infrastructure, lower population density, lower government consumption, lower trade openness, a more flexible labor market, reduced vulnerability to natural disasters, better health, and cheaper oil prices" (ECLAC, 2009).

Laframboise et al. (2014) examines what is driving tourism flows to the Caribbean region by estimating the determinants of tourism, exploring variations based on sample differences, and constructing a static nominal price comparison index. The study discovers that (i) tourism arrivals and expenditure are sensitive to both price and income factors in source markets; (ii) price and income elasticities of tourism have declined since 2008; (iii) price elasticity is statistically insignificant for high-end destinations; and (iv) the nominal cost of an average one-week beach holiday in the Caribbean is higher than in other beach destinations around the world (Laframboise et al., 2014).

Similar to Culiuc (2004), Martin and Abraham (2017) also use a gravity model framework to model tourism demand in the Eastern Caribbean region from 2000 to 2016. The study shows that traditional gravity model variables are significant in justifying tourism demand in the Eastern Caribbean Currency Union (ECCU). "Income variables are positive and highly significant, while prices and geographic distance affected tourist arrivals negatively. Marketing activity is an additional influencer of tourism demand. Gravity dummies, such as common language and colonial history, were also positive" (Martin & Abraham, 2017).

Hazel and George (2018) look at evidence from Tobago and use data from 2010 to 2016 to examine the primary factors that are influencing international tourist arrivals to the country. The study of this Poisson estimation shows that "familiarity with a destination from previous visits, income in the source market country, and availability of airlift from the source market country to Tobago, all positively affect tourist arrivals, while room rates and language negatively influence arrivals" (Hazel & George, 2018).

While the last four studies focus more on the Caribbean islands, Klein and Osleeb (2010) focus on an exploratory spatial data analysis of the tourism sector with a statistical study of the economic determinants of coastal tourism in Florida. The study uses:

> the predicted likelihood of beach nourishment projects over the 1970-2000 study period as an explanatory variable to estimate the growth in earnings in the tourism sector between 1970 and 2000. The two-equation model presents strong evidence for the

importance of beach nourishment projects to tourism industry counties in Florida (Klein & Osleeb, 2010).

Additional literature provides long-term satellite data, numerical models, field measurements, and more to measure sargassum over time. Overall, these sources will help with further research about the impact sargassum has on tourism in the Caribbean region.

Model

A time series analysis will examine the relationship of the following variables over time:

$$tourvolpop = \beta 0 + \beta 1(sarac) + \beta 2(gdprcap) + \beta 3(freedom) + \beta 4(homrate) + \beta 5(unrate) + \beta 6(natdis)$$

For further explanation of my variables, the descriptions, units of measure, and data sources are presented in Table 1. See Appendix B for the mean and standard deviations of some variables.

Table 1

Description of Variables

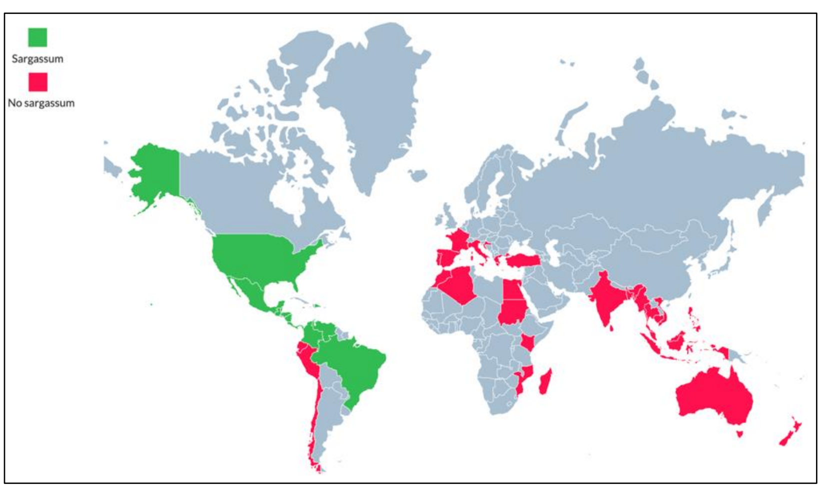
Type of Variable	Variable	Description	Unit of Measure	Data Source
Dependent	Tourism Volume per Population (*tourvolpop*)	How many passengers arrive in a country	Number of arrivals per population	The World Bank, United Nations, & World Data
Explanatory	Sargassum Areal Coverage (*sarac*)	How much an area is covered by sargassum seaweed	Estimated sargassum per square mile	Science & University of South Florida
	Real GDP per Capita (*gdprcap*)	Gross domestic product adjusted for inflation per person	2017 US$	Federal Reserve Economic Data, The World Bank, & United Nations
	Freedom Ratings and Statuses (*freedom*)	Political rights and civil liberties are measured to determine the freedom status of a country	One-to-seven scale (with one representing the highest degree of freedom and seven the lowest)	Freedom House

Type of Variable	Variable	Description	Unit of Measure	Data Source
Explanatory	Homicide Rate (*homrate*)	Number of estimated homicides	Percentage of estimated homicides per 100,000 people	The World Bank & World Health Organization
	Unemployment Rate (*unrate*)	Number of unemployed people	Percentage of total labor force	The World Bank
	Natural Disasters (*natdis*)	How many people affected by natural disasters (all geophysical, meteorological, and climate events, which include earthquakes, volcanic activity, landslides, drought, wildfires, storms, and flooding)	Total number of people affected (sum of injured, affected, and homeless)	Our World in Data

I expect that $\beta0, \beta2, \beta3 > 0$ and $\beta1, \beta4, \beta5, \beta6 < 0$. The dependent variable is tourism volume per population, and the key explanatory variable is sargassum areal coverage. My sample size includes 48 countries over the period from 2000 to 2019. Countries were selected based on offering beach destinations that either have no, minimal, or an abundance of sargassum, which is displayed in Figure 2.

Figure 2

Observed Countries With an Abundance of Sargassum or No to Minimal Sargassum



More than one-third (37.5%) of the countries in my sample are exposed to sargassum. The main goal is to show how sargassum affects tourism while controlling for other factors.

Data

Perhaps because of the global pandemic, there were a few challenges in collecting data. It was difficult to find data from 2000 to 2019 for developing countries and territories, so there are many countries that were not included due to the lack of data. This was a problematic issue since a great number of countries with an abundance of sargassum are developing countries. Some countries either had no data for some variables or incomplete data for the specified time period.

There were also other variables that could not be incorporated, such as COVID-19 cases, government expenditures on tourism, and the average temperature of a country, due to the lack of data as well. Data for the year of 2020 was unavailable for most of my variables. Overall, adding more countries and variables could have definitely helped strengthen the analysis, but the data was unattainable.

Additionally, some changes to the original data were necessary in order to obtain meaningful results. Since a few countries did not offer real GDP data, I had to find GDP and price-level data to calculate real GDP. This was then divided by population to calculate real GDP per capita. Similarly, tourism volume was calculated per population.

The most challenging variable to find data for was sargassum areal coverage. The sargassum invasion is fairly recent, so there is limited information about the topic. Only a few organizations, such as the National Aeronautics and Space Administration (NASA) and the University of South Florida, are observing the sargassum issue and have acquired data. The data is not public, so I contacted the University of South Florida in regard to their satellite-based sargassum watch system. A dataset was then provided that included the monthly mean sargassum areal coverage in the Caribbean region. However, data for each country was needed, so I resorted to my initial plan. Graphics of various countries showing the sargassum areal coverage each year from 2000 to 2019 were observed. Then, these areas were manually measured to calculate the estimated number for the sargassum areal coverage.

Results

Stata was used to conduct panel regression analysis. Since this is panel data, I tested for autocorrelation over time, and used the Hausman test to determine if fixed effects were needed in my regression. I then corrected for heteroskedasticity, autocorrelation, and fixed effects by using the “fe, vce(robust)” command for all of my equations. Originally, I did not plan to log my variables, but I noticed that my results improved after logging most variables as seen in Table 2 and Table 3. Table 2 shows the regression results for tourism volume per population (*tourvolpop*), while Table 3 shows the regression results for logged tourism volume per population (*ltourvolpop*) with logged explanatory variables.

Table 2

Regression Results for Tourism Volume per Population

Eq.	*sarac*	*gdprcap*	*freedom*	*homrate*	*unrate*	*natdis*	*year*	R-sq. Within	R-sq. Between	R-sq. Overall	F	# of Obs.
1	0.00002		-0.0662	0.0094	0.0021	7.17E-12		0.0279	0.0658	0.0614	0.00	960
	(1.93)*		(-1.10)	(1.11)	(0.12)	(0.19)						
2	0.00001	0.00004	-0.0766	0.0102	0.0127	-5.06E-12		0.0619	0.1309	0.1288	0.00	960
	(1.16)	(2.01)**	(-1.35)	(1.16)	(0.91)	(-0.08)						
3	0.00001	0.00004		0.0100	0.0122			0.0563	0.1114	0.1094	3.58	960
	(1.14)	(2.00)*		(1.12)	(0.88)							
4	0.00001	0.00004		0.0102				0.0524	0.0904	0.0888	2.50	960
	(1.16)	(1.55)		(1.13)								
5	0.00002		-0.0659	0.0095				0.0278	0.0576	0.0539	1.60	960
	(1.98)*		(-1.08)	(1.10)								
6		0.00004		0.0105	0.0120			0.0494	0.1101	0.1082	4.42	960
		(2.26)**		(1.09)	(0.87)							
7	3.36E-06	-0.00002		0.0083	0.0018		0.0295	0.1463	0.0347	0.0163	4.04	960
	(0.38)	(-0.65)		(1.18)	(0.16)		(3.28)***					
8	3.44E-06			0.0087	0.0053		0.0262	0.1436	0.0079	0.0101	4.43	960
	(0.37)			(1.13)	(0.36)		(3.71)***					
9	4.18E-06				0.0059		0.0263	0.1352	0.1565	0.0155	5.41	960
	(0.41)				(0.40)		(3.69)***					
10	3.29E-06	-0.00002		0.0083			0.0297	0.1462	0.0412	0.0208	3.70	960
	(0.37)	(-0.62)		(1.18)			(3.32)***					

Significant at: ***1% level, **5% level, *10% level

Table 3

Regression Results for Logged Tourism Volume per Population with Logged Explanatory Variables

Eq.	*lsarac*	*lgdprcap*	*lfreedom*	*lhomrate*	*lunrate*	*natdis*	*year*	R-sq. Within	R-sq. Between	R-sq. Overall	F	# of Obs.
1	0.0245		-0.0031	-0.5667	-0.2186	-5.74E-11		0.1042	0.0001	0.0000	0.00	960
	(5.53)***		(-0.02)	(-3.90)***	(-2.22)**	(-0.18)						
2	0.0148	0.6108	0.0155	-0.3897	-0.0711	1.38E-10		0.1759	0.1679	0.1681	0.00	960
	(3.02)***	(3.23)***	(0.09)	(-3.09)***	(-0.76)	(0.43)						
3	0.0148	0.6104		-0.3901	-0.0718			0.1758	0.1729	0.1729	15.01	960
	(3.04)***	(3.21)***		(-3.11)***	(-0.76)							
4	0.0150	0.6395		-0.3937				0.1741	0.1895	0.1887	18.74	960
	(3.05)***	(3.72)***		(-3.07)***								
5	0.0268		0.0233	-0.6068				0.0870	0.0055	0.0069	17.66	960
	(6.84)***		(0.12)	(-3.77)***								
6		0.6375		-0.3702	-0.0749			0.1709	0.1721	0.1719	11.07	960
		(3.37)***		(-2.89)***	(-0.78)							
7	-0.0101	0.1081		-0.3086	-0.1072		0.0329	0.2609	0.0131	0.0238	13.19	960
	(-1.33)	(0.48)		(-2.89)***	(-1.27)		(4.12)***					
8	-0.0110			-0.3222	-0.1266		0.0355	0.2595	0.0008	0.0009	14.30	960
	(-1.40)			(-2.94)***	(-1.49)		(4.73)***					
9	-0.0165				-0.1488		0.0388	0.2403	0.1720	0.0089	11.99	960
	(-1.88)**				(-1.66)		(5.09)***					
10	-0.0094	0.1587		-0.3152			0.0325	0.2572	0.0633	0.0722	15.03	960
	(-1.25)	(0.72)		(-2.85)***			(3.99)***					

Significant at: ***1% level, **5% level, *10% level

As previously mentioned, it was expected that an increase in real GDP per capita (*gdprcap*) and a higher degree of freedom (*freedom*) would show an increase in *tourvolpop*. It was also anticipated that an increase in sargassum areal coverage (*sarac*), homicide rate (*homrate*), unemployment rate (*unrate*), and natural disasters (*natdis*) would contribute to a decrease in *tourvolpop*.

Table 2 does not display the best results as many variables are not statistically significant and most coefficients in each equation are extremely similar. Out of 10 equations, *sarac* is positive and only significant in equations 1 and 5. *Sarac* is significant without *gdprcap* and *year* in equation 1, while *sarac* is significant without *gdprcap*, *unrate*, *natdis*, and *year* in equation 5. When all equations are observed, *sarac* is only significant when *gdprcap* and *year* are excluded.

For the other explanatory variables, *gdprcap* is positive and significant in equations 2, 3, and 6 when *unrate* is incorporated and *year* is removed. *Freedom*, *homrate*, and *unrate* are not significant in all equations. Lastly, *natdis* was excluded by Stata from most equations since it is a dummy variable.

Table 3 presents better results with the logged variables. By logging tourism volume per population (*ltourvolpop*), sargassum areal coverage (*lsarac*), real GDP per capita (*lgdprcap*), freedom rating (*lfreedom*), homicide rate (*lhomrate*), and unemployment rate (*lunrate*), there is more significance, and the R-squares are higher. In equations 1 through 5, *lsarac* is positive and significant, which is against my theory that an increase in sargassum areal coverage would show a decrease in tourism volume per population. However, adding *year* as a trend proxy for expanding tourism into equations 7 through 10 caused *lsarac* to become negative and increased the R-squared within. Equations 7 and 8 are similar, which means that *lgdprcap* did not have much of an effect. Equation 9 shows that excluding *lhomrate* increased *lsarac* from -0.011 to -0.0165 and also made it significant.

For the other logged explanatory variables, *lgdprcap* is positive and only significant when *year* is excluded as expected, since both exhibit a positive trend. *Lfreedom* is not significant. *Lhomrate* has consistent results as all equations show that the variable is negative and significant as expected. *Lunrate* is negative and only significant in equation 1. Overall, my regression results ultimately improved due to logging the variables and deciding what to include or exclude in each equation.

Conclusion

Based on the results, sargassum seaweed in the Caribbean region does not impact tourism. Although this does not align with my hypothesis, the results may change when accurate data for sargassum areal coverage in each country becomes available. Measuring the amount of sargassum around the coasts of each country may be difficult without the proper technology. As previously mentioned, only a few organizations are observing the sargassum issue and have acquired sargassum data for the Caribbean region as a whole. More data would be available if each affected country was heavily invested in the sargassum phenomenon. However, a lot of these countries are developing and do not have the funds to monitor the sargassum.

Additionally, real GDP per capita positively correlates with tourism. If the economy is doing well, more individuals are willing to travel since some may have more money to do so. A country with a good economy may also spend more to improve tourism, which will then increase the number of tourists. Homicide rate negatively correlates with tourism. If there are more homicides happening within a country, individuals would probably avoid traveling to a place with unsafe conditions and high crime. Unemployment rate also negatively correlates with tourism. If the unemployment rate is high, then individuals are less likely to travel. Overall, finding data for developing countries, including other variables that determine tourism, and expanding the time period would help with future studies.

References

Assaf, A. G. & Josiassen, A. (2012). Identifying and Ranking the Determinants of Tourism Performance: A Global Investigation. *Journal of Travel Research, 51*(4), 388–399. https://doi.org/10.1177/0047287511426337

Caribbean Alliance for Sustainable Tourism. (2015). Sargassum: A Resource Guide for the Caribbean. *Caribbean Hotel and Tourism Association*, 1-14. http://dx.doi.org/10.25607/OBP-798

Caribbean Regional Fisheries Mechanism. (2019). Fact-Finding Survey Regarding the Influx and Impacts of Sargassum Seaweed in the Caribbean Region: Final Report. *Japan International Cooperation Agency*, 1-83. http://dx.doi.org/10.25607/OBP-860

Chávez, V., Uribe-Martínez, A., Cuevas, E., Rodríguez-Martínez, R. E., Van Tussenbroek, B. I., Francisco, V., Estévez, M., Celis, L. B., Monroy-Velázquez, L. V., Leal-Bautista, R., Álvarez-Filip, L., García-Sánchez, M., Masia, L., & Silva, R. (2020). Massive Influx of Pelagic Sargassum spp. on the Coasts of the Mexican Caribbean 2014–2020: Challenges and Opportunities. *Water*, *12*(2908), 1-24. https://doi.org/10.3390/w12102908

Culiuc, A. (2014). Determinants of International Tourism. *IMF Working Papers*, *14*(82), 1-46. https://doi.org/10.5089/9781484383032.001

Economic Commision for Latin America and the Caribbean. (2009). An Econometric Study of the Determinants of Tourism Competitiveness in the Caribbean. *United Nations*, 1-31. Retrieved January 3, 2022, from https://repositorio.cepal.org/bitstream/handle/11362/27647/1/LCcarL190_en.pdf

Federal Reserve Economic Data. (n.d.). *Real GDP at Constant National Prices, 2000-2019* [Data Set]. https://fred.stlouisfed.org/categories/33405?t=gdp%3Breal&ob=pv&od=desc

Freedom House. (n.d.). *Freedom in the World, 2000-2019* [Data Set]. https://freedomhouse.org/report/freedom-world

Hazel, S. & George, K. (2018). An Empirical Assessment of the Determinants of Tourist Arrivals in the Caribbean Region: Evidence from Tobago. *Tobago House of Assembly*, 1-35. Retrieved January 3, 2022, from https://certnet.com/files/publications/conference/2018/CERT_SHazel%20and%20KGeorge_AMSC2018.pdf

Klein, Y. L. & Osleeb, J. (2010). Determinants of Coastal Tourism: A Case Study of Florida Beach Counties. *Journal of Coastal Research*, *26*(6), 1149–1156. Retrieved January 3, 2022, from http://www.jstor.org/stable/40928854

Laframboise, N., Mwase, N., Park, J., & Zhou, Y. (2014). Revisiting Tourism Flows to the Caribbean: What is Driving Arrivals? *IMF Working Papers*, *14*(229), 1-27. https://doi.org/10.5089/9781498351560.001

Louime, C., Fortune, J. & Gervais, G. (2017). Sargassum Invasion of Coastal Environments: A Growing Concern. *American Journal of Environmental Sciences*, *13*(1), 58-64. https://doi.org/10.3844/ajessp.2017.58.64

Martin, K. & Abraham, P. G. (2017). What is Driving Tourism Flows to the ECCU? Insights from a Gravity Model. *Eastern Caribbean Central Bank*, *1*(21), 1-22. Retrieved January 3, 2022, from https://www.eccb-centralbank.org/content-manager/documents/download/646

Ritchie, H. & Roser, M. (2021). *Number of Total People Affected by Disasters, 2000-2019* [Data Set]. Our World in Data. https://ourworldindata.org/natural-disasters#citation

Robledo, D., Vázquez-Delfín, E., Freile-Pelegrín, Y., Vásquez-Elizondo, RM., Qui-Minet, Z. N.,

& Salazar-Garibay, A. (2021). Challenges and Opportunities in Relation to Sargassum Events Along the Caribbean Sea. *Frontiers in Marine Science*, *8*(699664). https://doi.org/10.3389/fmars.2021.699664

The World Bank. (n.d.). *GDP (Current US$), 2000-2019* [Data Set]. https://data.worldbank.org /indicator/NY.GDP.MKTP.CD

The World Bank. (n.d.). *Inflation, Consumer Prices (Annual %), 2000-2019* [Data Set]. https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG

The World Bank. (n.d.). *Intentional Homicides (Per 100,000 People), 2000-2019* [Data Set]. https://data.worldbank.org/indicator/VC.IHR.PSRC.P5

The World Bank. (n.d.). *International Tourism, Number of Arrivals, 2000-2019* [Data Set]. https://data.worldbank.org/indicator/SP.POP.TOTL

The World Bank. (n.d.). *Population, Total, 2000-2019* [Data Set]. https://data.worldbank.org/ indicator/SP.POP.TOTL

The World Bank. (n.d.). *Unemployment, Total (% of Total Labor Force) (Modeled ILO Estimate), 2000-2019* [Data Set]. https://data.worldbank.org/indicator/ SL.UEM.TOTL.ZS

United Nations. (n.d.). *Population, Total, 2000-2019* [Data Set]. https://population.un.org/wpp/ Download/Files/1_Indicators%20(Standard)/EXCEL_FILES/1_Population/WPP2019_P OP_F01_1_TOTAL_POPULATION_BOTH_SEXES.xlsx

United Nations Environmental Programme. (2018). Sargassum White Paper - Sargassum Outbreak in the Caribbean: Challenges, Opportunities, and Regional Situation. *United Nations*. Retrieved November 3, 2021, from https://wedocs.unep.org/ 20.500.11822/35948

University of South Florida. (n.d.). *Satellite-based Sargassum Watch System* [Interactive Map]. Retrieved November 3, 2021, from https://optics.marine.usf.edu/projects/SaWS.html

Wang, M., Hu, C., Barnes B. B., Mitchum, G., Lapointe, B., & Montoya, J. P. (2019). The Great Atlantic Sargassum Belt. *Science, 365*(6448), 83-87. Retrieved November 3, 2021, from https://www.science.org/doi/10.1126/science.aaw7912

World Data. (n.d.). *International Tourism: The Most Popular Countries, 2000-2019* [Data Set]. https://www.worlddata.info/tourism.php

World Health Organization. (n.d.). *Estimates of Rate of Homicides (Per 100,000 Population), 2000-2019* [Data Set]. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/estimates-of-rates-of-homicides-per-100-000-population

Appendix A

Images of Sargassum

Figure A1. Image of sunken sargassum seaweed in the ocean on the coast of Martinique in April 2022.

Figure A2. Image of sargassum seaweed building up on the coast of Martinique in April 2022.

Appendix B

		Dependent Variable		Explanatory Variable		Explanatory Variable	
Number	Country	*tourvolpop* Mean	*tourvolpop* Standard Deviation	*gdprcap* Mean	*gdprcap* Standard Deviation	*freedom* Mean	*freedom* Standard Deviation
1	Bahamas	15.329	1.482	33578.30	1867.32	1	0
2	Barbados	4.079	0.338	11662.60	456.76	1	0
3	Belize	3.291	0.810	6208.61	199.97	1.500	0.158
4	Brazil	0.028	0.003	13617.15	1386.08	2.175	0.327
5	Columbia	0.049	0.024	11211.17	1853.26	3.450	0.384
6	Costa Rica	0.513	0.110	14968.29	2326.97	1.100	0.200
7	Dominican Republic	0.504	0.109	12596.12	2871.98	2.325	0.426
8	Guatemala	0.106	0.024	7039.03	642.66	3.775	0.248
9	Honduras	0.187	0.049	4701.63	478.26	3.550	0.497
10	Jamaica	1.098	0.207	8277.97	216.09	2.425	0.178
11	Mexico	0.821	0.125	17615.09	844.18	2.675	0.363
12	Nicaragua	0.184	0.051	1440.29	396.90	3.750	0.814
13	Panama	0.451	0.142	21367.60	5859.98	1.625	0.216
14	Saint Lucia	5.218	0.704	11082.81	766.50	1.100	0.200
15	Saint Vincent and the Grenadines	2.390	0.464	9487.35	974.97	1.250	0.250
16	Trinidad and Tobago	0.372	0.023	25534.14	3917.38	2.225	0.402
17	United States of America	0.453	0.143	55481.66	3516.23	1.075	0.178
18	Venezuela	0.024	0.010	561.82	117.74	6.125	0.217
19	Algeria	0.050	0.013	3658.40	1176.32	5.500	0
20	Australia	0.285	0.042	48102.48	3504.84	1	0

21	Bangladesh	0.002	0.001	2953.39	834.35	3.950	0.444
22	Cambodia	0.196	0.114	2788.02	869.18	5.550	0.150
23	Chile	0.168	0.146	19671.04	2998.14	1.150	0.320
24	Croatia	11.622	1.697	23139.68	2450.54	1.750	0.296
25	Ecuador	0.079	0.026	10167.66	1250.89	3.025	0.109
26	Egypt	0.112	0.031	10520.19	1365.69	5.625	0.268
27	France	2.656	0.736	40891.60	1539.99	1.150	0.229
28	Greece	1.813	0.631	28755.29	3052.92	1.725	0.248
29	India	0.006	0.004	4284.16	1293.48	2.500	0
30	Indonesia	0.033	0.012	8114.40	1865.38	2.925	0.396
31	Italy	1.244	0.161	41358.58	1545.97	1.150	0.229
32	Kenya	0.035	0.005	3394.16	468.88	3.850	0.673
33	Madagascar	0.012	0.003	1617.64	62.72	3.725	0.733
34	Malaysia	0.746	0.151	19101.89	3534.37	4.175	0.363
35	Maldives	2.226	0.518	17167.56	2121.50	4.750	0.750
36	Morocco	0.259	0.065	5988.09	1200.75	4.650	0.229
37	Mozambique	0.059	0.023	994.39	214.71	3.600	0.339
38	Myanmar	0.032	0.026	644.39	444.77	6.325	0.810
39	New Zealand	0.611	0.092	34877.49	2784.69	1	0
40	Peru	0.094	0.056	9294.55	2211.63	2.525	0.249
41	Philippines	0.041	0.015	5976.32	1288.84	2.975	0.334
42	Portugal	1.035	0.309	28988.24	1133.24	1	0
43	Spain	2.184	0.252	37062.06	1640.39	1.05	0.15

44	Sri Lanka	0.054	0.032	9193.75	2507.17	3.875	0.567
45	Sudan	0.011	0.007	3593.38	536.73	6.975	0.109
46	Thailand	0.300	0.139	13520.71	2450.82	4.225	1.209
47	Turkey	0.399	0.137	20209.59	4309.18	3.750	0.887
48	Vietnam	0.071	0.045	4889.76	1440.96	6.125	0.217
	Average	1.282	0.215	15153.14	1683.17	2.994	0.320

Appendix B. Mean and standard deviation of some variables for each country. Yellow shaded countries have an abundance of sargassum, while blue shaded countries have minimal or no sargassum.