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Regional Economic Impacts of Beach Closures by Environmental Threats:

An Empirical Study of Mississippi Coastal Counties

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Regional Economic Impacts of Beach Closures by Environmental Threats: An Empirical Study of Mississippi Coastal Counties

Abstract:

Beach closure as a result of various environmental threats is one of the major concerns of the regional economy in the coastal communities depending on tourism and its related industries. Among these various causes of beach closures, Harmful Algal Blooms (HABs) and *E. coli* bacteria have drawn special attention due to their higher frequencies and persistency expected to be worse following climate change or variabilities. Beach closures directly and significantly impact the local economies of coastal communities along the Gulf of Mexico, highly depending on tourism and recreation. To analyze how badly the local economy is impacted by beach closures, this study performs the difference-in-differences (DiDs) with monthly tax sales as a proxy for the direct economic impacts and socioeconomic, weather, and other controlling factors. With three coastal counties in Mississippi, we empirically demonstrate the beach closure impacts on the relevant industries and discuss how environmental threats could directly impact the local economy.

Keywords: beach closures, regional economy, harmful algal blooms, E. Coli

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I. Introduction

Environmental stressors are events that impact an individual's or a community's productivity or fitness (Freedman, 2015). There are many types of environmental stressors, such as anthropogenic, climatic, chemical, physical, and biological; depending on the frequency of the event and the resilience of the population these events can be considered environmental disturbances (Borics et al., 2013; Freedman, 2015). For tourism-based regions, environmental stressors such as natural disasters negatively impact regional economies in many ways, ranging from physical damage to lost revenue from would-be tourists (Kim & Marcouiller, 2015).

One such tourism-based region is the Gulf of Mexico (GOM) coastal area. In 2013, in Mississippi and Alabama alone, coastal tourism accounted for $17.6 billion (in 2013 dollars) in sales revenue (Guo et al., 2017). In 2021, tourist expenditures were valued at $6.7 billion for the state of Mississippi, with the coastal area being ranked as the top tourist destination in the state (Mississippi Development Authority, 2022). In 2019, the very popular coastal tourist state of Florida received $98.8 billion (in 2019 dollars) in visitor spending (Rockport Analytics, 2021). However, when these coastal areas experience events of environmental stress, tourism decreases, affecting the regional economy (Gordon et al., 2010; Guo et al., 2017; Kim & Marcouiller, 2015; Ritchie et al., 2014).

To protect residents and visitors from environmental harm in U.S. waters, the Beaches Environmental Assessment and Coastal Health Act (BEACH Act) was signed into law, amending the Clean Water Act.[1] As a part of these efforts, beach monitoring programs test beach waters for levels of bacteria or other substances and notify the public if these levels exceed

[1] See more details from the US Environmental Protection Agency available at https://www.epa.gov/beach-tech/about-beach-act (Retrieved: 5/13/2022).

standards set by the EPA through the Clean Water Act. To notify the public of harm, state governments will release beach advisories or beach closures, limiting access to beaches and beach activities for reasons such as high levels of Escherichia coli (E. coli), hurricane debris, oil spills, harmful algal blooms, sewage pipe breaks, and more. When access to beaches is limited or eliminated, tourism to coastal areas can be affected. Harmful algal blooms (HABs) and E. coli are two water-based threats that consistently occur in the Gulf of Mexico (GOM) area (Pierce et al., 2005), and are representative of environmental stressors in the region that can impact tourism through beach closures.

Through the goals of the Clean Water Act and the Beach Act, it is clear that the federal and state goverments are concerned with the water quality available at public beaches. Both HABs and high levels of E. coli are environmental stressors with anthropogenic triggers that are of concern to these water quality standards. Should the results of this study illustrate that beach closures due to environmental stressors are significantly damaging to local economies, there may be policy implications for the tightening of water quality standards to prevent these events.

Because of the dangerous health risks of HABs and E.coli, beach closures due to these ecological stressors pose a threat to the tourism-based regional economies of GOM communities. The previous literature on HAB economic impacts focuses on Florida, as it is the state most affected by this stressor. There is spatial heterogeneity of causes of beach closures, with *E. coli* being the more frequent cause of beach closures in the western GOM. The previous literature illustrates the importance of ocean-based tourism in Florida, and this importance is not any less in the western GOM. Toursim expenditures for coastal Mississippi in 2019 are estimated to be $1.26 billion for overnight trips and $553 million for day trips with ocean-based activities (beach

activities, swimming, and fishing), making up 41% as the reason for visiting (Longwoods Travel USA, 2019).

This study aims to evaluate the impact of environmental stressors on regional economies through beach closures and advisories from E. coli and HABs in three coastal counties in Mississippi. Using monthly sales tax by the county since 2013, this study uses the difference-in-differences (DiDs) of beach closures and advisories by different causes. The results are discussed with spatial heterogeneity over different counties and policy implications for general environmental threats to the local economy.

II. Literature Review

There is broad literature illustrating the damaging effects of environmental stressors on local economies. Environmental hazards such as air pollution (Xu & Dong, 2020), wildfires (Duffield et al., 2013; Kim & Jakus, 2019), oil spills (Garza-Gil et al., 2006; Ritchie et al., 2014), and hurricanes (Chandler, 2004; Gordon et al., 2010; Solís et al., 2013) have been shown to cause significant economic damage. For example, air pollution is a very concerning threat to Chinese tourism, which is the focus of the study done by Xu & Dong (2020). Using a gravity model with tourist data from 2010 to 2016, this study found that air pollution reduced inbound Chinese tourism by 1.7% – 3.8%. Air pollution as an environmental stressor in a destination deters tourists from traveling.

Another ecological deterrent to tourism is wildfires. Duffield et al. (2013) study the economic impact to the northern Rocky Mountains of wildfires in Yellowstone National Park. By using a travel cost model with wildfire and visitor data, an estimated $206 million loss in

tourism occurred for the 1986-2011 time period. The regional economic loss for the surrounding counties is estimated to be $159 million, a severe loss to the local communities. For five national parks in Utah, Kim & Jakus (2019) studied the effects of wildfires on park tourism, including fires that only occurred near the park. Using a linear regression with monthly fire and touism data from 1993-2015, a regional economic loss between $2.7 and $4.5 million was estimated for seasonal fires a year. The study also found that rural regions relying on the tourism industry were disproportionally affected by the economic losses.

One ecological stressor more known to the Gulf of Mexico area are oil spills. In one study from Spain, Garza-Gil et al. (2006) estimated the short-term economic effects of the Prestige oil spill in Galicia on the cleaning and restoration, coastal fisheries and aquaculture, and tourism industries. Using lodging and trip data, it was estimated that the tourism sector lost €133.8 million due to the oil spill. For the infamous British Petroleum Deepwater Horizon oil spill in the Gulf of Mexico that occurred in 2010, Whitehead et al. (2018) use the travel cost method to estimate the impact of canceled trips to Northwest Florida due to the oil spill. They estimate the cancelled trips amount to $207 million in damage to the regional tourism industry. Similar effects to ocean based tourism can be found through hurricanes, another infamous ecological stressor in the GOM. Hurricane Katrina was the worst hurricane in recent memory, which took the lives of 1,833 people and caused an estimated $180 billion in damages (NOAA National Centers for Environmental Information (NCEI), 2022). The hurricane destroyed all thirteen Mississippi coastal hotel casinos, and the damage to the tourism industry caused a 70% reduction in state tax revenues (Petterson et al., 2006). From the literature, it is clear that ecological stressors have a significant impact on regional economies through reduced tourism,

physical damage, illness, and lives lost. Focusing on the GOM area, the two most frequent ecological stressors resulting in beach closures are HABs and high levels of E. coli.

The research determining the economic effects of HABs across the United States goes back several decades. The literature provides a consistent conclusion that HABs negatively impact local economies, but the importance of regionally-varied industries has resulted in different approaches to the valuation and sizes of HAB impacts. Kahn & Rockel (1988) and Jin et al. (2008) estimated HAB impacts in the northeast using economic effects on local shellfish production, as the shellfish industry is the largest local ocean-based industry for these regions. HABs were found to cost New York shellfish fisheries $2 million a year in 1988 dollars (Kahn & Rockel, 1988) and cost Maine and Massachusetts shellfisheries $2.4 million and $18 million a year in 2008 dollars (Jin et al., 2008). However, in the southeast, the dominant ocean-based industry is tourism, leading researchers to rely on sales tax revenue as a method of measuring economic impact instead of production.

Larkin & Adams (2007), Bechard (2019), and Bechard (2020) narrow their analyses to the dining and lodging industries using sales tax revenue in Florida, providing more clear results. Larkin & Adams (2007) use a multiple regression time-series model (accounting for environmental conditions such as precipitation and storms/hurricanes) to find a reduction in dining revenue of 29.3% and in lodging revenue by 34.6% due to HABs in northwestern Florida from 1995-1999. Comparing their results to other environmental conditions, they find hurricanes to reduce the only the dining revenue by 4.8%. Bechard (2019) uses an ARIMA model (without accounting for environmental conditions) to find a reduction of 1.75% in dining revenue and 15% in lodging revenue due to HABs in Sarasota County from 2002-2018. Later, Bechard (2020) uses a larger dataset of county sales data in a difference-in-differences model (without

accounting for environmental conditions) to find that southwestern Florida counties with HAB events had 1.5%-2.5% less revenue in dining and 5%-7% less revenue in lodging than counties unaffected by HABs during four major algal blooms in 2005, 2006, and 2018. All three studies found that taxable sales revenues in the dining and lodging industries decrease due to HABs, but find the different sizes of impacts depending on their data and methodology.

The variations of models and results are due to data limitations across different geographical locations. One such limitation faced by Hoagland et al. (2002) and Bechard (2019) is a lack of data uniformity across states or counties. To avoid this, adopt three coastal counties in Mississippi, as their county sales tax data are uniform through state reporting guidelines.

The literature concerning E.coli valuation also consistently shows a negative economic impact. The majority of the literature surrounding E.coli focuses on its adverse public health effects (Cabelli et al., 1979; Chang et al., 2009; Russo & Johnson, 2003), and the valuation literature reflects this. Both Dwight et al. (2005) and Given et al. (2006) evaluate the health cost of illness caused by bacterial polluted recreational waters on California beaches. Dwight et al. (2005) used a cost-of-illness framework with annual income data and medical costs to evaluate the economic burden for specific illnesses related to polluted recreational swimming at two beaches in Orange County in 2001. The value amounts are $36.50 per gastrointestinal illness, $76.76 per respiratory infection, $37.86 per ear infection, and $27.31 per eye infection, adding up to a public health burden of $3.3 million a year (all in 2001 dollars). Given et al. (2006) conducted a similar study on beaches in Los Angeles County and Orange County beaches, using linear regression of attendance data and health cost of gastrointestinal illnesses in 2000 to come up with a regional economic loss of $21 million a year (in 2000 dollars). A study more centered on the economic effects of tourism instead of public health is Rabinovici et al. (2004). Using a

benefit-transfer policy analysis with beach closure and visitor data from 1998-2001 Rabinovici et al. (2004) estimate the economic loss of beach closures due to E. coli and other fecal indicator bacteria at a Lake Michigan beach to be between $1,274 and $37,000 a year. The literature consistently shows that the effects of high bacterial water negatively impact the economy.

Because HAB and E. coli events sometimes occur simultaneously with other weather events (such as precipitation, storms, and temperature), environmental effects need to be accounted for to prevent biased estimates of HABs' economic impact. Previous HAB studies isolated environmental hazard effects using daily weather/beach condition data (Adams et al., 2000; Larkin & Adams, 2007; Morgan et al., 2009), but there is some difficulty in aligning this type of data with taxable sales revenue. Larkin & Adams (2007) explains that it can be difficult to exactly estimate the effects of daily weather on monthly revenue in a time series model due to the different time intervals. Morgan et al. (2009) avoid this issue by using daily sales tax revenue; however, the data collection (asking individual restaurants to report daily revenues) is not feasible for the size of the area examined in our study. I will instead use monthly weather data with the monthly sales tax revenue.

The most direct way to measure the economic impacts of the ecological stressors on tourism-based local economies is through sales tax revenue in the dining and lodging industries. It is also shown that environmental hazards/events have their own negative effects on local economies that must be accounted for and isolated from HAB and E. coli effects. This study's contributions to the literature include: using beach closures to determine HAB occurrence, estimating the economic impact of *E. coli* in Mississippi recreational waters, and providing policy implications for the government in coastal recreational water standards.

III. Data and Methods

As an empirical study, this study analyzes the economic losses caused by beach closures and advisories in Mississippi. The three coastal Mississippi counties of interest are Hancock, Harrison, and Jackson, as they are reliant on ocean-based tourism. Leisure and hospitality employment in these three counties makes up 19% of local employment and supports 29,700 jobs as of March 2022; it is the second-largest non-farm industry for employment in the region after government employment (22%) (Mississippi Department of Employment Security, 2022). These three counties have beaches along the coastal line of the Gulf of Mexico and have been experiencing closures nearly every year due to HABs, high density of E. Coli, hurricanes, and sewage bypass. Due to the time period of available sales tax data, We will be analyzing the effects of these ecological stressors on the regional economy during the time period of October 2013 – December 2020.

Figure 1. The three coastal counties (Hancock, Harrison, and Jackson) in Mississippi
Note: taken from Johnson et al. (2012)

Figure 2. The locations of the 21 beach monitoring stations for the Mississippi Beach Monitoring Program.
Note: Retrieved from https://opcgis.deq.state.ms.us/beaches/

For a DIDs analysis of the economic impact of beach closures, the key variables needed are beach closures, sales tax revenue, weather, and socioeconomic characteristics. Beach closures will ideally be categorized by county, the reason for closure, and the duration of the closure. Monthly sales tax revenue is for each county, and comes from tourism-based industries such as lodging, dining, and recreation. To control environmental conditions to beach closures and beach visits, We add weather data containing temperature and precipitation measurements. Socioeconomic characteristics will identify the population, migration, and industry structure for each county.

We first collect historical beach closure records from the Mississippi Beach Monitoring Program. This data covers all advisories and closures information, including locations, causes, and start and end dates of closures since 2000 in all three Mississippi coastal counties. Monthly gross sales and taxes are borrowed from the Department of Revenue, Mississippi State. Particularly, this study builds the panel data of two industry categories of "Accommodation and

Food Services" and "Arts, Entertainment, and Recreation," in addition to gross sales by county for October 2013 – December 2020, all fixed for inflation in 2020 dollars.

Table 1. Descriptive Statistics for Gross Sales, 2013 – 2021

Variable	# of Obs.	Mean	Min.	Max	S.D.
Accomodation and Food Sevices	294	2,932,176	342939	96,385,608	7,766,011
Arts, Entertainment, and Regreation	285	259,482	4	1,611,102	310,321

Source: Mississippi Department of Revenue

Monthly weather conditions of temperature and precipitation are collected from PRISM (Parameter-elevation Relationship on Independent Slopes Model). This data contains average temperature (in degrees Fahrenheit) and total precipitation (in inches) for all three counties from October 2013- December 2020. Socioeconomic factors (for instance, population, migration, industry structure) come from the Census Bureau, Bureau of Labor Statistics, and Bureau of Economic Analysis. The unit of observation for this study is county level. Table 2 shows the major variables we consider in the model and their sources.

Table 2. Major socioeconomic and environmental variables

Variable	Description	Data source
population	Total population within a county	Census Bureau
diversity index	Regional industrial diversification index	Authors' calculation
temperature	monthly county-level min, max, or mean (°C)	PRISM
precipitation	Monthly county-level total precipitation (mm)	PRISM
hurricane	dummy for hurricane hit	NOAA

Note: PRISM: PRISM weather data by Oregon State University, and NOAA: National Oceanic and Atmospheric Administration.

We merge all data as a panel structure to implement difference-in-differences (DiDs). With the panel data, this study extends the DiDs suggested by Bechard (2020), which studied the economic impact of HAB-induced beach closures on tourism in the southwest Florida counties. The model specification is as:

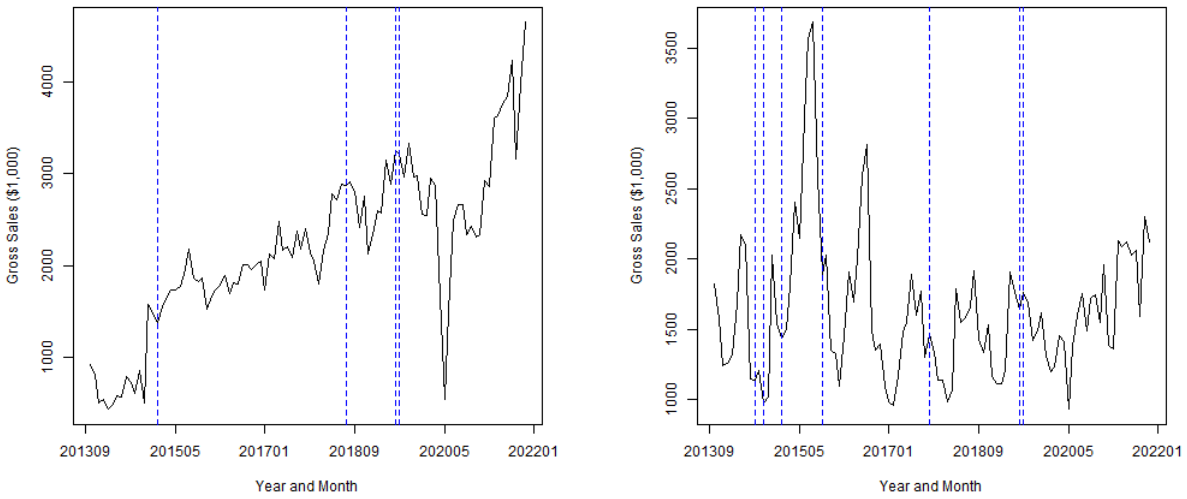
$$y'_{it} = X_{it}\beta + \sum_{p=1}^{m} \gamma_p y_{i,t-p} + \delta_1 T_{it} + \delta_2 R_{it} + \delta_3 T_{it} R_{it} + c_i + \mu_t, \quad (1)$$

where y'_{it} is a box-cox transformation of gross sales for county i at year-month t, $y_{i,t-p}$ is p-month lag of y'_{it}, X_{it} are a vector of other controls (e.g., weather and socioeconomic factors), c_i is county fixed effects, μ_t is month fixed effects, and β, γ_p, and δ are corresponding coefficients. To set up DiDs specification, we use T_{it} is a dummy for treatment period (1 for a month t with beach closure periods, 0 for otherwise) and R_{it} is a dummy for the treatment group (1 with a county i with beach closure, 0 for otherwise). Therefore, δ_3 is the average treatment effects this study is interested. In addition to the baseline regression of Equation (1) with sales data, this study will compare the industry-specific effects with two directly impacts industries of

"Accommodation and Food Services" and "Arts, Entertainment, and Recreation." We will also implement various robustness checks with different specifications of variables and different lengths of lagged terms.

V. Preliminary Results

At the current stage, we are still working on the data collection, modeling, and analysis. In this manuscript, we present a few descriptive results. During the AAEA, we will present and discuss more improved results. Figure 3 shows the sales tax data and beach closures over time.



(a) Hancock County, MS (b) Harrison County, MS

Figure 3. Gross sales and beach closures: 2013 – 2021

In the case of Hancock County, in panel (a) of Figure 3, no clear sales impact from beach closures, while beach closures are negatively correlated with gross sales in panel (b) of Figure 3 in Harrison County. During the same period, we do NOT present the case of Jackson County, which had only two beach closures and showed no significant impacts.

All three Mississippi coastal counties have experienced beach closures and advisories almost every year. Even though beach closures and advisories are expected to have a negative impact on the regional economy, their severities are spatially heterogeneous. Depending on the size of other industries, this impact would be relatively more or less severe than the others. More detailed analysis linked to population and industry structures is necessary. During AAEA, some partial results considering these factors will be presented.

After the completion of this study, we expect that the results of this study will help identify the economic impacts that the occurrence of ecological stressors have on coastal communities. Given that the results hold with the previous literature, HABs and E.coli present a threat to local economies. This study will build upon the previous literature, by using beach closures as a measure of HAB occurrence. This study will also be one of the first to evaluate the economic impact of E. coli on the Mississippi Gulf Coast. The results of this study will provide policy implications for government water quality recommendations.

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