

Part 4 - Project Report

Economic Impact of Wildfires on Tourism in St. Petersburg

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Introduction

The increasing frequency and intensity of wildfires, worsened by climate change, has created widespread challenges for communities across the globe. While often associated with regions closer to the fires, the effects of wildfire smoke can travel great distances, influencing air quality, visibility, and public health in locations far removed from the blaze. This project investigates the long-term impacts of wildfire smoke on St. Petersburg, Florida, a coastal city whose economy is heavily based on tourism, arts, and recreation.

Understanding these impacts is critical because the tourism industry is a cornerstone of St. Petersburg's economy, supporting local businesses, jobs, and infrastructure projects. However, as wildfire smoke compromises air quality and visibility, the appeal and accessibility of outdoor tourist destinations can be severely diminished. This study aims to quantify the economic repercussions of wildfire smoke, a phenomenon with similarity to the well-documented economic impacts of hurricanes, Florida's most frequent natural calamity.

This analysis is motivated by the need to bridge a critical knowledge gap. Despite its coastal location, St. Petersburg is not immune to the effects of wildfires from nearby regions' dense vegetation, such as the Everglades. By quantifying the revenue and visitor losses associated with wildfire smoke events, this project seeks to provide actionable insights for policymakers and local authorities. By these recommendations and findings, concrete actions can be taken to make the economy of the city or Pinellas county more resilient to such natural disasters in the future.

Background/Related Work

During the initial phases of the project, we did some background research to review the literature of related work on how wildfires or any natural calamity affect a region and what long-lasting economic impacts it could have. In [1] Alvarez et al. introduce a comprehensive framework to assess destination vulnerability and resilience to natural and human-induced hazards. The work bifurcates vulnerabilities into five key measurements: physical, socio-cultural, economic, ecological, and institutional. For instance, physical vulnerability considers the exposure of a destination to hazards, while economic vulnerability examines over-reliance on a single revenue stream, such as tourism. The authors argue the ability to recover or adapt post-disaster is

influenced by adaptive capacity, governance, and the integration of local stakeholders. Using real-world scenarios, such as hurricanes and pandemics, the framework provides actionable insights for destination management organizations to mitigate risks and foster long-term sustainability.

Huang et al. [2] performed research that analyzed the economic impact of hurricanes on Florida's tourism sector helping us get context about the regional challenges due to disasters and how have they been dealt with in the past. The findings highlight that natural disasters, like hurricanes, significantly affect tourism-driven economies, particularly in rural and coastal regions. For example, counties directly affected by hurricanes showed slower recovery rates, with the admissions subsector (e.g., theme parks and tourist attractions) experiencing sustained revenue losses. The paper stresses that beyond immediate infrastructure damage, long-term economic implications arise from altered tourist perceptions and reduced visitation. It suggests the need for resilience-building strategies, such as enhanced disaster preparedness, targeted recovery funds, and public-private partnerships. This study is relevant to our project as it provides a similar analysis of how environmental hazards, like wildfire smoke, may similarly challenge the tourism-dependent economy of St. Petersburg by altering air quality and outdoor conditions.

In the first phase of this project, extensive analysis was conducted on wildfire smoke and its implications for St. Petersburg, Florida. A custom metric, the "Smoke Estimate," was created using a logarithmic transformation of the ratio between acres burned and the shortest geodetic distance of fire perimeters from the city. This methodology accounts for the dispersion of smoke over distances while mitigating the effects of outliers through standardization. The study included a historical and forecast analysis spanning 1960–2050. Data from 1960–2020 served as historical input, while future trends (2021–2050) were modeled using Facebook's Prophet model, which effectively handles non-stationary data. The results showed that **wildfire smoke impacts, as represented by the Smoke Estimate, are expected to rise**, posing increasing risks to air quality and public health.

Additionally, a fire distance histogram was created to visualize wildfire distribution relative to St. Petersburg. Peaks at 200–300 miles and beyond 1500 miles indicated high fire activity in regions like northern Florida and neighboring states. Controlled burns and natural wildfire incidents were identified as primary contributors. A time-series analysis of annual acres burned within a 650-mile radius revealed key wildfire events, such as the Big Cypress National Preserve Fire (1989) and the Myakka Fire (2006). Finally, a combined time-series visualization of smoke estimates and air quality index (AQI) values revealed a **weak positive correlation, with a Pearson coefficient of approximately 0.117**. This indicates that while increasing wildfire smoke may deteriorate air quality, the relationship is not linear or strongly predictive.

Gathering this information from published research as well as performing initial exploratory analysis on the trends, patterns, and effects of wildfire smoke on the AQI of St. Petersburg, we

can take these findings forward and propose the following hypotheses to gauge the impact of the county's tourism economy. Firstly, wildfire smoke significantly disrupts St. Petersburg's tourism-driven economy by reducing visitor numbers and tourism revenue due to impaired air quality and outdoor conditions. Secondly, the ability of St. Petersburg to recover from these economic impacts is influenced by the sufficiency of financial support mechanisms, such as loans/grants, socio-economic policies, and institutional help. Our analysis aims to gather insights on these questions and provide recommendations to alleviate potential future detrimental impacts.

Methodology

To understand and quantify the economic impact of wildfires and smoke, we tried to find signals that would indicate or hint towards a potential downfall in economic indicators like revenue or GDP of specific high-impact industries in the county. Below is the list of data sources we have considered in our analysis.

- **USGS Combined Wildfire dataset:**

The USGS Combined Wildland Fire Datasets compile detailed data on wildland fire polygons across the United States and certain territories, spanning from the 1800s to the present. This dataset integrates fire records from multiple sources, providing a comprehensive view of fire perimeters for ecological, historical, and land management research. It is widely used for analyzing fire patterns, impacts, and trends across diverse landscapes

- **Tourist Development Tax:**

Represents revenue from tourism tax collections, reflecting the financial health of the local tourism sector. Previously known as "Bed Tax" it is collected from all the guests who engage in renting a Short-Term Rental (STR) for boarding and lodging purposes. As this signal is strongly correlated with the number of tourists visiting the city, we intend to use it to understand the impact of wildfire events/smoke estimates on the potential revenue of the tourism industry.

- **Airport Passenger Frequency Data:**

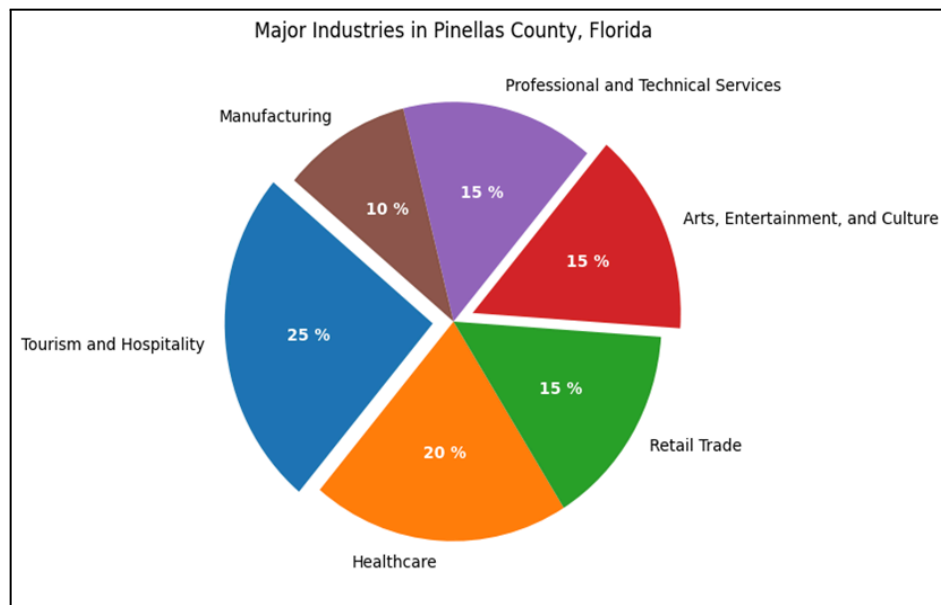
Tracks the monthly volume of arriving and departing passengers, a proxy for visitor traffic. By analyzing trends in passenger frequency during wildfire smoke events, we can observe the potential impact on visitor numbers.

- **Arts/Culture and Recreation Production Economic Impact Data:**

A measure of the economic contributions from the arts and culture sectors, which are one of the major sectors in economic impact in the region. By analyzing these turnover amounts alongside wildfire smoke data, we can infer potential declines in visitor-driven cultural activities.

- **SBA Disaster Loan Data:**

Records of disaster loans provided by the SBA ([USA Small Business Administration](https://www.sba.gov/)), reflect the level of federal assistance required by small businesses following various disasters (mostly contains hurricane data, but, can help as a tentative indicator). This dataset will help provide a tentative estimate of the economic toll on small businesses during natural disasters. We primarily intend to use this to drive insights on government aids, insurance coverage/defaults and what steps can the administration take to help local businesses bounce back from such events.



Firstly, we created a “Smoke Impact Estimate” using the USGS wildfire data. This metric was created to approximate the smoke impact on St. Petersburg, Florida. The logarithmic transformation of the ratio between the area burnt by fire in acres and the shortest distance of the fire polygon from the city in miles was used. The distance was calculated by doing a geodetic computation to include the curvature of Earth's surface and terrain difference. This nonlinear transformation is used for the standardization of values having large values or outliers and accounts for the spread of smoke over distances.

We implemented an Augmented Dickey-Fuller test to verify the stationarity nature of the time series. The null hypothesis of the test is that the series is not stationary. The results came as expected; namely, that the series was non-stationary ($p > 0.05$). Due to the non-stationarity of the series, we chose not to use standard Auto-Regressive models like ARIMA, as these models typically assume stationarity. Additionally, since the data lacked any strong seasonal patterns, we

did not pursue ETS (Exponential smoothening) or SARIMAX (Seasonal Auto-Regressive Integrated Moving Average with exogenous factors), which do well on more granular seasonal patterns. Instead, we opted to use the Prophet model, developed by Facebook which is well-suited for handling non-stationary data with irregular trends and potential changepoints.

After fetching and cleaning the data for the other economic indicators mentioned above, we conducted a correlation analysis to explore interactions among variables and test our initial assumptions. For example, we hypothesized that an increase in tourists or passenger traffic at the St. Petersburg airport should correlate with higher revenue from the Bed Tax and increased earnings from art and culture-related activities. These trends were visualized alongside the smoke impact estimate derived in Part 1, highlighting patterns during years with significant wildfire incidents in the region.

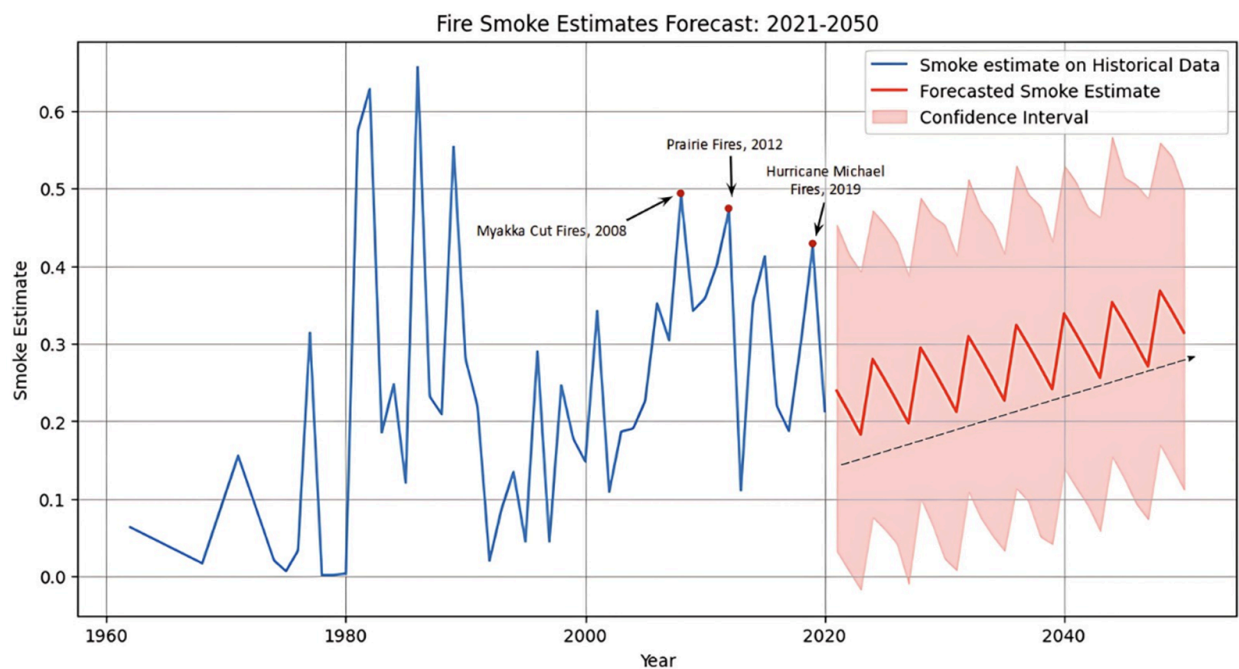
All monetary values were adjusted for inflation using a correction multiplier based on the Consumer Price Index (CPI) for Pinellas County for the corresponding year [3]. This normalization ensured the comparability of economic metrics across different years. The analysis helped identify potential correlations and outliers, providing insights into the hypothesized negative impact of wildfires on the local tourism economy.

Additionally, we posed a human-centric question “How resilient is the small business community of St. Petersburg to deal with the potential economic impact of natural disasters?” To assess recovery resilience, we analyzed the Small Business Administration (SBA) disaster loan data and filtered for major Federal Emergency Management Agency (FEMA)-tagged incidents in Pinellas County. **Note:** while these incidents primarily include hurricanes and tornadoes, St. Petersburg’s exposure to such disasters serves as a proxy for understanding community preparedness and economic recovery. We focused specifically on business losses, excluding personal or home-related impacts. To quantify resilience, we developed a sufficiency metric termed the “Coverage Ratio,” calculated as the ratio of the total approved loan amount to the total loss incurred. Loan data for individual businesses affected by each incident were aggregated annually, and the coverage ratio was plotted over time to observe trends.

Building on the smoke estimate forecasting model from Part 1, we also developed a forecasting model for this calculated coverage ratio. This model projects future trends, with an increasing coverage ratio indicating a resilient economy where small businesses have adequate access to emergency credit. Conversely, a declining trend would signal vulnerabilities in economic recovery and credit accessibility.

Findings

To begin, while plotting the calculated smoke impact estimate from the year 1960-2020, we could see a jagged appearance on the plot. There were distinct highs that indicated the major fires occurring in the 650-mile radius (scope of our data analysis) from St. Petersburg. The years corresponded to major fires from [4] like the Everglade fires (1980-81), the Myakka Cut fires (2008), and the Prairie fires (2012). There was no clear smooth relation visible in the fire trend for each year during the fire season nor any seasonality. The findings from the forecasted FB Prophet model as seen in the figure below, indicated a growing positive slope in the smoke impact estimate over the next 20 years which is a cause of concern. This finding gives an impetus to our analysis to dig deeper and find the impact of this increasing estimate on the major economic factors of St. Petersburg.

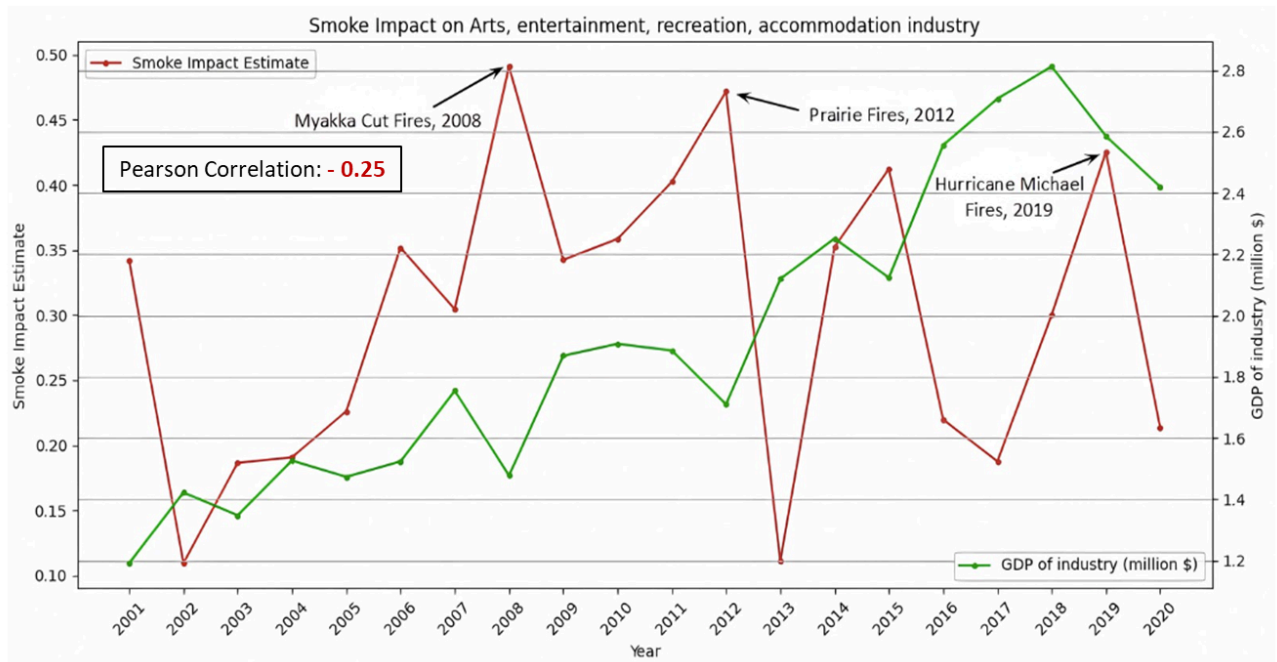
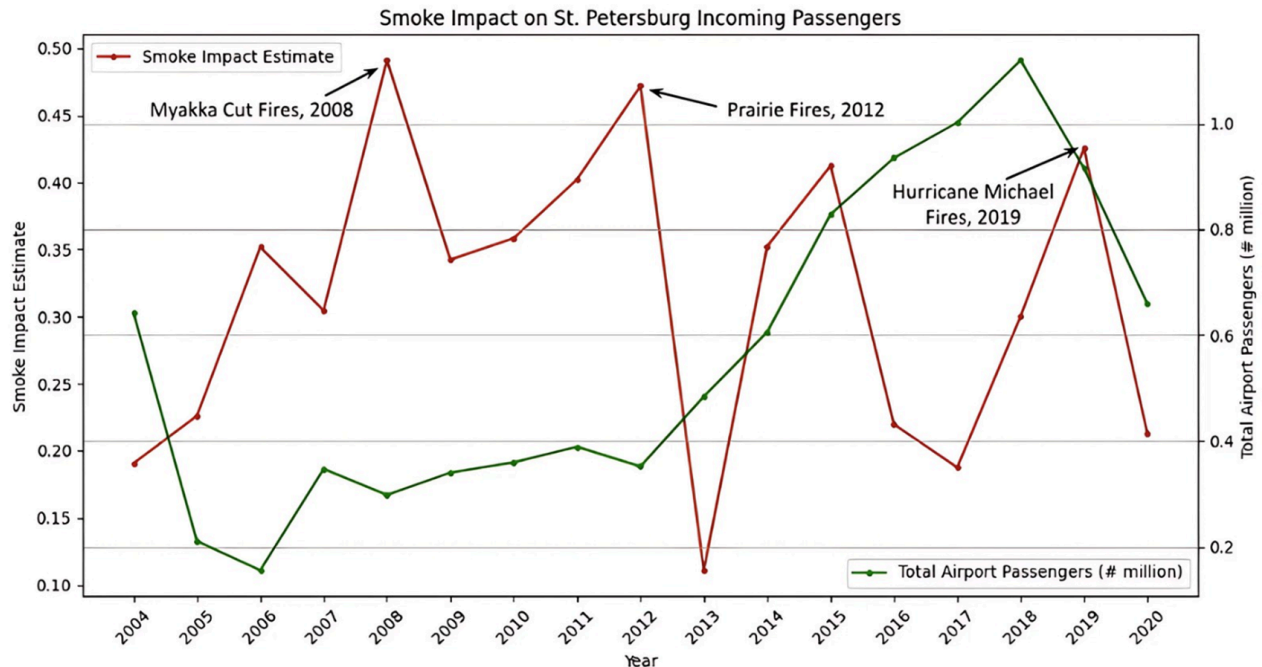


To find the correlation between the economic signals, we plotted the relationship between the Total Tourist Development Tax (TDT) revenues (in millions of dollars) and incoming international airport passengers (in millions) from 2004 to 2020, with a Pearson correlation of +0.896, indicating a strong positive correlation. Both metrics show a consistent upward trend from 2012 to 2019, suggesting that increases in international passenger traffic strongly align with rising TDT revenues. Notably, the decline in both metrics in 2020 aligns with the onset of the COVID-19 pandemic. The synchronization of trends reinforces the critical role of international arrivals in driving tourism tax collections in the tourism-driven economy of St. Petersburg.



Next while examining the relationship between smoke impact estimates from wildfires and the total incoming airport passengers, key wildfire events such as the Myakka Cut Fires (2008), Prairie Fires (2012), and Hurricane Michael Fires (2019) were highlighted, showcasing significant increases in smoke impact during these years. The visualization reveals an inverse relationship between smoke impact and passenger traffic. For example, the sharp rise in smoke impact during 2008 and 2012 coincides with stagnation or decreases in airport passenger numbers. Similarly, the 2019 spike in smoke impact aligns with a decline in incoming passengers, likely reflecting disruptions caused by Hurricane Michael. These findings illustrate how wildfire-related smoke significantly impacts air travel and tourism, posing challenges to the region's economic stability.

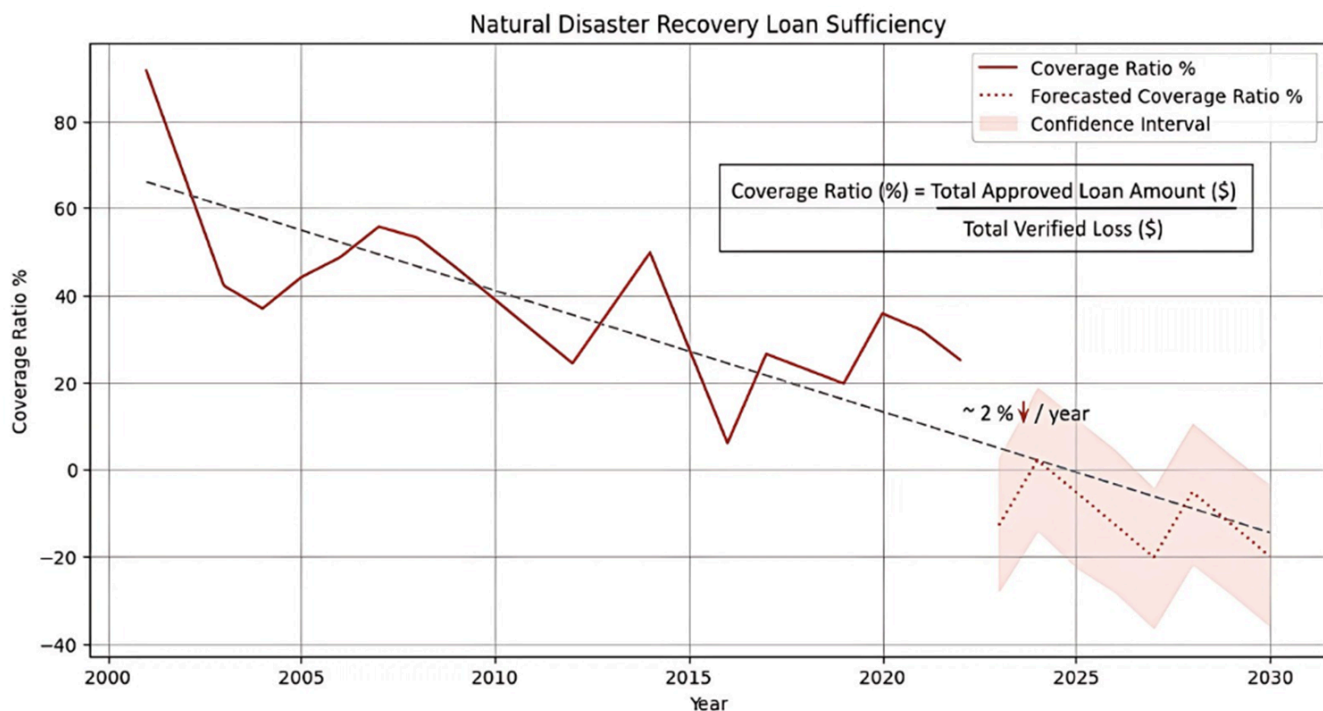
A more pronounced trend was observed when analyzing the relationship between smoke impact estimates and the GDP (in \$ millions) for the arts, entertainment, recreation, and accommodation industries. Significant revenue declines were evident during major spikes in smoke impact, corresponding to larger wildfires discussed in the previous visualization. The Pearson correlation coefficient was calculated to be -0.25, indicating a weak negative correlation between the economic performance of this industry and the increasing smoke impact from wildfires near St. Petersburg.



Lastly, to expand the analysis beyond general economic indicators and address the question of disaster recovery resilience among businesses in the St. Petersburg area and surrounding Pinellas County, a "Disaster Recovery Loan Sufficiency" metric was examined over time. This metric, measured by the Coverage Ratio percentage, was developed using SBA loan data for major FEMA-designated disasters in the region. The Coverage Ratio, calculated as the Total Approved

Loan Amount divided by the Total Verified Loss, provides a quantitative measure of the adequacy of loan support in mitigating losses from natural disasters such as wildfires.

The ratio as seen had fluctuated significantly over the years, ranging from a high of over 80% in the early 2000s to a low of around -20% in more recent years. This volatility suggests that the level of loan or grant support available has not been consistent, potentially leaving disaster-affected areas underserved during certain time periods. The graph also includes a Forecasted Coverage Ratio trend (using the FB Prophet model), which projects a gradual decline in the ratio over the next decade, approaching 0% by 2030. This forecasted trend, along with the confidence interval shown, implies that the current loan sufficiency may be insufficient to meet the expected future needs for natural disaster recovery. Furthermore, the slope indicates an approximate 2% annual decline in the Coverage Ratio, suggesting that the level of loan support available is not keeping pace with the increasing frequency and severity of such natural disasters.



Discussions/Reflections

This analysis emphasizes the increasing economic vulnerability of St. Petersburg to the impacts of wildfires, as demonstrated by the rising estimates of smoke impacts over time. Large-scale wildfire events, such as the Myakka Cut Fires and Prairie Fires, coincided with declines in key economic indicators like airport passenger traffic and tourism revenues, illustrating the disruptive effects of environmental shocks. The strong positive relation of +0.896 of TDT revenues with international airport passenger traffic indicates the local economy's dependence on tourism, while the weak negative smoke impact-GDP in arts and recreation correlation at -0.25 signifies that these industries are vulnerable to disruption by wildfire. These point to a pressing need for resilience strategies to safeguard the economic stability of this tourism-driven region.

The disaster recovery analysis further underscores gaps in support mechanisms. The "Disaster Recovery Loan Sufficiency" metric shows fluctuating and declining measures that indicate businesses may not be given sufficient financial assistance during disasters. The forecast for loan sufficiency to decline by almost 0% by 2030 portends a grim future regarding the region's ability to recover from increasingly frequent and severe wildfires. Without consistent and robust mechanisms of recovery, the economic impact of such natural disasters could be long and worsening, thus amplifying challenges for local businesses and communities.

To strengthen resilience against the economic impacts of wildfires, several targeted strategies can be implemented. Improved access to credit and emergency relief funds is essential to support businesses during and after disasters. For example, establishing state-backed low-interest loan programs or expanding the scope of SBA disaster loans could help ensure timely financial aid for affected businesses. Additionally, diversifying tourism offerings by promoting eco-tourism, virtual cultural experiences, and year-round attractions can reduce dependency on high-traffic seasons vulnerable to disruptions from smoke and poor air quality.

Airports can explore alternative revenue streams, such as investing in logistics and cargo operations, to mitigate financial losses from declining passenger traffic during wildfire events. For instance, partnerships with e-commerce companies for freight handling could offer steady income even during crises. Enhanced air quality monitoring systems and public awareness campaigns can provide real-time updates to residents and tourists, reducing exposure risks and helping to maintain confidence in the region's safety. By adopting these measures, St. Petersburg can build a more robust and adaptable economy capable of weathering the increasing threat of wildfires.

Limitations

- **Data Consistency and Scope:** The wildfire data used in this analysis was extracted from USGS and considered events within a 650-mile radius of St. Petersburg. This geographic scope provided valuable insights into the potential impacts that wildfire-related smoke may have on the region, although it may not represent the direct influence on St. Petersburg. The extent of the influence from wildfire smoke may vary according to local wind patterns, urban geography, and proximity to fire sources. This makes the radius-based approach an approximation potentially overlooking smaller, more localized impacts.
- **Confounding Variables:** The analysis focused on economic effects due to smoke from wildfires, but there were many confounding variables that could impact the relationships identified, including broader economic trends, changing patterns in tourism, and other exogenous factors like the COVID-19 pandemic. Such variables not considered in this analysis may well undergird the economic indicator fluctuations reported here, and thus relationships quantified may be driven not by smoke related to wildfires but rather by other factors.
- **Weak Correlation Estimates:** The analysis uncovered a weak correlation between the estimates of smoke impact and key economic variables, such as the GDP in arts and recreation, at -0.25. These weak correlations could suggest that the economic impact of wildfires is not quite as straightforward or pronounced as one might expect. Certainly, further research with more detailed data and deeper analysis is required in order to understand the true magnitude and long-term effects of wildfires on St. Petersburg's economy. This means that more intense data collection and statistical methods might allow clearer patterns to emerge and increase the validity of the conclusions drawn.
- **Assumptions in SBA Loan Data:** The SBA loan data used to assess disaster recovery sufficiency was not exclusive to wildfires but included all major FEMA-designated disasters, such as hurricanes and floods. This broad approach assumes that the economic impact of various disasters on St. Petersburg is similar, which may not hold true. Different types of natural disasters may affect the local economy in distinct ways, and this assumption could limit the accuracy of the analysis. Future studies would benefit from isolating wildfire-related data or comparing impacts across disaster types to gain a more nuanced understanding of the specific effects of wildfires on the region's resilience and recovery.
- **Aggregation Bias and Granularity:** this analysis was based on aggregated data, such as yearly estimates for smoke impact and GDP, which may obscure a more fine-grained

relationship that exists on a monthly or even weekly scale. Averaging may mask trends and fluctuations that are critical to actually understanding the relationship between wildfire smoke and economic indicators. For example, the monthly fluctuations in tourism or airport traffic during the wildfire seasons may provide indications of far more immediate disruptions or patterns of recovery that are obscured when series data is aggregated on an annual basis. Future research may be informed by the use of data at a finer resolution to capture these shorter-term relationships

- **Forecasting model accuracy:** the forecasting model was based on minimal data, which could lead to less accurate predictions. Given the complexity and variability of environmental and economic factors, the forecasted estimates need further validation with additional data and more sophisticated models before drawing firm conclusions about future trends.

Conclusion

This analysis underlines severe human-centric considerations intrinsic to the economic and social impacts of wildfires on St. Petersburg. Beyond economic metrics and statistical findings, disruption from wildfires underlines the vulnerabilities that residents, tourists, and local businesses are facing. Declining sufficiency of disaster recovery loans and fluctuating support mechanisms signal the demand for more just and accessible financial relief in order not to deprive people of their livelihood. Additionally, aggregated data and limited forecasting underscore the need for more nuanced and real-time analyses that capture in detail the experiences of those affected by such disasters. Pre-disaster diversification of tourism products, improvement of public health strategies during wildfires, and uniform post-event recovery assistance will go a long way in dampening these impacts. Ultimately, this project reinforces the need for solutions that prioritize the well-being and resilience of the people who drive and depend on the region's economy, ensuring their safety, security, and prosperity in the face of escalating environmental challenges.

References

1. Alvarez, S., & Fyall, A. (n.d.). Vulnerability and resilience in a tourism destination. *Rosen Research Review*, 3(2), Article 1. Retrieved from <https://stars.library.ucf.edu/rosen-research-review/vol3/iss2/1/>
2. Huang, A. (2022, December). How hurricanes impact Florida's tourism industry. *Rosen Research Review*. University of Central Florida. Retrieved from <https://stars.library.ucf.edu/rosen-research-review>

3. U.S. Bureau of Labor Statistics. (n.d.). Consumer price index, Tampa area – recent releases. Retrieved from https://www.bls.gov/regions/southeast/news-release/consumerpriceindex_tampa.htm
4. Florida Department of Agriculture and Consumer Services. (n.d.). Significant wildfires in Florida: 1981–2018. Retrieved from <https://www.fdacs.gov/Forest-Wildfire/Wildland-Fire/Significant-Wildfires-in-Florida-1981-2018>

Data Sources

- [USGS Wildfire dataset](#)
- [Florida Department of Revenue Tourism Tax Data](#)
- [Consumer Price Index Data](#)
- [St. Pete-Clearwater Airport Passenger Statistics](#)
- [Arts and Culture Production Annulized Data](#)
- [SBA Disaster Loan Data](#)