Friedrich-Alexander-Universität Erlangen-Nürnberg

Final Report: Impact of Extreme Weather Events on the United States

submitted by:

Richard Heinz

Course of Study: M.Sc. Informatik

Course: MADE

Project Work: 7

14. Januar 2025

Inhaltsverzeichnis

1 Introduction

The trend of extreme weather phenomena that include storms, floods and tornadoes has intensified in many regions within the United States. This is a trend of events that brings forth questions about their economic implications. The central question that this report is about to address is:

> **To what extent do extreme weather events such as storms, floods and tornadoes impact the GDP of the United States and consequently the availability of financial resources?**

The study addresses this issue by analyzing historical data on weather patterns and key economic indicators, focusing on regions most vulnerable to substantial losses. By estimating the economic damages caused by these events, the analysis hopes to provide actionable insights for policymakers and stakeholders, fostering better preparedness and enhancing economic resilience against future disasters.

2 Data Outputs

2.1 NOAA Storm Events Database

The primary data source for this analysis is the NOAA Storm Events Database, which provides detailed records of extreme weather events across the United States [NOAA, 2024]. After being processed through the data pipeline, the relevant datasets were persisted in an SQLite file, with tables corresponding to the years 1999 to 2024, covering the recorded events within this period.

Each table includes information on the events, such as their state, occurrence date, type, direct and indirect injuries and fatalities, as well as financial damages to property and crops. A unique characteristic of this dataset is the notation of financial damages in abbreviated formats. For instance, a property damage of $50,000 is represented as “50K” while damages in the millions are abbreviated as “<digits>M”

Additionally, injuries and fatalities are consistently recorded as numerical values, whereas financial damages often include specific numbers but occasionally have NULL values. These NULL values pose interpretational challenges, as it remains unclear whether they represent no damages ($0) or indicate an inability to calculate precise damages.

The following figure visualizes the database structure for the 1999 and 2000 table.

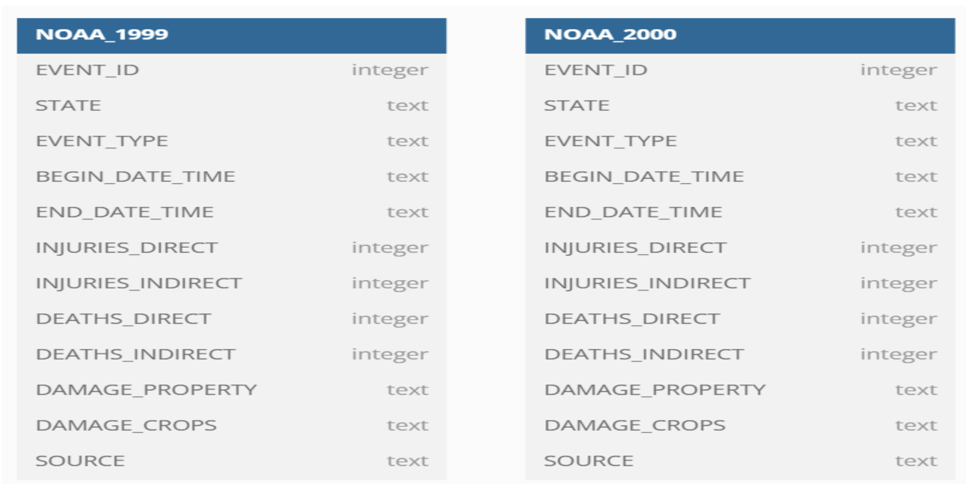

Abbildung 1: Visualization of the database model for the 1999 and 2000 table (Source: Own representation, created with dbdiagram.io).

The tables for subsequent years, including 2024, follow the same structure. A notable feature of the table structure is the inclusion of additional information, such as the *SOURCE* column. This column is relevant for the interpretation of the data and provides contextual information pertinent to the study.

In the subsequent correlation analysis, these factors must be carefully considered to ensure meaningful results and to avoid introducing bias into the findings.

2.2 Bureau of Economic Analysis: GDP by State

The BEA dataset provides comprehensive economic indicators, including GDP, personal income, and employment statistics by state [Bureau of Economic Analysis, 2024]. The data is divided into real dollar statistics and current dollar statistics, covering the period from 1999 to 2023. It encompasses both national and state-level information, enabling comparative analysis of economic development over time.

Compared to the NOAA dataset, the BEA dataset poses greater challenges, as it is primarily designed for manual analysis by individuals. For instance, the initial rows include supplementary information that is less relevant in the context of this study. The relevant section begins in the fifth row, presenting essential data such as geographic names, descriptions (including GDP, real personal income, and other categories) and columns representing annual percentage changes for these categories relative to the previous year. This structure complicates automated data processing and correlation analysis as geographic names need to repeat to accurately map the yearly differences for each category.

Another challenge in processing the BEA dataset is the presence of columns with (NA) values. While these values allow for less interpretive ambiguity compared to the NOAA dataset, they still impose constraints on subsequent correlation analyses.

To address these challenges, the data was stored in an SQLite file and divided into three interlinked tables. The GeoNames table contains the geographic names of the recorded locations. The Indicators table includes categories such as GDP, real GDP, personal income, and other economic indicators. Lastly, the GDPData table provides the annual percentage changes associated with a specific geographic location and indicator. The table structure is detailed in the accompanying figure.

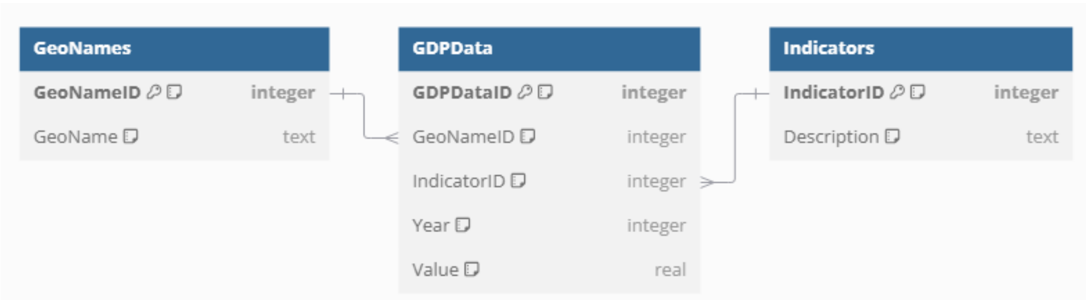

Abbildung 2: Visualization of the database modell of BEA (Source: Own representation, created with dbdiagram.io).

For example, according to the table structure, the year-over-year change in real GDP for the geographic location Alabama shows an increase of 5.1%. This value is determined by resolving the *GeoNameID*, which is associated with the state of Alabama, and the *IndicatorID*, which corresponds to the real GDP.

3 Data Analysis

The following section of the data analysis focuses on the examination of the two datasets to identify potential correlations.

Method To address the research question posed at the outset, a correlation analysis was conducted. The constant variable X was the financial damage caused by extreme weather events from the NOAA dataset, where property damage and crop damage were summed for the respective years. The variable Y was the percentage change in *Real GDP* from the BEA dataset. Additionally, Y was substituted with *Real per capita personal income* and *Real PCE* (Personal Consumption Expenditures). However, the primary focus was on Real GDP, as this economic indicator represents the total production of an economy and is already inflation-adjusted. This is particularly advantageous as it ensures better comparability of economic performance across the years under consideration.

To gain deeper insights, the correlation between *Real per capita personal income* and X was also analyzed. This allowed for a better understanding of how the average income of the population has changed over time, offering an opportunity to investigate the impacts of natural disasters on the people and their quality of life. Finally, *Real PCE* was also applied as the variable Y, which measures inflation-adjusted household expenditures on goods and services. This indicator is important for analyzing the purchasing power of the population in a specific geographical area, even if no clear negative correlation with *GDP* is found.

Results The relationship between financial losses and *Real GDP* was considered on an individual state basis to examine any relationships that may exist. For instance, New Hampshire had a moderate to strong negative correlation of -0.54 from 1999 to 2024. This means that the financial damages due to extreme weather events are negatively related to real GDP, with years of higher financial damages associated with a decrease in real GDP. On the other hand, in the same period, Kansas state recorded a moderate positive correlation of 0.42. In Kansas, real GDP tends to increase in those years when financial damages caused by extreme weather events are higher, which is clearly opposite to the findings in New Hampshire. The results can be viewed in detail in the following diagram.

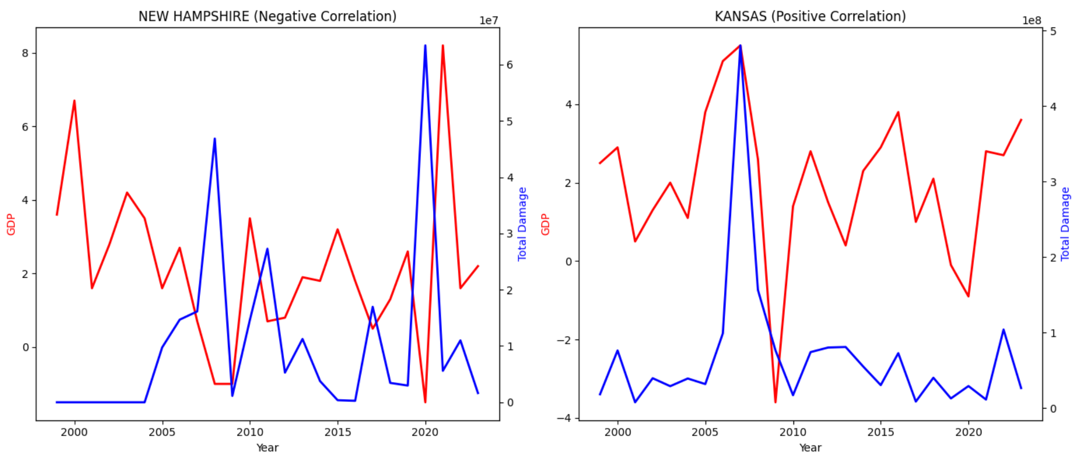

Abbildung 3: Correlation: New Hampshire, Kansas (Source: Own representation).

This correlation is -0.16 if taken for all states within the same period. Further analysis of the correlation with the variable *real per capita personal income* across all states and the entire period available reveals a weak positive of 0.29. The *Real PCE* variable, however, reported the same sign but with the value of 0.18.

Interpretation The results demonstrate varying correlations between financial losses from extreme weather events and real GDP across different states. The moderate correlation in New Hampshire (-0.54) indicates that as financial damages from extreme weather events rise, there is a more pronounced decline in real GDP, suggesting a negative impact of such events on the states economy.

In contrast, Kansas shows a moderate positive correlation of 0.42, indicating that despite higher financial damages, real GDP tends to increase. This could be due to Kansas' better preparedness for extreme weather events, which may help mitigate financial losses. Alternatively, the recovery costs in Kansas might have outweighed the damages caused by extreme weather, leading to economic growth. Another point is that Kansas, covering an area of 213,100 km^2 and a population of 2.941million, incomparably differs in size with New Hampshire, which covers only 24,097 km^2 and has a population of 1.402 million. The size of the state has a great effect on resilience and response in extreme weather conditions. Therefore, demographic data is very important to receive meaningful results.

The overall correlation for all states from 1999 to 2023 results in a low negative correlation of -0.16, which suggests a slight negative financial impact of extreme weather events on the states but lacks significance without additional data.

The analysis of the correlation between financial losses from extreme weather events and the variables *Real per capita personal income* and *Real PCE* yielded relatively low positive correlations for both. This contradicts the intuitive assumption that higher financial damages should generally correlate with a decrease in income or consumption. This discrepancy may be due to the long-term negative effects of extreme weather on these factors.

4 Conclusion

The objective of the paper is to establish how extreme weather conditions such as storms, floods, and tornadoes impact the United States' GDP and subsequently the disposable income of persons. The analysis revealed varying correlations between financial damages caused by these events and economic indicators across different states. In New Hampshire, the moderate negative correlation of -0.54 between financial losses and real GDP would indicate that the extreme weather events have a negative consequence on the economy. On the other hand, in Kansas, a positive correlation of 0.42 suggested that despite high financial damages, real GDP tended to increase, possibly due to the state's better preparedness or recovery efforts.

For the general time series for all states between the years 1999 to 2023, it's very weakly negative (-0.16). So there would be a slight economic impact of the country because of extreme weather conditions. In addition, low positive correlations of financial damages with the series *Real per capita personal income* and *Real PCE* that is opposite to intuition because one would think that greater financial damages decrease either the income or consumption of people. The deviation is important to underpin the fact that such extreme weather effects could be long-lasting and may impact over time these variables.

While the analysis provides a number of interesting insights, it also outlines the limitations of the data set, including missing values and the variation in responses to extreme weather at the state level. Furthermore, demographic and geographical factors such as state size and population have to be considered in order to interpret these results fully. In the end, though the study provides a useful starting point, further data and deeper exploration of regional mechanisms of resilience and recovery are needed to draw more concrete conclusions.

Literatur

Bureau of Economic Analysis. Gdp by state data table. https://apps.bea.gov/itable/?ReqID=70&step=1#eyJhcHBpZCI6NzAsInN0ZXBzIjpbMSwyOSwyNSwzMSwyNiwyNywzMF0sImRhdGEiOltbIlRh 2024. Accessed: 2024-12-30.

NOAA. Noaa storm events database. https://www.ncei.noaa.gov/pub/data/swdi/stormevents/csvfiles/, 2024. Accessed: 2024-12-29.