Title:

The Financial Correlations of Major Natural Disasters on Insurance Prices

Abstract:

Insurance is intended to be a protective measure against disasters or unforeseen events. However, large-scale natural disasters can mean insurance companies have to pay out huge sums to affected people, which may lead them to raise prices to recoup their costs. We analyze whether there is any relationship between the large-scale natural disasters (1 billion dollars or more of damage) and insurance prices, specifically property insurance prices, as well as overall insurance prices.

By combining datasets on natural disaster costs and insurance rate indices, we examined potential correlations between the financial impact of disasters and changes in insurance pricing. To standardize comparison, each disaster's total cost was divided by its duration in months to calculate a "cost-per-month," which was then applied across all datasets to ensure consistency.

Our analysis, however, indicates no strong linear correlation between the relative price of insurance and the relative cost of natural disasters, even after accounting for potential delayed effects. Severe storms remain the most frequent disaster type, and tropical cyclones still produce the highest overall costs, but these trends do not translate into proportional shifts in insurance prices. Instead, the data shows that both property insurance and overall insurance indices exhibit a strong linear upward trend over time, suggesting that insurance prices continue to rise regardless of the frequency or scale of major natural disasters.

Introduction

Our analysis aims to determine whether large natural disasters affect insurance prices and whether certain types, like property insurance, are more strongly affected. The main question is whether higher disaster costs correspond to increases in overall insurance rates or in specific insurance rates. Our project examines the correlations between disaster expenses and insurance indices to determine potential market responses. It can offer valuable insight for policymakers, insurance companies, and consumers seeking to understand how natural disasters shape financial risk and insurance affordability.

Data

We searched online for data relating to insurance prices and the costs of natural disasters. We ended up sourcing our data on insurance prices from the Bureau of Labor Statistics, which keeps of the relative track of the price index of insurance as a whole, as well as property insurance; both were adjusted for inflation. Unfortunately, no other information is provided, and only the relative cost to itself is given. Their downloadable data set contains data from 2009 to 2024.

The data on natural disasters came from the National Oceanic and Atmospheric Administration, which has a publicly available data set of billion-dollar natural disasters (adjusted for inflation) as far back as 1980. Each one included the event, the type of event, start date of the disaster, end date, as well as inflation adjusted and non inflation adjusted costs. It also had the number of deaths for that disaster. The natural disasters were divided into 6 types: Winter Storms, Wildfires, Tropical Cyclones, Severe Storms, Freezes, Floods, and Droughts

Data Cleaning:

Neither data set had any missing values, so cleaning it was just a matter of removing sone headers in the csv files that were describing how the data was formatted. The insurance data set contained data points for the relative cost of insurance each month for a total of 195 observations, and the natural disaster data contained 403 observations.

We assigned a cost to each month by dividing each natural disasters' cost by the number of months it spanned, before adding that result to the relevant months. Doing this with each natural disaster in the data set, we were able to assign a "monthly cost" of natural disasters to each month in our insurance data set.
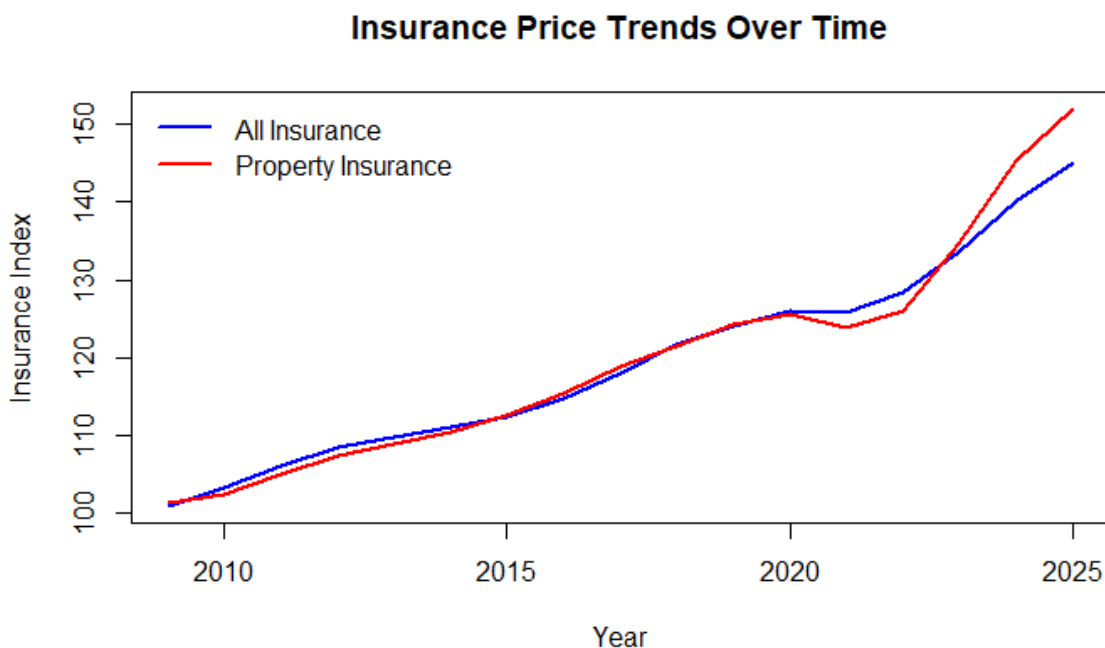
Visualizations

Figure 1: Relative insurance prices over time

This graph displays the cost of large natural disasters for each given month from 2009 and 2024, in millions. Overall, the cost seems to be relatively low with a few huge outlines Most of these come from hurricanes, as they are the most destructive and often don't span multiple months, and as such their cost is concentrated into a single month for our data. For example the two highest points in 2017 come mainly from Hurricane Harvey ($160 billion in damage) and Hurricane Maria ($115 billion in damage), in August and September respectively. However, because of the height of these two points, much of the data is hard to tell apart. As such, below is the same data, except on a log scale.

Some months had no large natural disasters during their time frame, and as such had 0 as their monthly cost data point. In order to generate this graph, we added 1 to each of the costs so they would be set to 0. However, this should not affect the graph much.

We can see that most natural disasters cause between 500 million to 5 billion dollars in destruction and other costs. If you squint, you may be able to see a positive correlation between time and the cost of diasters, although this correlation seems weak at best.
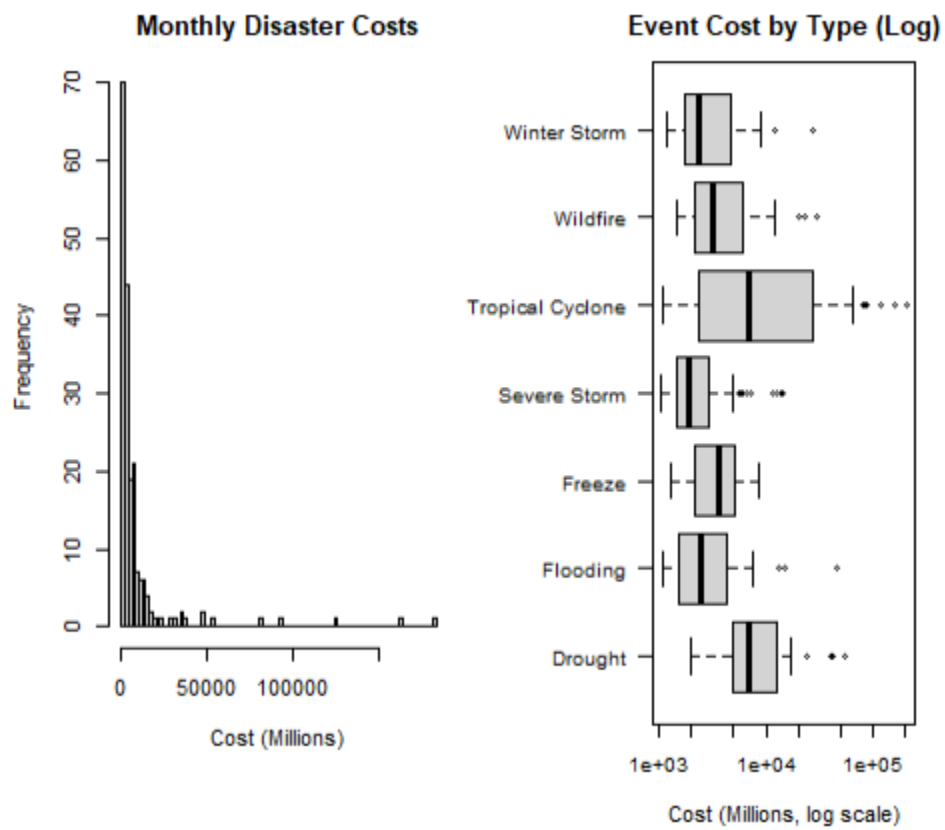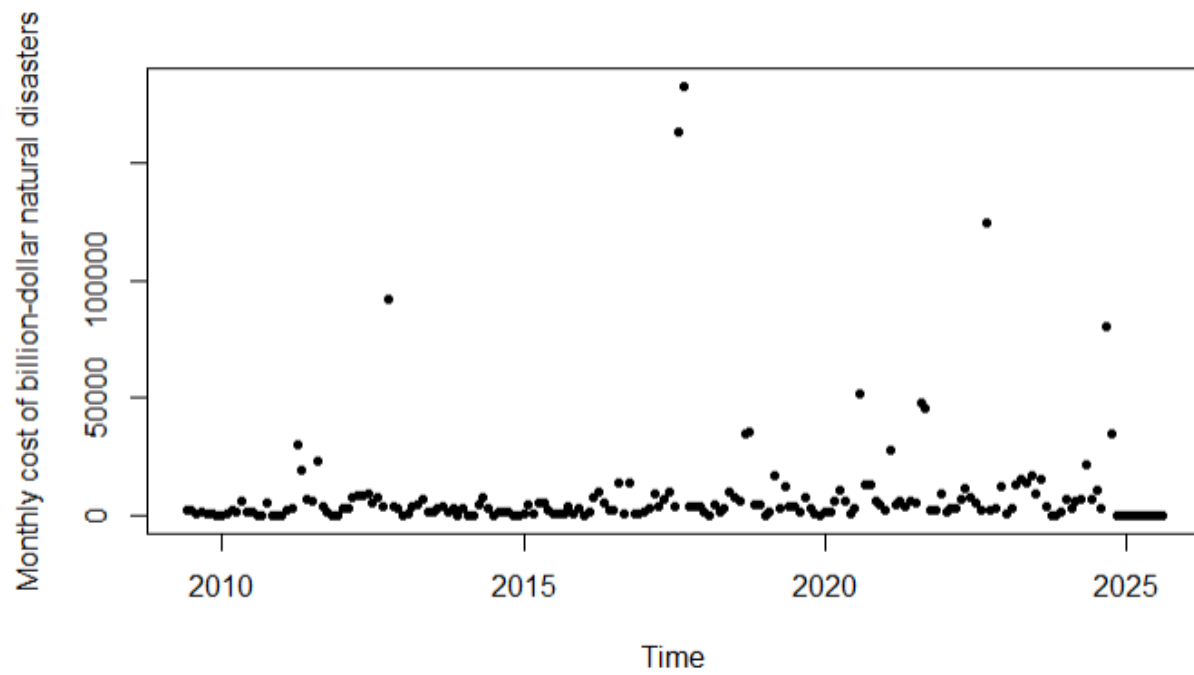
Figure 2: Disasters and their monthly cost

Figure 3: Disaster cost per month over time
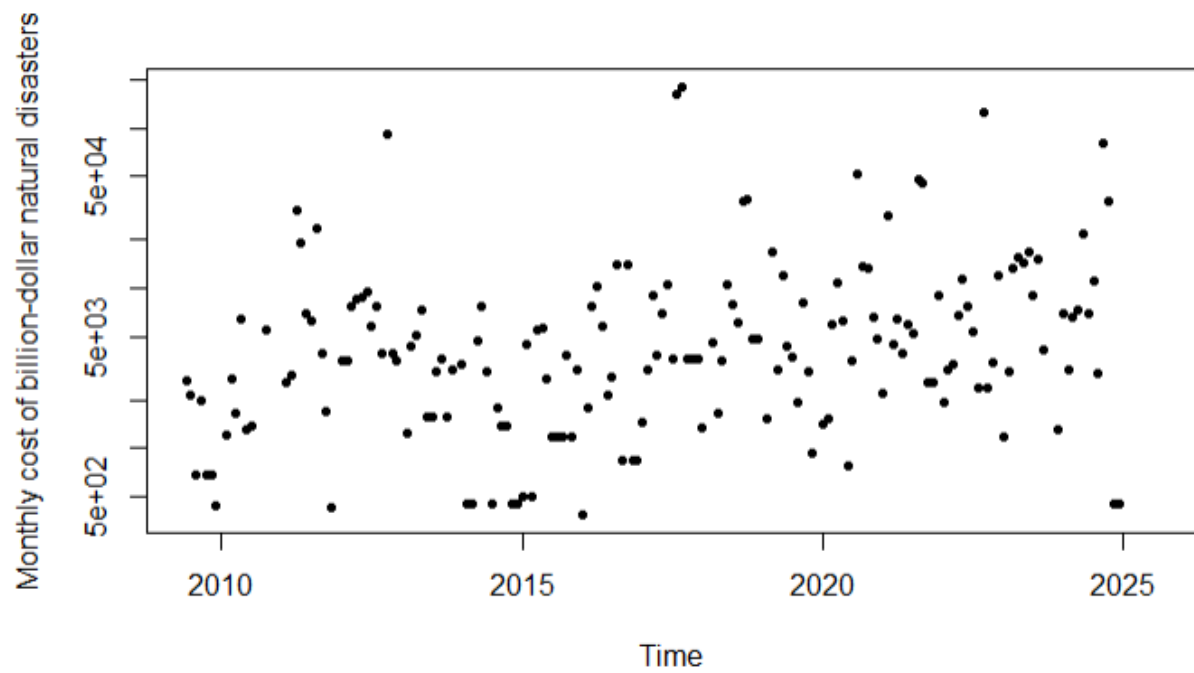

Figure 4: Log of the disaster cost per month over time

Analysis

With our data, we looked at how the financial costs of major natural disasters connect to changes in insurance prices over time. Beyond what we already analyzed earlier, we want to see if certain areas are more frequently affected by disasters and if they experience sharper increases in insurance prices. In order to do so, we will need to find additional datasets to do this analysis. We also want to see if factors such as inflation or GDP growth can determine whether changes in insurance prices are driven primarily by disasters or by general market conditions.

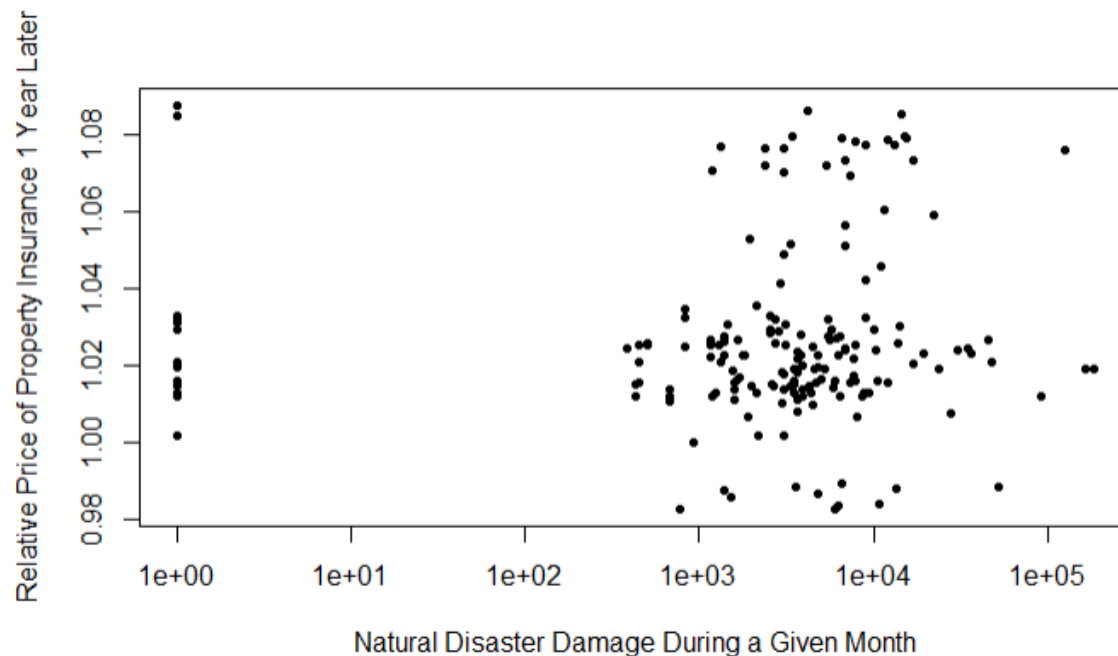| Predictor Variable	Explanatory Variable	Coefficient	P-value
Monthly Natural Disaster Damage	Time	0.0000376	0.756
Relative Property Insurance Price	Monthly Natural Disaster Damage	0.0000431	0.245
Relative Property Insurance Price	Log of Monthly Natural Disaster Damage	-0.480	0.148

Figure 5: Relative insurance prices given a year of delay

Github link (code, visualizations, etc.): https://github.com/puppy7777/STAT107_FINAL_PROJECT