Modeling stock market economy with past recessions and natural disasters

1st Danan High
computer science department
The University of New Mexico
Albuquerque NM, United States
dqhigh@unm.edu

***Abstract*—The purpose of this paper is to analyze and look at past recessions and natural disasters to find a comparison to the current pandemic involving Covid-19. To do this we will use unemployment rates and stock market prices, using a stock from each of the 11 sectors, over the time periods of Hurricane Katrina (micro-economy), the California wildfires of 2018 (micro-economy) and the economic recession of 2008. Comparisons will be made using cross entropy and then other stats such as growth rate and decrease rate for modeling and predicting the stock market future. It is important to look at the past disasters as a way to hopefully give an outlook to how the stock market economy could rebound given the current state during the Covid-19 pandemic.**

***Index Terms*—cross entropy, micro-economy, 11 sector market**

I. Introduction

The pandemic that has engulfed the country over the last few months has had many impacts on our lives. One of the main impacts that has occurred is the rapid drop in the stock market economy. Due to precautions being taken, such as the implementation of social distancing and isolation, the economy has slowed and has not been stimulated by its normal patrons. This has lead to increased unemployment rates and drops in stock market prices. The stock market drop started once the pandemic reached the United States in January of 2020 [1]. These two factors, unemployment and stock market downturn, are only two of the many factors that go into an economy [2], but they will be the ones we look at in this paper.

To understand how this drop in economy compares to different time periods we need to introduce the concept of cross entropy [3], which can be defined as the average number of bits from one data set needed to describe the events of the other data set.

$$H(A,B) = -\sum_{i=0}^{n} A(x_i)\log B(x_i) \tag{1}$$

The above equation takes the product of the probability of one data set and the logarithm of the probability of the compared data set. Then the sum of each of these comparisons is taken to give the total amount of information in the system. This comparison is intended to show how related one data set is to the other data set [3]. The lower the total amount of bits needed to compare the two systems, the more the systems are related. If a system needs more bits to compare one another, it means that it has a higher entropy and shows that the two data sets in the system are less alike.

Mutual information was not used due to the data sets not being dependent on each other. Because they are independent the mutual information will always be 0 because they will not have any information in common with each other.

We determined the stocks to analyze in the paper based on the eleven different sectors of the stock market [4]. The eleven sectors were defined in the API that was used to obtain the stock market data, yfinance. Each of the eleven sectors has different features and can thus be designated as distinct. There are also sub-categories in each sector, but to keep the data collection cleaner we resigned to one stock from each of the eleven sectors.

In the following sections of the paper the unemployment rates of different states, California and Louisianna (micro-economies), and the United States will be discussed and analyzed for differences and comparisons. A micro-economy in this paper is defined as the state unemployment rate during the time of their specific natural disaster. Also, the paper will look at stock prices and fluctuations in the mean market during the time frames of the 2008 recession, the natural disasters of Hurricane Katrina and the California Wildfires, and also of our current pandemic involving Covid-19. We will discuss similarities and differences in the stock prices, the cross entropy of the system, and unemployment rates over the different time periods in the following paper.

II. Methods and Results

A. Natural Disaster Unemployment

In August of 2005 Hurricane Katrina struck New Orleans, Louisiana causing mass destruction to the local economy. During this time there was a spike in unemployment rates and many people were left without jobs. Here we analyze the unemployment rate with data from the Federal Reserve Economic Data bank of St. Louis [5]. The data is incremented monthly, with each data point beginning on the 1st of the month.

Comparing the unemployment data of Louisiana [6] during the time period of August of 2005 through April of 2006 we find that before the hurricane there was an unemployment rate of 5.7%. After Hurricane Katrina hit New Orleans in August of 2005 the unemployment rate rose to 11.3%, increasing by about (11.3 / 5.7) * 100 ≈ 200%. The time period of the increased unemployment rate lasted for about six months, leveling out in September and when this period ended, the unemployment rate dropped back down to a rate of 4.9%. The above numbers can be seen in Fig. 1, which graphs the unemployment rate data spanning the duration of the Hurricane Katrina year.

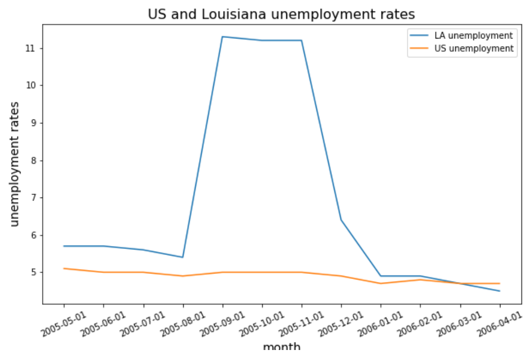

Fig. 1. The figure shows the unemployment rates during the year time period of Hurricane Katrina. The time period starts in May of 2005 and ends in April of 2006. There is a spike after Hurricane Katrina hit New Orleans and it continues while the affects of the disaster finishes around January of 2006.

We also see in Fig. 1 that the US unemployment rate does not follow or is affected by the unemployment rate of the micro-economy of Louisiana.

We see a similar pattern, US unemployment rates not being affected, when looking at unemployment data during the time period of the 2018 California wildfires. During this time period, April of 2018 through March of 2019, we see that there is little to no change in unemployment rates in California. The rate goes between 4.2% and 4.3%, but never higher or lower [7]. During this same time frame the US unemployment data does not see any major spikes or depressions in rate either with a standard deviation of 0.108 and a mean of 3.842%. The rate maintains a range from 4.0% to a low of 3.7%. The values are shown below in Fig. 2.

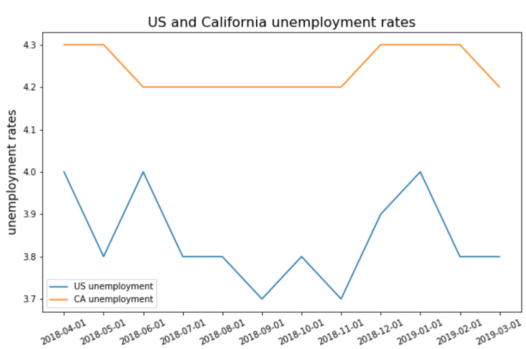

Fig. 2. The figure above shows the unemployment rates of the United States and California over the year spanning the California wildfires of 2018. The graph shows a steady unemployment rate between both the US and California data, and that there is no influence from the California rates on the US rates.

B. Recession Unemployment

During the recession beginning in 2008, unemployment rates in the United States spiked significantly due to the recession in the stock market and economy. The increase in unemployment started around April, but it didn't start to spike until the stock market hit the full recession in September [5]. When the spike started the unemployment rate was at 6.1% and when it hit the peak of 10.0% it was September of 2010. The growth rate was steady for the whole year until maxing the unemployment rate at about 150% of the begin point. This can be seen in Fig. 3 below.

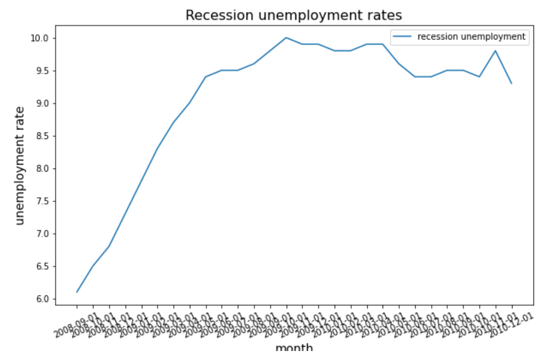

Fig. 3. The figure above shows the unemployment rates of the United States spanning the recession of 2008. The time frame lasts from September of 2008 through December of 2010. There is a max rate seen in September of 2009, and a minimum at the start of the recession.

Once the peak hit in 2010 the rate plateaued and remained around 10% unemployment until the rate started its drop in December of 2010. The increase, plateauing and then proceeding to decrease follows the same pattern seen in the Hurricane Katrina natural disaster, but the rates at which these occur do not relate to the other disaster.

C. Covid-19 Unemployment

The Covid-19 pandemic has caused the unemployment rate to climb at a significant rate. Once there were orders to social distance and isolate to prevent the spread of the virus [5], there was a rapid spike in unemployment rate. A few months before the pandemic started in May of 2019, the unemployment rate in the United States was a little below 4% at 3.6%. Once the pandemic was declared in the United States there was a rise in unemployment rate from 3.5% to 4.4%. Then in the last month the rate has risen about 300% = (14.7% / 4.4%) * 100. Fig. 4, below shows the data in the form of a line graph.

D. Stock Analysis

When comparing the stock data throughout the paper it was necessary to create a normalized range. This was due to the fact that some stock prices had a much higher income range than the other stocks. To perform normalization we used the following equation,

$$H(x) = \sum_{i=0}^{n} (x_i - x_{min})/(x_{max} - x_{min}) \tag{2}$$

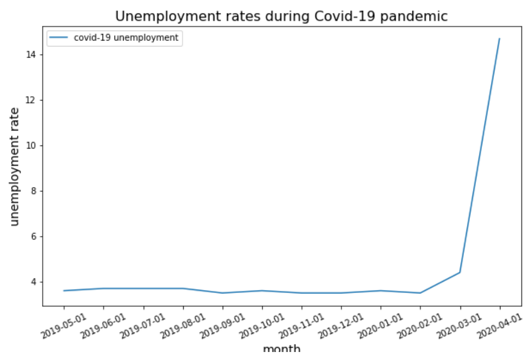

Fig. 4. The graph above displays the unemployment rate of the United States before and now during the Covid-19 pandemic. It shows how the social distancing and isolation has caused the unemployment rate to increase dramatically over the last two months.

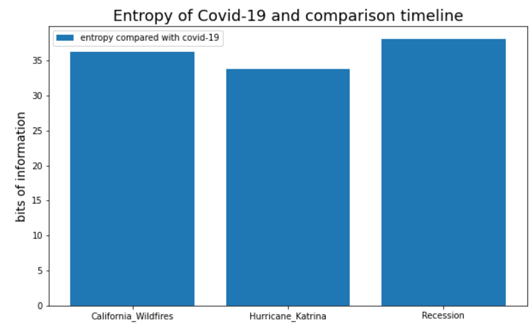

Fig. 5. The bar graph above shows the amount of information shared between each of the disaster time periods and Covid-19. In the graph we can see that the lowest entropy, meaning the most shared information, is between Covid-19 and Hurricane Katrina.

This produced a range between 0 and 1, allowing for easier comparisons and predictions for our stock data. The stock data consisted of one stock from each of the eleven different sectors of the stock market [4]. The stocks chosen were used because they fit the criteria of having data far enough back in the past for each of the three different natural disaster periods and they were all considered leaders in their eleven sectors.

The data from the stocks is daily closing prices collected during the time frame of the disaster. This ensured that the data was consistent and the last recorded price for that day was being used. This meant the most up-to-date information for each interval was being used for the analysis. The stock data was retrieved using API calls with the yfinance library. The tool allowed for collecting daily data between designated time periods.

Once the stock data had been collected and normalized there was a comparison made between each of the natural disaster timelines and the current Covid-19 stock data using cross entropy. After comparing the data it was discovered that the Hurricane Katrina and Covid-19 data sets shared the most information with 33.82 bits of information. This can be seen in Fig. 5, directly below.

Because the data from the Hurricane Katrina timeline matched with the Covid-19 stock data the closest, that was the data we used when looking at a potential stock forecast.

Fig. 6 below shows the daily closing prices of the Hurricane Katrina data mapped against the Covid-19 data. Here we see that the data sets do follow a similar pattern of general growth during the first part of the time frame, a slight drop in price and then a rebound towards the end of the graph.

The Covid-19 data had a sharper decline of (0.833 - 0.113) / 25 days $\approx$ 0.0288 during its descent. The descent for the Hurricane Katrina data set lasted longer and it was slower to decline, with a final value of (0.669 - 0.358) / 61 days $\approx$ 0.0051. This shows that in comparison the Covid-19 stock rate of decrease was 0.0288 / 0.0051 $\approx$ 5.467 times faster than the Hurricane Katrina decrease.

During the data increase, we see a similar result with the

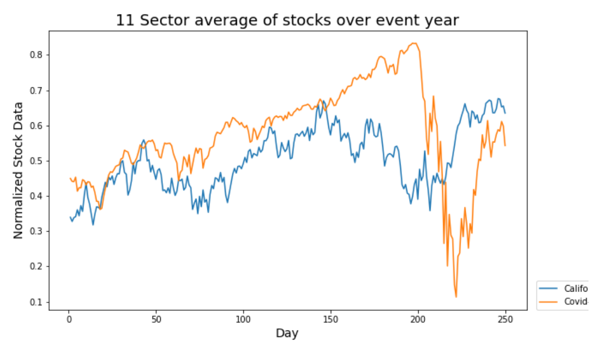

Fig. 6. The above figure displays the daily stock data of the Hurricane Katrina and the Covid-19 time periods. We see that the two graphs are similar and they have a cross entropy value of 33.82 bits.

data from Hurricane Katrina being slower to rebound than the Covid-19 data, however, the slowed rate isn't as pronounced as the decrease data. The growth rate for the Hurricane Katrina stocks was (0.661 - 0.358) / 20 days $\approx$ 0.0152. The increase rate for Covid-19 is (0.614 - 0.113) / 18 days $\approx$ 0.0278 with the difference between the two being (0.0278 / 0.0152) $\approx$ 1.182 greater increase in the Covid-19 data.

III. FORECASTING

Now we will focus on making some small forecasts of the stock market economy based on the past data we have shown and some assumptions from a model that gives possible finish dates on the Covid-19 pandemic [8]. In the model predicting outcomes and finish dates I will focus on the model showing a completion range of about 200 days, as the spread was somewhat mitigated with social isolation and quarantine techniques. However, these techniques were not followed adamantly by the public and spread is still happening.

Using the the Bedford blog [1], assuming that the first case of Covid-19 was in Seattle around January 1st, I will cap my timeline for the projected finish date around July. This follows the 200 day interval. When looking at the stock data growth rate seen now 0.0394, the market has already started to rebound. If the growth rate continues and we use the latest data point of 0.543, it will take approximately (0.833 - 0.543) / 0.0278 = 11 days to reach the height before the Covid-19 caused crash. This projection is unlikely as a rebound is generally quicker in the early days after the bottom out caused by a disaster.

To use a different rate, I used the growth rate from before the crash to model the upcoming days. This rate was 0.0026, and using this growth rate there was a projection of 112 days.

I then made the comparison using the growth rate from the Hurricane Katrina disaster on its rebound. When using the rate of 0.0152 for the growth we see that it will take about 20 days for a full recovery.

IV. Discussion and Conclusion

The pandemic has caused much upheaval in our lives and has introduced a new norm of the unknown. When looking at the unemployment rate for the country we see a massive spike that hasn't been seen since the time of the recession in 2008. If we continue this trend we will see the unemployment rate continue to rise until the social distancing and isolation restrictions are lifted.

This alone has been the cause of many local business being shut down, forcing them to furlough their employees. Once the restrictions are lifted we could see the unemployment rates level off and then drop once stability in the economy is reached. As seen in Fig. 3, this may not be a quick process as the trend downward in unemployment rates did not begin for about a year and a half after the initial recession spike. If this holds true it might mean that it will take until 2021 to reach levels of unemployment seen before Covid-19.

The stock market has also seen a drop due to the pandemic. In modeling the market we found that the best range for predicting a market return was somewhere between the Hurricane Katrina growth rate and the Covid-19 growth rate before the pandemic.

As seen in the [9], the market downturn was due to preparations of an economic downturn. Meaning that the market responded due to fears, correct in the end, that the economy would slow and fall due to issues caused by the pandemic. This doomed the market causing the stock market economy dip. There has been a slight bounce back in the stock economy with a growth rate of 0.0278 over the past few weeks. This likely won't hold and a lower rate somewhere between the Hurricane Katrina growth rate and the growth rate before the downturn, would be more likely to follow. Given this fact, I would still be apprehensive to predict a return to the peak value of 0.833 before the pandemic. The accuracy would be low when guessing from the large range of 20 to 112 days. We will most likely, and hopefully, see something in-between these two values.

For future analysis it would be interesting to break down the market analysis into more detail by comparing many stocks from each of the 11 sectors of the market [4]. This would mean that it would be possible to see if certain areas were doing better than others in certain natural disasters.

References

[1] T. Bedford. (2020) Cryptic transmission of novel coronavirus revealed by genomic epidemiology. [Online]. Available: https://bedford.io/blog/ncov-cryptic-transmission/

[2] B. Flowers, "The economics of natural disasters," *Page One Economics*, May 2018.

[3] "Cross entropy," Mar 2020. [Online]. Available: https://en.wikipedia.org/wiki/Cross$_entropy$

[4] R. Lake, "A guide to the 11 market sectors," Jan 2020. [Online]. Available: https://finance.yahoo.com/news/guide-11-market-sectors-142851510.html

[5] (2020) U.s. bureau of labor statistics, unemployment rate [unrate]. [Online]. Available: https://fred.stlouisfed.org/series/UNRATE

[6] (2020) U.s. bureau of labor statistics, unemployment rate in louisiana [laur]. [Online]. Available: https://fred.stlouisfed.org/series/LAUR

[7] (2020) U.s. bureau of labor statistics, unemployment rate in california [caur]. [Online]. Available: https://fred.stlouisfed.org/series/CAUR

[8] A. Atkeson, "What will be the economic impact of covid-19 in the us? rough estimates of disease scenarios," National Bureau of Economic Research, Tech. Rep., 2020.

[9] S. Ramelli and A. F. Wagner, "Feverish stock price reactions to the novel coronavirus," *Available at SSRN 3550274*, 2020.