# Executive Summary

There has been much speculation on the effects of COVID on the economy and financial markets since early 2020. Predictions have been made by economists, politicians, and investment firms with effects ranging from a mild economic setback, to a full on crisis comparable to the Great Depression. While economic predictions are abundant, there appears to be some reticence for investment firms to predict the future of financial markets. This is likely due to the real rammifications that can follow with poor predictions such as lawsuits for lost wealth or lost opportunity. None-the-less, it is possible to read between the lines and predict what may happen in the financial markets, based off of economic conditions, using the S&P 500 hundred as an indicator.

The economic impact of COVID is visible, but some of the long-term effects will take time to be reflected in the S&P 500. Using economic models and information does not translate directly to constructing a useful model for financial markets. Much of the perfomance of the markets is dependent on investor confidence and that confidence is not always tied to what is happening in the economy. There are three common models used to predict the stock market. Two of these models are focused on short-term strategies, while the other is focused on long-term market trends. An analysis of the strengths and weaknesses of each of these models give a good starting point to make some sense of the effects of COVID on financial markets.

An attempt to model how a typical investor can prosper, or at least survive in such market conditions. The model in question was made by gathering historical data in an attempt to forecast the mid-term (ten year) future of market conditions.

# Economic impact of COVID

The initial impacts of COVID were simultaneous shocks in supply and demand. Essential goods such as non-perishables and sanitation supplies were hoarded from store shelves. The supply chain was not ready to meet demand as news of the potentially lethal effects of the virus worried US consumers. Since the beginning of the outbreak in early 2020, global supply chains have been disrupted, consumer consumption has decreased, and at the time of writing umemployment is double the rate it was before the pandemic. Most early predictions agreed that service-oriented economies would suffer disproportionately as demand for basic goods increased, and demands for services such as tourism and transportation declined[1].

Early COVID models predicted up to 2.2 million deaths in the US alone[2], which meant that the traditional approach to evaluating the economic damages of an outbreak were used to model economic impacts. The traditional approac uses information on deaths and illness to estimate the loss of future income due to death and disability. Losses of time, income, and direct expenditure on medical care are also part of the traditional measures of economic costs.[1].

In reaction to these early predictions, governments across the world shut down economies and enforced essential-jobs-only policies. In the US these policies resulted in mass unemployment and the transformation of the economy to something akin to a wartime economy. Efforts to expand production and care were made. The CARES Act and Defense Production Act were implemented and borders were shutdown. The US economy looks like a wartime economy as it has balance resources spent on profit-seeking ventures and resources spent on the protection of its vulnerable citizens. An additional similarity with a wartime ecnomy is the need for state intervention and leadership. In order to maintain order and protect the most vulnerable members of society, special polcies have been put into place for those out of work, and unable to pay rent or mortgages. Some of these policies have immediate effect on the economy, while others are likely to have a delayed effect.

The COVID crisis led to massive cuts in business expenditures in innovation, training and general management improvements, [3], which we expect to lower productivity into 2021 and beyond.

The first historical example that comes to mind is the influenza pandemic of 1918. In a 2007 study, it was found that most of the economic impacts of time were short-term. The service and entertainment industries suffered double digit losses, while other businesses that specialized in healthcare had increased revenues. The study predicted hundreds of thousands to several million deaths and a cost of several hundred billion dollars on the economy[4].

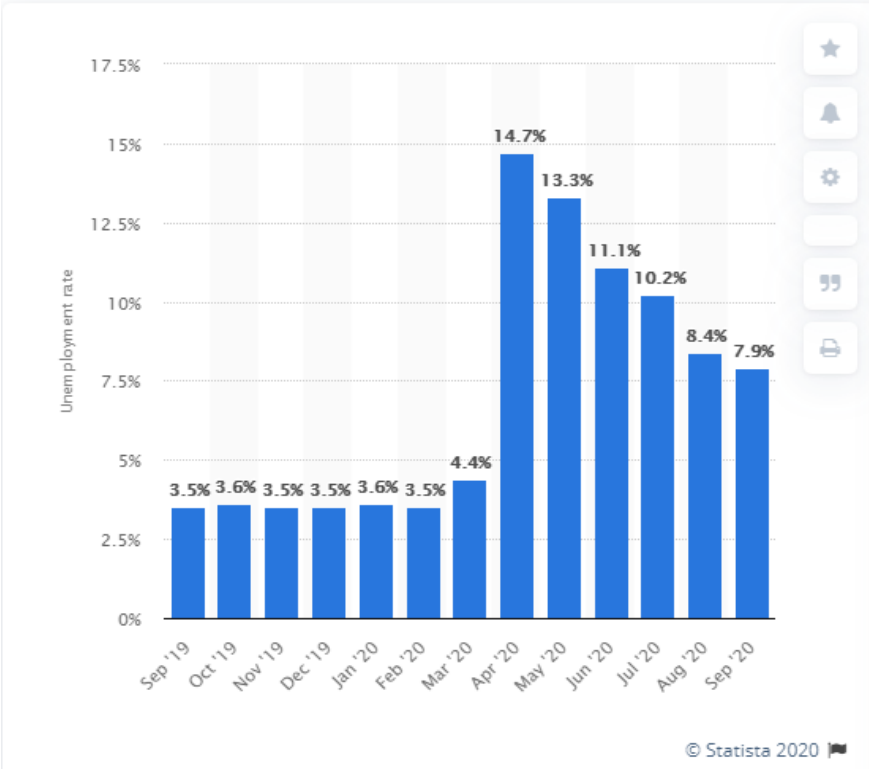
While some aspects of th 1918 pandemic give valuable insight, we live in a global economy

with global supply chains. Nations are likely to act in self-preservation if things get dire and resources become dangerously scarce. The US has already had minor disagreements with both China and India regarding certain medical supplies[5][6].

While globalism has enabled created massive economic growth and wealth globally, supply shortages highlight the dangers of becoming overly dependent on other nations for basic goods and resources. These quarrels highlight the risky position service-oriented economies find themselves in as they depend on production economies. Tensions have mounted between China - the world's manufacturer - and developed nations in North America, and Europe as well as South Korea and Japan. As developed nations seek to strengthen their supply chains, many have plans to decrease dependency on China. President Donald Trump enacted the Defense Production Act to try to make the US more independent on medical manufactured goods[7]. More manufacturing could become domestic as a response to global supply shortages.

## Where Do We Stand In Regards to COVID?

At the time of writing we are nearly 8 months into the pandemic, and what are some of the things we have learned regarding the pandemic? The mass shortages predicted at the onset have not yet revealed themselves. Unemployment rose to 14.7% in April and as of September it has eased back down to 7.9%.



[8]

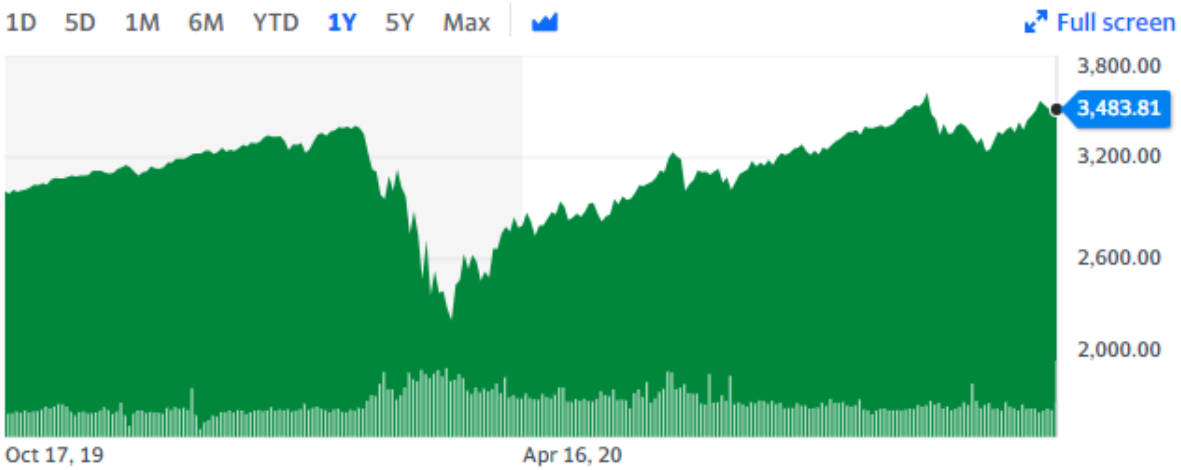
Total US deaths is about 220 thousand with total cases at 8.19 million. 70 percent of those that have died were 65 and older[9]. This will result in greater than expected intergenerational wealth transfer. This wealth transfer may result in greater economic activity, but it remains an open question.

Yelp's Local Economic Impact Report for September 2020 indicated that 60% of small businesses that had closed were closed permanently. With no end-in-sight to social distancing, it is likely that more small businesses will close as they are limited in the amound of business activity they can engage in, especially in sectors such as restaurants and retail.

Pandemics typically come in waves, and we are still in the midst of the first wave. The Global pandemic of 1918 and 1919 had three distinct waves. The Bubonic plague had three waves. These waves can be the result of new strains of the virus appearing, or due to relaxation of quarantine and social distancing practices. It is entirely possible - and should be kept in mind – that a newer, deadlier, or even more contagious strain of the virus appearing is a possibility. This means that it is unlikely that new small businesses will come along to replace those that have closed.

One stimulus package has been released, with another one on the horizon. These stimulus packages could have an impact on inflation, although economists do not expect a great impact on inflation[10]. While inflation may not experience a large rise, the US national debt has already increased by $4 trillion this year. Government debt has real consequences on the future viability of the economy.

## What Are the Financial Markets Telling Us?




The S&P 500 suffered a precipitous drop from the end of February nearly to the end of March. Since then it has recovered, reaching a new all-time high in September in the midst of the pandemic

and has remained high since. This is a curious outcome as the economic impact of COVID is clear and well known, but investors remain confident. This could be due to several factors, one of which being the disproportionately lethal effects of COVID on small businesses that do not have tickers on any stock exchange.

In the US, big businesses are coming out the pandemic virtually unscathed. The changes in business necessitated by COVID favored large companies over smaller ones. Large companies were more likely to have online ordering and delivery capabilities and bolstering these lines of business was easier for large companies than for small ones. While revenue has increased for large businesses, they will not be able to continue increasing revenue as there inevitable decline in consumer spending results from high unemployment and a massive decline in the number of small businesses.

While the S&P 500 is not always direclty correlated with the state of the economy, it is likely that investor confidence will dwindle over time as long-term effects of COVID on the economy become more apparent. The dichotomy between the stock market and the state of the economy is indicative of potential volatility in the future. Investor optimism does not remain high over the long term without some justification for stock prices through earnings.

## Common Models

Models used to describe or predict the stock market fall into one of two categories. Long-term growth models that are utilized by investment firms and financial advisors as a method of planning and preparing for retirement, and short-term models utilized by mathematicians and day traders. Unfortunately both models are filled with inherent risks that every day investors or typically unaware of.

Short term models predicting market outcomes most frequently come in two flavors – bayesian statistical models, and stock correlation or network models. Bayesian models generally less academic in nature and are employed by investors attempting to beat the market by using statistical forecasting. This is likely due to bayseian models being easy to create and employ, with detailed descriptions of the modeling process being widely disseminated online. Bayesian models make priori assumptions of the long-term outcome of the market being growth due to historical data:

**S&P 500: 1926-2015**

| Time Frame | Positive | Negative |
|---|---|---|
| Daily | 54% | 46% |
| Quarterly | 68% | 32% |
| One Year | 74% | 26% |
| 5 Years | 86% | 14% |
| 10 Years | 94% | 6% |
| 20 Years | 100% | 0% |

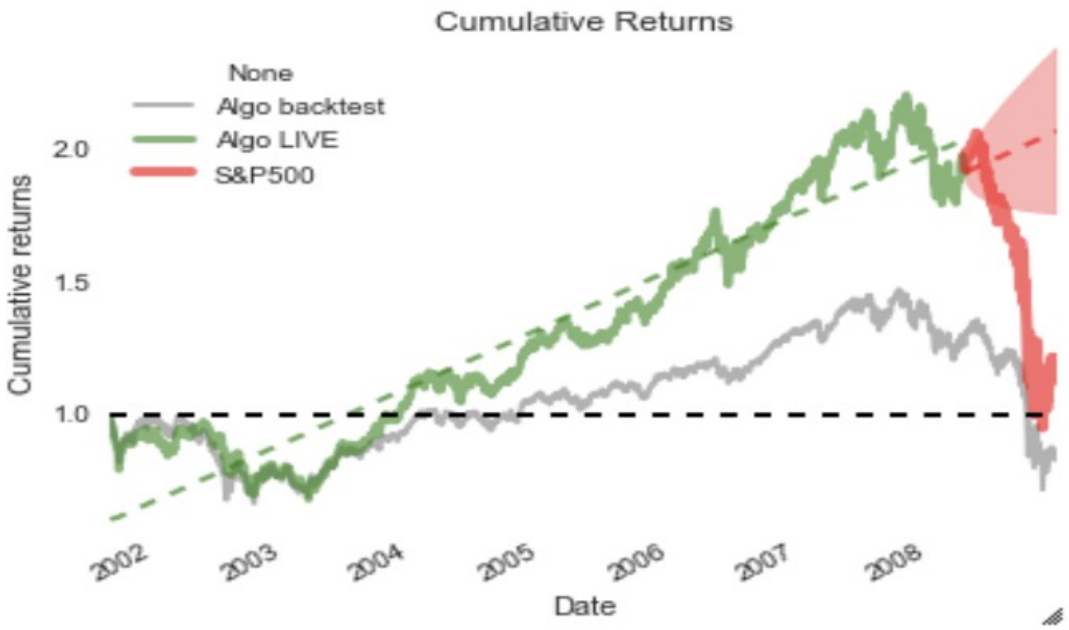
Source: Returns 2.0

Once the historical base rate is put into place, these bayesian models are highly customizable with most centering around market indicators that the modeler wishes to include. Many of these models employ technical analysis, which is the study of a stock's price movement over the short-term in relation to its rolling average over a six to twelve month period. Investment decisions are made based off of anomalies in the behavior of the stock's price against its historical behavior.

One of the benefits in using a bayesian approach is that it can provide a distribution of outcomes. Data Scientist, Sepideh Sadeghi showed that the utility of bayesian models can predict a range of outcomes as well as predict market behavior pretty well over a given time span if proper assumptions are made[11]:


The data signified by the gray line was data used to train the bayesian model employed by Sepideh Sadeghi and the green line is the model's behavior on live data. The probability cone in red appears to reasonably fit the data.

That same bayesian model completely fails when tested against the market crash in 2008:




This shows that the usefuleness of a bayesian model is limited by the data and assumptions it is constructed with. When something unexpected happens, or there is a fundamental shift in market dynamics, these models can be expected to fail.

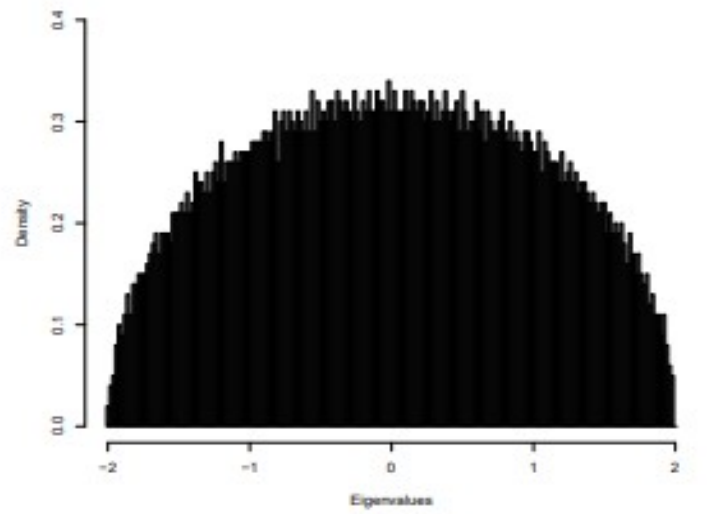
The other short-term predictive models are known as Dynamic Stock Correlation Networks, and are more popular among mathematicians. The models are based around correlation matrices and rely on understanding the underlying relationships between stocks, sectors, asset classes, or a combination of these things. The goal is to identify lead-lag correlations in the market by constructing correlation mamtrices of the various investments under investigation. These correlation matrices are typically 'messy with noise' [12] and thus require a technique known as Random Matrix Theory to filter out noise from meaningful data.

The technique is straight-forward in nature. The goal is to identify eigenvectors and eigenvalues of the correlation matrix that contain useful information from the eigenvalues and eigenvectors that have no real useful information. The properties of the correlation matrix are compared against those of a purely random matrix. Derivations from the random matrix case then might be useful information.

As described by the authors in Random Matrix Theory and Financial Correlations, the empirical correlation matrix **C** is constructed from the time series of price changes:

$$C\alpha\beta = 1\ T\ T\ t=1\ \Xi\alpha(t)\Xi* \beta(t) = r\alpha\beta\ \exp(i\theta\alpha\beta)$$

Randomness is filtered out from the correlation matrix by comparing it against the gaussian distribution of eigenvalues produced by a random matrix:




Random Matrix theory is the marriage of Probability Theory and Linear Algebra. T he result of a gaussian-like distribution is akin the the Central Limit Theorem in Statistics. This means that any deviations from the expected distribution of randomness shows a potential correlation worth investigating.

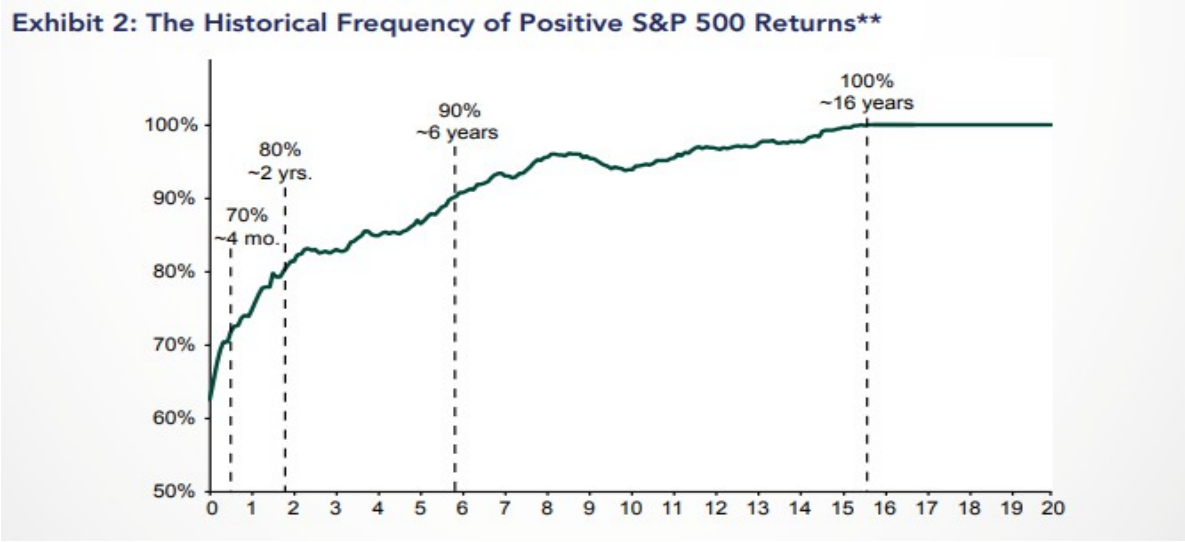
Works by Ricardo Coelho of the School of Physics in Dublin [https://www.maths.tcd.ie/~coelhor/Ancona_Presentation_v1.0.pdf], Jim Getheral, professor of Financial Engineering[13], and others[14] have shown that the the utilization of of Dynamic Stock Correlation Networks can identify relevant correlations between financial assets of various types. The model is primarily aimed at minimizing risk in investment portfolios. While the models have proven that they can be of use, all studies report the overall direction of the market is a much stronger force in the movement of stock prices when compared to correlation coefficients:

$$\mathbf{C = C_{market} + C_{group} + C_{random}.}$$

With the long-term outlook of the market predicted to be one of growth, this model has seemed to have lost popularity since the late 2000s with most studies being from that time period. If the economic impact of COVID proves to result in a flat market, this model may again grow in popularity as a means to identify potential growth opportunities when there is little market force either up or down.

The long-term models used by investment firms is built upon the historical returns of the S&P

500 and Dow Jones Industrial Average.

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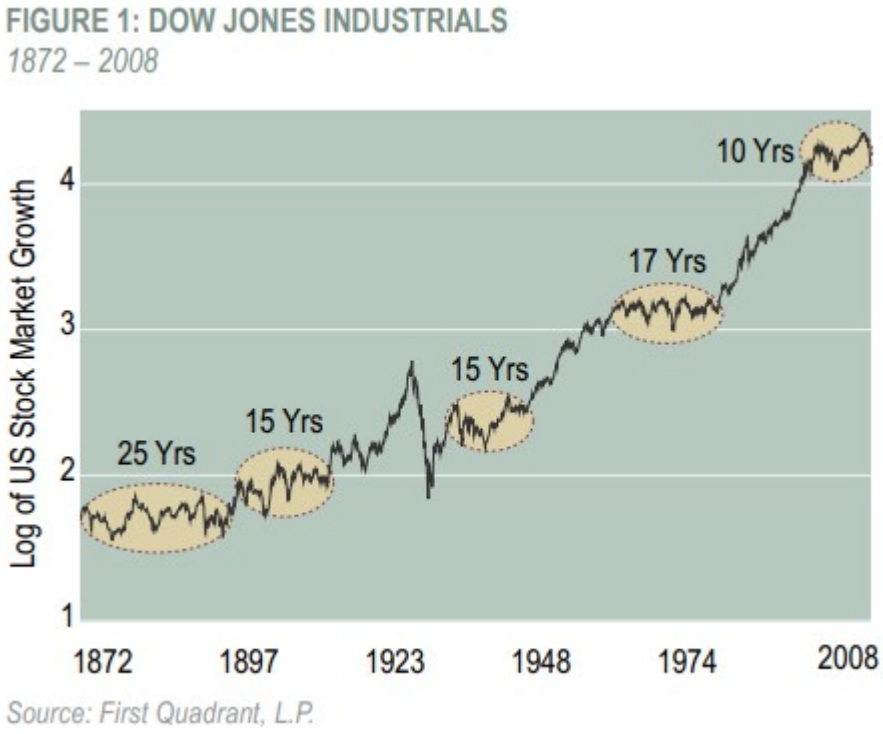
Source: Returns 2.0

Undeneath the historical returns of the S&P 500 are economic forces that partially justify the priori assumption that the financial markets will grow in the long-term. Population growth, economic participation, technological innovation, and government investment in infrastructure are some of the forces that have grown the economy in the 20th and 21st centuries. The industrial revolutions of the 19th century fueled economic growth before that. Historically speaking, economic slowdown is unlikely, but not impossible.

The technological innovations that followed the development of the semi-conductor in the 20th and 21st centuries are approaching the limits of Moore's Law, telecommunications appears to have already collected the low hanging fruits as each successive smart phone is les different from its predecessor. Aging populations in Japan and Europe have resulted in a 30 year decline in the Japanese stock market and a 20 year stagnation of the European stock market respectively. China is a good example of a nation that reaped phenomenal GDP growth in the last 30 years due to investment in infrastructure, but most of the easy projects have already been completed. The need to continually

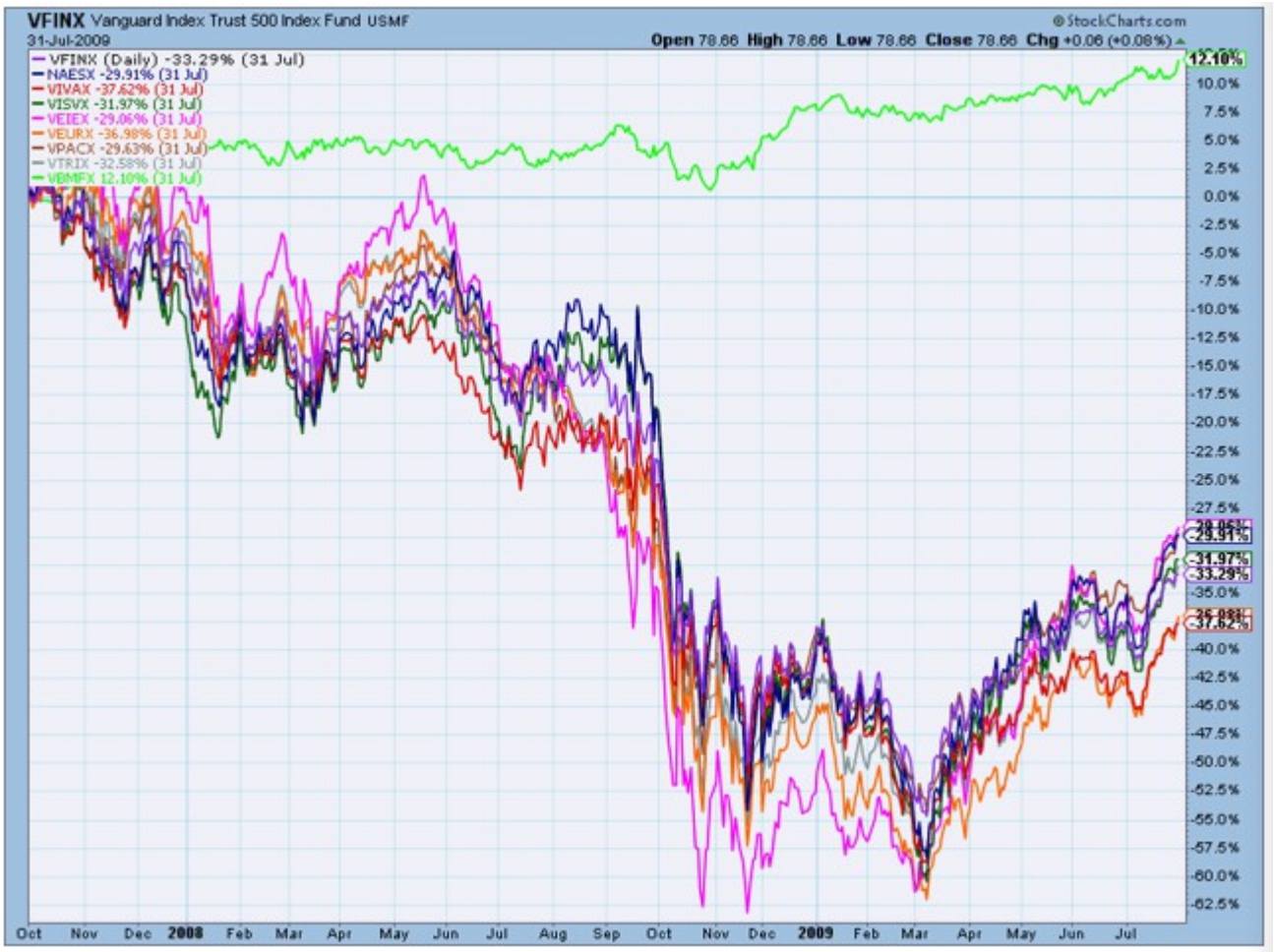
increase GDP has led to the interesting case of 'ghost cities' in China, which artificially inflates GDP, but results in no actually increase in national wealth.

It is possible that the US economy slows moving forward. While artificial intelligence sppears to be promising in increasing economic activity domestically and abroad, the financial damage due to COVID could slow down technological innovation as business investments in innovation have diminished this year as previously noted. While an again popultion is not as big of an impact in the US as it is in Europe, China, and Japan, millenials are much less likely to invest in the stock market than previous generations[16]. This could result in decreased demand for stocks in the future, further driving prices down.As the economic impact of COVID continues to be felt moving forward, it is not altogether unreasonable to predict long term stagnation for the US markets. Periodic stagnation in between periods of growth is infact quite common as noted by Ed Peters, Senior Partner at First Quadrant[17]. This shown in the table below:




Even if the risk of long-term stock market decline is low, there are still long and frequent periods where equity returns have been flat. A historical view of the S&P 500 shows similar periods of flat equity returns.


While a long-term buy and hold approach has worked when comparing 1950 to 2020, someone investing in the mid 1950s would have seen a net zero return for nearly 30 years. Just by viewing the graph, it is easy to see that if an investor was invested for the wrong 10 or 20 year period, they could very easily have lost value on their principal. So while long-term investing has historical justification, it should come with some disclosures. In periods of stagnation, volatility can be leveraged to provide portfolio growth provided there is enough volatility to cause a significant short-term changes in asset prices. This idea will be explored later. There is one other feature of long-term growth models that investment firms consider important: diversification. The concept of diversification revolves around dividing funds amongst non-correlated assets so that when one type of asset falls in value, the overall portfolio is not affected. This strategy works well in long-term growth markets because most asset classes tend to rise, but when the market crashes, all of these asset classes tend to fall together:




[18]

## Using Historical Data to Predict the Next Ten Years

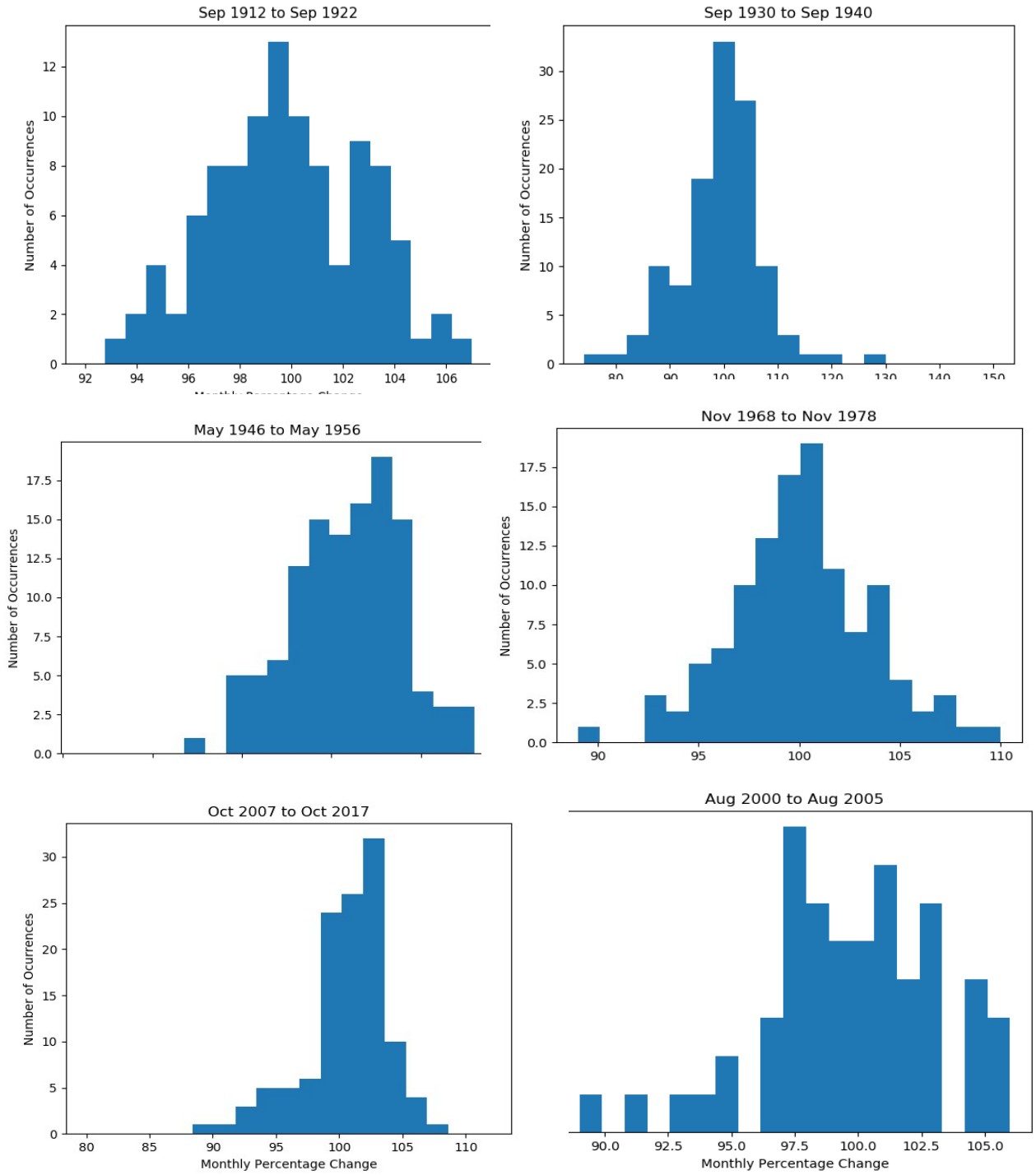
In an effort to model the next ten years of the S&P 500, I constructed a statistical model, ,using data from market crashes of the 20th and 21st centuries. While the current economic damages due to COVID are unique, this current market environment shares some similarities with these historical crashes.

The areas of study include World War 1 and the Influenza pandemic of 1918, the Great Depression, World War 2, the recession of 2008, the tech bubble of 2000, the stock market crash of 1987, and the recesion of the late 60s to mid 70s. While each of these situations unfolded differently and were unique in their causes, their effects were very much the same, though of varying impact. Each of these events were followed by periods of volatility and uncertainty. Government intervention played a large role in trying to combat these events, and we can expect the same moving forward. The amalgomation of these periods includes precipitous drops in the market, high unemployment, inflation, economic stagnation, supply shortages, and the introduction of economic policy set forth by the

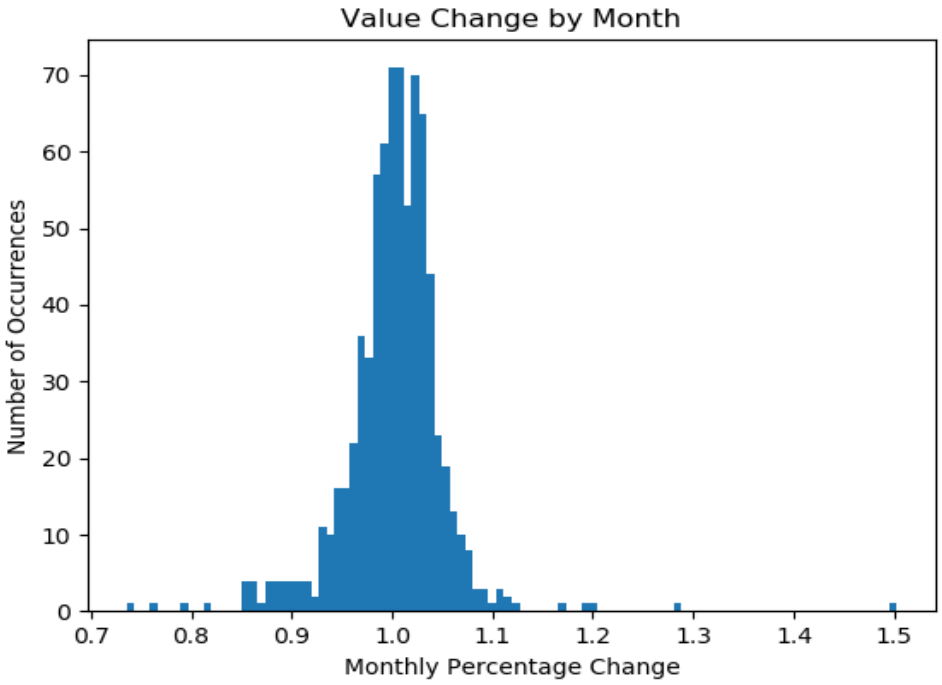
government.

It is unknown exactly how things will unfold in this current climate, but the uncertainty of all of these historical periods gives valuable insight into what we can possibly expect moving forward. I analyzed the monthly returns of the S&P 500 from the market peak preceding each of these market crashes to ten years after the peak. This method captured the precipitous drops, periods of stagnation and volatility, and the recovery of some of these periods. I used the market peak preceding each drop because with the benefit of hindsight, we know that the market peak was in late February at about $3386.15.

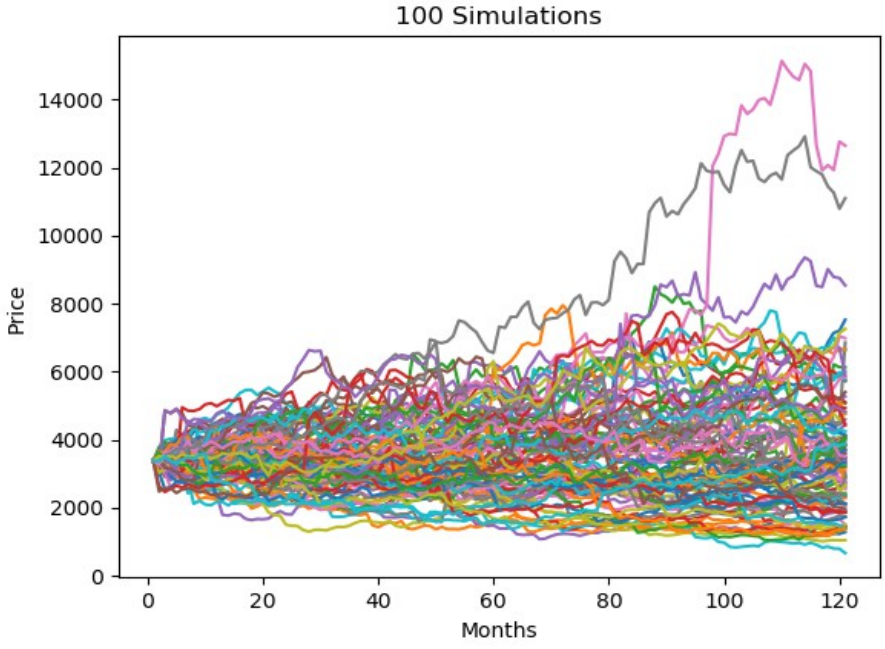
I made a histogram for each of these periods, measuring the returns for each month:



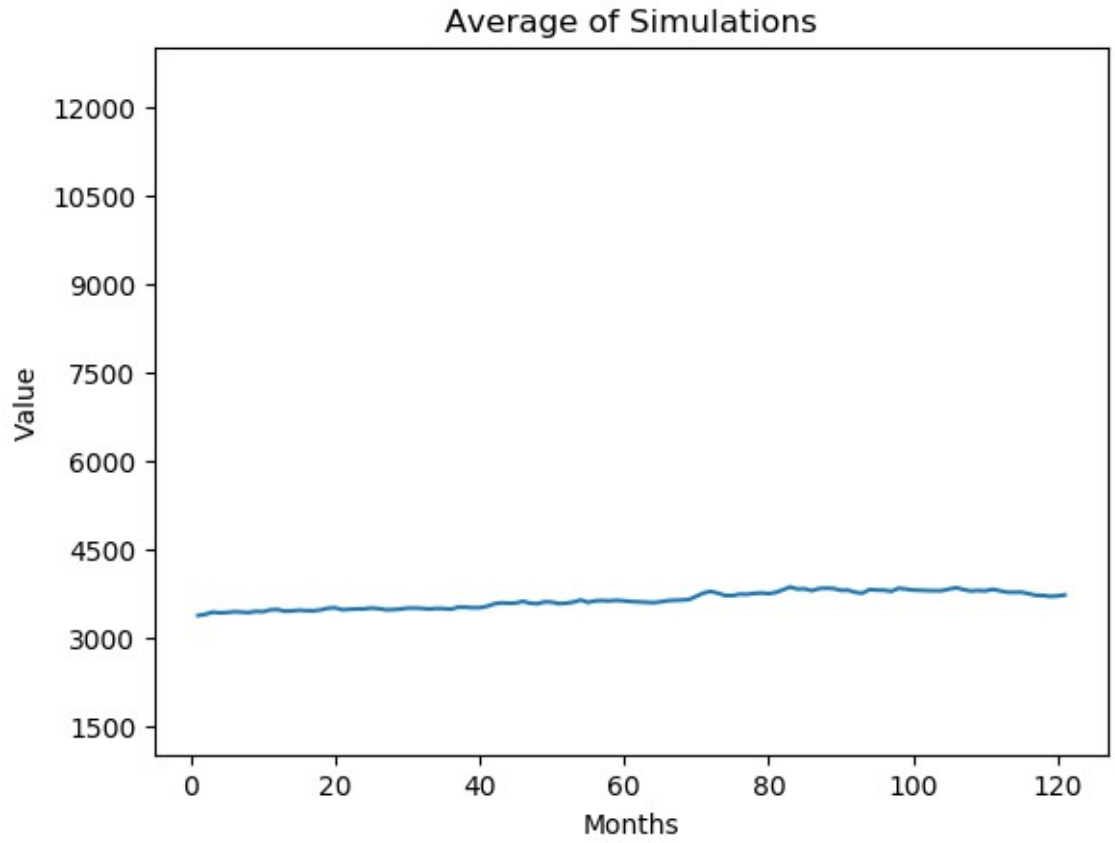
From each of these periods, a combined histogram can be made to create a probability distribution capable of forecasting the future based off of past market disruptions.




This histogram was used to simulate 120 months of returns starting from the market peak at the end of February. There were 763 data points to draw from, and a monte carlo simulation with 100 siumlations is shown below:



The average of all of these simualtions came out te be a pretty straight-line. This indicates that of all possible outcomes, a faily flat market is likely on the horizon.




The quick rebound in the S&P 500 is not likely to continue to climb in the coming years as the US economy will be tasked with dealing with everything that has happened. It is important to note that this average line does not show expected volatility. There is expected to be periods of volatility in the market moving forward, and that volatility is what we can take advantage of in the mid-term future .

Based off of historical data, both growth and decline are less likely than a flat market, but as can be seen from the results of the monte carlo simulation, there is a great deal of uncertainty in my model.

The next steps I would like to take with this model are to construct a cogent investment strategy based off of my model. In a flat market, provided enough volatility, portfolio growth can be attained by periodic rebalancing using a strategy known as tactical asset allocation. What this entails is the division of an investment porfolio of at least three primary investments, each with a target weight. For example a portfolio may have 10% cash, 35% bonds, 45% stocks, and 10% commodities. As asset prices change, the porfolio is rebalanced to maintain the target weights. When an asset goes up in value, a portion is sold and reinvested in other assets that are below their target weights. This is a way to cash in on temporary volatility and can result in portfolio growth even if the long-term market

outlook is flat.

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