Volatility Comparison of Daily Closing Stock Price before, during, and after COVID-19 Pandemic

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***Abstract*—From February 25, 2020, to Sept 11, 2023, the United States was affected by the COVID-19 pandemic. This study aims to evaluate the volatility of daily closing price of prominent fortune 500 companies and bitcoin and to check the forecast of the volatility using exponential smoothing, a established forecasting method for volatility forecasts, against the true behaviour of the daily closing price during the COVID-19 pandemic. Analysis of the volatility of these prominent financial entities should lend insight into how the market will react in trying economic time periods, which can be used as a predictor for similar future events following the same economic guidelines and restrictions during the COVID-19 pandemic.**

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I. Introduction

In the scope of the class we learned about stock volatility, which is often associated with the risk. There are two definitions of volatility, conditional and unconditional. For the purpose of this study, conditional indicates that we are interested over a specific period of time, while unconditional indicates it is over the whole time series. The volatility is useful for predicting the risk associated with a stock, and understanding how this volatility behaves is advantageous in understanding how the stock price changes on a larger scale.

There are several methods to calculate volatility, the easiest of which is finding the standard deviation of the returns. However, this assumes that the returns are normally distributed, which for many stocks is not satisfied [1]. Instead of assuming normal distribution, this paper calculates the sign correlation, and then from there gets the distribution of the returns. In all four cases they use, this was modelled by a t- distribution with between 3 and 4 degrees of freedom. They show that in these cases, because of the symmetric nature of the distribution, we can obtain an optimal estimate for σ given by

$$\hat{\sigma} = \frac{1}{n\rho}\Sigma|r_i - \mu|$$

where ρ is the sign correlation, μ is the average of the returns, and r_i is each individual return. As the paper indicates, if this t-distribution is less than four, GARCH models do not work for evaluating this risk. Thus this is one method that can be used to calculate a volatility estimate.

A systemic review from the pre-covid era [2], looks at a variety of GARCH models that explore the volatility of stocks. One of their major findings was the GARCH methods for VaR and volatility calculations have largely changed in the period after the 2008 financial crisis.

Another method is the calculate the volatility is to look at the log returns. This simple technique provides an easy method for computing an estimate of the volatility as

$$v_i = |\sqrt{l_i} - \sqrt{\mu}|$$

where μ is the mean of the logged returns, and l_i is the logged return value. This creates a volatility value for each individual data point. If we look at a graph of this, is shows that periods of higher variance are represented by larger values for v. The advantage to using this model is it allows us to easily highlight which time periods have higher or lower volatility, as well as being computationally simple.

II. Data selection

This study aims to investigate the effects of the COVID-19 pandemic on varying blue chip stocks, therefore, the elapsed time of the pandemic must be clearly defined. Since the US is a large financial centre, and many of the selected stocks are American based companies, we will be using the Us government's definition of the timeline for the pandemic. By this logic, we will define the economic start of the pandemic to be Feb 25, 2020. This is the first major announcement made by the CDC where Dr. Nancy Messonnier announced that "[control efforts in] the U.S. may include school closings, workplace shutdowns, and the canceling of large gatherings and public events" [4]. This seems the first time the CDC indicated there might be a large financial impact, and since it is in the initial stages of the pandemic, will be an appropriate choice of starting point. The selection of the end of the pandemic itself was Sep 12 2013, also as per the CDC [3].

One of the primary issues with looking at bitcoin it had not garnered much popularity until early 2010's, being released in 2009. This means that the only global financial event tracked by Bitcoin, is likely the COVID-19 pandemic. We will be tracking Bitcoin for all of it's lifetime. Based off the number of Bitcoin transactions per month, bitcoin transactions appear to stabilize at modern transaction numbers around 2012. Because of this, we will not select any data from before this point, since the low number of transactions may significantly affect it's volatility.

For the traditionally traded companies (GM, Google, Wal-Mart), the volatility appears to stabilize around the year 2000, with much higher volatility before this. This may be for a number of reasons, but we can consider this 2000-2007 period to be fairly stable. In 2008 the financial crises occurs, and we expect larger volatility. After some time that will be determined by the data, the stock will return to a more stable value for volatility. We then expect this volatility to remain fairly close to stable until 2020, when the pandemic occurs.

Fig. 1. An initial graph of the closing prices for Walmart (WMT), Google (GOOG), General motors (GM) and Bitcoin (BTC-USD) over the 2004 to 2023 time period.

The data will be gathered from Yahoo Finance web page via the quantmod package in R. The stock were selected to be WMT (Walmart), GM (General Motors), and GOOG (Google). These stock were selected to provide a variety of industries, one tech company, one heavy manufacturing, and one retail/supply chain. Bitcoin (BTC-USD) was selected for being the most widely available cryptocurrency, as well a being one of the earliest to ensure data collected for bitcoin is vast.

III. Methods

For the purpose of this study, since we wish to visualize the volatility estimate over time, the logged returns method seems to work best. The initial volatility graph over the selected period is shown in 1.

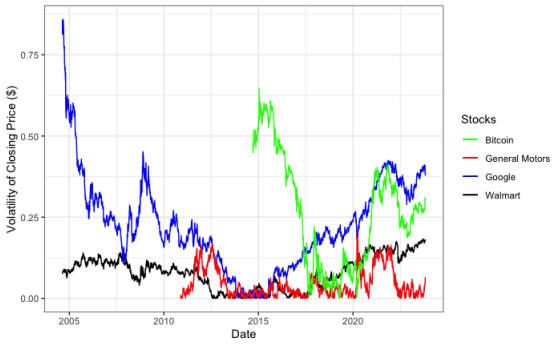

Fig. 2. An initial graph of the volatility for Walmart (WMT), Google (GOOG), General motors (GM) and Bitcoin (BTC-USD) over the 2004 to 2023 time period.

The above plots demonstrate interesting trends. First, we see that all three stocks appear to reach a maximum stable period right before the COVID-19 pandemic. In addition, Google seems to be a highly volatile stock that stabilizes over time, while the more established companies such as WMT and GM tend to demonstrate constant volatility in the chosen time frame. This may be due to Google becoming publicly traded in 2004, which is only just before bitcoin launched. Investigating the period of higher stability in the 2012- 2019 time period, get the more stable period shown in Fig 3. The graph shows a period of volatility that is highly stable, with occasional spikes that are much less pronounced than other time periods.

Fig. 3. Plot of the volatility for Walmart (WMT), Google (GOOG), General motors (GM) and Bitcoin (BTC-USD) over the COVID-19 pandemic.

From the above plot we can see that over the COVID-19 pandemic there is a large spike in the volatility of all stocks besides WMT, which stays relatively constant throughout the pandemics lifetime. Particularly we see a large spike in the volatility of the stocks between the end of 2021 and the end of 2023, peak COVID-19 pandemic. Where only GM seems to have recovered from the large spike in the volatility that persists with other stocks, aside from WMT remaining at a relatively constant level of volatility.

With the exception of bitcoin, all three stocks display a period of stability from 2012-2019. Bitcoin has a high volatility until around 2017, and then also stabilizes. This may be in part due to bitcoin not being seen as stable, leading to a self-fulfilling prophecy. It may also be due to slow adoption of bitcoin as a potential trading avenue.

Around the select date of the economic pandemic beginning, we see a sharp increase in volatility for all stocks and bitcoin. General Motors approximately reaches pre-pandemic stability around mid to late 2021, with Google and bitcoin displaying persisting elevated levels of volatility post pandemic and Wal-Mart remaining relatively constant volatility throughout the course of the pandemic. There may be several reasons for this [5]. For bitcoin, the FTX scandal and cryptocurrency crash of Oct 2023, are likely still influencing Bitcoin's volatility. This may mean that future research will have to break cryptomarkets into several subsections of the pandemic, since there are other factors that impact it's volatility during this period.

For Google and Walmart, who still haven't reached that pre-pandemic stability, the issue may be more nuanced.

A popular method for forecasting stock volatility is exponential smoothing. We wish to demonstrate the next year forecasts for the closing price volatility using the exponential smoothing to see if the method is accurate in reproducing the correct volatility trends within the volatility data.

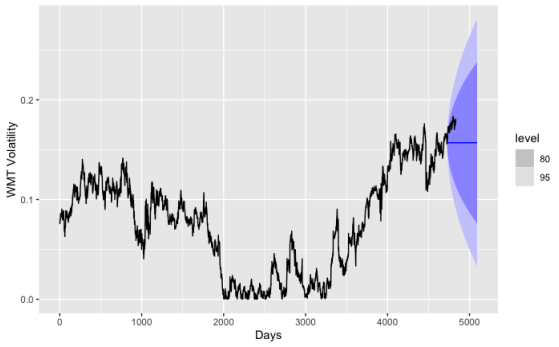

Fig. 4. Plot of the volatility forecast for the next 365 days post COVID-19 pandemic for Walmart (WMT) closing price.

The 95% forecast confidence interval is representative of the observed volatility seen in figure two for Wal-Mart closing price. Indicating that the method of exponential smoothing is accurate in predicting the upcoming volatility of the stocks closing price.

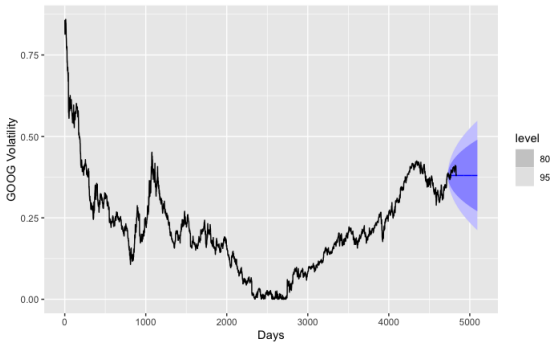

Fig. 5. Plot of the volatility forecast for the next 365 days post COVID-19 pandemic for Google (GOOG) closing price.

Google 95% forecast confidence interval is much narrower which encapsulates the small volatility of the stock post pandemic but based on historical factors is not representative of googles high past volatility, especially through the COVID-19 pandemic.

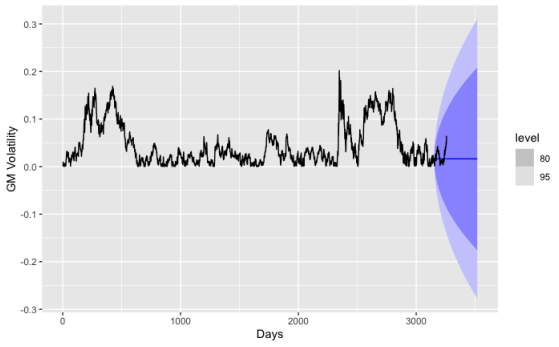

Fig. 6. Plot of the volatility forecast for the next 365 days post COVID-19 pandemic for General Motors (GM) closing price.

Large range for 95% confidence interval, largest of all stocks and Bitcoin in the General Motors forecast confidence interval which is not representative of the following trend post pandemic. From historical data it can be seen that General Motors does not display the same rates of higher volatility, with its baseline being close to zero where the two remaining stocks and Bitcoin have varying levels of baseline volatility.

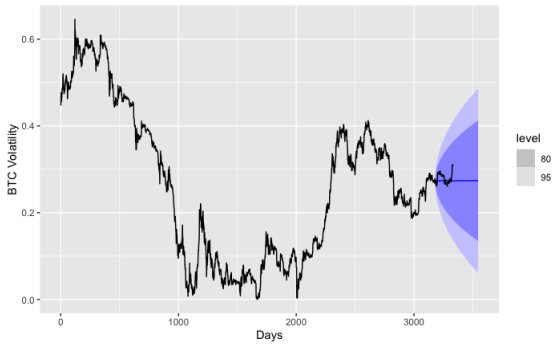

Fig. 7. Plot of the volatility forecast for the next 365 days post COVID-19 pandemic for Bitcoin (BTC-USD) closing price.

Bitcoin 95% forecast confidence interval is rather narrow which is unexpected as Bitcoin has the largest overall volatility throughout its lifetime containing the largest overall spike within the COVID-19 pandemic.

IV. Conclusion

Based off the analysis of the volatility for the three stocks: Google (GOOG), General Motors (GM) and Bitcoin (BTC-USD) we can conclude that well established stocks that offer necessities in people's daily lives such as Wal-Mart and General Motors display relatively constant volatility through time, with Wal-Mart displaying near constant volatility throughout the overall chosen time period from 2004 to current year 2023. These two stocks were slightly affected by the pandemic period, but have since then recovered to pre-pandemic volatility values.

Google and Bitcoin display varying and higher volatility's throughout their lifetime, being most effected by the COVID-19 pandemic, having high sustained volatility that never returns to pre pandemic value as of current stock data in 2023. This may be due to a variety of other factors, and specifically in Bitcoin's case, there are other major financial crises such as the FTX crash, that will likely have affected it to current day.

Appendix A
Link to Code/Data

https://github.com/kalebwilliams774/DASC-6510-Final-Project. The Link to the github repository that includes the code for reproducing the graphs, as well as the data.

References

[1] A. P. Aerambamoorthy Thavaneswaran and J. Frank. Generalized value at risk forecasting. *Communications in Statistics - Theory and Methods*, 49(20):4988–4995, 2020.

[2] R. Bhowmik and S. Wang. Stock market volatility and return analysis: A systematic literature review. *Entropy*, 22(5), 2020.

[3] CDC. End of the federal covid-19 public health emergency (phe) declaration.
[4] CDC. Cdc museum covid-19 timeline, Mar 2023.
[5] T. W. Hannah Lang, Elizabeth Howcroft. The crypto market bears the scars of ftx's collapse, 2023.