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Analysis of COVID-19 Effects on the US Stock Market

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Introduction

As the novel Coronavirus (COVID-19) has spread from China to all parts of the world, stocks have fallen drastically, and volatility has greatly increased. Due to the current conditions in the US, it seems rather normal to witness an established brand or company's stock plummet one day then jump to soaring highs the next. This extreme volatility and uncertainty have given me the impetus to further explore these ideas within certain sectors of the market. More specifically, I look to both quantify, compare, and visualize the volatility of the top three companies, by market capitalization, in four major sectors of the market: Technology, Retail, Airline and Pharmaceutical. The companies chosen in each sector are:

- Technology – Apple (AAPL), Amazon (AMZN), Google (GOOG)
- Retail – Costco (COST), Walmart (WMT), Target (TGT)
- Airline – Southwest (LUV), Delta (DAL), United (UAL)
- Pharmaceutical - Johnson and Johnson (JNJ), Merck (MRK), Pfizer (PFE)

Summary of Results

- A common pattern that emerged for each company despite the industry was that its Standard Deviation in return was much greater in 2020 than 2019. In addition, the graphs for return had greater fluctuation in 2020 compared to 2019. There were extremely high peaks and low dips relative to the jumps and dips in 2019. This signals that these stocks were much more volatile at the start of 2020 than they were at the start of 2019.
- In addition, every company seemed to be much more volatile after February 19th in 2020. This makes logical sense as news of the global spread of COVID-19 started to emerge around late February. Many regulations and trade restrictions followed this news causing a cease in business activity resulting in uncertainty and eventually increased volatility.
- The industry that experienced the most increase in volatility between 2019 and 2020 was the airline industry. Two of the three airline companies examined, United and Delta, had a standard deviation in return >20% in 2020 compared to 6% in 2019. This large uptick was

expected as air travel regulations, loss of customers and stimulus relief packages created confusion resulting in chaotic price changes.

- Within the technology industry, Amazon had a very weak positive correlation with its counterparts (Apple and Google). This may seem illogical at first, but one needs to realize that Amazon is a retail organization as much as it is a technology giant.
- For the retail industry, none of the companies had strong or perfect positive (.9 to 1) correlations: They were all weak positive correlations. This was unexpected as most retail companies could operate with little restriction on business within COVID-19 markets.

Methodology

- Accessed historical data page on Yahoo Finance
- Downloaded the adjusted closing stock price for each company listed above and the S&P500, between the dates of January 2nd and April 17th for 2019 and 2020
- From the closing prices, calculated the daily percent change of the adjusted closing stock price for each company and S&P500 in 2019 and 2020. Percent change is considered daily return
- Calculated the standard deviation (SD) of the return in adjusted closing price for each stock in 2019 and 2020. This metric is used to measure volatility of a stock. A high SD in return indicates high volatility
- Calculated the highest and lowest return for each stock in 2019 and 2020
- For each Industry, found the average daily return by adding the daily return from each of the three companies in the industry and dividing by three
- Created a correlation matrix for all twelve companies in 2020 using the stock prices (not stock price return) as the data. Used this tool to aid in finding patterns and possible correlations of different companies between different industries

*Standard Deviation = SD
*****Return = Percent Change
*Standard Deviation of Return is considered volatility

Layout

1. Four industry sections (Technology, Retail, Airline and Pharmaceutical)
    - Table that contains the standard deviations of return along with highest and lowest returns for each of the three companies in each industry in 2019 and 2020
    - Figure that contains graphs comparing the return for 2019 and 2020 for each company
    - Figure that compares return between the three companies for each industry in 2019 and 2020
2. Inter-Industry section
    - Table that displays the standard deviations of return for all twelve companies. This makes it easier to compare companies across industries
    - Figure that shows the average return for all four industries in both 2019 and 2020
3. Correlation Matrix section
4. Conclusion
5. Addendum

Technology

Standard Deviation of the Return in Adjusted Closing Price and Highest and Lowest Return for the Technology Industry Companies in 2019 and 2020

Company	**Standard Deviation**		**Return (%)**			
			Max		Min	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**
Apple (AAPL)	1	4	6.83	**11.98**	-9.96	**-12.86**
Amazon (AMZN)	1.7	2.8	5.01	7.38	-5.38	-7.92
Google (GOOG)	1.38	3.3	5.37	9.4	-2.85	-11.1
Average	1.4	3.2	n/a	n/a	n/a	n/a

Figure 1

In the figure above, all three technology stocks had a much greater standard deviation of return in 2020 than that in 2019. The greatest uptick in SD is seen in Apple which climbed 3% from 2019 to 2020. This shows the drastic difference in volatility that most likely occurred due to COVID-19. Also,

the highest and lowest returns for all three stocks were to a much greater degree in 2020. For example, Apple had a max stock price change of about 12% in 2020 compared to 6.8% in 2019.

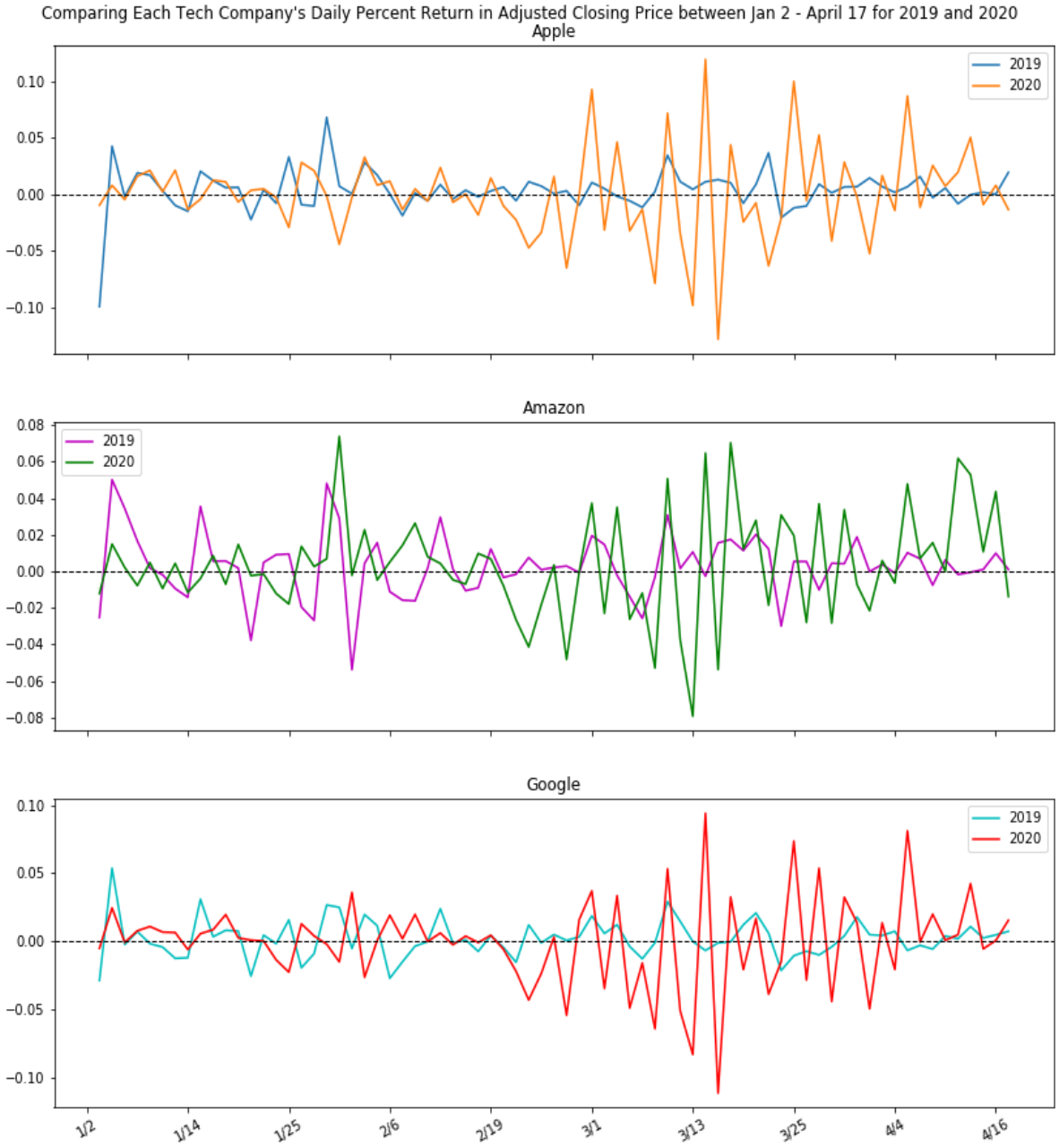

Figure 2

All three companies (Apple, Amazon, and Google) seemed to have much greater returns in 2020 compared to 2019 for the date range of January 2nd to April 17th. Specifically, this disparity becomes increasingly prevalent after February 19th: Large jumps begin to show for all three companies starting around March 1st, 2020. This is expected as COVID-19 began to emerge as a global threat.

When looking closer at dates before February 19th in 2020, the returns for all three technology companies seemed to be around the same degree as those in 2019. It seems as if the return is to a slightly higher degree in 2019 than 2020 before February 19th. For example, when looking at Amazon in Figure 1, the curve for 2019 has more extreme jumps and dips than the curve for 2020 in the first half of the date interval (before February 19th): 2020 seemed to have a relatively non-volatile start. Of course, things changed drastically after this.

Figure 3

An interesting observation about figure 3 is that the S&P 500 seems to be completely in sync with the three technology companies in 2020 regarding returns. In 2019, the S&P 500 curve seems to be remotely connected with returns of the three stocks. For example, when the S&P curve makes a jump, usually the three stocks will follow. However, this is not guaranteed. In 2020, specifically after

February 19th, the S&P and the other stocks seem to be completely connected with extremely high volatility. This probably occurred because a large percentage of the S&P 500 is blue-chip technology stocks with large stock prices.

Retail

The three retail industry leaders by market capitalization are Walmart, Costco, and Home Depot. However, Home Depot was not chosen for analysis because it specializes in home renovation which is for a very specific customer. Including Home depot would have skewed results, as during economic recessions and times of stress, people are less likely to renovate and shop for nonessentials. Instead, Target was selected for this study: a widespread retailer with a large market capitalization that sells various goods from essentials to nonessentials.

Standard Deviation of the Return in Adjusted Closing Price and Highest and Lowest Return for the Retail Industry Companies in 2019 and 2020

Company	**Standard Deviation**		**Return (%)**			
			Max		Min	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**
Costco (COST)	1	2.8	5.09	9.96	-2.12	-6.32
Walmart (WMT)	0.8	3	2.21	**11.71**	-2.27	-9.07
Target (TGT)	1.8	3.3	5.38	10.49	-2.85	**-12.28**
Average	0.8	2.9	n/a	n/a	n/a	n/a

Figure 4

It seems as if the Standard Deviation in return for each retail company in 2020 is about 2% greater than that in 2019. To exemplify this emerging chaos, one can look at Walmart which is usually a very stable and steady growth stock. In 2019, Walmart had a 0.8 SD. In the start of 2020, this metric jumped to 3. In addition, Walmart's highest and lowest return in 2019 was 2.2% and -2.2% respectively. In 2020, this was 11.7% and -9% respectively.

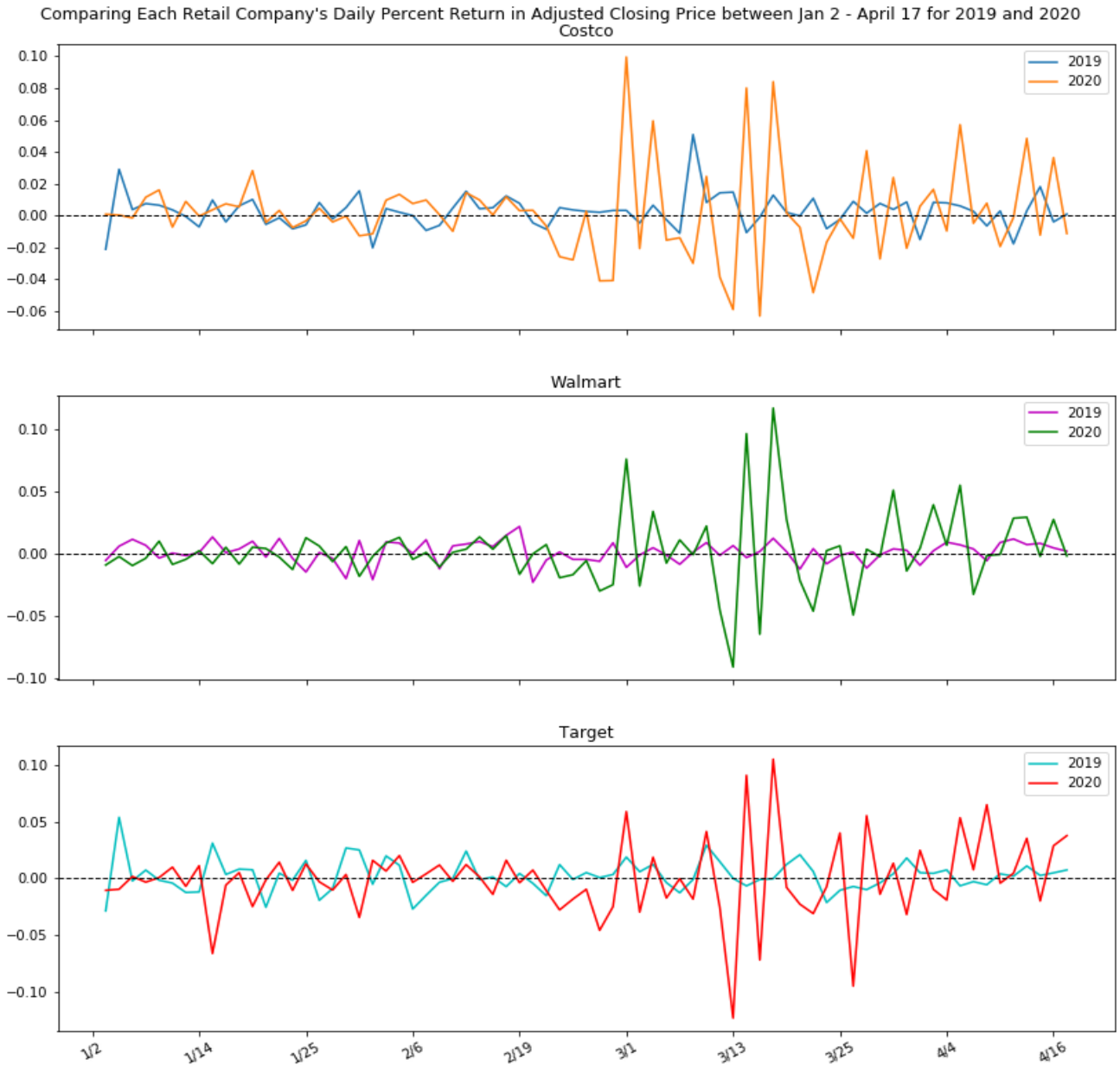

Figure 5

In figure 5, all three companies had higher degree returns in 2020 compared to 2019 especially after February 19th. This displays the extreme change in volatility for the retail industry.

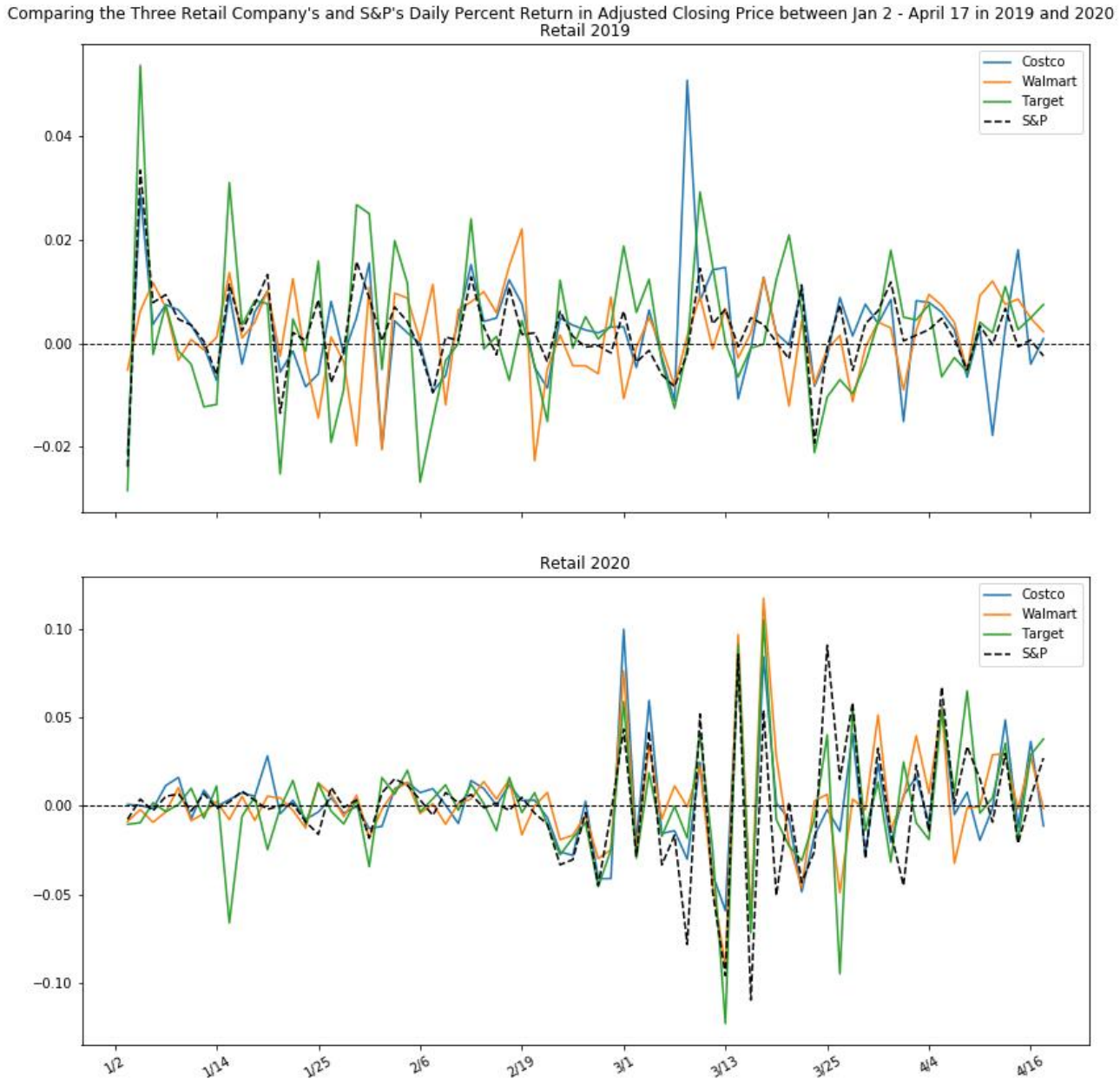

Figure 6

Figure 6 clearly displays the drastic difference in volatility between the start of 2019 and the start of 2020. The maximum return reached for any retail company in 2019 was a bit greater than 4%, while in 2020, returns reached >8% multiple times. Also, the S&P 500 does not seem to be correlated strongly with the retail industry in both years. In 2020 after February 19th, there are various instances where the S&P 500 had a much larger percent change than any of the three retail stocks. Something that rarely happened in 2019 as shown in the first graph.

I believe the volatility of the retail industry is not directly correlated to COVID-19 and is rather following the pattern of the overall market. Retail companies typically do just fine during economic downturns. Specifically, during COVID-19, many stores that sell food (Walmart, Target, Costco) can operate as they are considered essential businesses. I believe the price volatility of these companies has surfaced because investors are more focused on speculative investing and making small but quick returns within an already chaotic market. Investors understand prices are changing to a much higher degree than normal and are looking for short term results rather than long term gain.

Airline

The airline industry is arguably the hardest hit in the economy. With fears of COVID-19, customers are less likely to fly: Revenue has essentially come to a halt for most airlines. For safety measures many flights can only fill to 50% capacity. However, the government has bailed out several big-name airline corporations with the 2 trillion-dollar relief stimulus package. Due to these various factors and extreme uncertainty, the volatility has been amplified.

Standard Deviation of the Return in Adjusted Closing Price and Highest and Lowest Return for the Airline Industry Companies in 2019 and 2020

Company	**Standard Deviation**		**Return (%)**			
			Max		Min	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**
Southwest (LUV)	6	14	6.25	14.44	-5.65	-15.11
Delta (DAL)	6	21	6.04	**21.02**	-8.94	**-25.3**
United (UAL)	6	25.7	6.35	**25.71**	-4.97	**-30.29**
Average	6	13	n/a	n/a	n/a	n/a

Figure 7

Analyzing figure 7, one can see how drastic the difference is in return from 2019 to 2020 for all three US airline companies. For example, the standard deviation of the return for Delta in 2019 for the given date interval was 6% and in 2020 the return was an astounding 25.7%. In addition, the highest return in 2020 for United was 25.7% and the lowest return was -30%. All three airline companies were much more volatile in 2020 than 2019. However, the disparity in volatility between Southwest, Delta and

United for 2020 is rather interesting. For example, what is the reason that Southwest only reached a maximum return of 15% while Delta and United reached >20%? More generally, why was United and Delta much more volatile than Southwest? This is something that can be analyzed further in a separate study.

Figure 8

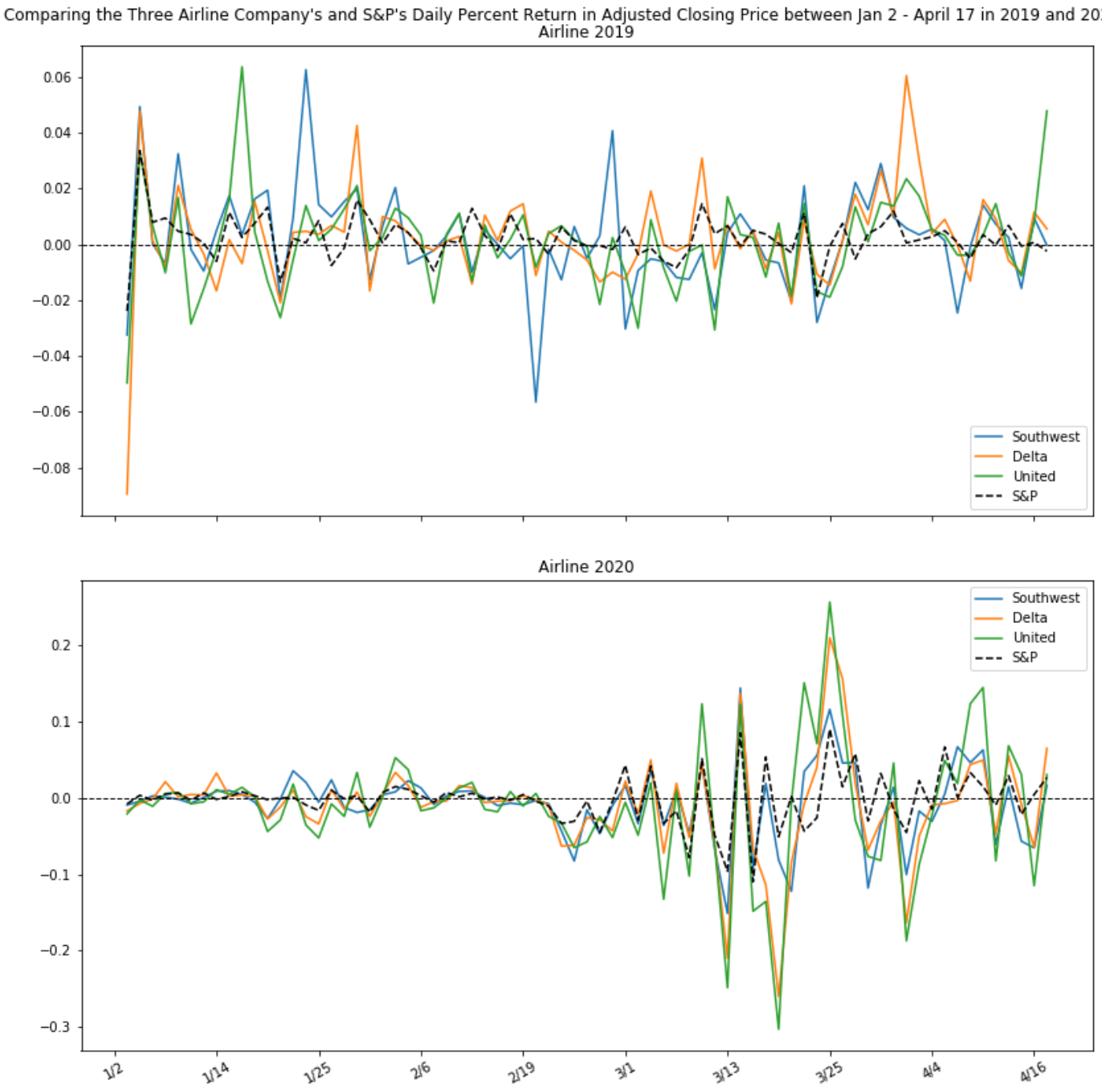

Figure 9

In figure 9, it is worth pointing out that all three airlines follow a common pattern following February 19th, 2020 (onset/realization of COVID-19 effects globally). All three airlines have a daily return following February 19th in the negative. This means the stock prices were consistently declining. Then in between March 13th and March 25th, 2020, the return for each of the three companies goes positive. This occurred as investors heard rumors of the airline stimulus package and started buying back

airline stock. Then the return is mostly negative until April 4th when the stimulus aid package is finally released. This flurry of events and various market signals greatly contributed to this volatility rise.

Pharmaceutical

The Pharmaceutical industry has not been as severely hit as its counterparts. With the need for vaccines, medical supplies and other health tools, this industry still has needy customers. The main change that is occurring within all Pharmaceutical companies is the restructuring of its operations cycle and making one's supply chain more "patient centric". One thing to note is that many hospitals and health clinics are turning down non-COVID patients to prevent the spread of infection. Thus, supplies for these ancillary nonlife-threatening medical conditions are not in high demand. Hence, the Pharmaceutical companies are shifting focus in their supply.

Standard Deviation of the Return in Adjusted Closing Price and Highest and Lowest Return for the Pharmaceutical Industry Companies in 2019 and 2020

Company	**Standard Deviation**		**Return (%)**			
			Max		Min	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**
Johnson and Johnson (JNJ)	2.3	8	2.32	8	-1.59	-7.3
Merck (MRK)	3	7.7	3.01	7.78	-4.69	**-8.9**
Pfizer (PFE)	3	8.9	3.14	**8.96**	-2.87	-7.73
Average	0.9	2.8	n/a	n/a	n/a	n/a

Figure 10

In 2019, the SD in return was about 2.5% to 3% for the three companies. In 2020, the SD in return was about 8% to 9%. In addition, each company has a highest return of about 8% to 9% and a lowest return of about -7.5% to -9% in 2020. These similarities suggest that these companies are very much in sync, especially within the COVID-19 markets of 2020. No company stands out regarding volatility.

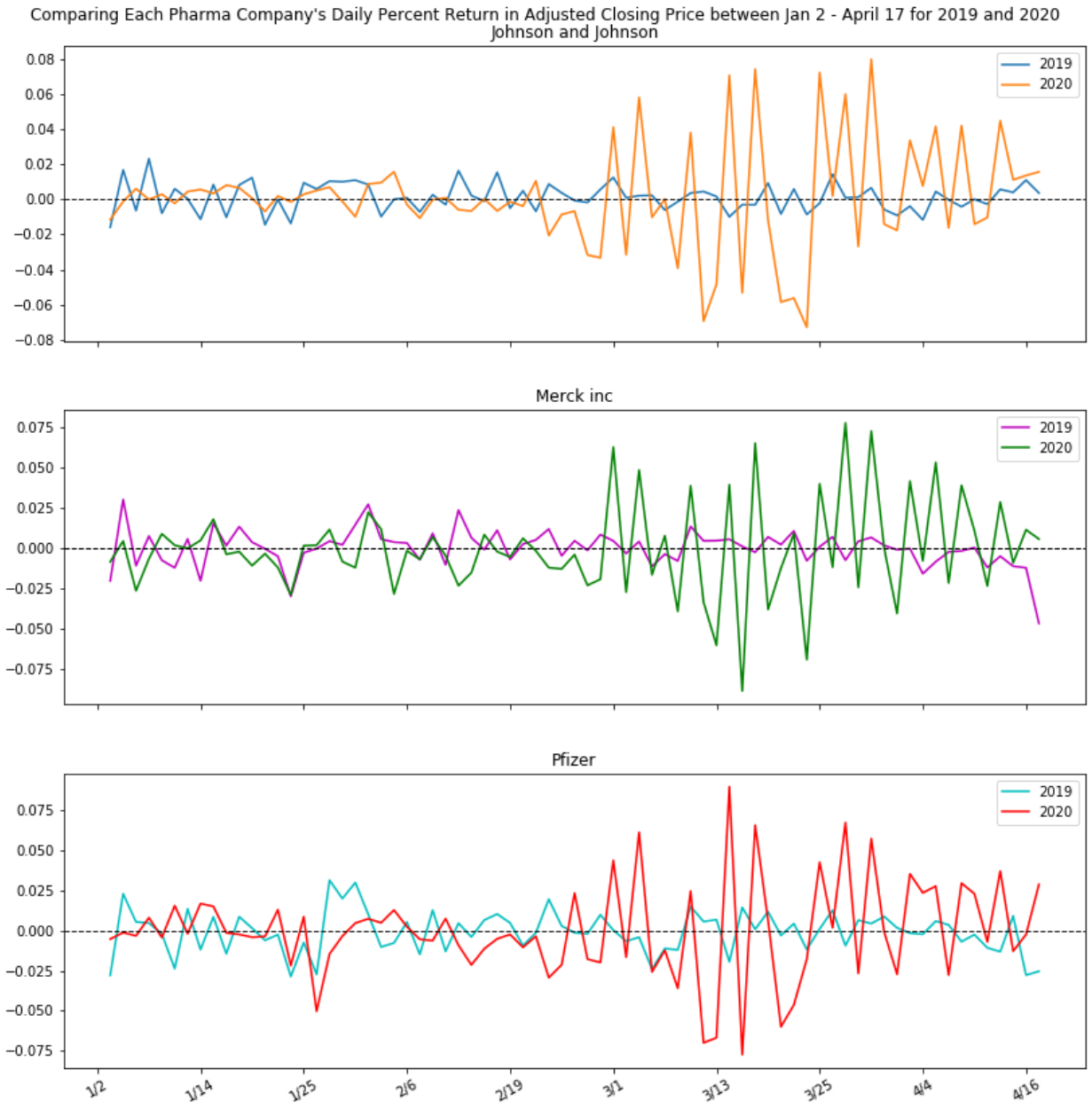

Figure 11

Similar to the other 3 industries, the three companies in the Pharmaceutical Industry were very volatile in the second half (after February 19th) of the 2020 time interval. Also, the return in 2019 before February 19th, seems to be as volatile as the return in 2020 before February 19th.

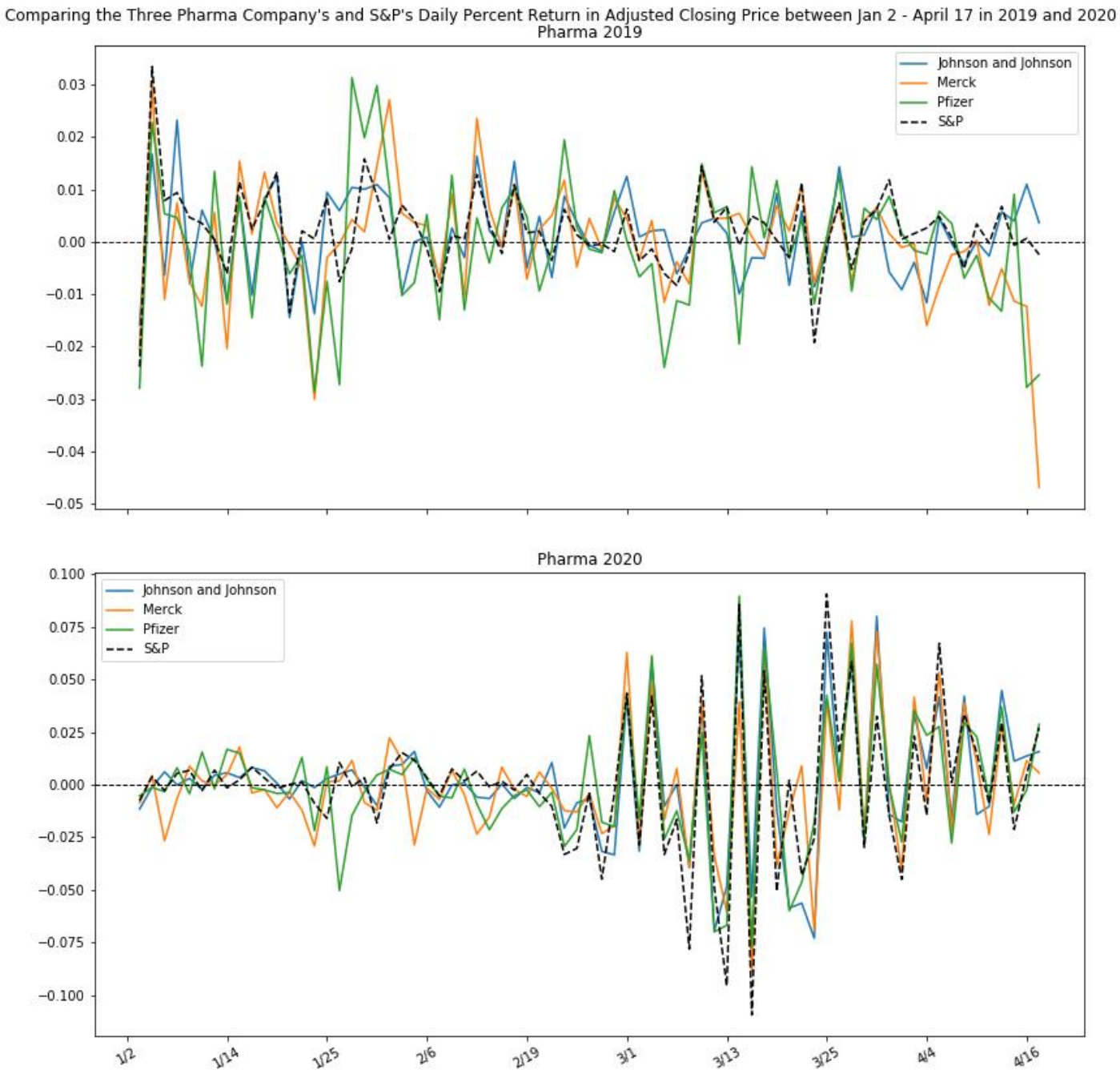

Figure 12

In the 2019 graph of Figure 12, the S&P 500 (SPY) seems to differ greatly with the three other companies. There are various instances where the return for S&P is negative while the three other companies have a return that is positive for the day. This is also the case for the first half of the 2020 time interval, before February 19th. However, after February 19th in 2020, the SPY returns seem to strongly correlate with the returns of Johnson and Johnson, Merck and Pfizer.

Inter-Industry

Standard Deviation of the Return of Adjusted Closing Price for all Industries in 2019 and 202

Company	2019	2020
Apple	1	4
Amazon	1.7	2.8
Google	1.4	3.3
Costco	1	2.8
Walmart	0.8	3
Target	1.8	3.3
Southwest	6	14
Delta	6	21
United	6	**25.7**
Johnson and Johnson	2.3	8
Merck	3	7.7
Pfizer	3	**8.9**

Figure 13

To reinforce ideas presented earlier, Figure 13 displays the SD in return of each company in the four industries included in this report. In 2019, the companies with the greatest SD in return were the three airline companies at 6%. In 2020, the company with the greatest SD in return was United at 25.7%.

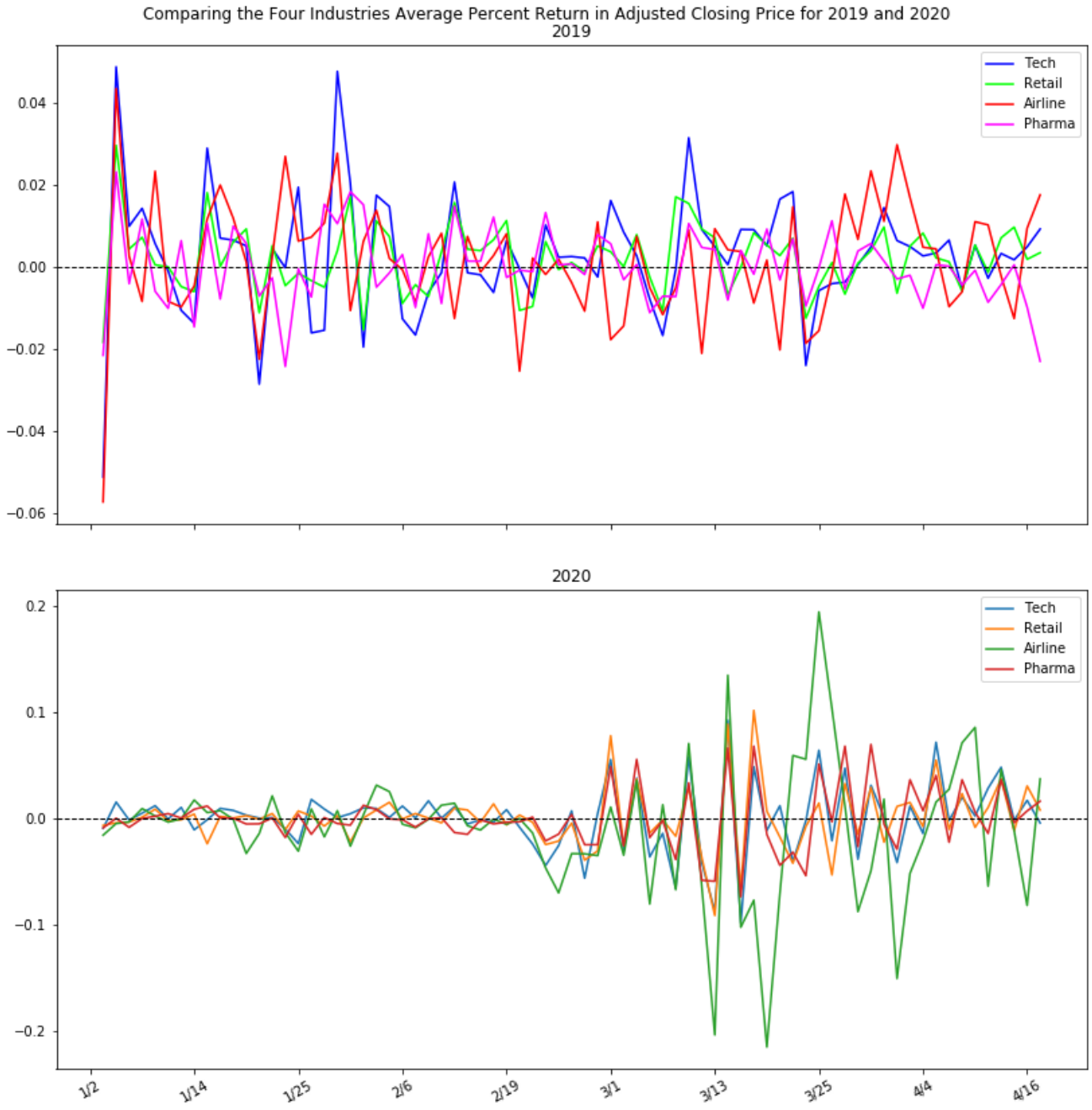

Figure 14

In all the previous figures displayed, it was evident that every company, despite the industry, was more volatile in 2020 between January 1st and April 17th than it was between these same dates in 2019. Another common pattern that emerged was that for each company, the first half of the time interval in 2020 (January 1st to February 19th) was similar in return and volatility to 2019. However, after February 19th in 2020, volatility and degree of return were amplified significantly. This is further reinforced in

figure 14. A rather reasonable and logical claim could be that COVID-19 and its trickle-down effects in terms of fiscal policy and overall media concern was a direct and indirect cause.

Figure 14 also exemplifies the idea that the airline industry was the most volatile in 2020 in the given date interval for the four industries examined. In the graph labeled 2020 in figure 14, the airline industry has the steepest jumps and dips. The average return of the three airline companies reaches 20% multiple times. Figure 13 shows that the three companies within the airline industry had the greatest standard deviations in return. Essentially, these three companies were the top three most volatile amongst the twelve companies in the study.

Correlation Matrix

The table below (Figure 17) is a correlation matrix in which the stocks are considered the variables and the data used to find correlations is the adjusted closing price of each stock between January 2nd and April 17th in 2020 (2019 was excluded for this analysis). Note that the data used in this analysis is different than the data used to build the graphs in the previous pages. This analysis uses the actual adjusted closing stock price while the analyses above, utilized return in adjusted closing price.

The Correlation Matrix was created to aid in finding correlations, patterns, and further insight into the possible connection between companies in different industries.

**Figure 15 is a visual that depicts the meanings of the possible values a correlation coefficient can be between two variables

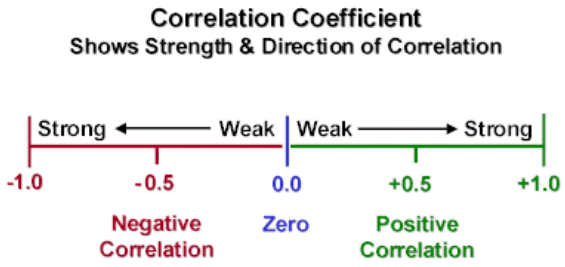

Figure 15

**Figure 16 is the color legend for figure 17, the correlation matrix for the stocks.

Correlation Matrix Legend

Correlation Strength	Positive & Color Fill in table	Negative & Color Fill in table
Perfect	0.9 to 1: Green	-0.9 to -1: Red
Strong	0.5 to 0.9: Blue	-0.5 to -0.9: Orange
Weak	0.1 to 0.5: Purple	-0.1 to -0.5: Gold
Uncorrelated	0 to 0.1: white	-0 to -0.1: white

Figure 16

Correlation Matrix

Ticker	AAPL	AMZN	GOOG	COST	WMT	TGT	UAL	DAL	UAL	JNJ	MRK	PFE
AAPL	1	0.2917	0.9795	0.6498	0.0403	0.8595	0.8986	0.8858	0.8876	0.8886	0.8252	0.8766
AMZN	0.2917	1	0.2772	0.5811	0.6708	0.2138	-0.0077	-0.0834	-0.0336	0.4638	0.1558	0.2065
GOOG	0.9795	0.2772	1	0.6139	-0.034	0.8556	0.9227	0.9097	0.9154	0.8537	0.7875	0.8467
COST	0.6498	0.5811	0.6139	1	0.4837	0.4669	0.399	0.3547	0.3184	0.7288	0.3843	0.4738
WMT	0.0403	0.6708	-0.0345	0.4837	1	0.1459	-0.305	-0.334	-0.2694	0.3524	0.2055	0.1968
TGT	0.8595	0.2138	0.8556	0.4669	0.1459	1	0.8218	0.8265	0.8769	0.7757	0.8485	0.8515
LUV	0.8986	-0.0077	0.9227	0.399	-0.305	0.8218	1	0.9812	0.9691	0.6806	0.6962	0.7455
DAL	0.8858	-0.0834	0.9097	0.3547	-0.3347	0.8265	0.9812	1	0.9856	0.6693	0.7333	0.7665
UAL	0.8876	-0.0336	0.9154	0.3184	-0.2694	0.8769	0.9691	0.9856	1	0.683	0.7868	0.8121
JNJ	0.8886	0.4638	0.8537	0.7288	0.3524	0.7757	0.6806	0.6693	0.683	1	0.8353	0.8738
MRK	0.8252	0.1558	0.7875	0.3843	0.2055	0.8485	0.6962	0.7333	0.7868	0.8353	1	0.9611
PFE	0.8766	0.2065	0.8467	0.4738	0.1968	0.8515	0.7455	0.7665	0.8121	0.8738	0.9611	1

Figure 17 (Correlation Matrix)

Expectations for Matrix

1) Companies within the same industry would either have strong, positive correlations (0.5 to 0.9) or perfect, positive correlations (0.9 to 1): The expectation is that companies within the same industry generally face the same conditions, sell to the same consumer, and compete with one another, so price change would be rather similar.

2) There will be some unexpected high positive (perfect or strong) correlations between companies within different industries: The expectation is that since all companies are living in a COVID-19 market, stock price patterns may begin to align giving a better insight into the connection between common consumers and conditions.
3) Negative correlations between companies in different industries are bound to emerge as some companies have barely been affected in terms of stock price (e.g. Walmart) while other companies (e.g. airlines) have become increasingly sporadic.

Observations for Matrix

Technology

- Apple and Google were perfectly correlated with each other. This was expected as these two technology giants compete for the same consumers and create technologies that overlap in the market (phones, tablets, headphones, etc.).
- Amazon had a very weak positive correlation with its technology counterparts (Apple and Google). This may seem illogical at first, but one needs to realize that Amazon is a retail organization as much as it is a technology giant. Although it may share some customers with Apple and Google, its more direct competitors are retail businesses like Walmart and Costco. This is reinforced in the correlation matrix in which Amazon had a strong positive correlation with both Walmart and Costco.

Retail

- None of the retail companies have strong or perfect positive correlations: They are all weak positive correlations, although Costco and Walmart have a correlation coefficient of .4837 which is close to the strong correlation cutoff.
- Walmart and Target, two low-cost retail stores with gigantic revenues, are barely correlated with a coefficient of .1459. This case is interesting as these two businesses are direct competitors with one another. In addition, both these companies could keep their stores running as they are considered essential businesses.

Airlines

- All three airlines had perfect positive correlations with each other. This was expected as the airline industry, as displayed above, was extremely volatile. It was also stated above that these three companies generally followed the same pattern due to the relief stimulus package and other government regulations in response to COVID-19. These common conditions led to extremely similar market sentiment, uncertainty and finally, stock price.

Pharmaceutical

- All three Pharmaceutical companies had either perfect or extremely strong (>0.8) positive correlation coefficients. This was once again expected as Johnson and Johnson, Merck and Pfizer compete for consumers, turned their focus towards COVID related treatments and changed their operations cycle to be more “patient-centric”.

Inter-Industry

- Apple and Google have a strong positive and perfect positive correlation respectively with the three companies in the airline industry.
- Both Walmart (retail) and Amazon (technology) have negative correlations with the airline industry (Walmart has weak negative while Amazon is negative but considered uncorrelated). This is because Walmart and Amazon were relatively stable throughout 2020 while airlines were extremely volatile.
- The three companies in the airline industry all have a strong positive correlation with the three companies in the Pharmaceutical industry.

Conclusion

This analysis gives an overview of how the top 3 companies by market capitalization within the Technology, Retail, Airline and Pharmaceutical industries performed throughout the beginning of the COVID-19 pandemic in 2020 from January 2nd to April 17th. More specifically, this study compares the volatility between these same companies during this time interval in 2019 and 2020. This combination of volatility and correlation matrix comparisons was an effective way of analyzing how COVID-19 truly impacted these industries. To add to this study, one can use co-variance in stock return as a second

measure of volatility. Also, one could expand the scope of this research to analyzing more industries. Some other interesting sectors that could be included are financial, utility, energy, and real estate.

An idea for another study can be splitting up the 2020 time interval into 2 different periods: January 2nd to February 19th and February 20th to April 17th. This would be extremely interesting as a common theme in this report was that many stocks had increasing volatility after February 19th. Comparing the standard deviation in return for these date intervals and graphing the daily return could give more insight and clearer visuals on the effect of COVID-19. Creating two correlation matrices for these two smaller time intervals would also be intriguing as it will illustrate how correlations changed over time within 2020.

The model and methods used in this study are flexible and can be used to compare any two time periods. Thus, one can use these procedures in the future to analyze economic recessions, booms, pandemics, and other market swaying events.

Addendum

Technical Tools/Languages Used

1) Python
    - Pandas
    - NumPy
    - Matplotlib
2) Jupyter Notebook

Coefficient value meanings

- A correlation coefficient of 1 means that for every positive increase in one variable, there is a positive increase of a fixed proportion in the other. A variable always has a correlation coefficient of 1 with itself
- A correlation coefficient of -1 means that for every positive increase in one variable, there is a negative decrease of a fixed proportion in the other. Strong negative correlation
- Zero means no correlation between variables