Oil/Natural Gas Market Prices and its Relationship to Exxon Mobil Corp Share Prices

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1 Introduction

1.1 Choice of Dataset

For this report, 3 data-sets have been chosen. The first data-set shows the historical prices of an oil barrel, the second - market prices of Natural Gas, and the third shows the market share prices of Exxon Mobil Corps.

Oil and Natural Gas comprise over half of the world's energy, with these natural resources often being the main drivers of a country's industrialised processes. Thus the prices of these natural resources, greatly influence global and local economies due to their impact on processes further along the supply chain. Exxon Mobil is the largest non-government owned company in the energy industry, producing 3% of the world's oil and 2% of the world's energy.

In this report, the relationship between the prices of these commodities and the share price of Exxon Mobil will be assessed. A 5-year timescale between 2015-2020 has been chosen for analysis, to clearly visualise the impact of COVID - 19 on the aforementioned prices. The data has been gathered from Yahoo Finance (https://uk.finance.yahoo.com/), via a CSV file downloaded from its archives.

1.2 Details of the Datasets

The data-sets show daily information, on the open,close, adj. close positions and volume of trades during these periods. The data-sets cover a 5 year period from 2015-2020; combined, there are over 4500 rows of information.

The market prices were initially stored separately in 3 Pandas dataframes named, *OilDF*, *GasDF* and *InvDF*. However, a new dataframe was created labelled *AnalysisDF* which contained 3 columns showing the open positions of Oil,Gas and Exxon Mobil respectively. This was done to more easily achieve a side by side comparison of the data.

The data-sets were partially pre-processed with 7 clearly defined columns: *Date, Open, High, Low, Close, Adj. Close, Volume*. The *Date* column was altered using the *pd.to_datetime()* command and was set as the index for all 3 dataframes. All numerical values were then checked to ensure that no *object* types existed. Each column was iterated over to isolate any instances of non-numeric values; they were then changed to float objects using *pd.to_numeric()* command. The original data-sets were well updated however there still existed some NAN values, which were dealt with through linear interpolation methods. For each dataset, an additional column was created to represent the 100-day rolling average of the volume of trades, as the raw data shown in graphical form was not conducive to any valuable insights. In the following report, comparisons of the market prices between the 3 data-sets will primarily concern the *Open* prices.

2 Report

2.1 Crude Oil Market Price Data

Crude oil is an essential commodity which provides energy and petroleum products to the global market, thus crude oil and its derivatives are the most actively traded commodities in the world.[1] However, crude oil is a particularly volatile commodity as its prices are 'inherently tied to the low responsiveness of both supply and demand to price changes in the short run' [2]. This means that crude oil prices, and its derivatives are vulnerable to events which have the potential to disrupt the flow of oil and products to market [3]. These events can be geopolitical or weather-related, but this report more aptly focuses on the impact of the COVID-19 pandemic on market prices.

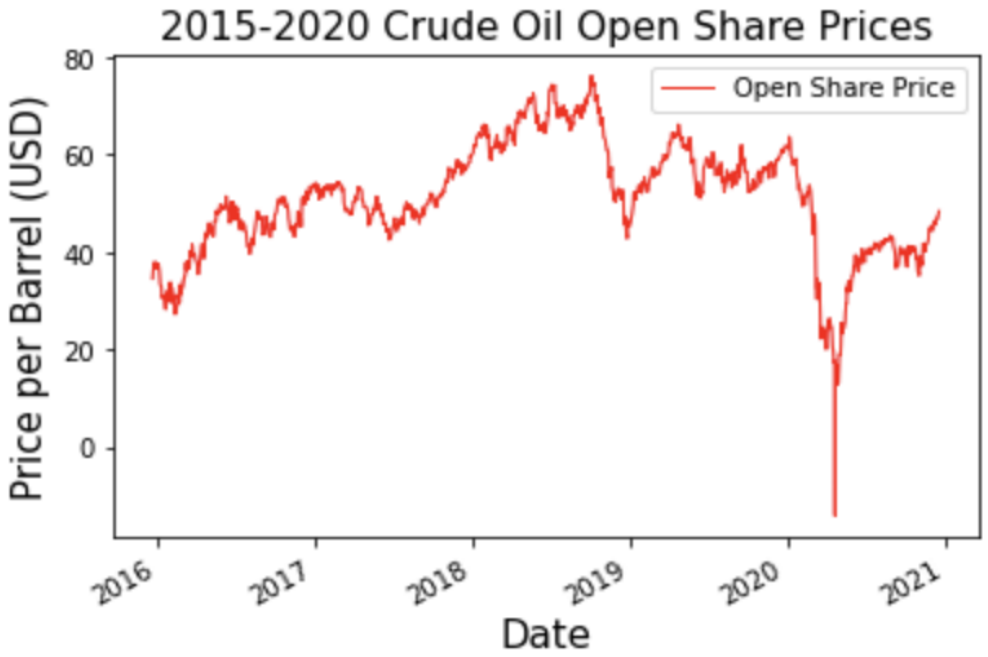

Figure 1: Daily timeseries of the price per barrel of crude oil (USD) between 21/12/2015 and 18/12/2020. The figure includes only the *Open* positions of crude oil

Figure 1 is a daily-timeseries of the Open price per barrel of crude oil (USD) from 2015-2020. There is a steady increase from late 2015 to late-2018, where crude oil prices rose by (USD) 41.6 from (USD) 34.58 to 5-yr high of (USD) 76.18 on 04/10/2018. This was followed by a sharp drop in price over a 2.5 month period to (USD) 42.85; this has been attributed to the geopolitical tensions between the Trump administration and OPEC's third biggest oil state, Iran, as well as an OPEC- Russian agreement to stop restricting supply [4]. The prices of oil rallied during the year of 2019-2020, before suffering a catastrophic plummet in price to (USD) - 14 on 21/04/2020. This drastic decrease is attributed to the startling impact of the COVID-19 virus.

Figure 2(LHS) shows the average yearly crude oil 'Open' price along with the yearly standard deviation. The prices of crude oil rose year on year from 2016 - 2018, however 2018 experienced the most deviation in oil prices, during this period with a standard deviation of 6.60 USD, despite not experiencing the dramatic volatility as seen in 2018 and 2020. In 2017 and 2019, crude oil prices were at their most stable with standard deviations of 3.68 USD and 4.10 USD respectively; as expected, 2020 was the most eventful year with the standard deviation reaching 11.20 USD - which is 28% of the average crude oil price. It is clear to see that COVID-19 is the largest factor affecting crude oil prices in the last 5 years.

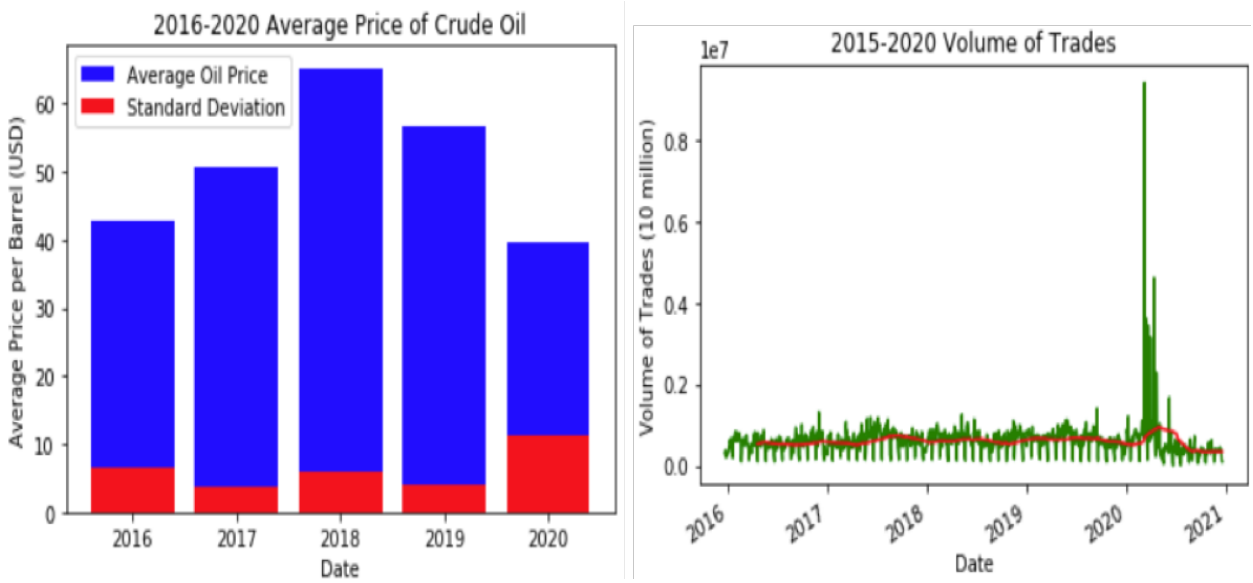

Figure 2: (LHS) Bar chart showing the average crude oil price each year along with the standard deviation in (USD) between 21/12/2015 and 18/12/2020. (RHS) shows the volume of trades in the same period. The red line is a 100-day rolling average.

Figure 2(RHS) shows the volume of trades each day during the 5 year period. Interestingly, the rolling average suggests a fairly constant volume of trades until the beginning of 2020. 2016 and 2018 were the two next most volatile years however, unlike the year of 2020 this volatility was not captured in the volume of trades. Perhaps this is due to investors looking to cut their losses on the near valueless barrels of oil in 2020. This is corroborated by the highest volume of trades occurring on 08/03/2020, triggering the dramatic decline in price thereafter.

2.2 Natural Gas Market Price Data

Natural Gas is a non-renewable source of energy that is primarily used as a source of energy for heating, cooking and electricity generation [5]. There are a limited number of natural gas reserves and sourcing, surveying and developing new reserves takes a long time. Similarly to crude oil, industries which consume large amounts of natural gas have a limited selection of alternatives in the short term, hence natural gas is price inelastic - small changes in the supply or demand can lead to large changes in the market share price [6].

The factors most affecting prices of natural gas are - Natural Gas Production, Weather, Economic Growth, Supplies in Storage and Substitutes. However in recent years, the main factor affecting prices of Natural Gas has been correlated with its production - a simple relationship ensues, the more that is produced the lower the price and vice versa. Natural Gas is also less prone to the geopolitical standoffs that are more prevalent in the oil industry, so natural gas is expected to be less volatile.

Figure 3 shows a daily timeseries of the *Open* positions of Natural Gas from 2015-2020.The price of shares of Natural Gas are based on the prices per million British thermal units (MMBtu), which is a measure of the heat content of fuel or other resources.

There is a sharp increase in price of Natural Gas from the beginning of 2016 to the beginning of 2017, where the price per share more than doubled from 1.626 USD on 04/03/2016 to 3.872 USD on 29/12/2016. The price then stabilised over a period of 1.5 years at an average of 2.964 USD from the 01/01/2017 to 21/06/2018, with a standard deviation of 0.205 USD - the lowest for any period of length 18 months.

Late 2018 is the one clear anomaly of this data-set. Gas prices rose to the 5-year period maximum;

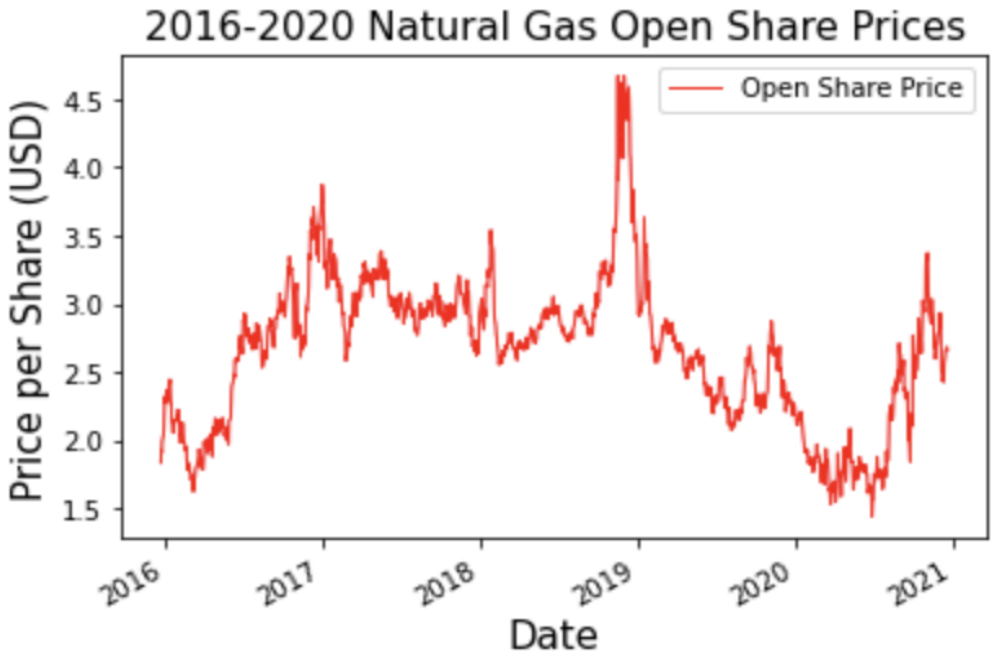

Figure 3: Daily timeseries of the price per share of Natural Gas (USD) between 21/12/2015 and 18/12/2020. The figure includes only the *Open* positions of Natural Gas.

the price per share was at a staggering 4.672 USD on 15/11/2019. The US Energy Information Agency have attributed this spike to the increased demand for heating brought about by the unusually colder temperatures [7]. This was compounded by America's relatively low levels of Natural Gas storage supplies. On the 23/11/2018, Natural Gas levels were 19% lower than the previous 5-year average, hence the market share prices were squeezed by the lack of supply and increased demand.

Following the sharp spike in prices of Natural Gas, the prices in 2019 subsequently dropped to similar levels as seen during the period between 2016 -2017. However, one key difference is that prices continued to fall well into 2020, where the 5-year period low was observed at only 1.441 USD on 26/06/2020. This is likely due to the steep decline of commercial and industrial usage as a result wide-scale business closures[8]. Lockdown measures have remarkable changed the patterns of energy usage, and overall the amount of electricity used has significantly declined [8]. This is suggested to prompt a mass migration to low carbon alternatives such as hydro, wind and solar power.

Figure 4(LHS) shows the average 'Open' price per share of Natural Gas during each year from 2016 to 2020. Note that the year 2020 is not quite a full year as this data-set was gathered on 18/12/2020. We can see from the figure that the average prices of Natural Gas rose from 2016 to 2018 - reaching a high of 3.043 USD; as expected, we then observe a decline in average share prices thereafter. This was forecast by the US Energy Information Agency which stated that there would be a downward pressure on prices during 2019 as a result of the ramping of US Natural Gas production.

Interestingly, despite the staggering spike in prices during late 2018, the year which suffered the most volatility is 2016. The prices per share of Natural Gas had a standard deviation of 0.500 USD in 2016 compared to 0.474 USD in 2018. The initially low prices in 2016 can be attributed to the unexpected impact of warm winter weather as well as the substantial US Natural Gas reserves. This meant that less Natural Gas was required for heating homes and businesses, and the abundance of supply meant that prices lowered.

However, as the year progressed, demand from these sectors as well as other commercial sources allowed the prices of Natural Gas to rally. One such commercial source, was the increased exportation of Natural Gas from the US pipeline to Mexico; by the end of 2016 87% of all US exports were to Mexico. For the first

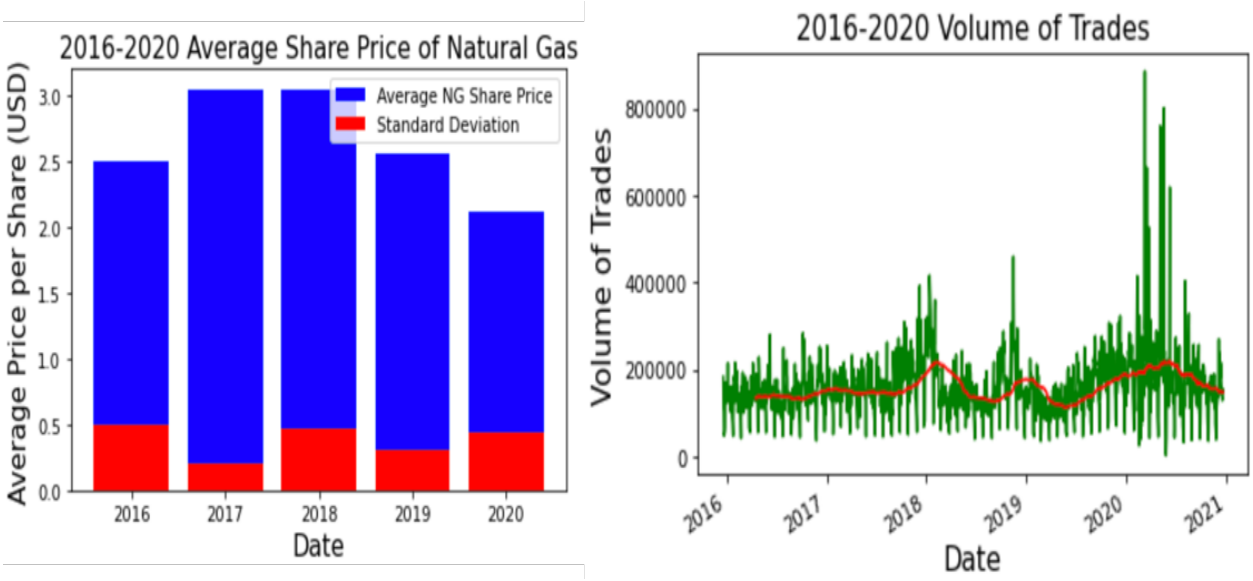

Figure 4: (LHS) Bar chart showing the average Natural Gas share price each year along with the standard deviation in (USD) between 21/12/2015 and 18/12/2020. (RHS) shows the volume of trades in the same period. The red line is a 100-day rolling average.

time since 1957 by November 2016, the US had become a net exporter of Natural Gas on a month by month basis [9]. Despite the impact of COVID-19, the volatility of the price per share of Natural Gas during 2020 wasn't extraordinary. 2020 was the 3rd most volatile year after 2016 and 2018 suggesting that Natural Gas share prices were not severely impacted by COVID-19. However, it is likely that COVID-19 has sparked the beginning of the phasing out of Natural Gas for power generation, as more regions move toward renewable sources. It has been suggested by SP Global that the Natural Gas industry will suffer the most long-term than other natural resources. However, global gas demand has not yet reached its peak as emerging markets in Asia and the middle - East will see their demand for gas rise for industrial purposes in the next 10-20 years [10].

Figure 4(RHS) shows the volume of trades during the 5 year period; similarly with oil, periods where there were large spikes or decreases in prices were accompanied with a higher recorded number of trades. Thus the beginning of 2018, the end of the 2018 as well mid - 2020, were the periods with the highest number of trades. Interestingly, there does not seem to exist a direct relationship between the magnitude of the price spike and the increase in the volume of trades. If we assess the rolling average, we can see that the highest number of trades over the 100-day period happened during the end of 2018 and towards the beginning of 2019. However, if a linear relationship were to be assumed with price and number of trades, figure 4 suggests that the period closing 2018 would have the highest volume of trades - this is not the case.

For both Crude Oil and Natural Gas, we observe the largest spikes in trade volumes in the year 2020. Unlike Oil, Natural Gas share prices during 2020 were not the most volatile, thus this result is somewhat unexpected. However, if we assess the standard deviation as a percentage of the average price for Natural Gas, this shows that the standard deviation is 20.8% of the value of the average - the highest ratio for all years. Perhaps this metric is more indicative than standard deviation alone when inferring trade volumes.

2.3 Exxon Mobil Market Share Price Data

Exxon Mobil is an American Multinational oil and gas corporation and it is the world's largest publicly traded oil and gas company. Its various business divisions concern the discovery, extraction, refining and retail sale of oil and natural gas. Hence, it is important to focus on the relationship (or non-relationship)

between the prices of Crude Oil and Natural Gas and the price per share of Exxon Mobil Corps.

Despite global attempts to slowly phase out natural resources in the energy sector, Exxon Mobil have stated that oil and gas "remain important energy sources and require significant investment". They further stated that, Natural Gas will continue to grow the most, and oil will continue to be the world's top energy source for decades to come. This is in direct contradiction to what many experts have suggested will happen to the non-renewable energy sector due to the impact of COVID-19 on the industry [11]. Up until the mid 20th century, the US was the largest producer of oil and largely controlled the oil prices. However the OPEC states which include but are not limited to: Saudi Arabia, Kuwait, Iran, Iraq and Libya have long since taken over since OPEC's formation in the 1960s. As of 2019, OPEC states control roughly 75% of the world's total crude oil reserves and produce around 42% of the world's total crude oil output, thus OPEC has the dominant ability to drive prices [12].

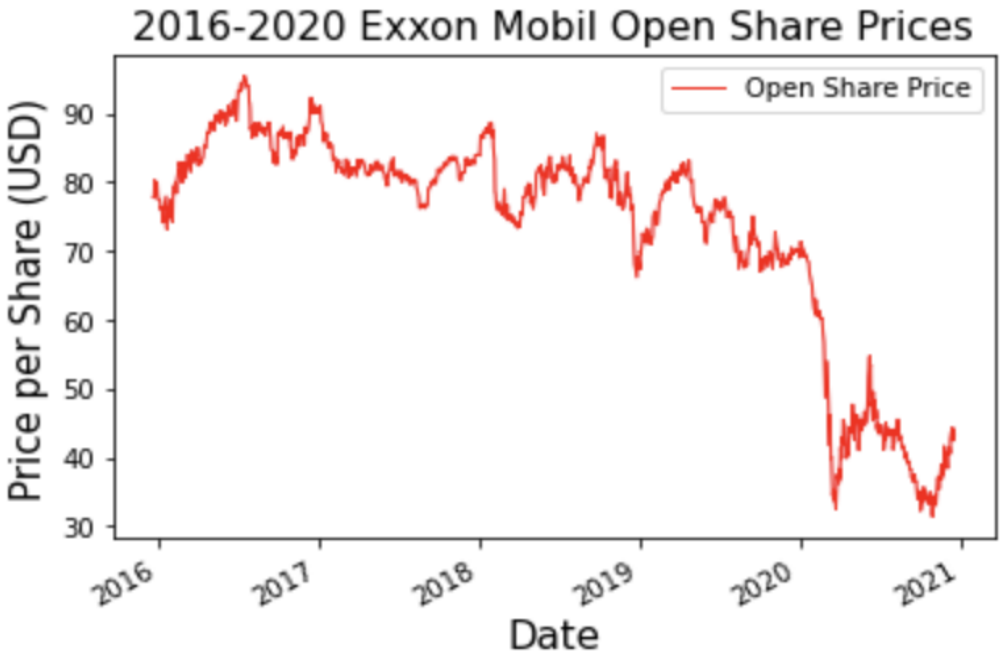

Figure 5: Daily timeseries of the price per share of Exxon Mobil (USD) between 21/12/2015 and 18/12/2020. The figure includes only the Open positions of Exxon Mobil.

Figure 5 shows the open share prices of Exxon mobil during a 5-year period between 21/12/2015 to 18/12/2020. One immediately sees that the overall trend of Exxon Mobil in the last 5 years has been a decrease in share price. The initial expectation would be for Exxon Mobil stock to mirror the trends seen in the Crude Oil market, however this has not necessarily been the case. Where the value of Crude Oil has rallied after losing value, Exxon mobil have continued to lose value. In 2013, Exxon was the most valuable company in the US, now it is just 37th [13].

Experts have attributed this to rising debt levels as well as expansive capital spending plans in an adversary oil price environment. Exxon Mobil has also been removed from the Dow Jones Industrial Average Index [14], further exacerbating the already declining investor confidence. In fact, Exxon Mobil stock,at its worst point, had fallen over 55.9% of the initial value of its stock on the 1/1/2020.

Figure 6(LHS) shows the average share price in USD of Exxon mobil for each year between 2015-2020, as well as the standard deviation; figure 6(RHS) shows the volume of trades during this same period. We can clearly see from figure 6(LHS) that the share price of Exxon Mobil has been steadily decreasing for the last 5 years; the standard deviation has also remained a small percentage of the average and has been remarkably similar across all years except 2020. This suggests that Exxon has been in a consistent decline

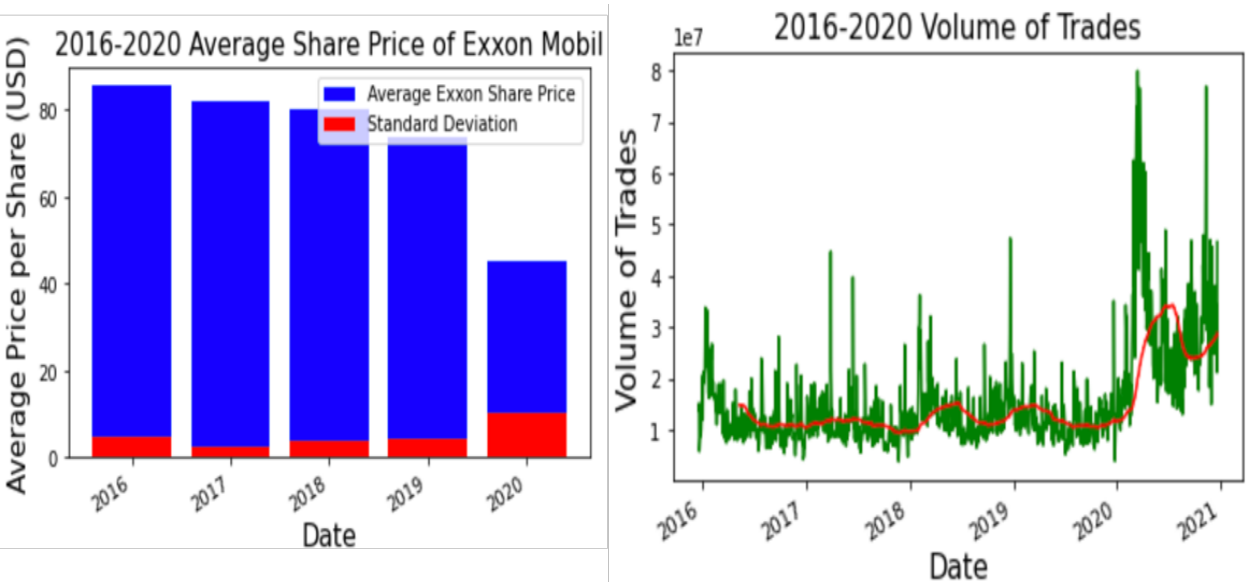

Figure 6: (LHS) Bar chart showing the average Exxon Mobil share price each year along with the standard deviation in (USD) between 21/12/2015 and 18/12/2020. (RHS) shows the volume of trades in the same period. The red line is a 100-day rolling average.

without significantly gaining on its value in any period.

As previously mentioned, 2020 was a particularly bad year for Exxon Mobil with their average 2020 price being only 53% of the average value in 2016. This is due to the global fall in energy demand - especially in key areas such as transportation. Exxon Mobil's share price decline was worsened with an all-out trade war that ensued between Saudi-Arabia and Russia. In march 2020, Saudi Arabia requested Russia to halt its production of oil in an attempt to keep the prices of oil at a moderate level, however Russia refused resulting in a trade war that facilitated a 65% quarterly decrease in the value of oil. [15] As a result, Exxon Mobil's stock value plunged due to the ubiquitous consequences of the tit-for-tat trade war. To mitigate their losses, Exxon Mobil have announced that they will be lowering their capital expenditure by 30% as well as lowering cash operating expenditure by 15%. [16]

Adhering to the previous trends found in section 2.2, the year with the highest volume of trades also has the highest standard deviation as a percentage of its average price. Figure 6(RHS) clearly evidences this relationship, showing 2020 to be the year which experienced the highest number of trades. In previous years, the volume of trades have stayed fairly constant between 10-20 million trades per day;we note that trading Exxon Mobil shares seems to be 10 times more frequent that trading in Crude Oil, and over 100 times more frequent than trading in Natural Gas. Perhaps this is due to Exxon's reputation of maintaining its dividend during low oil price periods, thus investors are still confident that they will be able to make a return from their investment despite a poor oil environment.

2.4 Final Thoughts

It is clear to see that the share prices for Natural Gas, Crude Oil and Exxon Mobil were susceptible to the damning impacts of Covid-19, however what is less clear is the inter-relationships between the industries. It is widely accepted that Exxon Mobil share prices often vary in tandem with Crude Oil and Natural Gas prices, however the extent of this correlation is debated.

Figure 7 is a graphical representation of the share prices of Natural Gas, Crude Oil and Exxon Mobil. Although all 3 market prices, share a similar dip in value as 2020 commences, a clear relationship between any of the industries is unclear visually. This is likely due to the volatility of each market, rendering spotting

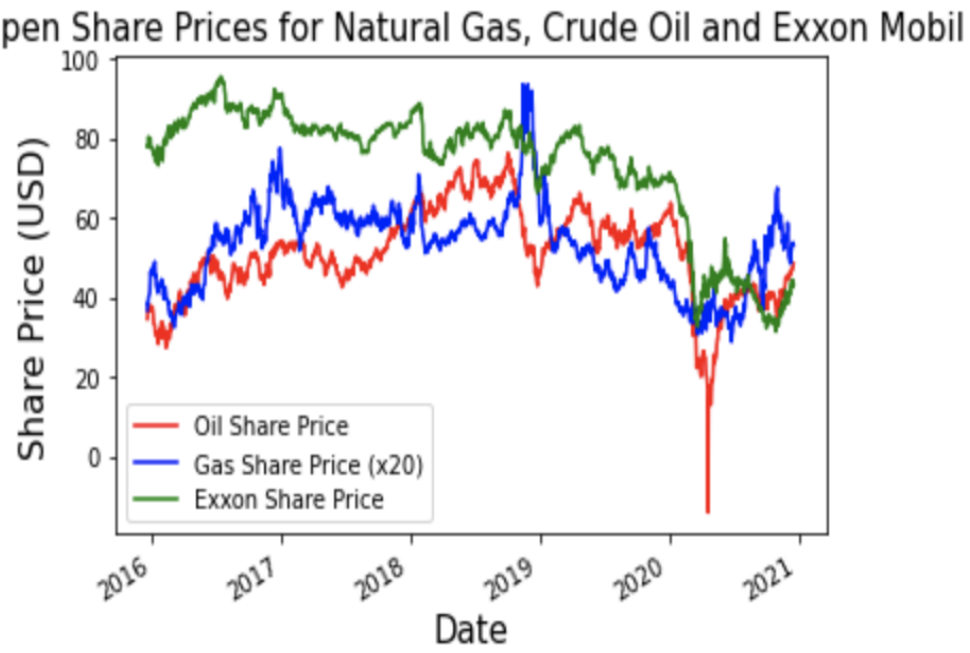

Figure 7: Daily timeseries of the price per barrel of crude oil (USD), and the price per share (USD) of Exxon Mobil and Natural Gas between 21/12/2015 and 18/12/2020. The figure includes only the Open positions.

a linear relationship between any two markets difficult. Instead we can use a correlation coefficient metric to understand quantitatively the relationships between the 3 industries. A correlation coefficient of 1 or -1 indicates a perfect positive or a perfect negative relationship respectively. As the number tends towards 0, the relationship becomes increasingly unimportant.

	Gas Open Share Price	Exxon Open Share Price	Oil Open Share Price
Gas Open Share Price	1.000000	0.458578	0.448379
Exxon Open Share Price	0.458578	1.000000	0.482737
Oil Open Share Price	0.448379	0.482737	1.000000

Figure 8: A correlation matrix, showing the relationships between the three markets. The Gas price has been multiplied by a factor of 20 to make comparisons easier.

Figure 8 shows a correlation matrix, exploring the numerical relationship between Natural Gas, Crude Oil and Exxon Mobil. The table suggests the correlation between the industries is not high; although, a score of 0.45-0.50 is not insignificant. However, what this highlights is the need to consider other metrics to more accurately display the relationships between the industries. Further work on this matter would need to account for non-shared factors that affect the prices of individual industries.

In conclusion, this report finds that COVID - 19 had a substantial, largely negative, impact on the Crude Oil and Exxon Mobil markets and a less substantial negative impact on the Natural Gas industry. This

report also finds that short-term changes to the volume of trades can be inferred by looking at the standard deviation as a percentage of the yearly average; but it also notes little evidence of a strong positive correlation between any of the concerned markets.

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