# COVID-19 and Investor Response – The case of the Oil and Gas Industry

Umesh Kumar
State University of New York, Canton

Biqing Huang
Angelo State University

**ABSTRACT**

This paper analyzes the COVID-19 proxies on Oil and Gas Industry firm stock performance. The direct measures of COVID-19 and daily prices for the top 10 Oil and Gas firms fit to GARCH models. The results reveal that COVID-19 is a statistically meaningful determinant of oil and gas firm returns before vaccination. Contrary to prior research, the results demonstrate that stock returns positively relate to COVID-19 proxies, but the relationship disappears after vaccination starts. Further, the corresponding improvement in stock returns and diminishing role of COVID-19 proxies during the vaccination period suggest investors take a long-term outlook on the stock markets.

JEL Classification: C 30, G10, G11, G40

Keywords: Corona virus, Stock Market, Investor, Stock Returns, Oil and Gas Firms

## INTRODUCTION

The ongoing COVID-19 pandemic is a profound economic challenge for all. It poses systemic risks to the global economy. Financial markets are prone to systemic risks and explicitly account for economic analyses and investment decisions. It has heightened economic disquiet and dwindled economic outlook among investors (Fetzer et al., 2020). At present, each country is affected by this pandemic and trying to offset the crisis and minimize its economic consequences.

Several studies have focused on contagions diseases, such as Ebola and SARS and their impact on stock market prices (Del Giudice & Paltrinieri, 2017; Ichev & Marinc, 2018; Goodell, 2020;). Financial scholars have started to study the COVID-19 effect on equity markets and how to minimize economic consequences. Recent studies suggest that the pandemic's effect may have a lingering influence on asset prices and expectations (Hanspal et al., 2020; Gormsen & Koijen, 2020; Zechner et al., 2020).

The COVID-19 effect produced volatility in equity markets, including oil prices (Iyke, 2020; Devpura & Narayan, 2020). Prior studies document oil prices negatively related to stock market prices. Further, the oil-producing firm stock returns rise with the oil prices. However, Lee and Zeng (2011) show that the oil price effect on equity market prices is based on investors' outlook about the market's performance. They conclude that market confidence lowers the oil market's sudden disturbances.

The oil and gas industry operate through long phases of fluctuating supply and demand, accompanied by shocks. These phases influence investor behavior towards firms operating in this industry. The detection and confirmation of COVID-19 as a pandemic in March 2020 has generated shockwaves around the globe's financial markets. The crisis presented a massive revenue shock to the industry at the beginning of the pandemic. The pandemic demand disruption and a supply glut have triggered an unusual situation for the industry, particularly for investors on how to respond in this challenging time.

COVID-19 has affected the supply and demand of oil and gas, causing global risk on asset prices and intensifying investor panic. In this study, the paper examines the COVID-19 effect on oil and gas industry stock prices using the top 10 oil and gas firms operating in the U.S. Prior studies suggest that COVID-19 infection projections on real-time basis and U.S. market performance are negatively related (Alfaro et al., 2020). This study would make better understanding of the ongoing crisis undercurrents more distinctly.

The hypothesis is that oil and gas firm stocks will respond intensely due to the COVID-19 pandemic. However, after the advent of vaccination and availability, the stock reactions will dissipate gradually. The rationale for this hypothesis is based on the study documenting the global financial crisis. Mollick and Assefa (2013) find that the U.S. stock market reactions to oil prices reverses from a negative effect prior to crisis to a positive effect post crisis. Therefore, it is pertinent to investigate if a similar phenomenon is observed in the COVID-19 crisis, particularly given vaccine development and availability in a year.

This paper studies oil and gas firm stock responses to COVID-19's arrival and control. It uses direct measures of COVID-19 proxies such as new covid cases, total covid cases, new covid deaths, total covid deaths, and hospitalized covid patients on a given day. This study examines the top 10 U.S. oil and gas firm stock responses to these covid proxies. The paper offers new insights into COVID-19 and financial markets.

(GARCH-M) model tests the hypotheses using a sample of the top 10 oil and gas firms. The results reveal that COVID-19 is a statistically meaningful determinant of oil and gas firm returns before the vaccination period. Contrary to prior research, stock returns positively relate to COVID-19 proxies, but the relationship disappears after vaccination starts. Further, corresponding improvement in stock returns and the critical role of COVID-19 proxies during the vaccination period suggest investors are taking a long-term outlook on the stock markets. Therefore, it is concluded that investors take a longer-term economic view even during massive health crises like the COVID-19 pandemic.

## LITERATURE REVIEW

Research shows COVID-19's effect on the stock markets. Scholars and academicians have shown that pandemics induce short- and long-term economic repercussions. Most scholars argue that the COVID-19 pandemic will increase volatility in financial markets. Fernandes (2020) notes that a global recession is unavoidable due to the severity of service-based economies. The International Energy Agency, in its 2020 report, has highlighted the COVID-19 pandemic's effect on the energy sector and estimated a fall of global energy use approximately 6% in 2020, or the equivalent of seven times of the 2008 global financial crisis impact. Tan et al. (2022) document the COVID-19 pandemic's risk spillover effect on the global finances.

Albulescu (2020) notes that COVID-19, a contagious pandemic, separates from similar pandemics, generating uncertainty in the financial markets and real economy. Recent studies acknowledge the pandemic effects on stock markets. COVID-19 is distinct and upsetting. He et al. (2020) investigate the effects of coronavirus and its spillovers on eight severely affected countries' daily stock market return pre- and post- COVID 19 period. Their results indicate that COVID-19 affects the stock markets negatively in the short run. However, they need more evidence about stock markets underperforming in the long term.

Baker et al. (2020) suggest that the COVID-19 pandemic has substantially affected stock market volatility during pandemics. They attribute the increased volatility to government restraints on businesses during lockdowns. Baldwin and Mauro (2020) note that pandemic, a health crisis, has generated considerable confusion in global economy and the financial markets. Haroon and Rizvi (2020) analyze COVID-19 news reporting and how it induces to market volatility swings. They find that changes in market volatility occur mostly on the travel & leisure, energy, transportation, and automobile industries. However, most industries examined do not show swings in volatility because of news sentiment and media coverage. However, Onali (2020) suggests that US stock markets show higher volatility due to COVID-19 cases and deaths in numerous countries.

The COVID-19 effects on financial markets and economic activities are analyzed in prior literature; however, an improved analysis is needed, particularly in the investor response to shifting undercurrents of the oil and gas industry, given that climate change needs further examination. Mainly earlier studies focus on COVID-19's effects from the financial market or economic viewpoints. However, exploring the effects on investor response to oil and gas stock prices and direct COVID-19 measures will enable a better insight into their reactions to the COVID-19 pandemic. Besides, the prior studies overlook the effect on critical sectors, such as the oil and gas industry. Only a few scholars encompass the oil and gas firms in their studies,

particularly their daily behavior to the visible effect of COVID-19; therefore, it needs to be explored carefully.

## DATA AND VARIABLES:

The COVID-19 variables dataset is obtained from Github (https://github.com/owid/covid-19-data/tree/master/public/data). It contains comprehensive information on worldwide COVID-19 related to patients, deaths, hospitalizations, testing, and other variables of potential interest. Control variables data are collected from the Federal Reserve Bank of St. Louis and the Oil and Gas firm's daily stock prices from Yahoo Finance.

The paper explores the U.S. oil and gas top 10 firm response to daily reporting on COVID-19. Data includes daily stock returns of oil and gas firms, control variables such as the S&P 500 Index, CBOE Crude Oil ETF Volatility Index, and the daily number of COVID-19 cases in the U.S. between January 22, 2020, to December 31, 2021. The COVID-19 cases are confirmed new and total cases, confirmed new and total deaths, and total hospitalized COVID-19 patients. The list of 10 oil and gas firms is presented in Appendix 1.

New confirmed cases of COVID-19 incorporate all reported cases including probable ones. Similarly, total confirmed cases of COVID-19 are all reported cases. Further, new and total deaths linked to COVID-19 as reported are included. It is pertinent to mention that differing protocols and challenges in assigning the basis of death, the confirmed deaths may not correctly show the correct deaths due to COVID-19. Hospitalized COVID-19 patients are the number of COVID-19 hospitalized patients on a day. Further, the paper uses COVID-19 proxies standardized per million people.

Figure 1 displays daily new COVID-19 cases reported from 1st case on January 22, 2020, to December 31, 2021. The graph indicates two humps before November 2021, while the highest number of new cases were reported in December 2021. Figure 2 illustrates the top 10 oil and gas firm's daily index graph. It suggests variation in the index during the sample period, but the index value is similar to the beginning period. Daily index returns declined precipitously in March 2020 as the government started imposing a lockdown. Overall, it reveals volatile stock markets for the oil and gas industry.

## METHODOLOGY

The paper tests the COVID-19 effects on Oil and Gas firms using an autoregressive error model. The time series data is regressed and regressor variables are distributed across time. The model includes any number of regressors with distribution lags and any number of covariates.

$$Y_t = \alpha + \sum_{i=0}^{p} \beta_i X_{t=i} + \gamma z_t + \ \ldots\ldots \ + \varepsilon_t$$

(1)

Here, $x_t$ is the regressor with a distributed lag effect. $z_t$ is a simple covariate, and $\boldsymbol{\varepsilon}_t$ is an error term.

$$b_i = \alpha_0^* + \sum_{j=1}^{d} \alpha_j^* i^j$$

For efficient estimation, orthogonal polynomials as follow is used.

$$b_i = \alpha_0 + \sum_{j=1}^{d} \alpha_j f_j(\dot{i})$$

Where $f_j(\dot{i})$ is a polynomial of degree *j* in the lag length *i*, and $\alpha_j$ is a coefficient estimated from the data. Based on above, the equation can be written as:

$$OGIndRet_t = \alpha + \sum_{i=0}^{p} \beta_i COVID-19\ Cases_{t=i} + \sum_{i=0}^{j} \gamma\ Control\ Variables_{t=i} + \ \dots\dots\dots\dots\dots\ + \varepsilon_t$$

Where $OGIndRet_t$ is the Oil and Gas stock Index returns proxied using 10 top firms by market capitalization. COVID-19 cases are the log transformed cases per million population. Control Variables are the S&P 500 Index returns and change in CBOE Crude Oil ETF Volatility Index and $\boldsymbol{\varepsilon}_t$ is an error term.

GARCH models have primarily been probed and employed to predict volatilities of stock indices, stock prices, or commodity price. Prior studies have demonstrated in analyzing the several GARCH-type models in financial markets exploiting linear vs. nonlinear and symmetric vs. asymmetric GARCH models. Hansen and Lunde (2005), used daily IBM stock prices and currency data and noted that GARCH (1,1) has an improved forecasting power. GARCH model primarily use (1,1) order where GARCH(1,1) denotes the small kurtosis for the actual data.

The paper uses alternative models to augment the analysis of the results using two generalized autoregressive conditional heteroscedasticities (GARCH) Models.

$$Y_t = x_t\beta + \gamma\sqrt{h_t} + \varepsilon_t$$

The residual $\varepsilon_t$ is modeled as

$$\varepsilon_t = \sqrt{h_t} * v_t$$

Where $v_t$ is *i.i.d.* with zero mean and unit variance, and where $h_t$ is expressed as

$$h_t = \kappa + \delta_1 h_{t-1} + \delta_2 h_{t-2} + \ \dots + \delta_{p1} h_{t-p} + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + \ \dots + \alpha_{q1} u_{t-q}^2$$

Alternative GARCH model is the Exponential GARCH (EGARCH) model used in this study has the conditional variance of $u_t$ as follows:

$$\log h_t = \omega + \sum_{i=1}^{q} \alpha_i\, g(z_{t-i}) + \sum_{j=1}^{p} \gamma_j\, ln(h_{t-j})$$

Where

$g(z_t) = \theta z_t + \gamma[|z_t| - E|z_t|]$

$z_t = u_t/\sqrt{h_t}$

## RESULTS

### Descriptive Statistics

This paper's primary focus is analyzing investor response to oil and gas firms during the COVID-19 crisis. Table 1 summarizes the primary variables of interest. Panel A of Table 1 presents the summary of variables prior to vaccination, while Panel B of Table shows the statistics of the vaccination period. As expected, the ten oil and gas firm index daily return (-0.022%) was negative and lower during the covid crisis when there was no vaccine available. The standard deviation of the index (4.503%) indicates high volatility and uncertainty. However, once the vaccination starts, the Index daily return (mean 0.148%, median -0.093%) slightly improves, and volatility (2.147%) declines.

Vaccination started on December 11, 2020, starting with medical professionals and increasingly expanded to a broader population. Based on health policy, it is expected that the expansion and availability of vaccination will subdue the number of covid cases. Analysis of COVID-19 proxies reveals that vaccination availability did not improve the situation during the sample period. Daily new covid cases (146.50) were lower before vaccination started than the daily new cases (304.13) observed during the vaccination period. Similar to new covid cases, daily new deaths (4.13) reported are higher during the vaccination period. In the case of patients in the hospital, the vaccination period shows higher hospitalization (172.87). In contrast, the results reveal that the volatility index for the oil industry comes down substantially during the vaccination period. The descriptive statistics show much has changed for the oil and gas industry and covid proxies after vaccination started.

Turning to the movement of these variables in tandem, the paper analyzes the correlation between pairs of variables, such as COVID-19 measures and stock returns. The correlation estimates will show how the pairs behave in new and volatile markets. Table 2 presents the results of Pearson correlation statistics. As expected, covid related variables are positive and highly correlated, as reported in Panel A of Table 2.

Further, the oil and gas firm index is also highly correlated to the S & P 500 index. Surprisingly, new covid cases show a negative relationship between total covid cases and total covid deaths during the vaccination period (Panel B of Table 2). Other pairs do not have a higher correlation; either way, that can warrant the problem of multicollinearity. However, the multicollinearity issue is tested in the regressions using the variance inflation factor.

### Regression Results

Tables 3 and 4 contain standard multivariate cross-sectional regressions for the top 10 oil and gas firms and covid cases. COVID-19 proxy variables, i.e., covid cases, are used in the regression models to see the relationship and effect of covid cases on oil and gas firm stock returns. The regression models include control variables, i.e., the S&P 500 Index and Crude Oil Volatility Index, to get better estimates of the relationship. Both tables report the regressions for each COVID-19 proxy, i.e., new covid cases, total covid cases, new covid deaths, total covid deaths, and hospitalized covid patients.

Table 3 reports multivariate regressions for the oil and gas industry. In both panels, the estimated coefficients for S&P 500 daily returns are positive, significant, and similar. The volatility index representing the riskiness of the oil and gas industry is negative and

significant. Both results are consistent with prior literature. Ramelli and Wagner (2020) examine stock market responses to pandemics and suggest that firms' features, such as firm cash, debt, and international trade, are critical drivers of exposure to the pandemic. Oil and gas firms have similar characteristics. Panel A of Table 3 presents covid proxies'proxies' impact on oil and gas industry index returns during the pre-vaccination period. Each model uses one covid proxy in the regression analysis. The estimates of covid proxies are positive and significant.

The paper considers the vaccination period, i.e., starting on December 11, 2020, and, onwards, significant policy measures to combat the COVID-19 crisis. Muller (2020) contends that governments should minimize uncertainty through precise communication and fast implementation of policy measures. When the regressions in Panel B of Table 3 for covid proxies are analyzed, there is no statistically significant relation between covid proxies and oil and gas industry index returns. However, the sign of coefficients remains the same positive. This suggests that overall, government policies, particularly vaccination ones, have been credible, and thus, the relationship between covid proxies and stock prices diminishes. It is crucial to test whether similar results emerge for individual firm analysis.

The paper tests the relationship of covid proxies with individual firm stock returns in Table 4. Each model represents the regression results for individual firms. Alfaro et al. (2020) find that the changes observed in firm-level in market risk differ among sectors. Since the firm response in the same industry is used, the model remains the same. Only estimates of covid proxy variables in each row are reported for brevity. The results are obtained similarly to the regression model of Table 3 using control variables and a single covid proxy in the model.

Panel A of Table 4 reveals that individual firm stock returns have a significant and positive relationship to contemporaneous new covid cases, new covid deaths, total covid deaths, and hospitalized covid patients. However, they are not related to total covid deaths. However, the estimates of total covid deaths are positive. The coefficients are quantitatively large and significant for new covid deaths and total covid deaths. When individual oil and gas firm stock returns are analyzed during the vaccination period, the covid proxies estimates become insignificant though having a positive sign. Overall, the findings in Table 4 suggest that covid proxies' sensitivity for stock returns has disappeared during the vaccination period.

Consistent with evidence on the time-series behavior of daily observations of covid proxies and stock returns, covid proxies are autocorrelated. Next, the paper accounts for this behavior and examines covid proxies' impact on the oil and gas industry (sample firms). Initial analysis shows the return variables to be stationary, distribution non-normal and the presence of heteroskedasticity. A vector autoregressive model is not a suitable model in this case since it overlooks heteroskedasticity. Hence, an autoregressive error model, i.e., GARCH (1, 1) is followed.

Similar to prior multivariate regressions, the papers include control variables in the autoregressive error model that also controls for endogeneity. Table 5 presents the results of this model. Panel A of Table 5 shows that all covid proxies except total covid cases positively and significantly influence oil and gas industry index returns. Even the sign of total covid cases estimate is positive. When the same regression analysis is performed during the vaccination period, the results show that covid death cases, i.e., new and total deaths are positive and weakly significant. Other covid case estimates are positive. The insignificant

impact of covid proxies experienced during the vaccination period for sample firms suggests that covid cases' role has gradually diminished after vaccination started.

For the robustness of the analysis, the paper uses various robustness tests. Four GARCH models are used to test the sensitivity of the primary findings. Prior studies show that the orders used in the GARCH model is important. The Akaike Information Criterion (AIC) shows that a (1,1) model can be used. However, higher orders of GARCH is tested. The paper utilizes higher-order GARCH-M models based on AIC criteria; GARCH-M (2,1), GARCH-M (1,2), and GARCH-M (2,2). Table 6 shows the results of these models.

The paper analyzes the GARCH model results in Panel A of Table 6. GARCH-M (2, 1) shows that covid proxies, i.e., new covid deaths, total covid deaths, and hospitalized covid patients, are positive and significant. Similar results show for GARCH (2, 2) as well. In the case of GARCH (1, 2), new covid deaths and hospitalized covid patients are positive and significant. Attention is turned to engaging several versions of the GARCH model. Similar to GARCH, the EGARCH model is followed. The paper further analyzes whether the results are responsive to an alternative GARCH models. It reveals that the EGARCH model yields similar results.

Panel B of Table 6 shows the GARCH model results during vaccination. The new covid deaths variable is significant and positive in all GARCH models. Thus, similar to prior results, the paper finds that covid proxies are not so significantly related to oil and gas industry index returns. This application confirms that the primary conclusions are unaltered. This application concludes that the results persist in several modeling technique tests.

## CONCLUSION

In this paper, the covid impact in explaining oil and gas industry stock returns is evaluated. The rationale for the hypothesis is based on prior studies examining the effects of COVID-19 on financial markets. Due to the lockdown and curtailment of transportation activity, COVID-19 has affected the oil and gas industry outlook in the short term. The paper uses daily price data for the top 10 oil and gas firms using the GARCH model, showing that COVID-19 is a statistically meaningful determinant of oil and gas firm returns prior to the vaccination period. The main contribution to the literature is the direct measures of COVID-19 proxies used in the study and their influence on the behavior of stock returns of oil and gas firms.

The findings suggest that COVID-19 has affected stock returns, but its influence diminishes during vaccination. Further, the corresponding correction in stock returns and diminishing role of covid proxies during the vaccination period suggest that investors are taking a long-term outlook on the stock markets. Therefore, it is concluded that investors take a longer-term economic view even during massive health crises like the COVID-19 pandemic. The study's implications can prompt more research into the role of vaccination and COVID-19 in the financial markets. This issue is left for future research.

## LIMITATION OF THE PAPER

The study uses only the top 10 firms from the oil and gas industry. The findings may not be used for the broader energy sector or stock markets. However, this is an essential initial

point. Further studies can utilize the findings to devise trading strategies for long-term investment.

**Appendix 1**

Top 10 firms used in this study are as follow:

| Firm | Ticker | Market Capitalization (April 2022) |
|---|---|---|
| ExxonMobil | XOM | $366.83 billion |
| Chevron | CVX | $337.31 billion |
| ConocoPhillips | COP | $129.90 billion |
| EOG Resources | EOG | $72.33 billion |
| Pioneer Natural Resources | PXD | $62.04 billion |
| Occidental Petroleum | OXY | $55.86 billion |
| Marathon Petroleum | MPC | $58.93 billion |
| Valero Energy | VLO | $42.55 billion |
| Phillips 66 | PSX | $40.00 billion |
| Hess Corp | HES | $35.51 billion |

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**Figure 1 - New COVID-19 Confirmed Cases**

This figure presents new COVID-19 cases reported daily. There are waves of higher new cases during November -December 2020 and August-September 2021 and increasingly going up in December 2021.

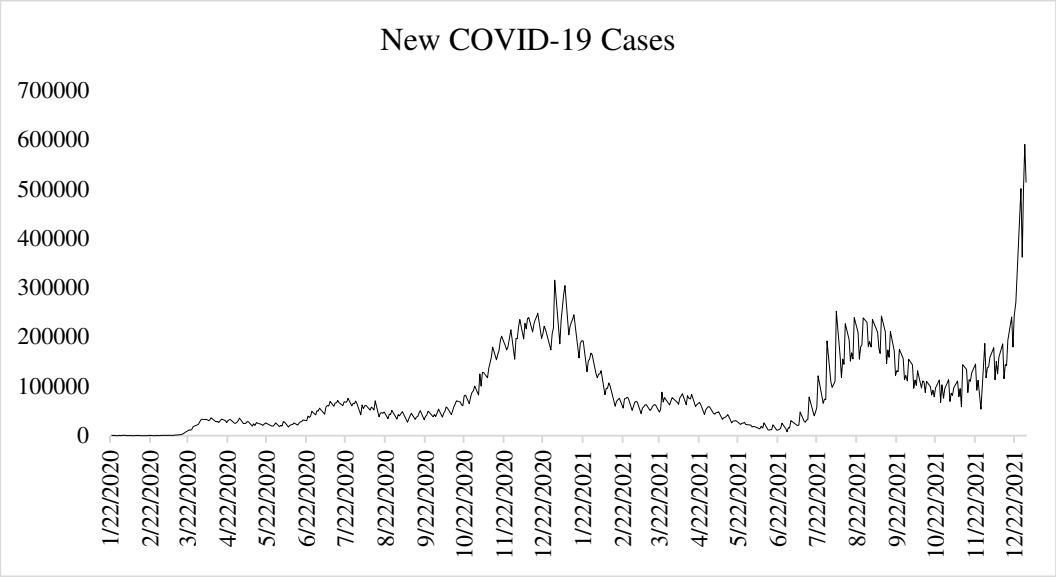
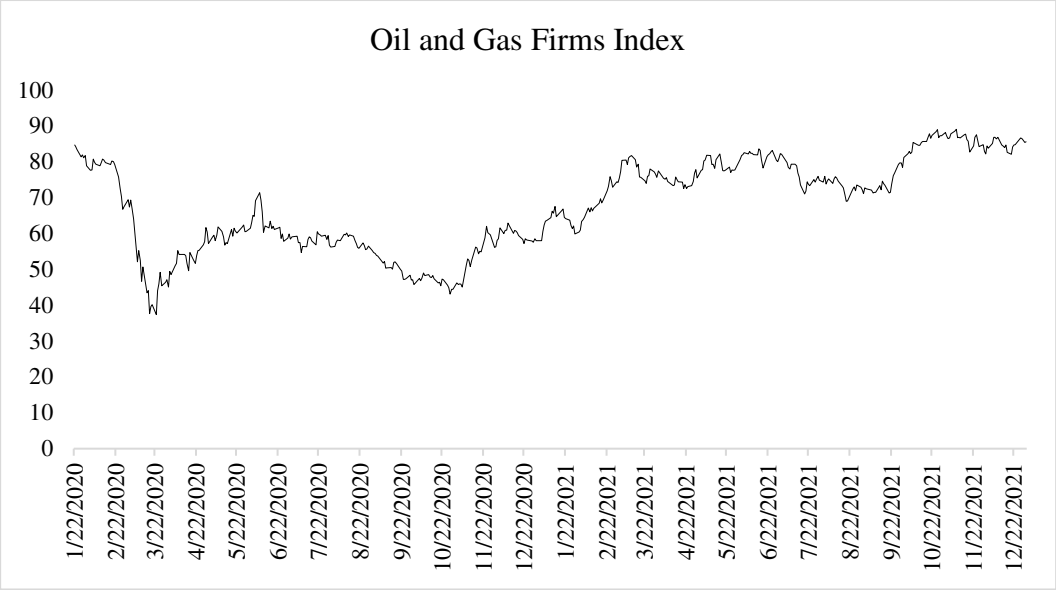



**Figure 2 – Top 10 Oil and Gas Firm Index**

This figure illustrates daily index value of top 10 oil and gas firm based on market capitalization as on April 2022. The index (y-axis) is the index value representing average stock price of sample firms.



## Table 1: Summary Statistics

This table presents summary statistics of variables examined for the top 10 oil and gas firms and COVID-19 proxies. S&P 500 Return is the percentage of change in the S&P 500 index value. CBOE Crude Oil ETF Volatility Index is the value of the expected 30-day volatility of crude oil as priced by the United States Oil Fund (USO). Oil and Gas Firm Index Return is the daily percentage return in the top 10 oil and gas firm stock prices. New COVID Cases Per Million is new confirmed cases of COVID-19 per million population. Total COVID Cases Per Million is the total number of confirmed cases of COVID-19 per million population. New COVID Deaths Per Million is new deaths attributed to COVID-19 per million population. Total COVID Deaths Per Million is the total number of deaths attributed to COVID-19 per million population. Hospitalized COVID Patients Per Million is the total number of COVID-19 patients in hospital on a given day per million population.

**Panel A: Descriptive Statistics for Pre-Vaccination Period**

| Variables | No. of Obs. | Mean | Median | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| **S&P 500 Return (%)** | 232 | 0.069% | 0.233% | 2.259% | -11.984% | 9.383% |
| **CBOE Crude Oil ETF Volatility Index** | 232 | 68.27 | 49.42 | 46.10 | 27.66 | 325.15 |
| **Oil and Gas Firm Index Return (%)** | 226 | -0.022% | -0.151% | 4.503% | -23.991% | 17.939% |
| **New COVID Cases Per Million** | 323 | 146.50 | 102.98 | 152.29 | 0 | 711.72 |
| **Total COVID Cases Per Million** | 324 | 12474.71 | 8175.32 | 12257.47 | 0.003 | 47320.38 |
| **New COVID Deaths Per Million** | 286 | 3.09 | 2.87 | 1.96 | 0 | 9.507 |
| **Total COVID Deaths Per Million** | 286 | 419.33 | 427.09 | 246.95 | 0.003 | 883.74 |
| **Hospitalized COVID Patients Per Million** | 149 | 140.78 | 120.09 | 65.92 | 76.54 | 315.54 |

**Panel B: Descriptive Statistics for Vaccination Period**

| Variables | No. of Obs. | Mean | Median | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| **S&P 500 Return (%)** | 276 | 0.098% | 0.109% | 0.797% | -2.568% | 2.380% |
| **CBOE Crude Oil ETF Volatility Index** | 276 | 38.72 | 37.32 | 6.48 | 31.30 | 78.18 |
| **Oil and Gas Firm Index Return (%)** | 266 | 0.148% | -0.093% | 2.147% | -5.518% | 5.432% |
| **New COVID Cases Per Million** | 386 | 304.13 | 225.67 | 250.89 | 12.87 | 1774.29 |
| **Total COVID Cases Per Million** | 386 | 106165.54 | 101133.46 | 26579.44 | 48038.00 | 164713.69 |
| **New COVID Deaths Per Million** | 386 | 4.13 | 3.12 | 3.25 | 0.12 | 13.25 |
| **Total COVID Deaths Per Million** | 386 | 1790.64 | 1796.99 | 380.62 | 893.87 | 2476.03 |
| **Hospitalized COVID Patients Per Million** | 386 | 172.87 | 145.60 | 97.53 | 36.75 | 400.31 |

**Table 2: Correlation Statistics**

This table presents results of the Pearson correlation statistics measuring the strength of the linear relationship between two variables. The variables are defined in Table 1 legend.

Panel A: Correlation Statistics for Pre-Vaccination Period

| Variables | S&P 500 Return | Volatility Index | Oil and Gas Firm Index Return | New COVID Cases | Total COVID Cases | New COVID Deaths | Total COVID Deaths | Hospitalized COVID Patients |
|---|---|---|---|---|---|---|---|---|
| **S&P 500 Return** | 1.000 | | | | | | | |
| **Volatility Index** | 0.078 | 1.000 | | | | | | |
| **Oil and Gas Firm Index Return** | 0.738 | 0.150 | 1.000 | | | | | |
| **New COVID Cases** | 0.126 | -0.027 | 0.119 | 1.000 | | | | |
| **Total COVID Cases** | 0.108 | 0.009 | 0.140 | 0.966 | 1.000 | | | |
| **New COVID Deaths** | 0.154 | 0.008 | 0.241 | 0.878 | 0.813 | 1.000 | | |
| **Total COVID Deaths** | 0.099 | -0.415 | 0.162 | 0.919 | 0.988 | 0.833 | 1.000 | |
| **Hospitalized COVID Patients** | 0.060 | 0.111 | 0.229 | 0.926 | 0.629 | 0.664 | 0.551 | 1.000 |

Panel B: Correlation Statistics for Vaccination Period

| Variables | S&P 500 Return | Volatility Index | Oil and Gas Firm Index Return | New COVID Cases | Total COVID Cases | New COVID Deaths | Total COVID Deaths | Hospitalized COVID Patients |
|---|---|---|---|---|---|---|---|---|
| **S&P 500 Return** | 1.000 | | | | | | | |
| **Volatility Index** | 0.109 | 1.000 | | | | | | |
| **Oil and Gas Firm Index Return** | 0.430 | 0.092 | 1.000 | | | | | |
| **New COVID Cases** | 0.010 | 0.265 | 0.026 | 1.000 | | | | |
| **Total COVID Cases** | -0.018 | 0.184 | -0.005 | -0.086 | 1.000 | | | |
| **New COVID Deaths** | 0.028 | 0.173 | 0.124 | 0.800 | -0.230 | 1.000 | | |
| **Total COVID Deaths** | -0.014 | 0.174 | -0.015 | -0.192 | 0.990 | -0.318 | 1.000 | |
| **Hospitalized COVID Patients** | -0.020 | 0.136 | 0.066 | 0.873 | -0.186 | 0.692 | -0.310 | 1.000 |

**Table 3: Multivariate Cross-Sectional Regression for Oil and Gas Industry**

This table presents results of cross-sectional regression analysis of the top 10 oil and gas index return and COVID-19 proxies. It reports the pooled OLS regression estimates. The regression models show the effect of COVID-19 proxies on oil and gas industry after controlling for crude oil volatility and stock market representative S&P 500. Table 1 legend defines the variables. The regression estimates are stated in the upper part. Parentheses number show the t-statistics.

Panel A: Pre-Vaccination Period Analysis

| Variables | Oil and Gas Firm Index Return as Dependent Variable | | | | |
|---|---|---|---|---|---|
| | New COVID Cases | Total COVID Cases | New COVID Deaths | Total COVID Deaths | Hospitalized COVID Patients |
| **S&P 500 Daily Return** | **0.941** (3.09) | **0.916** (2.97) | **0.941** (2.98) | **0.918** (2.97) | **0.923** (2.99) |
| **Change in Volatility Index** | **-0.003** (-2.51) | **-0.003** (-2.79) | **-0.003** (-2.57) | **-0.003** (-2.79) | **-0.003** (-2.56) |
| **COVID Cases** | **0.013** (2.71) | **0.016** (2.19) | **0.040** (2.54) | **0.029** (2.08) | **0.015** (2.23) |
| Intercept | **-0.068** (-2.68) | **-0.159** (-2.18) | -0.004 (-0.47) | **-0.187** (-2.08) | **-0.074** (-2.21) |
| *Adj.R* Square | 0.30 | 0.28 | 0.25 | 0.28 | 0.28 |

Panel B: Vaccination Period Analysis

| Variables | Oil and Gas Firm Index Return as Dependent Variable | | | | |
|---|---|---|---|---|---|
| | New COVID Cases | Total COVID Cases | New COVID Deaths | Total COVID Deaths | Hospitalized COVID Patients |
| **S&P 500 Daily Return** | **0.909** (5.87) | **0.909** (5.87) | **0.913** (5.93) | **0.909** (5.87) | **0.914** (5.92) |
| **Change in Volatility Index** | **-0.126** (-3.92) | **-0.127** (-3.93) | **-0.121** (-3.75) | **-0.127** (-3.93) | **-0.126** (-3.91) |
| **COVID Cases** | 0.029 (0.21) | 0.027 (0.06) | **0.249** (1.69) | -0.073 (-0.15) | 0.235 (1.28) |
| Intercept | -0.001 (-0.14) | -0.003 (-0.05) | -0.003 (-1.20) | 0.006 (0.16) | -0.011 (-1.21) |
| *Adj.R* Square | 0.22 | 0.22 | 0.23 | 0.22 | 0.23 |

**Table 4: Multivariate Cross-Sectional Regression for Oil and Gas Firms**

This table presents results of cross-sectional regression analysis of the top 10 oil and gas index return and COVID-19 proxies. It reports the pooled OLS regression estimates. The regression models present the effect of COVID-19 proxies on oil and gas firms after controlling for crude oil volatility and stock market representative S&P 500. Each model represents an induvial firm result. Table 1 legend defines the variables. The regression estimates are stated in the upper part. Parentheses number show the t-statistics.

Panel A: Pre-Vaccination Period Analysis

| **Variables** | **Top Ten Oil & Gas Firm Daily Return as Dependent Variable** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** | **Model 6** | **Model 7** | **Model 8** | **Model 9** | **Model 10** |
| **S&P 500 Return** | | | | | | | | | | |
| **Volume Turnover** | | | | | | | | | | |
| **Volatility Index** | | | | | | | | | | |
| **New COVID Cases** | 0.051 | **0.165** | **0.190** | **0.249** | 0.135 | **0.209** | **0.145** | 0.177 | **0.199** | **0.277** |
| | (0.71) | **(1.73)** | **(1.69)** | **(2.32)** | (1.24) | **(1.83)** | **(2.16)** | (1.56) | **(2.08)** | **(1.67)** |
| **Total COVID Cases** | -0.001 | 0.048 | 0.041 | 0.071 | 0.045 | 0.071 | 0.044 | 0.047 | 0.051 | 0.100 |
| | (-0.03) | (0.96) | (0.69) | (1.25) | (0.80) | (1.20) | (1.24) | (0.80) | (1.03) | (1.17) |
| **New COVID Deaths** | **0.197** | **0.472** | **0.583** | **0.638** | **0.534** | **0.794** | **0.341** | **0.546** | **0.470** | **0.828** |
| | **(1.36)** | **(2.62)** | **(2.47)** | **(3.06)** | **(2.57)** | **(3.68)** | **(2.58)** | **(2.45)** | **(2.46)** | **(2.76)** |
| **Total COVID Deaths** | **0.171** | **0.231** | **0.315** | **0.322** | **0.261** | **0.555** | **0.223** | **0.416** | **0.288** | **0.555** |
| | **(1.74)** | **(2.00)** | **(1.83)** | **(2.30)** | **(1.89)** | **(3.89)** | **(2.49)** | **(2.88)** | **(2.27)** | **(2.92)** |
| **Hospitalized COVID Patients** | **0.994** | 0.424 | **1.170** | 1.140 | **1.163** | 1.180 | 0.918 | 1.102 | 0.803 | **2.282** |
| | **(1.92)** | (0.54) | **(2.16)** | (1.44) | **(1.65)** | (1.55) | (1.57) | (1.17) | (1.02) | **(2.29)** |

Panel B: Vaccination Period Analysis

| Variables | Top Ten Oil & Gas Firm Daily Return as Dependent Variable | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 | Model 9 | Model 10 |
| **S&P 500 Return** | | | | | | | | | | |
| **Volume Turnover** | | | | | | | | | | |
| **Volatility Index** | | | | | | | | | | |
| **New COVID Cases** | 0.001 | -0.002 | -0.011 | 0.064 | 0.095 | 0.078 | 0.001 | 0.154 | 0.044 | -0.070 |
| | (0.02) | (-0.14) | (-0.06) | (0.34) | (0.60) | (0.61) | (0.01) | (0.99) | (0.31) | (-0.29) |
| **Total COVID Cases** | 0.341 | 0.251 | -0.194 | 0.060 | -0.057 | -0.013 | -0.189 | 0.138 | -0.060 | 0.070 |
| | (1.07) | (0.53) | (-0.34) | (0.10) | (-0.11) | (-0.03) | (-0.49) | (0.27) | (-0.13) | (0.09) |
| **New COVID Deaths** | 0.114 | 0.157 | 0.168 | 0.330 | **0.321** | 0.204 | 0.121 | **0.352** | 0.229 | 0.168 |
| | (1.06) | (0.98) | (0.88) | (1.63) | **(1.90)** | (1.50) | (0.94) | **(2.11)** | (1.46) | (0.65) |
| **Total COVID Deaths** | 0.332 | 0.336 | -0.234 | 0.058 | 0.022 | -0.151 | 0.211 | 0.020 | -0.181 | 1.269 |
| | (0.91) | (0.64) | (-0.36) | (0.08) | (0.04) | (-0.32) | (0.44) | (0.03) | (-0.34) | (1.35) |
| **Hospitalized COVID Patients** | 0.100 | 0.170 | 0.148 | 0.236 | **0.380** | **0.330** | 0.189 | **0.401** | 0.247 | 0.187 |
| | (0.75) | (0.86) | (0.63) | (0.93) | **(1.77)** | **(1.94)** | (1.18) | **(1.91)** | (1.26) | (0.59) |

**Table 5: Time-Series Regression Model**

The following regression model estimates the time series data.

$$OGIndRet_t = \alpha + \sum_{i=0}^{p} \beta_i COVID - 19\ Cases_{t=i} + \sum_{i=0}^{j} \gamma\ Control\ Variables_{t=i} + \ \ldots\ldots\ + \varepsilon_t$$

$OGIndRet_t$ is the Oil and Gas Index returns proxied using top 10 firms by market capitalization. COVID-19 cases are the log transformed cases per million population. Control Variables are the S&P 500 Index returns and change in CBOE Crude Oil ETF Volatility Index and $\varepsilon_t$ is an error term. Table 1 legend defines the variables. The regression estimates are stated in the upper part. Parentheses number show the t-statistics.

Panel A: Pre-Vaccination Period Analysis

| **Variables** | **Oil and Gas Firm Index Return as Dependent Variable** | | | | |
|---|---|---|---|---|---|
| | **New COVID Cases** | **Total COVID Cases** | **New COVID Deaths** | **Total COVID Deaths** | **Hospitalized COVID Patients** |
| **S&P 500 Daily Return** | **1.380** (14.24) | **1.390** (14.97) | **1.375** (13.84) | **1.393** (13.97) | **0.924** (2.99) |
| **Change in Volatility Index** | **-0.023** (-1.65) | **-0.023** (-1.75) | **-0.020** (-1.45) | **-0.021** (-1.54) | **-0.274** (-2.56) |
| **COVID Cases** | **0.017** (1.99) | 0.006 (1.27) | **0.040** (2.56) | **0.017** (1.73) | **0.152** (2.23) |
| Intercept | **-0.008** (-1.97) | -0.005 (-1.39) | -0.004 (-1.62) | **0.010** (1.76) | **-0.074** (-2.21) |
| *R* Square | 55.70% | 55.39% | 56.07% | 55.28% | 30.48% |

Panel B: Vaccination Period Analysis

| **Variables** | **Oil and Gas Firm Index Return as Dependent Variable** | | | | |
|---|---|---|---|---|---|
| | **New COVID Cases** | **Total COVID Cases** | **New COVID Deaths** | **Total COVID Deaths** | **Hospitalized COVID Patients** |
| **S&P 500 Daily Return** | **0.895** (5.82) | **0.896** (5.83) | **0.899** (5.87) | **0.895** (5.82) | **0.901** (5.87) |
| **Change in Volatility Index** | **-0.126** (-3.97) | **-0.126** (-3.99) | **-0.121** (-3.80) | **-0.126** (-3.99) | **-0.126** (-3.97) |
| **COVID Cases** | 0.004 (0.25) | 0.007 (0.16) | **0.025** (1.70) | **0.026** (1.75) | 0.024 (1.25) |
| Intercept | -0.014 (-0.18) | -0.008 (-0.15) | -0.029 (-1.25) | -0.002 (-0.05) | -0.011 (-1.18) |
| *R* Square | 23.89% | 23.88% | 24.68% | 23.87% | 24.29% |

**Table 6: GARCH Model**

This table reports the effect of COVID-19 proxies on Oil and Gas Index returns from alternative GARCH models.
$OGIndRet_t = \alpha + \sum_{i=0}^{p} \beta_i COVID - 19\ Cases_{t=i} + \sum_{i=0}^{j} \gamma\ Control\ Variables_{t=i} + \ \ldots\ldots\ + \varepsilon_t$

GARCH-M orders, p and q, are fit to (2,1), (1,2), and (2,2). Columns 2 to 4 present the results these models. Column 5 reports an exponential GARCH (EGRACH) results. The estimates relating to COVID-19 proxies are reported. The full-scale model is used including all control variables. Parentheses number show the t-statistics.

Panel A: Pre-Vaccination Period Analysis

| **Variables** | **Oil and Gas Firm Index Return as Dependent Variable** | | | |
|---|---|---|---|---|
| | **GARCH (2, 1)** | **GARCH (1, 2)** | **GARCH (2, 2)** | **EGARCH (1, 1)** |
| **New COVID Cases** | 0.016 | 0.017 | 0.019 | **0.158** |
| | (1.37) | (1.41) | (1.62) | **(1.93)** |
| | $R^2$ = 54.19% | $R^2$ = 55.68% | $R^2$ = 56.17% | $R^2$ = 55.43% |
| **Total COVID Cases** | 0.024 | 0.042 | 0.011 | 0.041 |
| | (0.78) | (0.68) | (0.27) | (1.04) |
| | $R^2$ = 54.09% | $R^2$ = 55.32% | $R^2$ = 53.24% | $R^2$ = 54.93% |
| **New COVID Deaths** | **0.450** | **0.375** | **0.416** | **0.376** |
| | **(2.89)** | **(2.57)** | **(3.07)** | **(2.35)** |
| | $R^2$ = 53.94% | $R^2$ = 56.05% | $R^2$ = 56.36% | $R^2$ = 55.99% |
| **Total COVID Deaths** | **0.255** | 0.172 | **0.195** | **0.175** |
| | **(2.52)** | (1.53) | **(2.02)** | **(1.92)** |
| | $R^2$ = 54.01% | $R^2$ = 55.25% | $R^2$ = 55.88% | $R^2$ = 54.98% |
| **Hospitalized COVID Patients** | **0.152** | **0.152** | **0.152** | **0.180** |
| | **(2.07)** | **(2.06)** | **(2.05)** | **(2.77)** |
| | $R^2$ = 30.48% | $R^2$ = 30.48% | $R^2$ = 30.48% | $R^2$ = 30.34% |

Panel B: Vaccination Period Analysis

| **Variables** | **Oil and Gas Firm Index Return as Dependent Variable** | | | |
|---|---|---|---|---|
| | **GARCH (2, 1)** | **GARCH (1, 2)** | **GARCH (2, 2)** | **EGARCH (1, 1)** |
| **New COVID Cases** | 0.029 | 0.029 | 0.029 | 0.058 |
| | (0.20) | (0.20) | (0.20) | (0.44) |
| | $R^2$ = 23.07% | $R^2$ = 23.07% | $R^2$ = 23.07% | $R^2$ = 23.04% |
| **Total COVID Cases** | 0.026 | 0.027 | 0.027 | 0.017 |
| | (0.05) | (0.06) | (0.06) | (0.39) |
| | $R^2$ = 23.05% | $R^2$ = 23.06% | $R^2$ = 23.06% | $R^2$ = 23.00% |
| **New COVID Deaths** | **0.249** | **0.249** | **0.249** | **0.284** |
| | **(1.74)** | **(1.73)** | **(1.72)** | **(1.98)** |
| | $R^2$ = 23.90% | $R^2$ = 23.89% | $R^2$ = 23.89% | $R^2$ = 23.83% |
| **Total COVID Deaths** | -0.074 | -0.073 | -0.073 | 0.081 |
| | (-0.14) | (-0.14) | (-0.14) | (0.16) |
| | $R^2$ = 23.07% | $R^2$ = 23.07% | $R^2$ = 23.07% | $R^2$ = 23.02% |
| **Hospitalized COVID Patients** | 0.235 | 0.235 | 0.235 | 0.025 |
| | (1.29) | (1.27) | (1.28) | (1.44) |
| | $R^2$ = 23.55% | $R^2$ = 23.54% | $R^2$ = 23.54% | $R^2$ = 23.50% |