The Impact of Crude Oil Price Changes in The Yield and Fluctuation of Manufacturing and Transportation Industries

Zhenhai Lyu

Victoria College, University of Toronto, Toronto, M5S1K5, Canada

zhenhai.lyu@mail.utoronto.ca

Abstract. Given that Russia was one of the largest oil exporters, has left the oil market unstable as the war between Russia and Ukraine intensifies. This report, studies the effect of the oil shock on returns and volatility of manufacturing and transportation industries of the US, to understand the relationship, lag, and intensity between these industries in conjunction with the Crude oil price in the international market. By using Time-Series data collected from NYME and constructing a VAR model, an ARIMA-GARCH model has been formulated using likelihood ratio lag of 12. The report finds out no significant relationship between the oil shock triggered by Russian-Ukrainian war on the US transportation and manufacturing industry. The Yield and Volatility of these two industries have not been driven due to exogenous factors, crude oil price. There is a possibility that the impact is lagged and hasn't occurred yet or is too statistically small that it is hard to be captured by the model. The impact of exogenous shocks may be lagged much higher until it destabilizes these sectors. Government must set countermeasures based on lag effect as the impact is indirect.

Keywords: Oil-Shock; War; Ukraine; Manufacturing; Transportation.

1. Introduction

The recent event of Russian-Ukrainian war has caused the international crude oil price to become unstable. Russia was one of the largest oil exporters, and because sanctions were imposed by the US, Europe, and other nearby countries, the supply of oil is affected. Further countries like Europe are the most affected as they were the major importer of not only oil from Russia but other natural resources as well such as gas. Because of the sanctions, Europe experienced a rising inflation rate and instability in the economy. Especially those effects are stronger for firms with large revenue exposure to Russia [1]. The Manufacturing and transportation sector were the most affected in Europe. Based on this the motivation for this paper comes from the same event. Does the US experience the same problems as Europe? Does the war affect the transportation sector and the manufacturing sector or not? The paper tries to answer these questions, by answering the effect of volatility and returns due to international oil market shock.

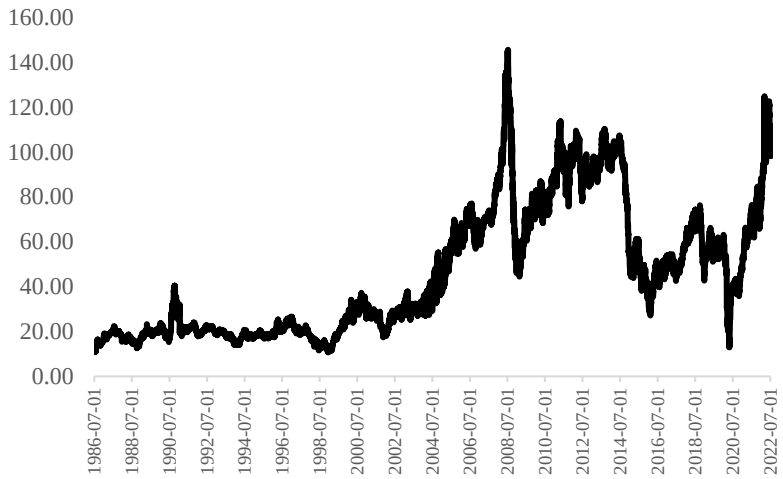

Figure 1. International Crude oil price (USD per barrel)

Figure 1 shows the data and can help understand the raw crude oil price volatility, which is measured in USD/barrel graphically.

The graph above shows data on crude oil prices from 1986 to 2022. It shows that there have been a lot of fluctuations, especially in 2008, which was accompanied by a financial crisis. Looking at it the current year, the price of oil has been increasing sharply. This spike in the oil price is due to the war and the Pandemic. The recently COVID-19 outbreak indicates significant volatility in economic activities and oil prices during the period of crisis [2]. Let us now look at the research paper already published and understand the data, process, and conclusion.

In 2005 a paper was published by Lutz Kilian under the banner of the University of Michigan with the topic "Exogenous Oil Supply Shocks: How Big Are They and How Much Do They Matter for the U.S. Economy?". In this paper, the author has tried to answer how oil production shortfall in the international market affects the oil prices, US real gross domestic product growth, and the consumer price index, as an inflation indicator. The author not only tried to figure out the impact of oil production shortfall in the US but also compared the 1973 oil shock to the event of 1990. The report concludes that back in 1973 US, did have a negative and significant impact if the oil price in the international market was disrupted. However, as time passed the performance of the US economy became much sturdier than it was in 1973. Also, in some events oil shocks did little to no impact on US local economy. Exogenous oil supply shocks made remarkably little difference in the evolution of the U.S. economy [3].

A paper by a group of authors namely Congqi Bai, Chenglin Gong, Ziyang Qiu, Yingjie Sheng, and Tong Wu wrote about the relationship between oil prices and the US stock market return. The topic of the paper is "The Impact of Oil Prices on the U.S. Stock Market". Here the authors analyzed that the crude oil prices do not directly affect the stock market return but rather affect it indirectly. The study was conducted using the US stock market, S&P 500, and EPS (earnings per share) monthly to know the profitability of the corporates. Higher crude oil prices mean that the input cost of the production increases which then implies that the company's profitability falls. A falling profit then affects the stock market return. U.S. real stock returns to an oil price shock differ greatly depending on whether the change in the price of oil is driven by demand or supply shocks in the oil market.[4] The paper also explains that if the price of crude oil remains stable there is a less indirect impact, as growth is gradual. However, in the case of high volatility the world inflation rate increases, which then affects the stock market. Rising inflation then affects the interest rate of the economy which then further affects the stock market performance. The oil price has little influence when it is stable, but it has more influence when it is volatile [5].

Another paper was published in the national institute of Economics and social research with the topic "The Economic Costs of the Russia - Ukraine Conflict". This paper was published on 2 March 2022, with a group author Iana Liadze, Corrado Macchiarelli, Paul Mortimer-Lee and Patricia Sanchez Juanino. Here the authors have described the effect of war on the global economy and forecasted the negative impact that countries could have. It uses its global economic model called NIGEM. As per their forecast, the world economy would lose about 1 percent of GDP by 2023. This 1% is almost equal to $1 trillion. The main reason for such a massive drop is that Ukraine and Russia both were major exporters of vital natural resources, such as oil, gas titanium wheat, etc. Because of the war, the supply of these natural resources dropped. Emerging markets such as countries in Europe are the most affected, as compared to advanced markets which are matured. Even though the sanctions have been applied on Russia, their loss to the economy won't be very high, as it will gain from a rise in the price of these goods. Despite that, Russia will still face a negative effect on the economy. The impact on the UK could be to reduce GDP growth by around 0.8 percent to 4.0 percent in 2022 and 0.5 percent in 2023 [6]. The economy has already been impacted by COVID-19, and the war further intensifies the issue.

Similar to oil shock and economic growth of the US, there is another paper called "Impact of Oil Price and Shocks on Economic Growth of Pakistan: Multivariate Analysis". Rather than the US, it is now Pakistan. Paper written by Nazir, Sidra and Qayyum in 2014. As per the paper, the demand for

Oil is increasing and becoming an important factor in its economy as economic growth takes place. It uses the cobb Douglas production function with the oil price and GDP to understand the relation. To test the order of integration it used, the Augment dicky fuller test, Johansen cointegration, and granger causality and applied it to the dynamic model. This paper is based on the time series data collected from the year 1972 to 2011. And as per the results, the model indicates that Oil prices impact real GDP negatively in long run but positively in the short run [7]. Furthermore, the oil price shock in the international market has a direct connection to economic growth. And it has a negative impact on economic growth in the short run as well as in the long run.

A paper by Peterson K Ozili on the topic of "Global Economic Consequence of Russian Invasion of Ukraine" was published by the Central Bank of Nigeria. This paper analyzed that the sanctions that were imposed on Russia to constrain them to stop the war, have a spillover effect which means, that even though the sanctions were meant for a positive impact, they created a negative impact by disrupting the supply of natural resources. Oil supply disruptions are associated with positive effects on the covariance of return and volatility [8]. The most affected area is the euro area, of which the highest is Ukraine, which makes sense as it is the one under war. However, because other European countries also traded with Russia, their supply of natural resources such as gas and oil increased. Core consumption prices have increased drastically in European countries. This includes a rise in fuel price, food, and most importantly transportation. As per the report, the transportation component of the consumer price index rose in the month of the invasion due to a shortage of energy and fuel supplies [9].

Based on various reports it turns out that there was a strong correlation between oil price shock and the economic performance of the countries. However, some countries such as the US, have become immune over time. Yet, the impact does become significant as time passes. Countries like the Netherlands, Germany, France, Italy, the US, the UK, and China get a negative direct effect and positive indirect effect from oil-producing countries [10] from the oil shock. That means the indirect effect now plays a role whenever there is an oil shock in the international market. The consequences are lagged; hence it takes time to impact the economy. Furthermore, the most affected economies are those that had direct trade. For example, in the case of the Ukraine Russian war, European countries are the most affected regions. This report first tests the data, regarding unit root, heteroscedasticity, and lag length. Then Construct a General VAR model, which is then narrowed down to ARIMA-GARCH model. A standard method to construct a time-series model.

2. Research design

2.1 Data sources

To evaluate the effect of the crude oil market on returns and volatility of manufacturing and transportation industry, crude oil price USD/barrel and stock market performance of manufacturing and transportation industry has been used. Stock market performance is one of the best proxies to understand the volatility in the market and provide details of the yield of the industry. The data is collected from NYME i.e. New York mercantile exchange.

2.2 Unit root test

Before the construction of the model, it is important to look for stationarity in the data collected. Since it's time-series data, the unit root test will allow us to understand the existence of stationary which means that the statistical properties of the data such as mean-variance and covariance of the distribution are constant over time. If there exists a trend in the data then it is said that it is nonstationary series, whereas if there exists no trend, it is said that the data is stationary series. This report used the augmented dickey fuller test to test stationarity. As per this, the test model is:

$$\Delta y_t = \alpha + \delta y_{t-1} + \sum_{i=i}^{n} \beta_i \, \Delta y_{t-1} + \varepsilon_t \quad (1)$$

The test hypothesis is as follows:

$$\begin{aligned} \mathrm{H}_0 &: \delta = 0 \\ \mathrm{H}_1 &: \delta \neq 0 \end{aligned} \quad (2)$$

The null hypothesis claims that the data is nonstationary while the alternative hypothesis says there is stationary, which is what is required to run the data. If the data is not stationary, then it is better to have a diff to make it stationary. The result of the unit root is shown below:

Table 1. Augmented Dicky Fuller Test

Variables	t-statistic	p-value
Price		
Transportation	-2.900	0.1622
Manufacturing	-0.579	0.9800
Crude oil	-2.483	0.3365
Yield		
Transportation	-9.64	0.0000***
Manufacturing	-8.617	0.0000***
Crude oil	-9.424	0.0000***

By analyzing the ADF report above the augment dicky fuller test tells us that stock market price variables for transportation, manufacturing, and Crude oil, all have a p-value greater than the 0.05 threshold. In contrast to this Yield, variable is stationary as their p-values are below the 0.05 threshold, i.e., 0.05 percent significance level. Hence for Yield, reject the null hypothesis and conclude that it is stationary

2.3 VAR model setting

Once the nature of time-series data is understood, it's time to set up our VAR model. VAR is a type of stochastic model where it tries to capture the relation between the multiple variables as they change over time, including the lag length of various variables. VAR stands for Vector autoregression. A simple mathematical format of a VAR model is:

$$Y_{1,t} = \propto_1 + B_{11,1} Y_{1,t-1} + B_{12,1} Y_{2,t-1} + \cdots + B_{1p,1} Y_{2,t-p} + \varepsilon_{1,t} \quad (3)$$

$$Y_{2,t} = \propto_2 + B_{21,1} Y_{1,t-1} + B_{22,1} Y_{2,t-1} + \cdots + B_{2p,1} Y_{2,t-[} + \varepsilon_{2,t} \quad (4)$$

It can be said that the VAR model is very useful where the variable lag i.e., past value affects the future value. This model applies here as the volatility and returns of the market may be lag driven.

Given the general form of the model above, let us construct our model based on our variable. Crude oil as our independent variable and our stock market performance as our dependent variable

$$Price_{1,t} = \propto_1 + B_{11,1} Price_{1,t-1} + B_{12,1} CrudeOil_{2,t-1} + \varepsilon_{1,t} \quad (5)$$

$$Yield_{2,t} = \propto_2 + B_{21,1} Yield_{1,t-1} + B_{22,1} CrudeOil_{2,t-1} + \varepsilon_{2,t} \quad (6)$$

2.4 ARMA-GARCH model setup

ARMA-GARCH is divided into two equations, a mean equation, ARMA, and a variance equation, GARCH. An ARIMA model helps to forecast the value based on past values. It uses lagged moving averages to balance out the fluctuations in the time series data. This model is popular in forecasting

highly volatile stock prices. One of the assumptions it follows is that future values will be resembling the past. Mathematically it is expressed by:

$$y_t = \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{i=1}^{m} \beta_i \varepsilon_{t-i} + \varepsilon_t \quad (7)$$

In contrast to ARIMA, a GARCH model estimates the volatility in the stock markets. This model is used to calculate the expected return of an investment based on its volatility. It resembles the more realistic approach to predicting stock prices and returns. The mathematical expression of GARCH model is as follows:

$$\sigma^2 = \omega + \sum_{i=1}^{n} \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^{m} \beta_i \sigma_{t-i}^2 \quad (8)$$

If ARCH effect is found in the data, then the ARCH or GARCH model will be used, however, if no ARCH effect is found then ARMA Model is used. And ARCH model stands for Autoregressive conditional heteroskedasticity while GARCH stands for Generalized Autoregressive conditional heteroskedasticity. And these models are used when the data has non-constant variance (heteroskedasticity), which is also supported by our unit root test. Once our unit root has been finalized, it's time to find the variance ratio test, meaning heteroskedasticity. If the variance is constant, then an ARIMA model with appropriate lag for AR and MR can be used. If there exists heteroscedastic data, then ARIMA with ARCH or GARCH effect is used. Then the appropriate lag for AR and MR needs to be found and try to detect the arch effect. If there exists, no arch effect then it is better to stay with our ARMA model. If there is an ARCH effect, then ARCH and GARCH component is added until the diagnostics are clear.

3. Empirical Results and Analysis

3.1 VAR order selection

To get the required lag length there are various test results. Such as Akaike information criterion, Bayesian information criterion or Hannan and Quinn's Information Corrected Criterion, etc. Our comprehensive results are shown below:

Table 2. Lag length criteria

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1128.99				3.6e-11	-15.5309	-15.5059*	-15.4693*
1	1138.45	18.924	9	0.026	3.6e-11*	-15.5373*	-15.4372	-15.2909
2	1143.89	10.878	9	0.284	3.8e-11	-15.4881	-15.313	-15.057
3	1148.88	9.9695	9	0.353	4.0e-11	-15.4328	-15.1825	-14.8169
4	1155.65	13.553	9	0.139	4.1e-11	-15.4021	-15.0768	-14.6015
5	1162.5	13.688	9	0.134	4.2e-11	-15.3724	-14.972	-14.387
6	1175.48	25.967	9	0.002	4.0e-11	-15.4273	14.9518	-14.2571
7	1179.16	7.3649	9	0.599	4.3e-11	-15.354	-14.8034	-13.999
8	1183.13	7.9394	9	0.540	4.7e-11	-15.2846	-14.6589	-13.7449
9	1193.25	20.246	9	0.016	4.6e-11	-15.3001	-14.5994	-13.5756
10	1197.72	8.9295	9	0.444	4.9e-11	-15.2375	-14.4617	-13.3283
11	1207.84	20.232	9	0.017	4.9e-11	-15.2529	-14.402	-13.1589
12	1217.73	19.798*	9	0.019	4.9e-11	-15.2653	-14.3394	-12.9866

The table above shows all the possible lag length that is suitable for our model based on our data. There are various testing criteria. By observing the above table, Table 2, FPE and AIC are suggesting taking 1 lag length, while HQIC and SBIC are suggesting taking no lag variable into account. And only likelihood ratio is suggesting taking lag of 12. Because it's time-series data, let us consider going with likelihood ratio, which suggests taking lag 12. Taking lag of 0 or 1 may also be suitable to reach to the same conclusion.

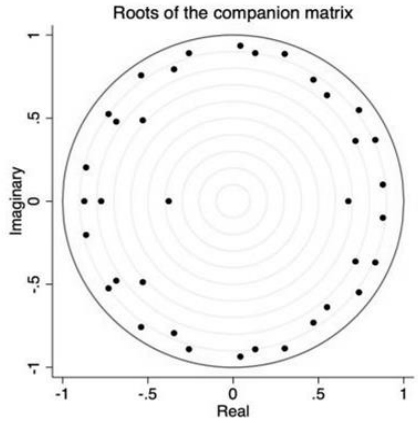

Figure 1. AR Root Graph

The above AR roots graph helps to know the stability of our model. As all the dots fall under the circle, this is a clear indication that our model is stable, and the results will be reliable.

3.2 Impulse response

An impulse response is a test of a model that tells us how the model would react if it were given a shock in one or more than one variable. In our case, the variables are Transportation, manufacturing, and crude oil price. Based on our model the shock would be given the stock lagged price of manufacturing and transportation and the crude oil. The output of impulse response is represented in the graph below.

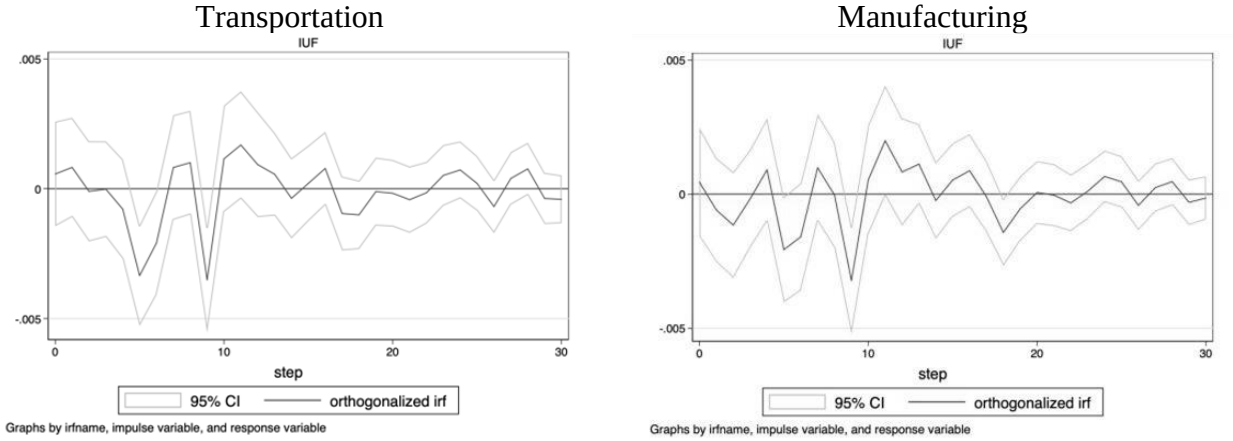

Figure 2. Impulse Response Function

From the estimation results of the impulse response, the short-term net effect of crude oil futures price changes on the transportation industry and the manufacturing industry's profitability is negative.

Specifically, the t=0 period crude oil futures revenue rate will increase by 1%, the traffic transportation industry revenue rate will decrease within the next 10 periods, the 9th period and the 5th period will be the highest value, and the absolute value will be about 0.35%. From the perspective of the net effect of the previous 20 periods, the impact of the increase in crude oil prices at that period on the revenue rate of the transportation industry is negative.

As the lifeblood of the modern industry, the impact of crude oil price changes on the manufacturing industry is also very large.

From the perspective of the time effect, the impact of the crude oil price increase will gradually decline after 20 periods. Therefore, if the crude oil price does not continue to increase, then the impact on the transportation industry and the manufacturing industry will be short-term.

3.3 ARMA order selection

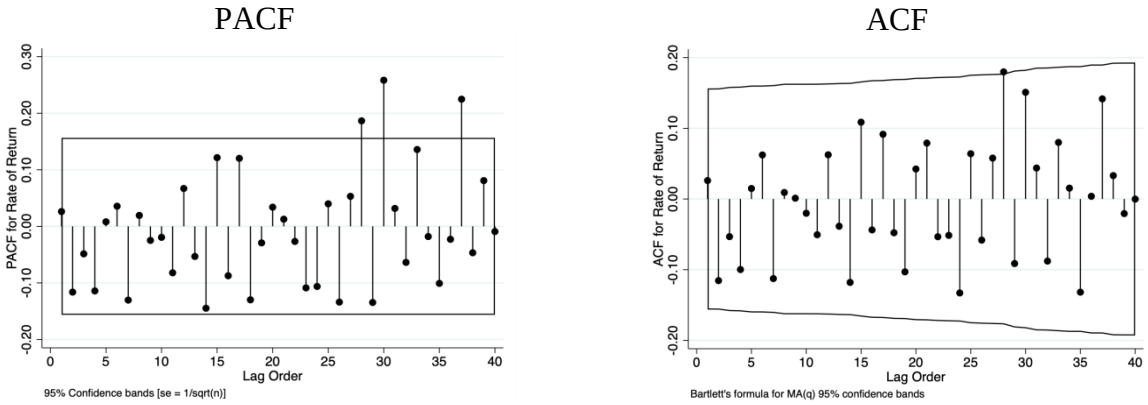

Figure 3. PACF and ACF, transportation

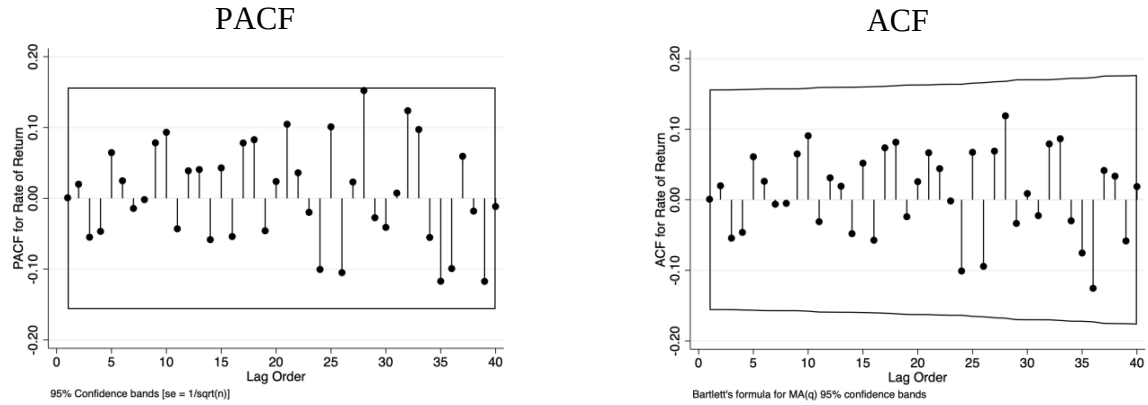

Figure 4. PACF and ACF, manufacturing

This part uses PACF and ACF to know which model to use, either AR or MA model. How many days should be looked back to predict the value? Autocorrelation is used in the VAR model to detect any degree of correlation between a variable and its lag value. In general, it tells us how the lag variable is linked with its present value. Based on our output the autocorrelation results are displayed in the above graph. For each industry, ACF (autocorrelation function) and PACF (partial correlation function) is presented.

3.4 ARMA-GARCH estimation results

Finally, the model is run and the estimated results are found. The table below tells us the relationship between crude oil, transportation, and manufacturing volatility and returns.

Table 3. ARMA-GARCH estimation results

Variables	(1)		(2)	
	Transportation		Manufacturing	
	Coef.	Std. err	Coef.	Std. err
Crude oil	-12.1893	17.7242	-8.0357	6.9417
ARCH (-1)	0.0992**	0.04500	0.1985	0.1530
GARCH (-1)	0.8734***	0.0488	0.4444	0.3564
Constan	-11.9139***	0.7475	-9.4571***	0.7868

As the table shows the ARCH effect of lag 1 and GARCH effect of lag 1. Judging from the estimation results of the ARMA-GARCH model, the ARCH item of the transportation industry revenue rate and the GARCH item of the revenue ratio does not exist. Conditions heteroscedasticity, models lost effect.

Judging from the estimation results, the impact of crude oil yield rate changes on traffic transportation industry revenue fluctuations is not evident.

4. Discussion

It turns out that the US transportation sector and manufacturing sector are not significantly affected by the oil shock. The stock market volatility and yield are not strongly linked to the oil shock that happened recently. This could be because the US may have its strategic oil reserve which it could release in the case of crude oil shortages. Or perhaps, it has other sources of oil import. As per the Us energy information administration, the US imports about 62% of the total oil imports from Canada. This is also supported by the gravity model, as Canada not only has oil but is the closest country with which it can trade.

It could be possible that the Russian and Ukrainian war has affected the manufacturing and transportation sector in most of Europe, as they are the ones who are closer to that and had trade agreements between Europe and Russia. So, because the United States of America does not have disturbance from its trade partner, and also has a strategic oil reserve, the NYME did not show a significant impact. Even though the transportation sector had a strong ARCH and GARCH effect, meaning its past value affects the current value, the impact of crude oil on it was not significant. In contrast to this, the manufacturing sector did not show the ARCH nor GARCH effect as significant. Also, the variable did not show a significant impact through crude oil too.

5. Conclusion

Our analysis showed that Price variables are non-stationary and there exists heteroscedasticity. The reason is that the price variable is more volatile than any other variable in stock market data. Whereas the stationary exists in the Yield variable. It means, that despite the existence of price volatility, the market yield for these sectors is very much stable and constant. The AR root graph shows, that given the data the model is stable and reliable to use. After running various steps such as lag length and AR and MR lag detection, our model found that the US transportation and manufacturing returns and volatility are not affected by the international oil market, which caused instability due to the Russian and Ukrainian wars. It cannot be confirmed that the international oil price shock, does not affect the US market at all. Given the time range of the study, the scope was only limited to oil shock due to war. There is a possibility that there may be a statistically significant result between the return and oil shock by considering historical oil shocks.

References

[1] Bougias A, Episcopos A, Leledakis G N. Valuation of European Firms During the Russia-Ukraine War. Available at SSRN 4086982, 2022.

[2] Yu Y, Guo S L, Chang X C. Oil prices volatility and economic performance during COVID-19 and financial crises of 2007-2008. Resources policy, 2022, 75: 102531.

[3] Kilian L. Exogenous oil supply shocks: how big are they and how much do they matter for the US economy? The Review of Economics and Statistics, 2008, 90(2): 216-240.

[4] Kilian L, Park C. The impact of oil price shocks on the US stock market. International Economic Review, 2009, 50(4): 1267-1287.

[5] Bai C, Gong C, Qiu Z, et al. The Impact of Oil Prices on the US Stock Market. 2021 3rd International Conference on Economic Management and Cultural Industry (ICEMCI 2021). Atlantis Press, 2021: 69-77.

[6] Liadze I, Macchiarelli C, Mortimer-Lee P, et al. The economic costs of the Russia-Ukraine conflict. NIESR Policy Paper, 2022, 32.

[7] Nazir S, Qayyum A. Impact of oil price and shocks on economic growth of Pakistan: Multivariate Analysis. 2014.

[8] Kang W, Ratti R A, Yoon K H. The impact of oil price shocks on the stock market return and volatility relationship. Journal of International Financial Markets, Institutions and Money, 2015, 34: 41-54.

[9] Ozili P K. Global economic consequence of Russian invasion of Ukraine. Available at SSRN, 2022.

[10] Hesary F T, Yoshino N, Abdoli G, et al. An estimation of the impact of oil shocks on crude oil exporting economies and their trade partners[J]. Frontiers of Economics in China, 2013, 8(4): 571-591.