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The Impact of Oil Price Change and its Volatility on Major Global Stock Markets

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Abstract

This paper investigates the impact of oil price change, and its volatility on the stock market returns of the US, Japan, and China. Moreover it highlights the association between the returns of each market with respect to the returns of the other markets. More specifically, the study uses daily data of three indices to represent the markets which are Standard & Poor 500, Nikkei 225, and Shanghai Composite (SSE), beside daily data of crude oil price. The GARCH model employed to measure the volatility. The findings indicate that, the S&P500 returns are influenced significantly by oil price change, the returns of both N225 and SSE, as well as its own past volatility. Regarding Nikkei 225 returns it influenced by the returns of the S&P500 and SSE, and by its own previous day volatility. In contrast, Shanghai Composite returns are not influenced neither by oil price change, nor by the returns of the two other indices, rather it's only affected by its own previous volatility, and S&P500 and Nikkei 255 returns are influencing each other. The impact of oil price volatility on the three stock indices returns is insignificant during the sample period.

Keywords: oil price change, volatility, stock markets, Japan, US, China.

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1.INTRODUCTION

From theoretical perspective oil prices affect the stock markets returns in two ways; first the change in oil prices affects the cost of manufacturing and transportation of businesses. When oil prices increase inputs costs increase and corporations' earnings decrease, and vice versa. For companies that work in oil and gas industry their earnings increase as oil prices increase then investors would like to buy their stocks, and this increase in demand will increase their share prices.

Second, the change in fuel prices affects the disposable income for consumers. Whenoil price increase it reduces their available money for investing in stock markets and the opposite is true. Therefore knowingthat if there is an impact of oil prices volatility on Stock market returns is important for both corporations as well as for investors when making their decision of investing in stock markets.

This paper aims to answer this question: "Do Oil price change and volatility have impact on the industrial countries' stock markets returns? "

In this paper we focus on three of the largestindustrial countries which are the US, China, and Japan. Stockmarketswhich operate in the largest industrial countries in the world.

We study the impact of oil prices change and volatility on three of these countries' stock market indices returns, specifically the returns of: Standard & Poor 5oo index (S&P500), Shanghai Composite (SSE), and Nikkei 225 index (N225).

This paper fills the gap in the existing literature by adding two aspects. The first aspect is that it highlights the association between the returns of each market with respect to the returns of other markets and oil price change during the period of Covied19. The second aspect is that, it uses oil price volatility as explanatory variable to the return of each market.

The remaining of the paper is organized as follows, section two contains the literature review, parts three and four include data & methodology, and the analysis respectively. The conclusion is in section five of the paper.

2- Literature review:

Previous empirical studies including among others, Lake & Katrakilidis[1] studied the impact of oil price returns and oil price volatility on the Greek, the US, the UK and the German stock markets. They used EGARCH models to measure the volatility of the indices, and the relationship between the variables has been examined by structural equation models. the results obtained reveal that the Greek stockmarket index returns and the US stock market index returns are both sensitive tothe oil price returns movements while the German and the UK stock marketreturns are not affected at all.

Onour[2] investigates the short and long-term determinants of Gulf Cooperation Council (GCC) stock markets' volatility using crude oil price volatility and its returns. He used daily stock market price indices and Brent oil price during the period 3 May 2004–2 September 2006. GARCH-M model employed to consider the impact of oil price uncertainty on GCC stock markets returns. The

results show that unobservable speculative factors drive short term stock market returns. While The influence of oil price change on GCC stock markets returns is evidenced in the long-term.

Jones and Kaul[2,4], using quarterly data studied effect of oil prices on stock prices. They detect significant effects of oil prices on aggregate real stock returns, including a lagged effect, in the period from 1947 to 1991. In their second study they test whether the reaction of international stock markets to oil shocks can be justified by changes in expected returns. They find that the reaction of Canadian and U.S. stock prices to oil price shocks can be completely accounted for the impact of these shocks on the real cash flows. The results for Japan and theU.K. are, not as strong. Sadorsky [5] by focusing on the American economyhe attempted to examine therelationship between oil price volatility, stock market returns and the economic activity .using an unrestricted vector autoregression model, Forthe period 1947-1996. The resultsconfirm that both the oil prices and the oil price volatility play an important rolein affecting economic activity. Moreover it shows that oil pricemovements are important in explaining movements in the stock returns.

Huang, Masulis and Stoll[6] investigate the dynamic interactions between daily oil futures returns and stock returns, Using of a vector autoregression (VAR) model. they find evidence of Granger causal effects from oil futures to stocks of individual oil companies, they detect no impact on a broad-based index like the S&P 500. [7]

Maghyereh[8], examines the dynamic relation between oil price shocks and stock market returns in 22 emerging economies. using daily data covering the period between 1/1/1998 and 30/4/2004, the vector autoregression (VAR) analysis is carried out. the results imply that oil shocks have no significant impact on stock index returns in emerging economies.

Papapetrou[9] by employing amultivariate vector autoregression (VAR) approach, attempts toassess the dynamic relationship among oil prices, real stock prices, interest rates, real economic activity and employment in Greece. The findings reveal that oil price change affect real economic activity, employment, and also are important in explaining stock price movements. while stock returns do not lead to changes in real activity and employment.

Bensafta[10] investigates the relation between oil prices and stock markets. The analysis is conducted using Multivariate GARCH models, it includes four indices: the WTI index price, the Brent index price, the U.S. market index and the aggregate index of European markets. The results show that the mean and uncertainty of the U.S. stock markets are transmitted to the oil and European stock markets.

Park and Ratti [11] use a sample of thirteen developed countries over the period 1986-2007. Their findings are that oil price shocks significantly affect the volatility in real stock returns. Moreover, oil price volatility has a significant negative impact in most of the sample countries. In addition, when the oil price shock is included to the same model with oil price volatility, then the impact of oil volatility become weaker than before.

3- Data & Methodology:

The data employed for this study is daily data covering the period between November 2020 and November 2021. It has been collected from Yahoo Finance site. It includes the closing prices of three indices which are, Standard & Poor 500 (S&P500), Shanghai Composite (SSE), and Nikkei 225 index (N225), which have been used to calculate the returns of the US, China, and Japan stock markets, respectively. Moreover the oil pricechange has been calculated using crude oil closing prices from the same web site. In the following equations, the returns of the stock markets indices are denoted ΔS&P500, ΔSSE, ΔN225. While the change in oil price is denoted ΔOIL.

The study aims to assess impact of oil price change and volatility on the stock markets returns. As well as assessing the relationship between each of the stock markets returns with those of the other markets.

The methodology employed is the GARCH technique, (conditional volatility)

The models specifications are as follows:

$$\Delta S\&P500=c_1+\beta_1\sum_{i=0}\Delta SSE_{t-i}+\beta_2\sum_{i=0}\Delta N225_{t-i}+\beta_3\sum_{i=1}\Delta S\&P500_{t-i}+\beta_4\sum_{i=0}\Delta OIL_{t-i}+\theta_1\sigma_{t2}+e_{(t)} \quad (1)$$

$$\Delta N225=c_2+\varphi_1\sum_{i=0}\Delta S\&P500_{t-i}+\varphi_2\sum_{i=0}\Delta SSE_{t-i}+\varphi_3\sum_{i=1}\Delta N225_{t-i}+\varphi_4\sum_{i=0}\Delta OIL_{t-i}+\theta_2\sigma_t^2+e_t \quad (2)$$

$$\Delta SSE=c_3+\alpha^1\sum_{i=0}\Delta S\&P500_{t-i}+\alpha_2\sum_{(i=0)}\Delta N225_{t-i}+\alpha_3\sum_{i=1}\Delta SSE_{t-i}+\alpha_4\sum_{i=0}\Delta OIL_{t-i}+\theta_3\sigma_t^2+e_t \quad (3)$$

Where:

$\Delta S\&P500_t \equiv$ returns of S&P500Stock index

$\Delta N225_t \equiv$ returns of Nikkei Stock index

$\Delta SSE_t \equiv$ returns of Shanghai Stock index

$\Delta OIL_t \equiv$ change of oil price

$\theta\,\sigma_t^2 \equiv$ oil price change conditional volatility

GARCH (1,1)specification:

$$h_t = c_0+\lambda_1 h_{t-1}+\lambda_2 e_t \quad (4)$$

Where:

$e \sim N(0,\mu_t)$,

$h_t \equiv$ conditional volatility

$\lambda_1 \equiv$ implying the impact of previous day volatility of index returns.

$\lambda_2 \equiv$ reflect the effect of news & rumors on the volatility of returns.

4- The Analysis:

In the beginning, the stationary of the stock markets' returns and the oil price changeexamined by using the Augmented Dickey –Fuller test (ADF).

Tables (1) below presents the results obtained from the ADFtest applied on the first differences of the variables. The results of the test reject the null-hypothesis of random walk, implying that the series are stationery at the first difference.

Table (1) ADF Unit root test for the stock markets' returns and oil price Change

Variable	ADF	P-value
ΔOil	238.546	0.0000*
ΔS&P500	242.450	0.0000*
ΔSSE	238.330	0.0000*
ΔN225	243.105	0.0000*

***Significant at 1% confidence level.**

The mean equations (from 1 to 3) above, postulates the association between each of the stock markets returns, as dependent variable,withits own lagged returns, other markets returns, the oil pricechange and its volatility, all included as explanatory variables. The returns of the other markets and their lags have been included in the analysis to consider any interdependence between the markets returns.Equation (4) above represents the conditional volatility of oil price change.

Table (2) below presents the estimation results of the relation between the returns of S&P500 as dependent variable, with its lagged returns, the returns of N225, SSE, and their lagged returns too. Also the change in oil price, its lags, and its volatility are included as independent variables. Moreover the table presents the GARCH estimation of S&P500 returns.

The model fitness is indicated by the log likelihood value, as well as the Wald test significance which implies that all the independent variables that included are relevant in explaining the dependent variable.

The returns of S&P500 are positively and significantly related to the returns of Nikkei 225 (N225), the change in oil price and its second lag. Moreover S&P500 returns significantly but negatively related to its lagged returns.On the other hand there is insignificant negative association with Shanghai composite returns (SSE). These results indicate that returns of US stock market, as measured by S&P500 returns, are influenced by the returns of the Japanese stock market returns and the change in oil price.

On the other hand, the same results show that there is no association between the returns of the S&P500 and China stock market returns as measured by Shanghai Compositereturns (SSE). The insignificance of the oil price conditional volatility (θ_1) implies that the volatility of oil price change has no effect on the returns of S&P500.

The GARCH specificationshows that the volatility of the S&P500 returns ,as indicated by (λ_1)is significantly affected by its own past volatility which implies that investors are not influenced by change in returns when it is around the mean. On the other hand, the insignificance of ⟦(λ⟧_2)indicates that the volatility of the returns is not affected by the market news and rumors.

Table (2) S&P500 Returns

Variables	Coefficients	P-value
c_1	-5.823	0.012**
ΔN225	0.012	0.033**
ΔSSE	-0.038	0.537
ΔOil	4.544	0.003*
$\Delta S\&P500_{t-1}$	-0.182	0.002*
$\Delta S\&P500_{t-2}$	-0.111	0.027**
ΔSSE_{t-1}	0.059	0.314
ΔSSE_{t-2}	-0.097	0.152
$\Delta N225_{t-1}$	0.004	0.387
$\Delta N225_{t-2}$	0.010	0.103
ΔOIL_{t-1}	2.88	0.054***
ΔOIL_{t-2}	1.88	0.287
θ_1	0.934	0.306
GARCH:		
c_0	251.85	1.34
λ_1	0.524	0.073***
λ_2	0.190	0.119
Observation No.	240	
Log likelihood	-1146.623	
Wald chi2	34.36	0.000

***Significant at 1% confidence level.**
****Significant at 5% confidence level.**
*****Significant at 10% confidence level.**

Table (3) below shows the estimation results of the association between the returns of Nikkei 225(N225) as dependent variable, and the independent variables which include, its lagged returns, the returns of S&P500, SSE, and their lagged returns. Moreover the change in oil price, its lags, and its volatility are included too. In addition the table presents the GARCH estimations of the N225 returns.

The model fitness is indicated by the log likelihood value, and the Wald test significance whichindicates that all the variables included, as independent variables, are relevant in explaining the dependent variable.

The results show that N225 returns are positively and significantly related to S&P500returns,their lags, and the lagged returns of Shanghai composite (SSE). While the oil price change and its lags are not significant. Furthermore, the returns of N225 negatively but insignificantly related to their lagged returns.

The insignificance of the oil price conditional volatility, as indicated by (θ_2), implies that the volatility of oil price change has no effect on the returns of N225.

The GARCH specification shows that the volatility of the N225 returns insignificantly affected by its own past volatility which implies that investors are not influenced by change in returns when it is around the mean. In addition, the insignificance of the coefficient (λ_2) indicates that the volatility of the returns is not affected by its news.

The estimation results presented in table (4) below show the relation between the returns of Shanghai composite (SSE) as dependent variable, and the independent variables which include its lagged returns, the returns of S&P500, N225, and their lagged returns. In addition, the change in oil price, its lags, and its volatility are included. Moreover, the table presents the GARCH estimations of the SSE returns.

The model fitness is indicated by the log likelihood value. SSE returns are negatively butinsignificantly related to S&P500 returns and its lags. SSE also has positive but insignificant association with its own return lags. Regarding SSE associations with N225 returns and its lagsare insignificant. Also the oil price change and its lags are not significant.

The insignificance of the oil price conditional volatility (θ_3) implies that the volatility of oil price change has no effect on the returns of SSE.

The significance of GARCH specification (λ_1) indicates that the volatility of the returns is influenced by its own previous day volatility. While the insignificance of the coefficient (λ_2) shows that the volatility of the Shanghai Composite returns (SSE) insignificantly affected by its own news which implies that investors are not influenced by change in returns when it is around the mean.

5. Conclusion:

The objectives of this study are to investigate the impact ofoil price change and volatility on the US, Japan, and China stock markets' returns. In addition it aims to assess the association between these markets, and to

Table(3)N225 Returns

Variables	Coefficients	P-value
c_2	-7.771	0.745
ΔS&P500	1.082	0.074***
ΔSSE	0.827	0.185
ΔOil	11.804	0.484
$\Delta S\&P500_{t-1}$	1.913	0.002*
$\Delta S\&P500_{t-2}$	1.492	0.030**
ΔSSE_{t-1}	0.109	0.876
ΔSSE_{t-2}	2.312	0.000*
$\Delta N225_{t-1}$	-0.0719	0.225
$\Delta N225_{t-2}$	0.398	0.563
ΔOIL_{t-1}	-17.616	0.297
ΔOIL_{t-2}	-12.766	0.454
θ_2	8.280	0.434
GARCH:		
c_0	1229	0.085***
λ_1	-0.395	0.598
λ_2	0.071	0.324
Observation No.	240	
Log likelihood	-1712.7	
Wald chi2	43.76	0.000*

Table(4) SSE Returns

Variables	Coefficients	P-value
c_3	-1.806	0.470
ΔS&P500	-0.042	0.537
ΔN225	0.008	0.198
ΔOil	0.298	0.875
$\Delta S\&P500_{t-1}$	-0.011	0.886
$\Delta S\&P500_{t-2}$	-0.021	0.749
ΔSSE_{t-1}	-0.020	0.765
ΔSSE_{t-2}	0.038	0.575
$\Delta N225_{t-1}$	-0.004	0.538
$\Delta N225_{t-2}$	0.010	0.133
ΔOIL_{t-1}	1.435	0.374
ΔOIL_{t-2}	-0.558	0.743
θ_3	1.353	0.422
GARCH:		
c_0	95.90	0.517
λ_1	0.859	0.000*
λ_2	0.041	0.355
Observation No.	240	
Log likelihood	-1163.3	
Wald chi2	8.72	0.726

***Significant at 1% confidence level.**
****Significant at 5% confidence level.**
*****Significant at 10% confidence level.**

The findings of the estimations reveal that the US stock markets as measured by S&P500 returns are influenced positively by oil price change and Nikkie225 (N225) returns. On the other hand,Shanghai composite returns (SSE), and oil price volatility have no effect on S&P500 returns. In addition, the S&P500 return also are affected by its own previous day volatility.

Regarding Japan stock market as it measured by the returns of Nikkie225, the results show that, it is positively and significantly related to S&P500 returns, and SSE lagged returns. On the other hand the oil price change and its conditional volatility have no effect on the returns of Nikkei225 returns. Moreoverthe GARCH model result indicates that Nikkei stock returns are neither influenced by their own past volatility, nor their news.

China stock exchange, as indicated byShanghai Composite returns(SSE) in the estimations, appeared as not influenced by any of the independent variables, since the results show that it has insignificant relation with S&P500, N225, oil price change and its volatility. On the other hand, SSE return is affected by its own previous volatility as implied by the significance of its coefficient in the GARCH estimation.

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