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A STUDY ON THE PRICE VOLATILITY OF CRUDE OIL POST DEMONETIZATION PERIOD IN INDIA

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***Abstract**:* Crude oil is impacted by so many different regional and worldwide circumstances, it's crucial to have a firm grasp on how its price fluctuates. Using daily statistics for the post demonetization period in question, this paper attempts to understand the volatility in crude oil prices between November 9, 2016, to December 31, 2021. We have utilized the ADF test to check stationary of the data and volatility by using GARCH model followed by random walk model as well. The outcome of the ADF test confirmed the non-stationarity of the data which means the time series has no unit root. The paper concludes that fluctuations in oil prices are best explained by a random walk model, which does not include large levels of stochasticity or volatility and the same identified by using GARCH model as there is absence of Arch effect.
Keywords: *Crude oil, Price Volatility, Random walk model, Augmented Dickey Fuller Test*

1.Introduction

Since oil is so vital to international trade and industry, changes in its price have taken on more significance in recent years. Oil's price is determined by more than just supply and demand and the general mood of the market, as is the case with most other commodities. Instead, supply and demand and investor sentiment toward oil futures contracts are the primary drivers of price. Speculators engage in a massive volume of trading of these contracts. As a result, it's important to understand crude price volatility since it may threaten oil producers and industrial customers. Prices of commodities tend to be very unpredictable, and few commodities, including gold and crude oil, are on par with one another in terms of the impact they have on the state of the economy and the major economic indicators. Volatility in price influences the “marginal value” “component of the total marginal cost of production” or “the opportunity cost of producing the commodity now” than to anticipate more information on price. This might affect the larger market in terms of oil refinery investments. (Pindyck, 2004). During the course of the last decade the prominent ups and downs in crude oil prices have been witnessed (Herrera et al., 2018). As a consequence of this, academics from all over the world are displaying a strong interest in modelling and predicting the instability of prices of oil as a result of the influence of this factor on both the global and regional economies (Rahman & Serletis, 2012). The term "price volatility" refers to the extent to which prices go up or down over the course of a certain length of time. Prices accurately represent the known current and predicted future conditions of supply and demand, as well as the variables that might alter them, in a market that is efficient. Since “commodity-based contingent claims” is affected by the price fluctuations that is, derivatives whose source is uncertain is influenced by volatility. The behaviour of price is instrumental in determine the valuation of derivatives. Decisions related to investments and “hedging” in the stock market are influenced by the variations in the price. Price volatility alters

the firms' "operational and opportunity cost value", which in turn affects the overall marginal cost of production (Pindyck, 2004).

Uncertainty in oil rates is directly proportional to its volatility. This leads to economic destabilization for nations that both export and import oil. When the crude oil causes inflation there is a multiplicative influence over economies of oil exporters, causing them to decline. In addition, these fluctuating oil rates impart multiplied effects on both the domestic market and the international economy. For instance, a rise in the cost of oil causes means increased rate of the transportation system. This in turn causes an increase in the cost of manufacturing. There is a body of research in this field that suggests that the rates impart a detrimental influence over the expansion of a country's economy (Jimenez-Rodriguez & Sanchez, 2005). The unpredictable nature of oil prices is not well understood since not enough research has been done on the topic. In recent years, especially, there has been more price volatility in oil markets throughout the globe. The pandemic ridden world has experienced significant changes in the economic activity. Relevant research has attempted to forecast crude oil price fluctuations (Kang, Kang, & Yoon, 2009; Zhang & Zhang, 2008), looked into the link between oil rates fluctuations and economic aspects (Karali & Ramirez, 2014), and studied the relationship of oil price and stock prices in terms of fluctuations of both (Tiwari et al., 2021). However, there is a lack of knowledge concerning the causes of the crude oil price's extreme fluctuations. This paper streamlines the stationarity and volatility with reference to crude oil for post demonetization closing price for a time series concerned unit root and "ARCH" impacting the series "q" in the remaining part, and investigation has also made using Random Walk theory for same period. Further in second section we present a literature review of price volatility and crude oil fluctuation. In third section data methodology and fourth section Data analysis and findings are presented attaching conclusion and appendix at the end.

2. Literature Review

Several writers have studied and analyzed the price fluctuations of crude which includes price forecasting as well as the influence of this volatility on India's important economic factors (Ghosh, 2011; Bhattacharya & Ahmed, 2018; Jain, 2013). Ghosh (2011), used GARCH and Exponential GARCH to employ oil price shock, result shows inverse relation leading to depreciation of Indian currency due to increase in oil prices. Jain (2013), identifies the positive relation between inflation and oil price fluctuation in pursuance with NSE as dependent variable using regression model in SPSS. Bhattacharya & Ahmed (2018), for instance, forecasting the price fluctuations of India's oil prices (crude) using a "hybrid ANN-GARCH model". Meher et al. (2020) The findings suggest that the highest performance may be obtained from a "hybrid model consisting of ANN and EGARCH". The author studied the link between the pandemic and swings in the rates of oil (crude) and gas in India. Findings suggest that COVID-19 may dramatically increase crude oil price volatility. In contrast, this leverage effect does not seem to be influencing natural gas price volatility. Rastogi et al. (2021) performed research applying bi-variate GARCH models to estimate the volatility of two types that is, shock and price in gold and crude markets on Indian interest rates. These three factors, prices of gold, interest rates, and crude are all studied in connection to their volatility in this study.

Some academics investigate how "changes in the price of crude oil affect broad economic indices" (Jain, 2013; Salim & Rafiq, 2011). Jan (2013) studied how the stock market (NSE) and inflation rate is related to the rate of oil. In addition, we looked at how different economic factors were connected to the cost of crude oil. The analysis states that inflation and crude rates are positively related to each other. Sreenu & Rao (2021) research were significantly similar to this one as they looked at how changes in macroeconomic parameters affected the futures rates of oil, agriculture, and metals, in terms of understanding the volatility in the Indian commodities futures market. A positive effect of low-frequency components on commodities futures market long-run variance was found in the research. The vast majority of independently sourced evidence likewise corroborated these conclusions. Hosseini et al. (2011) conducted an analysis of the connection that prevails between the indices of the stock market and four types of macroeconomics variables in India and China. The "price of crude oil" (COP), "money in circulation" (M2), "industrial production" (IP), and "inflation rate" (IR) were the variables in question. The authors have used many methodologies, including the "Augmented Dickey-Fuller unit root test", "Multivariate Cointegration", and the "Vector Error Correction Model technique". The authors of another study, which was done by Kumar et al. (2019), looked at the amount of "time-varying volatility and correlations" that exist among the rates of oil, gas, and stocks in India. They utilize a variety of "multivariate GARCH models", some of which contain asymmetry and others of which do not. The data indicate that the "VARMA-DCC-GARCH model" is better as compared to "CCC model with asymmetry" in terms of its power to properly predict time-varying correlations. The literature research revealed long- and short-term relationships between a wide range of macroeconomic variables and equity market indices. However, there has been effort to analyze the crude oil price trends in India but this paper specifically emphasizing on post demonetization prices which becomes the research gap.

3. Methodology

This research derives its data from the MCX's (Multi commodities Exchange) daily returns from future on the closing basis for the WTI (West Texas Intermediate) crude oil. There are a total of 1319 observations included in the data set for crude oil, which covers the time period from November 9, 2016, to December 31, 2021. The period is selected specifically to showcase the post demonetization affect. The objective of the paper is to understand the whether demonetization affected the price volatility of crude oil. The statistical tool used is Eviews beneath ADF model, ARCH model and Random Walk model to illustrate the volatility pattern during the period.

3.1 "Augmented Dickey Fuller Test" (ADF Test)

Because "stationarity of Time series data" is crucial to the success of several analytical tools, statistical tests, and models, checking for it is a must. The stability of a Time series may be evaluated with the use of a statistical test called the "Augmented Dickey Fuller test" (ADF Test) (Schlitzer, 1995). The ADF Test is used in the current study to check for stationarity in the Time series. The following are the hypotheses that were developed for the ADF analysis.

H_0: Closing Price of the time series data contain Unit root

H_1: Closing price of the time series data does not contain Unit root

3.2 Autoregressive conditional heteroscedasticity (ARCH)s Test for Heteroscedasticity

"The autoregressive conditional heteroscedasticity" (ARCH) model is a statistical tool that examines the past and present volatility of time series in order to make predictions about the future volatility of those series (Bollerslev et al., 1994). As a consequence of this, the ARCH, GARCH and TARCH models is be used to investigate the return series of spot prices over a variety of time intervals. An ARCH model is used for the variance of a time series (Bollerslev et al., 1994). In this study used the ARCH model to illustrate variations in volatility at high prices and turbulence at low ones using data from November 9, 2016, to December 31, 2021. The hypothesis formulated for the ARCH test are described below

H_0: There is no existing ARCH effect up to order q in the residuals.

H_1: There is existing ARCH effect up to order q in the residuals.

4. Findings

Given the frequency and magnitude of the macroeconomic shocks that happened over this time span, this data set presents an extremely challenging modelling challenge (Covid 19 pandemic outbreak).

Table 1: **Descriptive Statistics of crude oil prices**

	HIGH	LOW	OPEN	PRICE
Mean	3998.438	3886.077	3944.487	3943.584
Median	3948.000	3842.000	3898.000	3896.000
Maximum	6428.000	6283.000	6352.000	6360.000
Minimum	1064.000	795.0000	960.0000	1.000000
Std. Dev.	904.0867	901.9814	902.0115	908.0821
Skewness	0.115874	-0.011368	0.063018	0.016792
Kurtosis	3.165846	3.394499	3.257319	3.445649

Table 1 provides details about the statistics of chosen 1319 observations representing the Open, High, Low and close price as well. Oil prices shows average log return and standard deviation and when compared, the daily average returns are much higher than normal. The data has a very negligible skewness as 0.016 and kurtosis as 3.44 for a random variable that follows a normal distribution.

Table 2: "**Augmented Dickey Fuller Test" (ADF Test)**

Null Hypothesis: D(PRICE) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-43.97495	0.0001
Test critical values:	1% level	-3.435104	
	5% level	-2.863527	
	10% level	-2.567877	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PRICE,2)
Method: Least Squares
Date: 08/21/22 Time: 20:49
Sample (adjusted): 11/11/2016 12/31/2021
Included observations: 1317 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PRICE(-1))	-1.190854	0.027080	-43.97495	0.0000
C	2.374928	2.870371	0.827394	0.4082

R-squared	0.595235	Mean dependent var	-0.059226
Adjusted R-squared	0.594927	S.D. dependent var	163.6377
S.E. of regression	104.1478	Akaike info criterion	12.13102
Sum squared resid	14263501	Schwarz criterion	12.13889
Log likelihood	-7986.275	Hannan-Quinn criter.	12.13397
F-statistic	1933.796	Durbin-Watson stat	1.989132
Prob(F-statistic)	0.000000		

Table 2 represent the "ADF test" stating the “p-value” in the test is lower than 0.05. Since the data does not exhibit signs of a unit root, “null hypothesis” i.e., closing price of time series data contains the unit root stands rejected and alternate hypothesis accepted thus, the data declared to be stationary. An ARCH model is applied in the study to illustrate variations in volatility in the higher regime of price and volatility in the lower regime of price using data from 2016 to 2021.

Table 3: ARCH test for Heteroskedasticity

F-statistic	0.259971	Prob. F(1,1314)	0.6102
Obs*R-squared	0.260316	Prob. Chi-Square(1)	0.6099

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 08/22/22 Time: 00:02
Sample (adjusted): 11/10/2016 12/29/2021
Included observations: 1316 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.016617	0.129071	7.876406	0.0000
WGT_RESID^2(-1)	-0.014065	0.027584	-0.509874	0.6102

R-squared	0.000198	Mean dependent var	1.002514
Adjusted R-squared	-0.000563	S.D. dependent var	4.572208
S.E. of regression	4.573496	Akaike info criterion	5.879951
Sum squared resid	27484.76	Schwarz criterion	5.887827
Log likelihood	-3867.008	Hannan-Quinn criter.	5.882905
F-statistic	0.259971	Durbin-Watson stat	2.000266
Prob(F-statistic)	0.610225		

Table 3. Showcases the result of the ARCH model under which Chi-square value as 0.6099 must be observed which is higher than p-value as 0.05. The results considered as null

hypothesis stands true i.e., there is no ARCH effect in the time series data and reject alternate hypothesis. Additionally, it states that there is no white noise exist during the post demonetization.

Table.4 Random walk model for studying crude oil price volatility

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.56155	4.459116	3.041310	0.0024
PRICE	-0.003184	0.001102	-2.889958	0.0039

R-squared	0.006302	Mean dependent var	1.003289
Adjusted R-squared	0.005547	S.D. dependent var	36.42819
S.E. of regression	36.32702	Akaike info criterion	10.02452
Sum squared resid	1737982.	Schwarz criterion	10.03238
Log likelihood	-6609.168	Hannan-Quinn criter.	10.02746
F-statistic	8.351857	Durbin-Watson stat	2.024577
Prob(F-statistic)	0.003916		

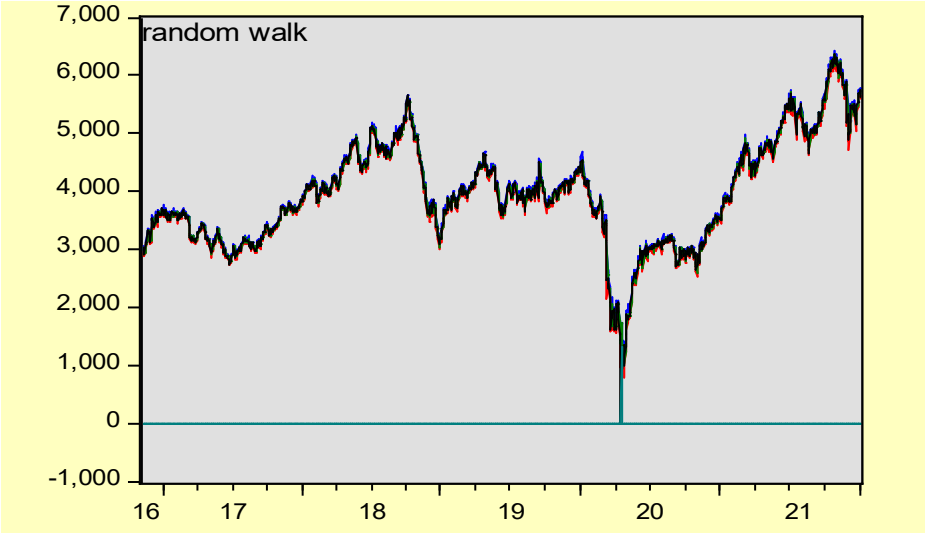

Figure.1 Random walk for crude oil price volatility

Table 4 and figure 1 presents the findings of the random walk model. According to this model, fluctuations in the stock prices follow the same pattern of distribution and may be said to be independent of one another. As a result, when intraday price fluctuations are not continuous, the random walk model is applied. Let us suppose that we are interested in a random walk model with N steps (RW N), where the variance of each step is equal to 1/N. When N is sufficiently enough, the random walk model provides an approximation of the Brownian motion. "The p value" of the Random walk "model is less than 0.05" which indicates that the crude oil prices follow random walk and does not pertain to high volatility and stochastic in nature.

In statistical analysis, Durbin-Watson tests autocorrelation which helps technical analysts understand how previous prices affect a security's future price Results also shows that the Returns are non-stationary by the study of R-Square value smaller than the Durbin Watson statistic of 2.02 evident to be positive autocorrelation.

Conclusion

In the 21st century the global commodity is dominated by the importance of Crude oil as a direct result of the rise in the demand for energy all over the world. Moreover, the rapid changes in geo political dynamics along with the speculation on the shift towards electric mobility and consequent changes in the crude oil demand has observed in recent times. In addition to this, cyclical movements in the commodity market could also play a part in the outcome (Lu, Sun & Duan, 2021). It is possible that the influence of these dynamic developments will impart a prominent effect on the economic situations of both industrialized and developing nations. Study reveals that after the financial crisis, oil market volatility remains unaffected which altered scale-invariant property which negatively impacted the market efficiency (Joo *et al.,* 2020). As a result, the research examines crude oil price volatility patterns and applies random walk theory to explain the tendency. The data on daily returns of WTI crude oil futures were obtained from MCX and were used in the research. The time period covered by the study was from November 9, 2016, through December 31, 2021. The data have been shown to be stationary by the ADF test, and the ARCH test for heteroskedasticity has shown that there is no evidence of an ARCH effect. A study by Yildirim (2017), also propose the crude oil volatility using ARCH and GARCH model for 2015-16 period indicate the appropriate method for volatility measurement in crude oil prices resulted to no arch effect among error terms. Finally, we have used the random walk theory to investigate the patterns of volatility, and the findings have led us to the conclusion that crude prices follow a random walk model. Because of this, we have found that historical price trends cannot be used to predict the rate of crude oil in the future. Author Klepacz (2020), put efforts to recognize the price volatility shocks implies the random walk following the prices substantive that aggregate volatility does not mean ability reduction of future returns. Sreenu (2022) confirmed that oil prices positively volatile to stock market returns in bearish time period using quantile regression model. Also, states that crude oil prices at oil price volatility index (OPVI) does not place strong relationship thus indicating the random walk. Thus, the movement or trend of crude oil prices in the past cannot be used to correctly predict their future movement, as they follow random walk theory but are not subject to return policies.

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