Auto Regressive Distributed Lag Model for Crude Oil (Brent) and Crude Oil (WTI)

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Abstract*: It has been found through various literatures that Crude Oil (Brent) and Crude Oil (WTI) series moves in close proximity. This paper tries to examine the causality relationship between Crude Oil(WTI) and Crude Oil(Brent). In absence of cointegration between the two series Auto Regressive Distributed Lag Model was used.

Keywords: Crude Brent Oil, West Texas Intermediate (WTI) Oil.

I. INTRODUCTION

Crude Oil, commonly known as petroleum, is a liquid found in the inner crust of Earth. It includes organic compounds, hydrocarbons and metals. Due to the different usage of crude oil in industry, they are traded on different bourses based on its grade, delivery and money terms. Crude oil can be classified into two broad categories. Crude Oil (Brent) and Crude Oil (Brent). Crude Oil is the barometer of world's economy. Fluctuation in Crude Oil can give rise to unstable economy in any country. It has been found that price of Brent Crude Oil and WTI Crude Oil are correlated with each other. Shell UK Exploration and Production have policy to name all its fields with bird names. So Brent is a goose bird. It is also acronym of **B**room, **R**annoch, **E**tive, **N**ess and **T**arbert. They are oil fields formed in layer of B-R-E-N-T.

II. LITERATURE REVIEW

The international oil prices are affected by prices of Crude (WTI) and Crude (Brent). The prices of WTI and Brent according to **Chen, Huang et al.** are used an indicator for any business decisions and government policies. **Adelman and Watkins (1997)** and **Smith (2004)** had raised strong objections for considering oil in Reserves of any country. **Kilian (2014)** observed that Brent and Crude started diverging from each other after 2014. An econometric relationship was tried to establish between natural gas price and Crude (WTI) Price by **Jose and Joutz (2006)**. In the recent years it has been observed that correlation between natural gas prices and crude oil price does not exist anymore according to the cointegration test applied by **Ramberg and Parsons (2012)**.

III. RESEARCH METHDOLOGY

3.1. Objective of the study

The primary objective of this study is to investigate the relationship which exists between Crude Brent Oil and Crude West Texas Intermediate.

3.2. Period of the study

To carry out above mentioned study data of Crude Brent Oil and Crude West Texas Intermediate (WTI) oil is collected from 1st February, 2009 to 1st February, 2019.

3.3. Sources of data

For the purpose of the above study data has been collected from Macro Trends Official Website (www.macrotrends.net).

3.4. Hypothesis for the study

The hypothesis considered for this study is:

H_0: There does not exists any relationship between Crude (Brent) and Crude (WTI) Oil Price.

H_1: There exists relationship between Crude (Brent) and Crude (WTI) Oil Price.

3.5. Econometric Models

Granger Causality Test

The basic condition in Granger causality is that both the series should be stationary. By using different lags of X_t and Y_t both we try to establish direction in the Granger causality test which identifies dependent and independent variable.

$$y_t = a_1 + \sum_{i=1}^{n} \beta_i x_{t-i} + \sum_{j=1}^{m} \gamma_j y_{t-j} + e_{1t}$$

$$x_t = a_2 + \sum_{i=1}^{n} \theta_i x_{t-i} + \sum_{j=1}^{m} \delta_j y_{t-j} + e_{2t}$$

where it is assumed that e_{1t} and e_{2t} does not have correlation between them.

Auto Regressive Distributed Lag (ARDL) Model

The ARDL model given below has lags of Y and X

$$Y_t = a + \beta_1 X_t + \beta_1 X_{t-1} + \beta_3 Y_{t-1} + \varepsilon_{yt}$$

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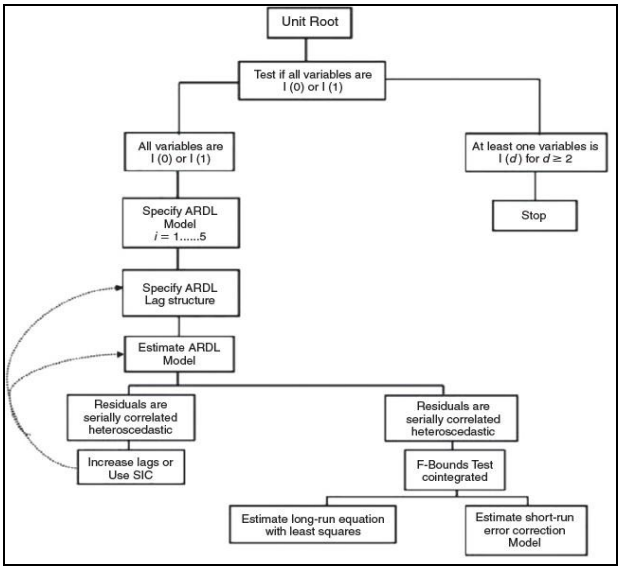

FIGURE 1: STEPS FOR ARDL MODEL

IV. RESULTS AND DISCUSSIONS

In Appendix, Figure 2 it can be seen that Crude (Brent) and Crude (WTI) prices are moving together. Table 1 gives descriptive statistics of Brent Oil and WTI Oil. From Table 1, it can be seen that mean of WTI and Brent is 78.98 and 85.24 respectively. As the minimum and maximum range of both these variable is too dispersing, the mean value is not able to give the actual picture for all variables in Table 1. As range is bigger for both the series, the standard deviation of each variable in Table 1 is too high. Standard deviation of WTI and Brent is 24.264 and 27.601 respectively. All the variables in Table 1 shows positive skewness which means that right tail is longer than left and thus are positively skewed. To measure the extent of peak of data, statistical measure Kurtosis is used. A kurtosis value > 3 means data is leptokurtic which is sharp peaked data and is thus having heavy tail near mean. A kurtosis value < 3 is for platykurtic data which have flat top and for normal distribution kurtosis value will be 3. Looking at the table 1, kurtosis values of WTI and Brent is 2.0715 and 1.652 respectively which means both variables are platykurtic. The p-value for Jarque Bera statistics is 0.1148 and 0.1090 for WTI and Brent Oil series. So we can say that WTI is normally distributed while Brent Oil series is not normally distributed. In Figure 3 and Table 3, it can be seen that there is a high degree of correlation between first difference of Brent Oil series and WTI Oils series. To establish causality between Brent and WTI Oil series we run Granger Causality Test. In Table 4, we fail to reject null hypothesis which means that DWTI (first difference of WTI) does not Granger Cause DBRENT (first difference of Brent) and vice versa. It can be seen that though there is correlation between these two series but as causality is absent we cannot use any Cointegration Models. So we employ Auto Regressive Distributed Lag (ARDL) model. In Table 5, ARDL model which is identified is ARDL(1,1) according to AIC Criterion which will be formally tested.

According to Table 6, the model which is considered for this series is:

$$BRENT = 0.936WTI - 0.937WTI_{(-1)} \quad \ldots\ldots(1)$$

The coefficient of WTI is negative and significant which means that it is correcting the system at the rate of 93.7% which is very good. Moreover by using this equation WTI is able to explain 87.2% variance in BRENT. Equation (1) is tested for Serial Correlation Test, Heterosekdasticity Test and Normality Test. From Table 7, it can be seen that residuals are not serially correlated, residuals are homoscedastic and residuals are normally distributed. It is necessary to run Bound Test for the variable $WTI_{(-1)}$. The null hypothesis is that the coefficient of $WTI_{(-1)}$ is zero or in other words long run association does not exist. As the p-value is 0.0211 which is less than 0.05 so we reject null hypothesis which means that long run association exists between Brent and WTI. From Figure 4, it can be seen that blue line is between two red lines and so above mentioned model is stable. In Figure 5, it can be seen that blue line is between the two red lines so this model is able to forecast BRENT based on WTI. The test considered for good forecasting is Theil's coefficient. Theil's Inequality Coefficient is 0.0544 which is less than 1, it means that model used for forecasting is better than guessing. Root Mean Squared Error is 1.6366 which is also very less so our model is good.

V. CONCLUSIONS

It can be concluded that though Brent Oil and WTI Oil series are highly correlated but there is no cointegration between these two series. In this scenario we cannot use Error Correction Mechanism (ECM) model so we employed Auto Regressive Distributed Lag Model (ARDL). The ARDL model of Brent Oil Series and WTI Oil Series is also good for forecasting. So we can say that there exists a short run as well as long run association between Brent Oil and WTI Oil.

APPENDIX

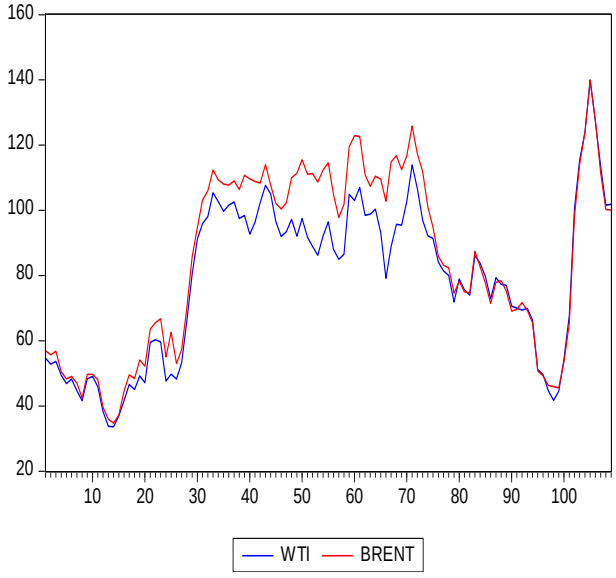

FIGURE 2: TIME SERIES GRAPH OF WTI AND BRENT

	WTI	BRENT
Mean	78.98688	85.24321
Median	84.11000	87.44000
Maximum	140.0000	139.8300
Minimum	33.62000	34.74000
Std. Dev.	24.26418	27.60132
Skewness	-0.150796	-0.208643
Kurtosis	2.071513	1.652532
Jarque-Bera	4.328423	9.036996
Probability	0.114840	0.010905
Sum	8609.570	9291.510
Sum Sq. Dev.	63585.05	82277.93
Observations	109	109

TABLE 1: DESCRIPTIVE STATISTICS OF WTI AND BRENT

Series	Level	P Value	Null	Conclusion
Brent	Base	0.2040	Fail to Reject	Non Stationary
Brent	1st Difference	0.0000	Fail to Reject	Stationary
WTI	Base	0.1479	Fail to Reject	Non Stationary
WTI	1st Difference	0.0000	Fail to Reject	Stationary

TABLE 2: UNIT ROOT TESTING OF WTI AND BRENT

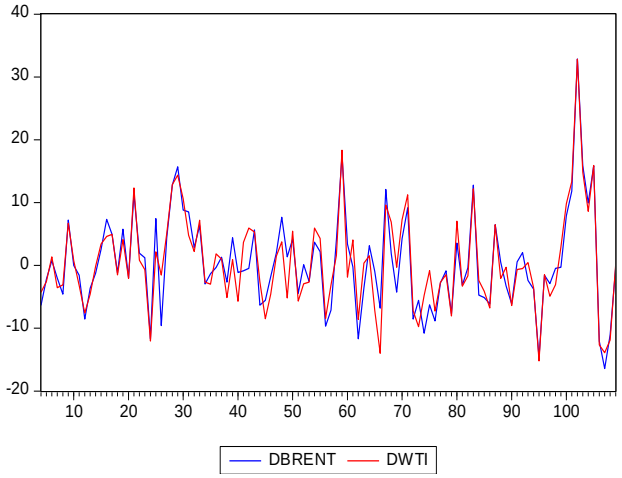

FIGURE 3: TIME SERIES GRAPH OF DWTI AND DBRENT

	WTI	BRENT
WTI	1.000000	0.969341
BRENT	0.969341	1.000000

TABLE 3: CORRELATION BETWEEN BRENT AND WTI

Null Hypothesis	Obs	F-Statistic	Prob.
DWTI does not Granger Cause DBRENT	106	0.22191	0.8014
DBRENT does not Granger Cause DWTI		0.26676	0.7664

TABLE 4: PAIRWISE GRANGER CAUSALITY BETWEEN BRENT AND WTI (Lag=2)

ARDL Model	AIC	SC	Log likelihood	F Wald test	P of Wald test
ARDL(1,1)	6.830303	6.955937	-357.0060	15.29805	0.000000

TABLE 5: ARDL MODEL TEST BETWEEN BRENT AND WTI

Dependent Variable: DBRENT				
Sample: 4 109				
Included observations: 106				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
WTI	0.936960	0.035046	26.73493	0.0000
WTI(-1)	-0.937350	0.035226	-26.60950	0.0000
R-squared	0.872611	Mean dependent var		0.408302
Adjusted R-squared	0.871386	S.D. dependent var		7.582264
S.E. of regression	2.719211	Akaike info criterion		4.857248
Sum squared resid	768.9873	Schwarz criterion		4.907502
Log likelihood	-255.4342	Hannan-Quinn criter.		4.877616
Durbin-Watson stat	1.731700			

TABLE 6: ARDL MODEL BETWEEN BRENT AND WTI

Residual Test	P Value	Null
Breusch Godfrey Serial Correlation LM Test	0.3391	Fail to reject
Heteroskedasticity Test: Breusch Pagan Godfrey	0.1146	Fail to reject
Jarque Bera Normality Test	0.5478	Fail to reject

TABLE 7: RESIDUAL TEST BETWEEN BRENT AND WTI

Null	Bound F Test	P Value	Hypothesis
Coefficient of WTI(-1) =0	5.487	0.0211	Rejected

TABLE 8: BOUND TEST FOR ARDL MODEL

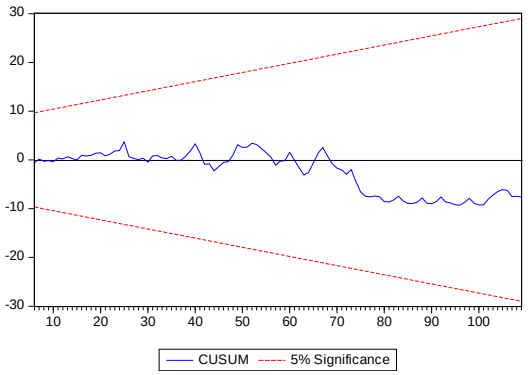

FIGURE 4: STABILITY TEST OF ARDL MODEL BETWEEN BRENT AND WTI

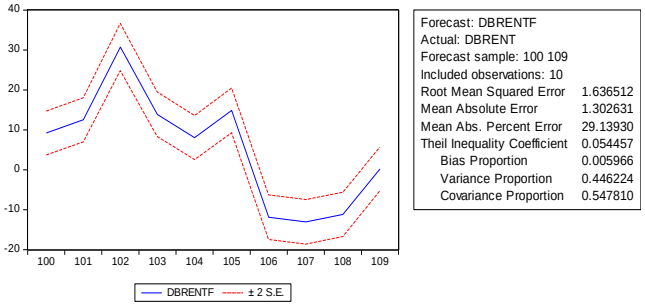

FIGURE 5: FORECASTING USING ARDL MODEL BETWEEN BRENT AND WTI

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