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Determinants of International Crude Oil Price

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Abstract: The objective of study was to identify the factors influencing international crude oil price using annual data for the period of 1970 to 2014. The Augmented Dickey Fuller (ADF) unit root test suggested the stationarity of different data series at different order of integration. Therefore, the results of long-run and short-run dynamics were obtained via Autoregressive Distributed Lag (ARDL) approach and Error Correction Model. The outcomes confirmed the existence of both long-run and short-run relationship among variables. The findings suggested that industrial productivity growth, population growth, oil demand-supply gap and terrorism positively determined crude oil price. While US dollar exchange rate and capacity utilization determined crude oil price negatively.

Jel Classification: Q41 · Q43
Key words: Oil Price · US dollar exchange rate · Population growth · Terrorism.

INTRODUCTION

Crude oil has always experienced uneven and persistent up and down trends over time (Figure 1). In 1970s, United States long recession, stagflation and increased dependence on imports due to industrialization decline in OPEC (Oil producing and Exporting Countries) oil production and constancy in non-OPEC production contributed to inflate crude oil price [1-3]. The dramatic oil price shocks of 1970s extremely damaged the economic environment and business in all realms of world. The crude oil price again rose at the start of 21st century and dropped suddenly at the end of 2008 [4]. In 2011, it again hiked by Libyan civil war [5]. Recently, the crude oil price has faced decline as a result of increased oil supply from the non-OPEC and the Middle East countries [6].

The irregular trends in oil price are deleterious for both oil producing and oil importing nations of world and generate uncertainty in economic and business circumstances [7-8]. Crude oil prices peaks has always stimulated the worst losses in business and global agriculture and food prices [9-10].

Crude oil is one of the precious and highly demanded commodities in the entire world [10]. The oil consumption engages 40% of international energy consumption [4]. The demand of oil is increasing with each coming day as a result of recent economic growth in developing countries especially in china and increased population of world, most noticeably in India [11]. According to Yan 2012 and Energy Information Administration (EIA) 2014 [4-5], China is the second largest oil utilizing and exporting nation and it exhausts one third of overall oil

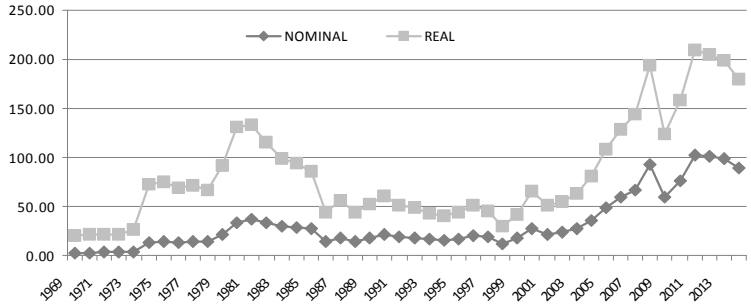

Fig. 1: Historical Crude Oil Price
Source: EIA, Short Term Energy Outlook, 2014

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consumption. The variations in oil demand are also affected by future expectations of oil market growth. The disparity between the oil supply and the oil demand directly hits oil prices and cause huge variations. The oil crisis of 1970s has resulted to link the oil price with the United States dollar for exchange rate. Therefore, the trends of US dollar exchange rate are highly deterministic for oil price [4].

The objective of study is to identify the factors influencing international crude oil price for the period of 1970 to 2014.

MATERIALS AND METHODS

Data Sources: The study was based on annual, secondary data from 1970-2013 obtained from Energy Information Administration (EIA), World Bank, Global Terrorism Database, International Monetary Fund (IMF) and United Nations Population Division.

Model Formulation: The following model was formulated to determine the influencing factors of international crude oil price:

$$P_O = \beta_1 + \beta_1 LEXCHANGE_{rate} + \beta_2 LTERR + \beta_3 LINDUS + \beta_4 LPOP + u$$

where;
P_O = International Real Crude Oil Price (In Thousand Barrels/day)
$EXCHANGE_{rate}$= US Dollar Real Effective Exchange Rate
TERR = World Terrorism (No- of Bomb Blast)
INDUS= World Real Industrial Productivity Growth (In US Dollar)
POP= World Population Growth Rate (In Percent)
DSG= Demand- Supply Gap
CAP=World Crude Oil Capacity Utilization (crude oil distilled capacity/total crude oil production)

Augmented Dickey Fuller (ADF) Unit Root Test: Dickey and Fuller modified the simple Dickey Fuller (DF) test into Augmented Dickey Fuller (ADF) unit root test by introducing extra lag length for the sake of removing autocorrelation. The extra lag length is defined by Akaike Information Criterion and Schwartz Bayesian Criterion.

ADF considers following three probable equations:

$$\Delta V_t = \varphi V_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta V_{t-i} + \varepsilon_t \quad \text{(i)}$$

$$\Delta V_t = \chi_0 + \varphi V_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta V_{t-i} + \varepsilon_t \quad \text{(ii)}$$

$$\Delta V_t = \chi_0 + \varphi V_{t-1} + b_2 t + \sum_{i=1}^{q} \alpha_i \Delta V_{t-i} + \varepsilon_t \quad \text{(iii)}$$

Equation 1 describes the probability of data without trend and intercept. Equation 2 explains the probability of data with intercept only. Equation 3 reports the probability when data possess both trend and intercept. These three equations are differentiated by x_0 and $b_2 t$. While conducting ADF test, two important points should be considered. First identify the adequate lag length for the sake of eliminating serial correlation. Secondly, consider different probabilities of ADF, as described above. The acceptance and rejection of null hypothesis of ADF is determined by McKinnon (1991) table of critical values.

Autoregressive Distributed Lag (ARDL) Approach: ARDL approach is used when all data series are not integrated at same order but are stationary at I(0) or I(1). Pesaran and Pesaran,(1997); Pesaran and Shin, (2001) formulated augmented ARDL equation.

$$\delta(V,l) w_t = \beta_o + \sum_{i=1}^{k} \beta_i (V, m_i) r_{it} + \phi' x_t + e_t \quad \text{(iv)}$$

$$\exists_t = 1, 2, ..., n$$

where;

$$\delta(V,l) = 1 - \gamma_1 V - \gamma_2 V^2 - ..... - \gamma_l V^l \quad \text{(v)}$$

And

$$\beta_i (V, m_i) = \beta_{i0} + \beta_{i1} V + \beta_{i2} V^2 + ... + \beta_{im} V^m$$
$$\exists_t = 1, 2, ..., k \quad \text{(vi)}$$

$$\beta_i (V, m_i) = 1 - \beta_{i1} V - \beta_{i2} V^2 - .... - \beta_{im} V^m \quad \text{(vii)}$$

Equation (iv) describes that w_t, r_{it}, V, x_t are explained variables with intercept terms, a lag operator, time trends, D ×1vector of deterministic variables and exogenous variables with fixed lags. Optimum lags are selected by Akaike Information Criterion (AIC) and Schwarz Bayesian Criteria (SBC). Long run parameters are measured via these criterions and long run elasticity is measured by following equation;

$$\varphi_i = \frac{\hat{\beta}_i\left(1,\hat{m}_i\right)}{\gamma\left(1,\hat{l}\right)} = \frac{\beta_{i0}+\beta_{i1}+\beta_{i2}+....+\beta_{i\hat{m}}}{1-\gamma_1-\gamma_2-.....-\gamma_{\hat{l}}} \quad \exists_t = 1,2,.....,k$$

$$\hat{\pi}_i = \beta_{i0}+\beta_{i1}+\beta_{i2}+....+\beta_{i\hat{m}}$$

$$1-\hat{\pi}_1-\hat{\pi}_2-....-\hat{\pi}_l \qquad i=1,2,.....,k$$

where i = 1,2,....,k are selected values of $\hat{l}$ and $\hat{m}_i$. The long-run relationship can be illustrated as follow;

$$w_t-\hat{\pi}_0-\hat{\pi}_1 r_{1t}-\hat{\pi}_2 r_{2t}-....-\hat{\pi}_k r_{kt}=e_t \quad \exists_t=1,2,.....,n \text{(viii)}$$

The long-run relationship coefficients are presented as;

$$\psi = \frac{\hat{\phi}\left(\hat{l},\hat{m}_1,\hat{m}_2,...\hat{m}_k\right)}{1-\hat{\gamma}_1-\hat{\gamma}_2-.....-\hat{\gamma}_{\hat{l}}} \qquad \text{(ix)}$$

where $\hat{\phi}\left(\hat{l},\hat{m}_1,\hat{m}_2,...\hat{m}_k\right)$ generates OLS outcomes of ϕ for ARDL model in eq. (ix) and by writing this eq. again with respect to lagged levels and 1st difference of $w_t, r_{1t}, r_{2t},.....,r_{kt}$, ECM of ARDL $\hat{l},\hat{m}_1,\hat{m}_2,.....,\hat{m}_k$ can be obtained.

$$\Delta w_t = \Delta\beta_0-\gamma\left(1,\hat{l}\right)EC_{t-1}+\sum_{i=1}^{k}\beta_{i0}\Delta r_u + \phi' x_t-\sum_{j=1}^{\hat{l}-1}\gamma^* j\Delta w_{t-1}-\sum_{i=1}^{k}\sum_{j=1}^{\hat{m}_t-1}\beta_m\Delta r_{t,t-j}+e_t \qquad \text{(x)}$$

Equation of ECM is explained as follow;

$$ECM_t = w_t-\hat{\beta}-\sum\hat{\beta}_t t_u-\phi' x_t \qquad \text{(xi)}$$

ARDL analyzes long-run relationship in two stages. Firstly the long-run relationship is estimated via F-statistics. Pesaran *et al*. (1996) presented critical values with respect to number of explanatory variables and presence/absence of intercept or trend. If F-statistic exceeds the band of these critical values, a co-integration exists among variables. If value of F-statistic places within the band the outcome is indecisive and if F-statistic exists below this band than a partial co-integration is found among variables. Secondly the coefficients of long-run are explored. While speed of convergence towards equilibrium is determined by Error Correction Model (ECM)[1].

RESULTS AND DISCUSSIONS

ADF was used to test the stationarity of data series in order to avoid the probability of spurious regression explained in Table 1. The results of ADF show that all variable were not integrated at same level. The variables of crude oil price, terrorism and industrial productivity growth and population growth are integrated at first order. While all other variable including real effective exchange rate, oil demand-supply gap and utilization capacity were not stationary at first order. Therefore, the ADF results suggested that ARDL bound approach is appropriate to obtain the regression results as ARDL generates better estimates in case of different order of integration of variables.

The results of ARDL bound test in order to check the long-run relationship among variables are given in Table 2. According to Afzal *et al*., [13], there has to be one F-stat of any model that is greater than upper bound to confirm the evidence of long-run co-integration. Therefore, the results of ARDL bound approach expressed that long run relationship existed among variables because F-stat was above upper bound in model 2. However, these are initial results and there is need to explore more evidence to support the evidence of long run dynamics.

Table 1: Results of ADF Unit Root Test

	Intercept		Trend and Intercept	
Variables	Level	1st Diff	Level	1st Diff
LP_O	-1.882	-6.280***	-1.873	-6.2099***
L EXCHANGE $_{rate}$	-2.224	-5.673***	-3.679**	---------
LTERR	-0.148	-5.806***	-1.018398	-5.756814
LINDUS	0.318	-7.543***	-1.772264	-7.565312***
LPOP	-1.593	-4.568***	-2.292867	-4.802923***
LDSG	1.942632	-13.44078***	-7.222***	---------
LCAP	-5.694480	--------	-5.806924***	---------

[1]The methodology is adopted from Waqas and Awan (2012) [12].

Table 2: Results of ARDL Bound Test

VARIABLES	F-Stat	Conclusion
F (LP_O /LEXCHANGE $_{rate}$ LTERR LPOP LINDUS LDSG LCAP)	2.8708**	Inconclusive
F (LEXCHANGE $_{rate}$ /LP_O LTERR LPOP LINDUS LDSG LCAP)	4.96178***	Co-integration
F (LTERR /LP_O LEXCHANGE $_{rate}$ LPOP LINDUS LDSG LCAP)	2.5936**	Inconclusive
F (LPOP /LP_O LEXCHANGE $_{rate}$ LTERR LINDUS LDSG LCAP)	1.4695*	No Co-integration
F (LINDUS /LP_O LEXCHANGE $_{rate}$ LTERR LPOP LDSG LCAP)	0.75403*	No Co-integration
F (LDSG /LP_O LEXCHANGE $_{rate}$ LTERR LPOP LCAP LINDUS)	3.5281**	Inconclusive
F (LCAP /LP_O LEXCHANGE $_{rate}$ LTERR LPOP LDSG LINDUS)	3.2068**	Inconclusive

Note: AIC and SBC defined the lag length. * illustrates that F-statistic is less than lower bound, ** indicates that it stands between lower and upper bounds and *** it exists outside the upper bound.

Table 3: Results of Error Correction Model for Selected ARDL Model

Error Correction Representation for the Selected ARDL Model ARDL(1,0,0,0,1,0,0)selected based on Schwarz Bayesian			
Variables	Coefficient		T-Ratios
ΔLEXCHANGE $_{rate}$	-0.78292**		-2.1769
ΔLTERR	0.37897***		3.0277
ΔLINDUS	0.96797**		2.0174
ΔLPOP	0.35017*		1.7383
ΔLDSG	0.16278**		2.1988
ΔLCAP	-1.0631**		-2.3061
ECM(-1)	-0.20890**		-2.0730
R-Squared	0.60243	R-Bar-Squared	0.51156
S.E. of Regression	0.082678	DW-statistic	2.5336
F-Stat	7.5764 [.000]	Residual Sum of Squares	0.23925

*,**,*** shows the significance at P = 0.10, 0.05 and 0.01% respectively.

Table 4: Results of Long Run Coefficients using ARDL Approach

Estimated Long Run Coefficients using the ARDL Approach ARDL((1,0,0,0,1,0,0)) selected based on Schwarz Bayesian Criterion		
Variables	Coefficient	T-Ratios
LEXCHANGE $_{rate}$	-3.7478	-1.2461
LTERR	1.5656*	1.7920
LINDUS	4.6337**	2.0418
LPOP	1.6763*	1.7732
LDSG	0.77923**	2.1804
LCAP	-5.0891**	-2.2734
C	-47.8565*	-1.7317

*,**,*** shows the significance at P = 0.10, 0.05 and 0.01% respectively.

The outcomes of ECM are given in Table 3. The value of ECM was negative and significant, which confirmed the convergence of model towards equilibrium. In short run, appreciation of real effective exchange rate of US dollar minimizes oil prices. In accordance with Yan, 2012, the transactions and trade of oil is officially made with US dollar, therefore the devaluation of US currency lead to increase oil price and its appreciation results to decrease oil price. The result is consistent with Cheng (2005) [14]. Capacity utilization also determined oil price negatively and significantly. Terrorism, industrial productivity growth, population growth and demand-supply gap significantly and positively determined crude oil price.

Table 4 reveals the results of Long-run estimates of ARDL approach. The results suggested that exchange rate and capacity utilization determined oil price negatively. Terrorism, industrial productivity growth, population growth and oil demand/supply gap positively determined oil price.

The plot of Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ), introduced by Brown *et al*., 1975 to test the stability of model are given in Figure 2 and Figure 3. The figures confirm the structure stability of model as the residuals exists within critical bounds of 5%.

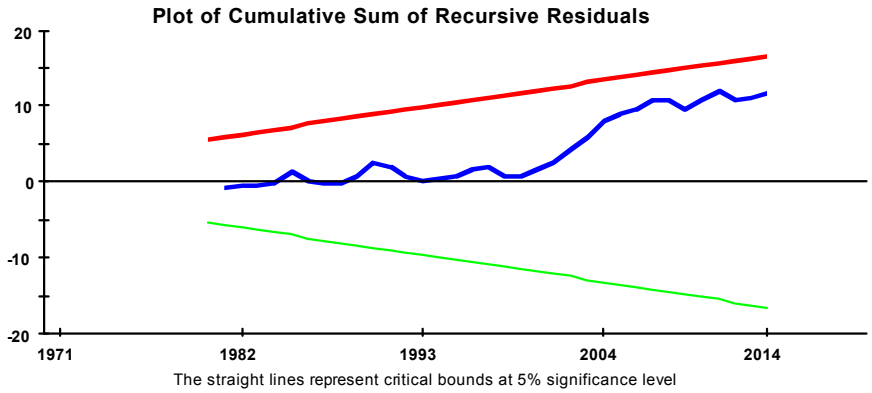

Fig. 2: Plot of Cumulative Sum of Recursive Residuals

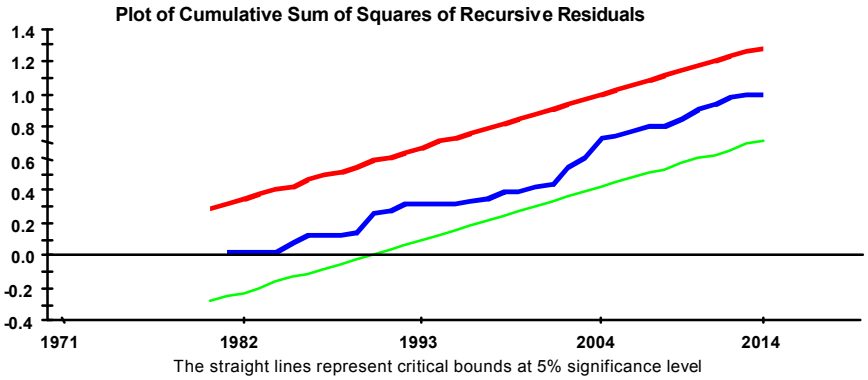

Fig. 3: Plot of Cumulative Sum of Squares of Recursive Residuals

CONCLUSION

The aim of study was to empirically examine the determinants of international crude oil price using annual data from 1970 to 2014. The results of ADF stationarity test suggested that all variable were not stationary at same difference. Therefore, ARDL approach and Error Correction Model was applied to test the long-run and short-run relationship among variables. The findings recommended that there was both long-run and short-run relationship among variables. The outcomes further revealed that US dollar exchange rate and capacity utilization illustrated negatively determined crude oil price. Whereas terrorism, industrial productivity growth, population growth rate and demand-supply gap determined crude oil price negatively.

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