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ASYMMETRIC CO-INTEGRATION ANALYSIS OF EXCHANGE RATES AND CRUDE OIL PRICES: EVIDENCE FROM INDIA

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ABSTRACT

Using monthly data from January, 1980 to July 2013, the aim of the article is to find out whether there is cointegrating relationship between the two macroeconomic variables of Exchange rates and Crude oil prices in India. The result indicates that there exists cointegration between the variables and speed of adjustment shows symmetric based on TAR model, while MTAR model exhibit asymmetric adjustment. The findings indicated that exchange rates have significant influence on Crude oil prices in India but the adjustment to equilibrium when variables deviated is non-linear. The implication is that Indian policy makers should focus more on their exchange rates dynamics in line with the persistent rises of crude oil prices that affects other macroeconomic variables.

Keywords: Crude oil prices; Exchange rates; Asymmetric; Cointegration, Error correction model.

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INTRODUCTION

Crude oil plays significant roles in the global economy considering its importance as one of the main source of energy and accelerates growth to the global economy. The global crude oil prices determine other macro-economic variables in different economies, exchange rate is not exempted. The global economy grew at 3.2% in 2014 and is projected to rises to 3.6% in the subsequent year. The OPEC reference basket ended down 11% for November 2014 which is the fifth straight month of oil price failures, since 2008 global financial meltdown this the longest time of oil prices decline. Theoretically, it is established that there exist negative relationship between crude oil prices and exchange rates, this signify that higher oil prices leads to exchange rates appreciation and vice versa, though it depends on whether a country is net importer or exporter of the product. The level of oil prices in the global market affects the performance of the economies considering its relevance to the global economy. The motivation of the study is that India has oil but the volume is insignificant, it therefore imports crude oil from the global oil market using American dollar as the transaction currency.

AN OVERVIEW OF INDIAN ECONOMY

India is the second largest populated country in the world. It has more than 1.21 billion people based on 2011 population census. Economically the country ranked tenth in the world based on nominal GDP and third largest by purchasing power parity (PPP). India is a member of G-20 major economies and also a member of BRICS economic union and it is among top 20 global players in terms of trade volume as recognized by WTO. In 2014 the GDP growth rate of India is 5.5%, with $1,625 as its GDP per capita. With a consumer base of 1.2 billion people India has the large capacity of long term sustainable growth. The crude oil production in India for 2013-2014 production years was estimated at 37.788 million metric tonnes which surpass the previous year's output 37.862. Considering the high demand of petroleum products in Indian economy the country has to import crude oil in order to meet up with the high rising demands. During 2013-2014 the value of crude oil import was 189.238 metric tonnes which is about Rs.8, 64, 875 as against 184.795 metric tonnes for the previous years valued at Rs.7, 84,652.

Contrary to Engle-Granger symmetric adjustments analysis, various empirical studies exhibit asymmetric adjustments of the variables in the long-run. (See Neftci, 1984; Falk, 1986; Terasvirta and Anderson, 1992; Beaudry and Koop, 1993) for more details about non-linearity of adjustments.

LITERATURE REVIEW

Oil price fluctuations was given much attention by both economists and econometricians during the mid-1970s, this is because of its influence on the business cycle volatilities. This gave an impetus to study, analyse and figure out on how oil price shocks influence other macro-economic variables, and to quantify such shocks on economic growth (see the detailed reviews by Jones and Leiby, 1996; Brown and Yücel, 2002). From the supply side effect point of view, increase in the oil prices will lead to decline in output as it result in the rises of the production inputs (see, among others, Barro, 1984; Brown and Yücel, 1999; Abel and Bernanke, 2001). As a result production cost will shut up this influenced the growth of output and productivity negatively. Increase in the price of oil may result in the rises of money demand, if the monetary authority failed to monitor the mechanism, interest rates will increase which will also impede economic growth (Brown and Yücel, 2002). An increase in oil prices could lead to more inflation, and this would result to price wages twists.

Several empirical studies were conducted about oil price shocks in relation to various macro-economic variables. For example, Mansor and Kanokwan, 2014, examined the relationship between oil price and other price indexes of Thailand using both symmetric and asymmetric co-integration and found that the main influence of oil price dynamics are on the energy price inflation, followed by transportation and communication inflation, and lastly non-raw food and energy price inflation. J. E. Chen et al., 2013 using quarterly data from 1970Q1 to 2011Q4 of crude oil price and exchange rate for Philippine, and concluded that the threshold auto regressive (TAR) model disclose that the two variables are non-stationary in the long run, they are however non-linearly adjusted using momentum autoregressive (MTAR) model. The relationship between oil prices, turkey's currency in relation to $USD exchange rate and agricultural products prices (wheat, maize, cotton, soybeans and sunflower) using monthly data from

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January, 1994 to March, 2010 and applied both Toda Yamamoto causality test and generalized impulse response function analysis. The finding based on impulse response analysis shows that agricultural prices do not respond to oil prices and exchange rates shocks in Turkey, and the long-run causality indicated that changes to oil prices and exchange rates volatility of the Turkey's currency are also not transferred to agricultural commodities prices in Turkey (Nazlioglu and Soytas, 2011).

DATA, METHODOLOGY AND EMPIRICAL RESULTS

The data for the study obtained from two data bases, crude oil prices sourced from Western Texas intermediate (WTI)[1], while exchange rates and Consumer Price Index (CPI) obtained from Data Stream International. Monthly data from January, 1980 to July, 2013 is used for the study. Real oil price is obtained by multiplying the world crude oil price with each country's local currency per US$ dollar at average period and divided by the country's CPI. Real exchange rate is obtained by taking each country's local currency per US$ dollar at average period multiplied with the Consumer price index of the United State and divided by the CPI of each country. Oil prices and exchange rates were both expressed in natural logarithms for normalization purposes.

ECONOMETRIC MODEL SPECIFICATION

$$LER_t = \beta_0 + \beta_1 LOP_t + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

LER refers to log of exchange rates and LOP is the log of oil prices, β_0 is the intercept and β_1 is the slope of the coefficient that explains the nexus between the two variables, and μ_t is the error term that may be serially correlated (Enders and Siklos, 2001). When the variables are stationary which will be shown by either Augmented Dickey–Fuller (ADF) or Phillips–Perron (PP) unit root tests, and then test to see if variables are co-integrated in the long-run by testing the residual as initiated by Engle and Granger (1987) method, as well as the Johansen (1988) and Johensen and Juselius (1990) Vector Auto Regressive (VAR) test.

Table 1: Results of the ADF and PP unit root tests for exchange rates and oil prices

Variables	**ADF (at level)**	**ADF (First Difference)**	**PP (at level)**	**PP (First Difference)**
$\boldsymbol{LER_t}$	-1.979 (0.296)	-5.707 (0.000)*	-2.648 (0.084)	-18.355 (0.000)*
$\boldsymbol{LOP_t}$	-1.335 (0.613)	-6.077 (0.000)*	-1.335 (0.613)	-6.077 (0.000)*

*NB: The ADF and PP test equations include both constant and trend terms. The Schwarz information criterion (SIC) is used to select the optimal lag order in the ADF test equation. The values in brackets are corresponding p-values. * Denote significance level at 1%, ** at 5%, and *** at 10% respectively.*

[1] For data on crude oil prices check: http://research.stlouisfed.org/fred2/series/MCOILWTICO

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The null hypothesis cannot be rejected at level because all the p-values are insignificant at level. However the null hypothesis for both ADF and PP unit root tests was rejected at first difference because the p-values are significant at 5%. This signifies that all variables are non-stationary at levels but stationary at first difference and all integrated at order of 1 or I(1).

Based on Engle-Granger test the residual must be moving together at level (Stationary), the residual estimation is shown below:

$$\Delta\mu_t = \rho\mu_{t-1} \sum_{i=1}^{q} \delta_1 \Delta X_{t-1} + v_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

The long-run estimated equation is presented below;

$$LER_t = 2.21 + 0.86LOP_t + \mu_t$$
$$(0.095)^{**}\ (0.019)^{**}$$
$$R^2 = 0.83,\ \text{D.W} = 0.02 \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

The values in brackets are P-values, to obtain Engle-Granger values however we regress the residual using ADF at level without trend or intercept, the residual after estimation is as follows;

$$\Delta\mu_t = 0.032\mu_{t-1}$$
$$(-2.128)$$
$$R^2 = 0.085, D.W. = 1.974 \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Based on the t-statistics values of (-2.128) we reject null hypothesis at 5% which implies that residuals are stationary at level, means there exist cointegration between exchange rates and oil price for the two economies, since the variables are cointegrated we then move to test for asymmetric cointegration to find out the speed of adjustment for the variables when deviated from the equilibrium. The above mentioned tests assumed symmetry adjustment co-integrating relationship among variables. To test whether non-linear long-run relationship exists we apply the asymmetric cointegration tests initiated by Enders and Granger (1998) and Enders and Siklos (2001). We need to test and see if the relationship between the variables is asymmetric by testing the null hypothesis of no cointegration as proposed by Enders and Siklos[2] (2001), Ho: $\rho_1 = \rho_2 = 0$. If null is rejected, we then use F-equality values in order to determine asymmetric adjustment by testing the null hypothesis of Ho: $\rho_1 = \rho_2$.

Table 2: Estimation of the impacts for exchange rates on Oil prices: Engle –Granger, TAR and M-TAR cointegration

	Engle-Granger (1)	TAR (2)	TAR-consistent (3)	M-TAR (4)	M-TAR-consistent (5)
$\rho_1{}^a$	-2.128** (-1.941)	-0.012 (-1.124)	-0.008 (-0.824)	-0.024 (-2.544)	-0.062 (-4.136)
$\rho_2{}^a$	N/A	-0.016 (-1.649)	-0.0238 (-2.068)	-0.000 (-0.031)	0.000 (0.087)
Φ	N/A	0.833	1.063 [6.927]	2.571	13.101 [8.106]**
$\rho_1 = \rho_2$	N/A	1.9798	2.474 [6.914]	3.236	8.554 [7.910]**
τ		0	-0.465	0	0.041

[2] See Enders & Siklos, 2001:Cointegration and threshold adjustment, on non-linear cointegration adjustment

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N.B: t-statistics and critical values are given in round and squared brackets respectively. Monte Carlo simulation is used to obtain critical value at 5% significance level.

The Engle-Granger test signify the existence of cointegration among the variables as null hypothesis was rejected at 5% critical value, the threshold adjustment for TAR show that the variables are stationary and converge to equilibrium as shown by the negative signs for both coefficients except for M-TAR below threshold which shows positive sign possibly because of the nature of most commodities prices of persistence. The F-statistics and F-joint shows that we cannot reject null for TAR model. Moving to M-TAR model the null hypothesis was rejected at 5% which shows the variables were cointegrated asymmetrically using Enders and Siklos (2001) technique.

CONCLUSION

The present study examined the effects of global crude oil prices on the real exchange rates in India. The result shows an evidence of long-run relations between crude oil prices and exchange rates. While TAR model shows no cointegration, MTAR indicated the existence of cointegration and the speed of adjustment for the variables are asymmetric, means oil prices and real exchange rates are asymmetrically cointegrated in India for the specified period of the study.

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