

Crude Oil Prices and Exchange Rate in India: Evidence from Toda and Yamamoto approach

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Abstract

India is one of the fastest growing economies with a tremendous increase in the import of its oil resources. It imports around 80% of its oil resources which constitutes a third of the total import of the country. The unfavourable movement of oil price creates issues like inflation, economic instability and slumped growth in the economy. The objective of this paper is to analyse the dynamic relationship between oil price fluctuation and rupee dollar exchange rate by using daily time series data from 16th February, 2015 to 1st February 2018. To investigate the causal relationship, the study employed innovative and advanced version of Granger non-causality test proposed by Toda and Yamamoto (1995). The results of Granger non-causality test indicate that there is a unidirectional causality running from oil price to

exchange rate, not vice versa. This result is substantiated by the movement of rupee exchange rate during the period of study.

Keywords: Oil price; exchange rate; causality; Toda and Yamamoto; rupee volatility.

Introduction

Oil, used as a source of energy, plays a significant role in the economic development of the countries, all over the world (Kaygusuz, 2007). The importance of the crude oil is reached at such level that there is no country left in the world which doesn't need oil and its by-product. Most of the countries don't have sufficient crude oil reserve to meet their current demand for oil. Therefore, most of the countries import oil and its by-product from producers and payment is done in USD because of the dominance of USD in the price determination. So, the large fluctuation in oil prices affects the economic growth of both, oil importing and oil exporting nations (Wu and Zhang, 2014). On one hand, a sharp increase in oil prices has a negative effect on economic growth and inflation in oil importing countries. On the other hand, a significant drop in oil prices creates a budget problem for oil exporting nations as they mainly depend on petrodollars (Abosedra and Baghestani, 2004). Furthermore, intrinsic and complex price behaviour of oil also has an impact on macroeconomic variables, i.e. gross domestic product and industrial production (Ali Ahmed, Bashar and Wadud, 2012; Pinno and Serletis, 2013), inflation (Abounoori, Nazarian and Amiri, 2014; Kargi, 2014; Misati, Nyamongo and Mwangi, 2013), monetary policy (Ali Ahmed and Wadud, 2011), reduction of investment (Hamilton, 2003; Rafiq, Salim and Bloch, 2009) and stock prices (Huang, Masulis and Stoll, 1996; Sadorsky, 2003).

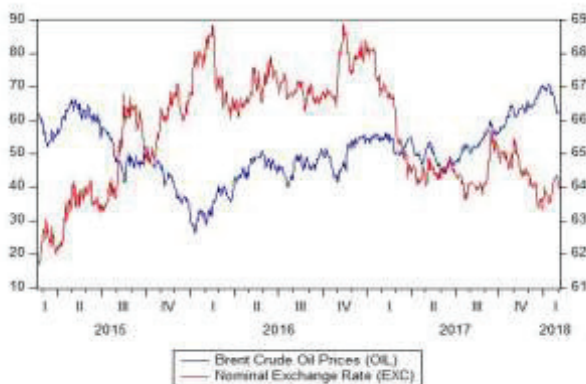
After mid of 2014, international crude oil market experienced a significant drop in the price from 110 \$ per barrel to 46\$ per barrel in early 2015. It was mainly because of the supply shocks, especially Saudi Arabia, Russia and newly discovered shale oil fields in North Dakota and Texas unlocked the vast quantity of their oil reserve and flooded the entire market with their oil supply (Baffés, Kose, Ohnsorge and Stocker, 2015; Husain et al., 2015). In the meantime, the appreciation of USD among other non-dollar dominating currency was also observed. Therefore, researchers had

dubious on the role of recent persistent oil price drop on the appreciation of USD. This has motivated us to investigate the causal interaction and character of their relationship.

Theoretically, it is argued that the oil price hike, transfers wealth from importing countries to exporting countries and widens the current account deficit of the importing economies (Krugman, 1983a). But falling oil prices can create vulnerabilities in exporting countries, but they overcome this issue by adjusting the supply. So, oil price fluctuation has an impact on the exchange rate of both, importing and exporting economies.

The basic idea behind the causal relationship between exchange rate and oil price is because of the denomination and settlement of oil price in USD (Krugman, 1983a). The fluctuations in the demand and supply conditions of the USD and oil price affect each other. If we consider exchange rate and oil price are asset prices, they will be determined by the equilibrium point where demand and supply intercepts. The increase in the demand for crude oil also increases the demand for USD and vice versa. Oil imports represent a significant portion of trade balance of energy-dependent economies (Dawson, 2007). Fluctuations in oil prices have a vital impact on the value of the currency in such economies. This is more crucial for a country like India, which is the third largest crude oil importer in the world (Kennedy, 2015). The fluctuation of the daily rupee exchange rate and the international oil prices are shown in figure no. 1.

Fig. no. 1. Oil Price and Exchange Rate Nexus



Source: Author's calculation using Eviews software, version 8.1

Crude oil prices and the exchange rate are getting more attention in the Indian scenario as the economy is shifting to a more and more liberalised economic framework. Rapid economic transformation and economic growth increased the demand for non-renewable energy sources like crude oil, which has limited domestic production. The massive depreciation of INR during this period enhanced the export earnings, but it was at the cost of increased inflation which might be derived from the record hike in crude oil price. Similarly, the energy subsidy during this period also contributed to a sizeable fiscal deficit. It can be noticed that during this period, the rupee was depreciating rapidly, while the crude oil price was increasing.

More than one-third of India's gross import is constituted by crude oil alone, so fluctuations in the price of crude oil directly influence the Balance of Trade. These fluctuations also broaden the current account which leads to the depletion of foreign exchange reserve. Theoretically, the current account is a major long-term determinant of exchange rate (Mussa, 1984). Any increase in the oil price will result in current account deficit and this will, in turn, reflect on the exchange rate. Petroleum products are used as an input for different industries, due to which oil price hike affects price levels through the cost of products. In case of India, such price hikes were not fully transmitted to the domestic prices because of the regulatory measures of the government. But it affected the exchange rate because USD is the accepted currency in the international oil market. In the present Indian scenario, the ongoing price deregulation of petroleum products shall cause inflation if the Reserve Bank of India (RBI) fails in its inflation targeting policy during a period of unfavourable movement in oil price.

Understanding the causal relationship between oil price and exchange rate is important in case of emerging markets because of their continuing growth and contribution to the global economy. This study argues that the oil price plays a unique role in rupee-dollar exchange rate determination in case of India. Historically, devaluation of the INR has happened solely during periods of Balance of Payments crises or expected payment crises. Import payment, especially related to import oil is considered a crucial lead variable contributing to the crisis situations. It has been observed that historically, all instances of such crises in India were preceded by a hike in crude oil price. The last few

decades have witnessed tremendous fluctuations in crude oil price. Similarly, currency volatility also increased in this period.

It is essential to understand the causal relationship between exchange rate and oil price in a developing country like India, especially since rupee-dollar exchange rate and crude oil prices have recorded extreme fluctuations during a small period of time recently. Inspired by these recent incidents of fluctuations, the present study, with the help of Toda and Yamamoto (1995) approach, seeks to find out how rupee-dollar exchange rate and crude oil price influence each other.

Theoretical and Empirical Review

Theoretical arguments of Golub (1983) and Krugman (1983a, 1983b) about the dynamics of the exchange rate and oil price is quite popular in the literature. Researchers summarised three transmission channels through which oil price fluctuations transmit to exchange rate: wealth effect channel, portfolio reallocation channel and terms of trade channel (Habib, Bützer and Stracca, 2016). The terms of trade channel emphasise oil as a major determinant of the terms of trade (Amano and van Norden, 1998). It assumes that each sector uses both tradable input (oil) and non-tradable input (labour). If the non-tradable sector is more energy intensive than the tradable sector, a hike in oil price increases the output price and appreciates the real exchange rates of exporting countries. As per the theory, oil price hike increases the price of tradable goods than that of non-tradable goods in an oil importing country, and thus cause depreciation of domestic currency. Similarly, any hike in oil price increases the inflation and depreciates the domestic currency.

Theory of international portfolio and wealth channel by Krugman (1983a, 1983b) and Golub (1983), depends on the three country approach. It assumes that the oil price hike causes wealth transfer from an oil importing country to oil exporting nations. The wealth channel reveals the short-run effect because it assumes that oil exporters have an aggressive preference on USD denominated assets than US goods. So, oil price hike will affect only for short-run, not for long-run. But portfolio channel assumes that oil price impact extends to a medium to long-term period because the wealth transfer improves the current account balance of the exporting country. This results an appreciation of domestic currency. But on the contrary, increased current account deficit in the importing country depreciates its currency.

Following these arguments, Blomberg and Harris (1995) explained the impact of exchange rate movement on oil price with the help of the law of one price. It assumes that the homogeneity and international tradability of oil products force the oil buyers to pay more for sufficient quantity of oil products. So, exchange rate has a significant impact on oil price. This argument is supported by different researchers (see Pindyck and Rotemberg 1990; Sadorsky 2000). More specific findings by Zhang et al. (2008) found a strong relationship between the USD and the international oil price for long-run, but it is limited for short-run.

Researchers agree that the behaviour of real oil price had contributed to the non-stationarity performance of exchange rate after the collapse of the Bretton Woods system. The existence of a co-integration relationship of the real exchange rate and real oil price in the post-Bretton Woods regime is one of the causes of the persistent shock and non-stationarity of the exchange rate (Amano and van Norden, 1998; Chaudhuri and Daniel, 1998).

Some of the empirical researchers argued that oil price volatility led to exchange rate volatility, but they found only weak relation during the times of economic turbulence i.e. financial crisis (Reboredo, 2012). But the findings of Reboredo and Rivera-Castro (2013) contradicted these results. They detect strong evidence for the influence of oil price turbulences on exchange rate during the crisis period, but failed to find such relation in the pre-subprime crisis period.

Oil price fluctuation has a different impact on currency when looked at from both short-term and long-term perspectives. For instance, oil price hike appreciates USD in short-run, but it depreciates in long-run (Krugman, 1980). Likewise, oil price shocks for short-term periods may have a long run impact on the exchange rate (Brahmasrene, Huang and Sissoko, 2014). Similarly, Throop (1993) found that real oil price productivity growth and the government budget deficit can affect almost 80% of exchange rate variation in the long term. This finding is important for Indian scenario where oil products have a linear connection with productivity growth and budget deficits.

Researchers found a strong co-integration relationship between exchange rate and real oil price in different economies (Amano and van Norden, 1998; Chaudhuri and Daniel, 1998). However, some argued that it may not be constant for long-term, but can vary across different

time intervals (Basher, Haug and Sadorsky, 2012; Lizardo and Mollick, 2010; Narayan, Narayan and Prasad, 2008).

As per the literature, the currencies of different countries undergo fluctuations during the episode of an oil price hike, based on their dependency on oil resources. For instance, the Fijian Dollar appreciated in relation to the USD (Narayan, Narayan and Prasad, 2008) during such an episode. Supporting this argument, Lizardo and Mollick (2010) argued that increase in real oil price depreciates (or appreciates) the USD relative to the exporting (or importing) countries' currencies. Further, it may help appreciate the currency of those countries, without any international trade on oil products. This substantiated the findings of MacDonald (1998) who argued that during the episodes of the price hike, the currency of countries with sufficient oil resources get appreciated relative to the currency of the country which depends on other economies for its oil needs (MacDonald, 1998).

An inconclusive debate on causality between oil price and exchange rate exists in the literature. For instance, Huang and Tseng (2010) identified the two-way causal relationship between oil price shock and exchange rate in the case of USA. A similar result of bidirectional causality was established by different studies (Ding and Vo, 2012; Tiwari, Dar and Bhanja, 2013). However, Uddin et al. (2013) found only unidirectional causality running from exchange rates to oil price. Some other group of researchers found that oil price fluctuation cause exchange rate volatility (Amano and van Norden, 1998; Bénassy-Quéré, Mignon and Penot, 2007; Brahmasrene et al., 2014; Coudert, Mignon and Penot, 2007). Contrary to that, Pradhan, Arvin, and Ghoshray (2015) found bidirectional causality between exchange rate and oil price in G20 countries.

Most of the developing economies are oil dependent. Researchers like Coleman, Cuestas and Mourelle (2011), found that oil price shocks are the major determinants of the real exchange rate in some African economies. Doğan, Ustaoglu and Demez (2012) found similar trends in the Turkish economy. In case of China, Huang and Guo (2007) argued that the oil price shock appreciates long-term real exchange rate of Renminbi.

Basher, Haug and Sadorsky (2012) found that oil price shock caused exchange rate movements in Emerging Market Economics (EMEs). Similarly, unfavorable movement of oil prices in the EMEs changes the exchange rate for a short-run period, while the positive

shock of oil price reduces the trade-weighted exchange rate. Studies of Turhan, Hacıhasanoglu and Soytas (2013) found that the oil price hike and currency depreciation moves together. They argued that the oil price hike created positive sentiments among the EMEs as they expect faster growth than developed economies. Aziz (2009) found causality from oil price to exchange rate. But the findings of Shaari, Hussain and Abdullah (2012) from Malaysia contradicted this by arguing that the oil price fluctuation influences the exchange rate for long-term only. They also failed to find any causal relationship between these variables. In case of India, only a limited number of studies investigated the issue. For instance, Ghosh (2011) found a direct relationship between oil price shock (increase) and rupee depreciation. He also found that such price movement has a persistent impact on rupee volatility.

Despite the growing corpus of academic literature on the causal relationship between exchange rate and oil price, the situation in the Indian economy has received scant attention. The present study seeks to address this research gap by understanding the dynamics between these two variables at a time when both these variables show extreme fluctuation tendencies. The accelerated growth of oil consumption and the policy of the open economy with a flexible exchange regime also motivated us to find the causal relationship between these variables. The recent policy of market-linked oil pricing also has motivated us to investigate the link between exchange rate and oil price in Indian economy.

Apart from this, review of literature has also revealed the methodological shortcomings of the past studies, especially in the prevalent use of low-frequency data. This trend can be a strategy to overcome the stationarity and structural break issues of the variables when conventional econometric models are employed. To overcome this shortcoming and to explore the dynamics of these variables in an innovative manner, the present study has used high-frequency daily data. However, use of daily data causes stationarity issues. To address this challenge, this study has employed Toda and Yamamoto (1995) version of Granger non-causality test.

Data and Methodology

The present study tries to examine the relationship between the global price of Brent crude oil (proxy for international crude oil prices) and the nominal exchange rate of INR vis-à-vis USD. In order to get a

better insight, we utilize the daily time-series data from February 16th, 2015 to February 1st, 2018. This particular time period is chosen due to the oil price shock of June 2014, when the oil prices rose to 114\$ per barrel in June 2014 and sharply fell down to 46\$ per barrel in January 2015. The economists believe that both long-term and short-term factors contributed to this plunge, including an extraordinary renaissance in the US and Canada shale oil production (Alquist and Guénette, 2014), robust production by Saudi Arabia and other OPEC member nations (Holodny, 2016), investment in renewable energy sector (MacDonald, 2016), weak global demand for oil (Hamilton, 2015) and stronger USD relative to other currencies (Akram, 2009; Zhang et al., 2008). Besides this, the study employs nominal data because of the non-availability of the daily consumer price index. For understanding the daily exchange rate and oil price behaviour, it is not necessary to have knowledge of their real values (Narayan, Narayan and Smyth, 2008). Both the variables were converted into a natural logarithmic form to deal with normality and heteroscedasticity issues. The data and variable definition are shown in table no. 1.

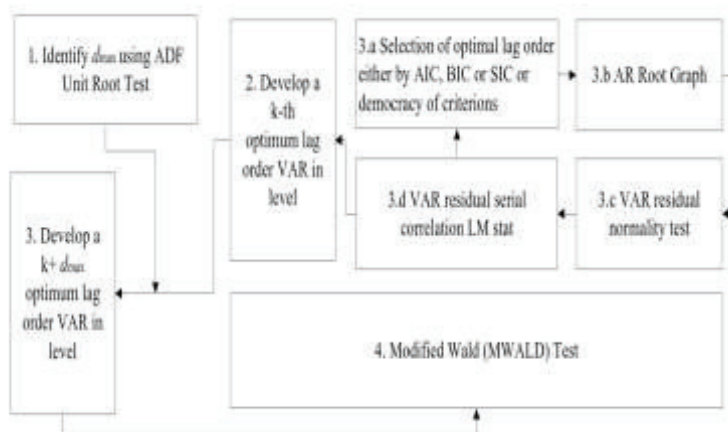
Table no. 1. Data and variable definitions

Variables	Definitions	Source
Lexc	Natural logarithm of Indian rupee to one U.S. dollar, not seasonally adjusted	Board of Governors of the Federal Reserve System (US) https://fred.stlouisfed.org/series/DEXINUS
Loil	Natural logarithm of Brent crude oil spot price in US dollar per barrel, not seasonally adjusted	U.S Energy Information Administration http://www.eia.doe.gov/dnav/pet/TblDefs/pet_pri_spt_tbldef2.asp

In this article, the authors applied innovative and modified version of Granger (1969) causality test as proposed by Toda and Yamamoto (1995). This approach employs a modified Wald test (MWALD) as suggested by Dolado and Lütkepohl (1996), based on augmented VAR modelling, which allows flexibility and asymptotically to chi-square (χ^2) distribution regardless of the order of integration or

co-integration among the variables. Conversely, one cannot conduct the conventional Granger causality test if the order of integration is different.

Fig. no. 2. Framework of Toda and Yamamoto approach (1995)



Source: Shakya (2015)

Usually, two-step procedure is followed in Toda and Yamamoto (1995) approach. The first step includes the maximum order of integration (d_{max}) which one has to decide by checking the stationary characteristics of the series either through Augmented Dickey-Fuller (ADF) and Phillip and Perron (PP), or through Breakpoint unit root test followed by artificial augmented VAR model to assess the levels of the data, in turn to determine the maximum lag length (k) for the variable (p) using the usual information criteria.

Once this is done, a $(k+d_{max})^{th}$ order of VAR is estimated and the coefficient of the last lagged d_{max} vectors are ignored (Pittis, 1999; Rambaldi and Doran, 1996; Zapata and Rambaldi, 1997). Overall, this approach may be more suitable for our analysis and presents more accurate results about the causality for the nominal exchange rate of INR vis-à-vis USD and Brent crude oil prices.

The novelty of the Toda and Yamamoto approach over conventional Granger's (1969) causality test are:

a) First, this framework can be applied regardless of the condition that a time series is at $I(0)$, $I(1)$, or $I(2)$, or is mutually cointegrated or non-cointegrated (Clarke and Mirza, 2006);

b) Secondly, it does not require the pre-testing of cointegration and thus reduces the potential bias for unit root properties (Rambaldi and Doran, 1996);

c) Normality is not a problem as the whole procedure relies on asymptotic properties;

d) Finally, one can incorporate the structural breaks by using dummy variables such as exogenous regressors.

To undertake the Toda and Yamamoto version of the Granger non-causality test, for VAR ($k+d_{max}$), we estimate the following system equations:

$$y_t = a_0 + \sum_{i=1}^{k+d_{max}} \varphi_i y_{t-i} + \mu_t \dots\dots\dots (1)$$

where,

$$y_t = \begin{bmatrix} lexc_t \\ loil_t \end{bmatrix}_{2X1},$$

$$a_0 = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix}_{2X1}, \varphi_i = \begin{bmatrix} \delta_{11,i} & \delta_{12,i} & \delta_{13,i} \\ \delta_{21,i} & \delta_{22,i} & \delta_{23,i} \end{bmatrix}_{2X3},$$

$$y_{t-i} = \begin{bmatrix} lexc_{t-i} \\ loil_{t-i} \end{bmatrix}_{2X1}, u_t = \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix}_{2X1} \dots (2)$$

The coefficient matrix in equation (2) are specified as follows, where φ_i is 2X3 matrix of the regression coefficient, a_0 is the 2X1 matrix of the coefficient term, e_{ts} are the 2X1 white noise error term with zero mean and constant variance. Based on the results of equation (2), we can test the null hypothesis H_{01} . $\delta_{12,1} = \delta_{12,2} = \dots = \delta_{12,k} = 0$, implies that *loil* does not Granger cause *lexc* and we can also test the causality running from *lexc* to *loil* with the following specifications H_{02} . $\delta_{21,1} = \delta_{21,2} = \dots = \delta_{21,k} = 0$.

Econometric Modelling and Discussion

Before any analysis, one should know whether the Data Generating Process (DGP) of the series fits a regression model. Otherwise, non-stationary data may lead to a spurious result (Granger and Newbold, 1974). A time-series is said to be stationary if its mean and variance remains constant over time (Hendry, 1995). The main thrust to apply the unit-root test is to identify whether time-series are

affected by transitory or permanent shocks. Therefore, we first conducted the most commonly used unit-root test in the literature, i.e., the Augmented Dickey-Fuller (ADF) and Phillips and Perron (PP) (Dickey and Fuller, 1979; Phillips and Perron, 1988), to identify the statistical characteristics of the concerned variables on the level as well on first differencing. The results are reported in Table no. 2. The test statistics show that both the variables are not stationary at level. However, after first differencing, both variables become stationary.

It should be noted that both the above tests do not account for structural breaks, as both of them believe that current shocks only have a temporary effect and any long run movement in the series will not be affected by such shocks. But in a real situation, the random shock may have a permanent effect on the macroeconomic variables, henceforth; these fluctuations are not transitory (Nelson and Plosser, 1982). To overcome this problem, the authors substantially carried out the breakpoint unit-root test. Table no. 3 shows that the null hypotheses of a unit-root test for both the variables cannot be rejected on levels. But after transforming the data into the first difference, the null hypothesis can be rejected for both of them. Since January 14th 2016 shows a significant break, we incorporate January 14th, 2016 as a dummy variable in our model.

Admitting the fact that selecting the optimum lag length is an arduous task as sometimes overfitting the lag length unnecessarily increases the mean squared forecast error and underfitting the lag length often creates the autocorrelation problem in the VAR model (Lütkepohl, 1993). Different information criteria such as the Akaike information criteria (AIC), Bayesian information criterion (BIC), Final prediction error (FPE) and Hannan-Quinn information criteria (HQ) statistics are often used for lag order selection.

Table no. 2. Unit Root Tests

Variables	Augmented Dickey-Fuller (ADF)			Phillip and Perron (PP)		
	Intercept	Intercept & Trend	None	Intercept	Intercept & Trend	None
Lexc	- 2.258	- 2.18	0.32	- 2.18	- 2.10	0.34
Δ lexc	- 29.51**	- 29.59**	- 29.53**	- 29.56**	- 29.66**	- 29.57**
Loil	- 1.64	- 2.01	0.02	- 1.68	- 2.03	0.02
Δ loil	- 27.53**	- 27.55**	- 27.54**	- 27.53**	- 27.55**	- 27.54**

Source: Author's calculation using Eviews software, version 8.1

Note: ** and * denotes the values are significant at 1%, and 5% significance level respectively. The optimum lags in ADF test are selected on Schwarz Information Criteria with a maximum lag length of 20, whereas the Parzen kernel with Newey-West Bandwidth is used for PP test.

Table no. 3. Breakpoint Unit Root Test

Variables	At Levels		At First Difference	
	TBs	T-Statistics	TBs	T-Statistics
Lexc	23/2/2017	-3.144 [20]	17/8/2015	-30.098***[20]
Loil	13/6/2017	-2.453 [20]	14/1/2016	-28.332***[20]

Source: Author's calculation using Eviews software, version 8.1

Note: *** and ** denotes the values are significant at 1%, and 5% significance level, respectively. The maximum lag is set at 20. The break type is an innovational outlier and the breakpoint is selected by Dickey-Fuller min-t method, the maximum lag length is set at 20 based on Schwarz Information Criteria.

There is no consensus regarding which information criteria performs better than others as they all depend on the time-frequency and number of observations. For instance, Ivanov and Kilian (2005) reported SIC criteria as most appropriate for quarterly data having less than 120 observations, whereas for larger sample sizes HQ criteria were found most suitable. However, Liew (2004) and Gutierrez, Souza and Guillén (2009) reported that AIC produces better and consistent results

than other information criteria as shown in Table no. 4. Therefore, we choose the lag 8 based on AIC criteria in our augmented VAR model. We then employed VAR residual serial correlation LM test and inverse root of AR characteristic polynomial and found that the VAR is well-specified; there is no autocorrelation problem at the optimal lag at 5% level (reported in Table no. 5), all the inverse roots of the AR characteristic polynomial fall inside the unit circle (reported in Figure no. 3.).

Table no. 4. VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	2148.246	NA	1.35e-05	-5.540686	-5.516647	-5.531437
1	5199.861	6071.690	5.11e-09*	-13.40513	-13.36758*	-13.39716*
2	5203.159	6.545473	5.12e-09	-13.41385	-13.34173	-13.38610
3	5204.715	3.078964	5.16e-09	-13.40753	-13.31138	-13.37054
4	5207.301	5.105572	5.17e-09	-13.40388	-13.28368	-13.35763
5	5208.397	2.157231	5.21e-09	-13.39637	-13.25214	-13.34088
6	5209.238	1.652471	5.26e-09	-13.38821	-13.21994	-13.32347
7	5210.826	3.110357	5.29e-09	-13.38198	-13.18967	-13.30799
8	5216.491	11.06616*	5.27e-09	-13.41566*	-13.16993	-13.30304

Source: Author's calculation using Eviews software, version 8.1

Note: * indicates lag order selected by criteria, LR stands for sequentially modified LR test statistics, FPE stands for final prediction error, AIC stands for Akaike information criteria, SC stands for Schwarz information criteria, HQ stands for Hannan-Quinn information criteria

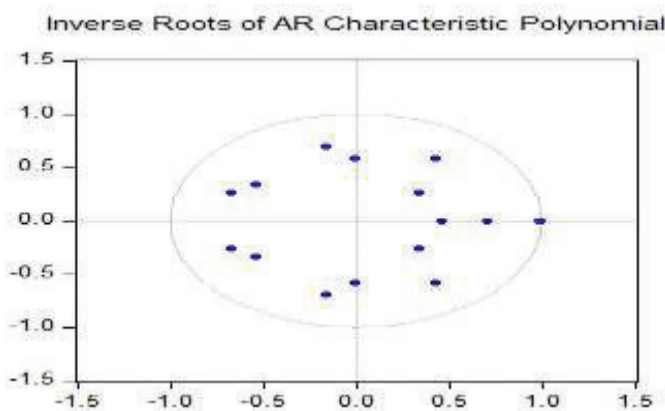
Table no. 5. VAR Residual Serial Correlation LM Test

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	Df	Prob.	Rao F-stat	Df	Prob.
1	5.857266	4	0.2101	1.466192	(4, 1506.0)	0.2101
2	2.307255	4	0.6794	0.576873	(4, 1506.0)	0.6794
3	2.227020	4	0.6941	0.556797	(4, 1506.0)	0.6941
4	7.044958	4	0.1335	1.764191	(4, 1506.0)	0.1335
5	1.948915	4	0.7452	0.487220	(4, 1506.0)	0.7452
6	3.344154	4	0.5020	0.836411	(4, 1506.0)	0.5020
7	6.697804	4	0.2122	4.194877	(4, 1506.0)	0.2122
8	5.305882	4	0.1710	2.080822	(4, 1506.0)	0.1710

Source: Author’s calculation using Eviews software, version 8.1

Fig. no. 3. Inverse Root of AR Characteristic Polynomial



Source: Author’s calculation using Eviews software, version 8.1

Toda and Yamamoto Version of Granger Non-Causality Test

Finally, the Granger non-causality test is performed to assess the causal relationship between concerned variable. We witnessed the

maximum order of integration ($d_{max} = 1$) and maximum lag length ($k=8$). Therefore, ($k+d_{max} = 9$) order of augmented VAR is estimated. Table no. 6 presented the TY procedure results.

Table no. 6. Null Hypothesis of Non-Causality; χ^2 Statistics

Null Hypothesis	Chi-square (χ^2)	Df	Prob.
loil does not Granger cause lexc	22.361	8	.004***
lexc does not Granger cause loil	6.805	8	0.557

Source: Author's calculation using Eviews software, version 8.1

Note: ***,** indicate statistical significance at the 1% and 5% level of significance.

Results reported in Table no. 6 reveals one-way causality running from crude oil prices to the nominal exchange rate (INR/USD) and not vice-versa. Our results are in line with the findings of other researchers (Amano and van Norden, 1998; Bénassy-Quéré et al., 2007; Brahmairene et al., 2014; Coudert et al., 2007).

One of the main reasons for the one-way causality from oil price to exchange rate is because of the monopolistic determination of oil price and its pricing based in USD. So the oil price fluctuation influences the USD appreciation (or depreciation) and its counter impact is reflected on Rupee exchange rate. Even though India is the third largest importer of oil, it can't influence the oil price because the payment is made in USD, not in INR and the price is determined in the international market. Moreover, oil is one of the monopolistic products in the world market, so it is not easy for a country to influence its pricing.

As a high energy intensive developing economy, India can't cut short its oil demand beyond a particular level. So, oil price hike increases the current account deficit of the country. It has a negative impact on the rupee. Similarly, high oil price influences the general price level in the economy, which further depreciates the rupee exchange rate. In short, oil price fluctuation influences the demand for USD than the quantity of oil, so there is one-way causality from oil price to exchange rate (due to its pricing in USD), not vice versa.

Conclusion

This study has analysed the causallinkage between exchange rate and oil price fluctuations during the recent episodes of oil price volatility. The results of the study show that oil price volatility Granger causes the exchange rate volatility of rupee, not vice versa. It shows that fluctuations in the price of crude oil directly influence the Balance of Trade and broaden the current account deficit and deplete the foreign exchange reserve by transferring wealth from India to oil exporting nations. One major reason for this is the determination of the oil price in the USD. India should diversify its oil trading and enhance trading in local currencies. Similarly, adopting more policies in the line of the present ‘oil against food products’ with Middle Eastern countries with the rest of the world can also help to protect the economy from the hazards of a possible currency crisis. There should be a necessary action to diversify its energy sources by utilizing the available modes of renewable energy production, which can provide a multiplier effect on the economy.

An increase in the crude oil price causes depreciation of the rupee and it leads to an increase in the general price level, which further depreciates rupee. In order to reduce the impact of oil price on the general price level, there should be some mechanism to adjust the tax on petroleum products. This will reduce the pass-through effect of oil price fluctuation to the general price level. This can be achieved by generating a special fund for supplying subsidized petroleum products to the key sectors in the economy.

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