Examination of oil import-exchange nexus for India after currency crisis

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Examination of Oil Import-Exchange Nexus for India after Currency Crisis

Abstract

Purpose: This study looks into the nexus between crude oil import and dollar-rupee exchange rates for India, considering monthly data from April, 1992 to March, 2014. Through this study, we intend to assess the economic and ecological sustainability of India, from the perspective of crude oil import behavior and balance of payment condition.

Methodology: Multivariate generalized autoregressive conditional heteroskedasticity (MGARCH) models have been applied for looking into the effect of oil import behavior on the exchange rate.

Findings: The study discloses that the rise in the oil import leads to depreciation of dollar-rupee exchange rate. It also tells that the impacts of positive and negative shocks on exchange rate volatility have asymmetric consequences, and oil import fluctuations have undeviating effect on exchange rate volatility.

Practical/Policy Implications: Import substitution for crude oil should be implemented in India in a phased manner. Providing renewable energy sources to the households at a subsidized rate, and recovering the price differential from the industrial sector in the form of economic rent on crude oil can be a solution to this situation. Implementation of this phased substitution policy will be not only be sustainable, but will also comply with the inclusive growth paradigm of India.

Keywords: exchange rate; oil import; MGARCH; India

1. Introduction

India is one of the major crude oil importing nations across the world, as for catering to the demand of energy in industrial sector, India has to embark on crude oil, and thereby, India's net export of crude oil has mostly been negative over the years. During 1992-2014, crude oil import of India has gone up by 119.60 percent, along with the depreciation of the foreign exchange rate by 52.58 percent for US Dollar. Due to industrial growth and inadequate supply of coal, captive power plants of India are turning towards the energy trade market. However, the traded energy also failed to cater to this augmented demand of energy (Lijesen, 2007), and in order to supplement this demand, crude oil import has increased. This increase in crude oil import has been reflected directly in India's worsening balance of payment (Manne and Rutherford, 1991), which has in turn adversely affected the domestic foreign exchange rates. This most severe form of this phenomenon was observed in India in the year 1991 in the form of balance of payment and exchange rate crisis, just prior to the economic liberalization of India. Taking a cue from this discussion, it is not hard to understand the dynamic association between trade of crude oil and exchange rate movement.

From the standpoint of the economic sustainability of a nation, crude oil importing behavior of a nation plays a significant role. This role has two specific dimensions, namely demand side and supply side (Beveridge et al., 1997). When the crude oil price movements are considered, then essentially we look into the demand side aspect of the scenario. Similarly, when we look into the crude oil import behavior of a nation, then essentially we look into the supply side aspect of the scenario. In order to ensure the sustainability of the economic condition, the balance between these two aspects needs ascertaining (Krichene, 2002). Moreover, insensitivity towards the price movement of crude oil in turn results in ecological imbalances, as the economy will continue sustaining on the imported crude oil, and continuous burning of the same deteriorates the environmental quality. Therefore, ignoring the supply side of the entire scenario will eventually result in environmental degradation in the form of air pollution, thereby, causing harm towards ecological sustainability (Kilian and Murphy, 2014). Moreover, in the wake of Sustainable Development Goals (SDGs) (United Nations, 2015), the supply side aspect will come out to be more prudent, as the SDG 8 (Decent Work and Economic Growth) will have a direct impact on SDG 13 (Climate Action).

Now, the aforementioned two aspects need deliberation, i.e. price of crude oil in international market, and the trade of crude oil. For a nation with low price elasticity of demand for crude oil, the price factor will not come to pass, as the nation will keep on importing crude oil irrespective of its price. Now, if we look at the literature on the association between trade of crude oil and exchange rate, then we can see that the researchers across the world have majorly considered the crude oil price aspects, rather than the importing behavior of nations. Based on works of Sims (1980) and Hamilton (1983) on oil price-macroeconomy nexus, several studies have emerged on various contexts. Out of those works, we are focusing mainly on oil price-exchange rate nexus. Ghosh (2011) has analyzed global crude oil price volatility and exchange rate in the Indian context for 2007-2008 by considering daily data, and found out that the rise in oil price devaluates Indian currency and the exchange rate. The similar phenomenon has also been observed by Harri et al. (2009), while analyzing the effect of crude oil price on exchange rate and crop prices. While looking into the impact of oil price shock on effective exchange rate during the post-Bretton Woods regime, Amano and Van Norden (1998) have found that there lies a causal association between oil price and permanent exchange rate shocks, and it has been found in several contexts, such as LDCs (Cottani et al., 1990), China (Bénassy-Quéré et al., 2007), G-7 countries (Chen and Chen, 2007), Fiji (Narayan et al., 2008), and OPEC countries (Yousefi and Wirjanto, 2004). However, in almost all of the cases, researchers have identified the effect of oil price shock, while considering the changes in exchange rate behavior and the demand side of the story has largely remained undiscovered. In the recent works of Kilian (2009), evidences of the demand side aspects can be seen, as he has tried to disintegrate the effects of demand and supply side in the study. However, the empirical investigation of this aspect has hardly been tried so far, and considering Indian context, no such studies have been encountered. In accordance with this, there lies a gap in the literature in terms of investigating this aspect for India.

Considering the context of a developing nation, the pattern of economic growth is largely dependent on consumption of commercial energy generated from fossil fuel, of which crude oil shares a giant percentage (Bosupeng, 2015; Delang, 2016; Hussien et al., 2016; Ibrahiem, 2016; Ramlall, 2016; Siedenburg, 2015; Sinha, 2014, 2015a, 2015b; Sinha and Bhattacharya, 2014, 2016a, 2016b, 2017; Sinha and Mehta, 2014). Now, in order to determine the exchange rate, only crude oil price may not be a good indicator, as the balance of payment condition of a nation largely depends on the crude oil importing behavior. In the work of Ghosh (2011), the supply side aspect has been considered predominantly in the form of crude oil price, and the crude oil import behavior has totally been overlooked. For a net crude oil-importing nation like India, it is not viable to leave this demand side aspect apart for determining the behavioral pattern of the exchange rate (Salameh, 2003; Marazzi and Sheets, 2007). If the crude oil importing behavior of the nation is elastic to the changes in crude oil price, then price fluctuation may not have significant impact on the exchange rate. On the other hand, inelastic behavior of the nation with regard to importing crude oil possibly can have serious consequences on the exchange rate behavior, which India has already experienced in the form of balance of payment crisis in 1991, and it is by and large known as the currency crisis. The similar kind of situation was experienced in the Latin American nations (Szklo and Tolmasquim, 2001) during 1999-2002, in Mexico (Salameh, 2003) during 1994, and Russia (Rasmussen, 2003) during 1998. Therefore, the supply side aspects predominantly depend on the demand side aspects in the case of a crude oil importing nation. Works by Brock (1984), Manne and Schrattenholzer (1984) have focused on the qualitative political nexus between crude oil import and balance of payment condition of any oil importing nation, and this view was reinforced in the works of MacKillop (1980) in case of developing nations in particular.

As the literature has not focused on this aspect empirically and especially for Indian context, addressing this research gap is the primary objective of our paper. In order to fulfill this research objective, we have adapted the methodology followed by Ghosh (2011), Narayan et al. (2008), and Kutan and Wyzan (2005). The only difference in the methodological adaptation lies in terms of taking oil import as a variable in place of oil price, since we are focusing on the demand side aspect. Expected contribution of this study in the literature of energy policy is in terms of providing empirical evidence of oil import-exchange rate nexus in the context of a developing nation.

2. Methods

For this study, we have collected monthly data from April, 1992 to March, 2014 on real crude oil import and real dollar-rupee exchange rates from Ministry of Petroleum and Natural Gas, Govt. of India (www.petroleum.nic.in) and Reserve Bank of India (www.rbi.org.in). Descriptive summary of the variables is represented in Table 1. Absence of normality in all the variables is indicated by the Skewness, Kurtosis, and Jarque-Bera statistics.

Table 1: Descriptive summary of variables

Statistics	ex_t	oil_t
Maximum	1.074319	1.479225
Minimum	0.932588	0.010467
Standard Deviation	0.020086	0.152958
Skewness	0.565680	0.828635
Kurtosis	6.078242	9.586952
Jarque-Bera	118.3110 (0.00)	507.4793 (0.00)

While estimating the nexus between oil import and exchange rate, a number of empirical strategies can arise. In view of the interdependence of the time series parameters, it leads us towards considering a vector of oil import and exchange rate, whose covariance matrices progress through time. Therefore, we are considering VAR and MGARCH models for empirical estimation.

2.1. Vector autoregressive model

In keeping with the study of Sims (1980), a VAR(n) process can be defined as:

$$y_t = A_1 y_{t-1} + \cdots + A_n y_{t-n} + \varepsilon_t \quad (1)$$

Where, y_t are is a set of N endogenous variables, A_i are the coefficient matrices, and ε_t is a white noise error.

This VAR(n) model specification allows us to generate stationary time-series, with time-invariant covariance matrix structure. Therefore, application of this methodology to estimate the nexus between oil import and exchange rate can be perfectly in line with our research question. Now, we will move towards the MGARCH specifications.

2.2. MGARCH model

In view of p time-series of returns as $\{Y_{it}, i= 1, 2\ldots p\}$, we can describe $\sigma_{ii,t} = var(Y_{it} \mid \Sigma_{t-1})$ and $\sigma_{ij,t} = cov(Y_{i,t}, Y_{j,t} \mid \Sigma_{t-1})$, where Σ_t is conditional variance-covariance matrix for both the time series.

In this study, we employ two parametric formulations for the structure of Σ_t. Those are namely, constant conditional correlation (CCC) MGARCH models and dynamic conditional correlation (DCC) MGARCH models. In the subsequent sections, we will discuss about these two models.

2.2.1. CCC MGARCH model

Following the study of Bollerslev (1990), this GARCH model is scrutinized in view of disintegration of the conditional covariance matrix into conditional standard deviations and correlations. Conditional variance of a Y_{it} process is similar to a univariate GARCH(p,q) model, i.e.

$$h_t = \omega + \sum_{j=1}^{q} A_j Y_{t-j}^2 + \sum_{j=i}^{p} B_j h_{t-j} \quad (2)$$

Where, ω is N x 1 matrix of vectors, A_j and B_j are diagonal N x N matrices, $Y^2_t = Y_t \cdot Y_t$. The conditional covariance matrix in this case, can be written as:

$$H_t = D_t P D_t \quad (3)$$

Where, D_t is the diagonal matrix of the conditional variance, and P is the conditional correlation, which is positive definite with $\rho_{ij} = 1$. The elements of the conditional covariance matrix can be stated as:

$$[H_t]_{ij} = h^{1/2}{}_{it}\, h^{1/2}{}_{jt}\, P,\ i \neq j \quad (4)$$

In this case, H_t has also become positive definite.

2.2.2. DCC MGARCH model

Following the study of Engle (2002), this GARCH model used restricted conditional correlation. The conditional covariance matrix in this case, can be written as:

$$H_t = D_t P_t D_t \quad (5)$$

In this case, the dynamic process can be written as:

$$Y_t = (1 - p - q)\, R + p\, \varepsilon_{t-1}\, \varepsilon'_{t-1} + q\, Y_{t-1} \qquad (6)$$

Where, p, $q > 0$, $p + q < 1$, and R is unconditional correlation matrix. In view of this, the applicable form of conditional correlation matrix is:

$$P_t = (I \cdot Y_t)^{-1/2}\, Y_t\, (1 \cdot Y_t)^{-1/2} \qquad (7)$$

3. Results

3.1. Unit root test results

Empirical analysis starts with checking the nature of stationarity of both the series, which is mandatory for proceeding with the VAR and MGARCH modeling. For this purpose, Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests have been applied. In the first two cases, null hypothesis has been defined as the presence of unit roots in the series, which have been rejected at 5% significance level for both the cases, thereby, indicating stationarity of both the series. In case of KPSS test, null hypothesis has been defined as the absence of unit roots in the series, which has been accepted in both the cases, thereby, indicating the same result as per the previous two tests. The results are recorded in Table 2. The results show that the variables are integrated to order one, i.e. they are I(1) in nature.

Table 2: Unit root test results

	Variables	*ADF*	*PP*	*KPSS*
Level data	ex_t	-0.475239	-2.55638	0.216000
	oil_t	-0.095074	-1.06034	0.382116
Intercept and trend	ex_t	-1.232869	-2.35862	0.739000
	oil_t	-0.907629	-1.95326	0.599623
Level data	Δex_t	-14.20519*	-14.18889*	0.105770
	Δoil_t	-22.19689*	-22.09164*	0.046825
Intercept and trend	Δex_t	-14.17760*	-14.16053*	0.105334
	Δoil_t	-22.16117*	-22.06453*	0.041882

* significance level 5%

3.2. VAR model results

Once the stationarity of the data is ensured and it is observed that they are I(1) in nature, then we have checked for the optimum lag length for an unrestricted VAR model, and with the maximum of eight lags. In Table 3, the results for lag length selection are recorded, and it has been seen that the selection criteria are indicating the optimum lag length as one (n=1).

Table 3: Lag length selection criteria

Lags	*FPE*	*AIC*	*SC*	*HQ*
0	9.86e-06	-5.851757	-5.811266	-5.840617
1	9.44e-06*	-5.894356*	-5.824060*	-5.860938*
2	9.48e-06	-5.890935	-5.752451	-5.835237
3	9.55e-06	-5.883498	-5.689621	-5.805521
4	9.71e-06	-5.866908	-5.617638	-5.766653
5	9.91e-06	-5.846635	-5.541971	-5.724100
6	9.82e-06	-5.855332	-5.495275	-5.710519
7	1.00e-05	-5.836496	-5.421046	-5.669403
8	1.03e-05	-5.810181	-5.339338	-5.620810

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

* indicates lag order selected by the criterion

Now, we can formulate the bivariate VAR(1) model, which can be specified as per the following:

$$\begin{pmatrix} ex_t \\ oil_t \end{pmatrix} = \begin{pmatrix} a_1 \\ a_2 \end{pmatrix} + \begin{pmatrix} b_{1,1} & b_{1,2} \\ b_{2,1} & b_{2,2} \end{pmatrix} \begin{pmatrix} ex_{t-1} \\ oil_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \quad (8)$$

While analyzing the VAR model, it is needed to be considered that there is a visible structural break in the year 2008, after the financial crisis. Therefore, we will estimate the VAR model with a dummy variable, which is zero before September 2008, and 1 after September 2008. Significance of this structural break has been analyzed by the LR statistics.

The estimation results are recorded in Table 4. First, VAR(1) model has been estimated without using the dummy variable, and it can be seen that out of four coefficients, three are significant. The exchange rate is positively influenced by the oil import and its own lag, and the oil import is influenced by its own lag. The plot of CUSUM test based on this estimation in Figure 1 shows that the empirical processes do not stay within their bounds, and it has a peak around the breakpoint. It leads us towards the estimation of VAR(1) model with the dummy variable for structural break. The LR statistics is calculated based on the residuals of both the estimations and it is significant at 10 percent level. It shows that the considered structural break is significant. Therefore, the entire dataset is needed to be segregated into two sub-samples, namely from April, 1992 September 2008, and from September 2008 to March, 2014.

Table 4: VAR(1) estimation results for with and without structural dummy

Parameters		a_1	a_2	$b_{1,1}$	$b_{1,2}$	$b_{2,1}$	$b_{2,2}$
Without Dummy	Coefficients	0.202	0.011	0.977[a]	0.117[c]	0.000	0.996[a]
	Std. error	0.496	0.031	0.037	0.014	0.000	0.007
With Dummy	Coefficients	0.783	0.086[c]	0.965[a]	0.121[c]	0.001	0.980[a]
	Std. error	0.754	0.047	0.024	0.017	0.001	0.010
LR test statistics		5.46[b]	(The structural break is significant)				

a is significant at 1%

b is significant at 5%

c is significant at 10%

Results of the diagnostic tests tabulated in Table 5 show that there is no significant autocorrelation present among the residuals, and it is confirmed by the Ljung-Box-Pierce Portmanteau test Q-Statistics. On the other hand, the autocorrelation in the squared residuals demonstrate the presence of multivariate ARCH effect at 5 percent level of significance. This result indicates the need of MGARCH model estimation.

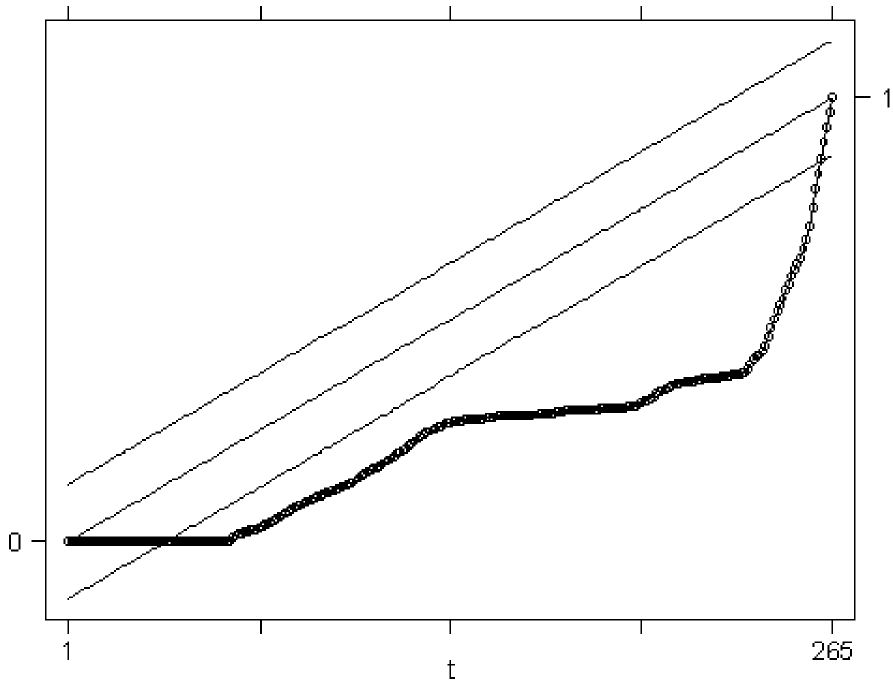

Figure 1: OLS-CUSUM test for the VAR(1) model

Table 5: Diagnostic test results

Parameters	*Values*	*P-value*
Q Statistic (36 lags)	34.491	0.5400
Jarque-Bera	15102.96	0.0000
M ARCH (10 lags)	1.769745	0.0180

3.3. CCC MGARCH model results

In this section, we will estimate the constant-correlation model in which the conditional variances of $Y_t = (Y_{1t}, Y_{2t} \ldots Y_{Kt})$ follow a GARCH process, such that:

$$\sigma_{it}^2 = \omega_i + A_i \, \sigma_{i,t-1}^2 + B_i \, Y_{i,t-1}^2, \; i = 1, 2, \ldots, K \quad (9)$$

$$\sigma_{ijt} = \rho_{ij} \, \sigma_{it} \, \sigma_{jt} \quad (10)$$

Where, ω_i, A_i, $B_i > 0$, $A_i + B_i < 1$, σ_{ijt} is the covariance matrix, and ρ_{ij} is the correlation matrix.

A bivariate CCC(1,1) MGARCH model has been estimated based on the residuals of VAR(1) models of oil_t and ex_t, and the results are recorded in Table 6. The analysis has been carried out by dividing the entire dataset into two subsamples as described in the previous sub-section. For both of the subsamples, all the coefficients are significant. Now, if we compare these coefficients for both the subsamples, then some contradicting scenarios emerge. First, consider the level of the ARCH coefficient. For the first subsample, the response to new information is low for the *oil* equation and high for the *ex* equation, whereas, these responses are high and low respectively for the second subsample. Second, consider the value of $A + B$. Its close proximity to one indicates no integration of the variance processes (Engle and Bollerslev, 1986). For the first subsample, this value is very low for the *oil* equation and near to one for *ex* equation, whereas these values are close to one and very low respectively for the second subsample. Third, the correlation parameters can be considered. For the first subsample, the correlation coefficient is negative and for the second subsample, the correlation coefficient is positive. These results indicate the presence of time-varying correlations between the bivariate time-series, and nature of the correlation seems to change subsequent to the financial crisis.

Table 6: CCC-MGARCH Estimation results

April, 1992 to September 2008		*September 2008 to March, 2014*	
Parameter	*Estimate*	*Parameter*	*Estimate*
GARCH parameters		*GARCH parameters*	
ω_{oil}	0.601^{a} (0.021)	ω_{oil}	0.678^{a} (0.024)
A_{oil}	0.041^{a} (0.011)	A_{oil}	0.808^{a} (0.005)
B_{oil}	0.001^{c} (0.001)	B_{oil}	0.109^{c} (0.004)
ω_{ex}	0.522^{a} (0.197)	ω_{ex}	0.211^{b} (0.061)
A_{ex}	0.742^{a} (0.151)	A_{ex}	0.018^{a} (0.009)
B_{ex}	0.203^{a} (0.064)	B_{ex}	0.441^{c} (0.033)
Correlation parameter		*Correlation parameter*	
$\rho_{oil,\ ex}$	-0.194^{b} (0.008)	$\rho_{oil,\ ex}$	0.827^{a} (0.004)
Log Likelihood	2666.418	*Log Likelihood*	913.373

a is significant at 1%; b is significant at 5%; c is significant at 10%

standard errors are inside the parentheses

It has been indicated in the result that during first subsample, the parameters demonstrate low correlation, and therefore, it is not hard to assume that this association is not stable. Evidence of this statement can be seen in the change of the correlation coefficient during second subsample. These results motivate us to look into the association between oil import and exchange rate from a dynamic correlation perspective. This analysis has been done in the next section.

3.4. DCC MGARCH model results

In this section, we will estimate the dynamic conditional correlation model i.e. DCC(*a*, *b*) and Engle (2002) has defined this model as:

$$h_t = \omega + \sum_{j=1}^{q} A_j Y_{t-j}^2 + \sum_{j=i}^{p} B_j h_{t-j} \quad (11)$$

$$P_t = \left(1 - \sum_{i=1}^{a} A_i - \sum_{j=1}^{b} B_j\right)\bar{P} + \sum_{i=1}^{a} A_i(\varepsilon_{t-i}\varepsilon'_{t-i}) + \sum_{j=1}^{b} B_j P_{t-j} \quad (12)$$

$$C_t = \tilde{P}_t^{-1} P_t \tilde{P}_t^{-1}$$

Where, $\varepsilon_t = D_t^{-1}Y_t$, $\varepsilon_t \sim N(0, C_t)$, $\tilde{P}_t$ is the diagonal matrix of the squared diagonal elements of P_t, and $\bar{P}_t$ is the unconditional covariance matrix. Eq. 12 is the standard DCC(*a*, *b*) model, and it is fitted to the VAR(1) residuals of *oil* and *ex* equations.

Results of the DCC(1,1) MGARCH model are recorded in Table 7. The analysis has been carried out by dividing the entire dataset into two subsamples as done in the previous sub-section. For both the subsamples, all the coefficients are significant. Stability of the coefficients between CCC(1,1) and DCC(1,1) models can be seen through the diagnostic tests. The correlation structure of DCC(1,1) MGARCH model shows that the interactions between the two parameters are non-constant subject to conditional correlation, and it impacts the constant correlation by a single lag. Now, we will apply the test of Engle and Sheppard (2001) to check the dynamic correlation in the DCC(1,1) MGARCH model residuals. Null hypothesis of this test is that the constant and lagged coefficients of the model should be zero. According to the χ^2 test result recorded in Table 7, the conditional correlation among the parameters is dynamic, and the null hypothesis is rejected at 1 percent significance level. This case is visible for both of the subsamples.

Table 7: DCC-MGARCH Estimation results

April, 1992 to September 2008		*September 2008 to March, 2014*	
Parameter	*Estimate*	*Parameter*	*Estimate*
GARCH parameters		*GARCH parameters*	
ω_{oil}	0.601[a] (0.021)	ω_{oil}	0.678[a] (0.024)
A_{oil}	0.041[a] (0.011)	A_{oil}	0.808[a] (0.005)
B_{oil}	0.001[c] (0.001)	B_{oil}	0.109[c] (0.004)
ω_{ex}	0.522[a] (0.197)	ω_{ex}	0.211[b] (0.061)
A_{ex}	0.742[a] (0.151)	A_{ex}	0.018[a] (0.009)
B_{ex}	0.203[a] (0.064)	B_{ex}	0.441[c] (0.033)
Correlation parameter		*Correlation parameter*	
A_i	0.774[a] (0.047)	A_i	0.852[a] (0.248)
B_i	0.199[a] (0.048)	B_i	0.488[a] (0.167)
Log Likelihood	2665.977	*Log Likelihood*	913.152
ES χ^2 value	0.458[a] (0.054)	*ES χ^2 value*	0.686[a] (0.177)

a is significant at 1%; b is significant at 5%; c is significant at 10%
standard errors are inside the parentheses

In Figure 2 and 3, the dynamic correlations between *oil* and *ex* have been graphically demonstrated for both of the subsamples. The biasness of the constant correlations can be seen in both the subsamples (downward in first and upward in second), and the dynamic correlations demonstrate a clearer picture of the actual correlations.

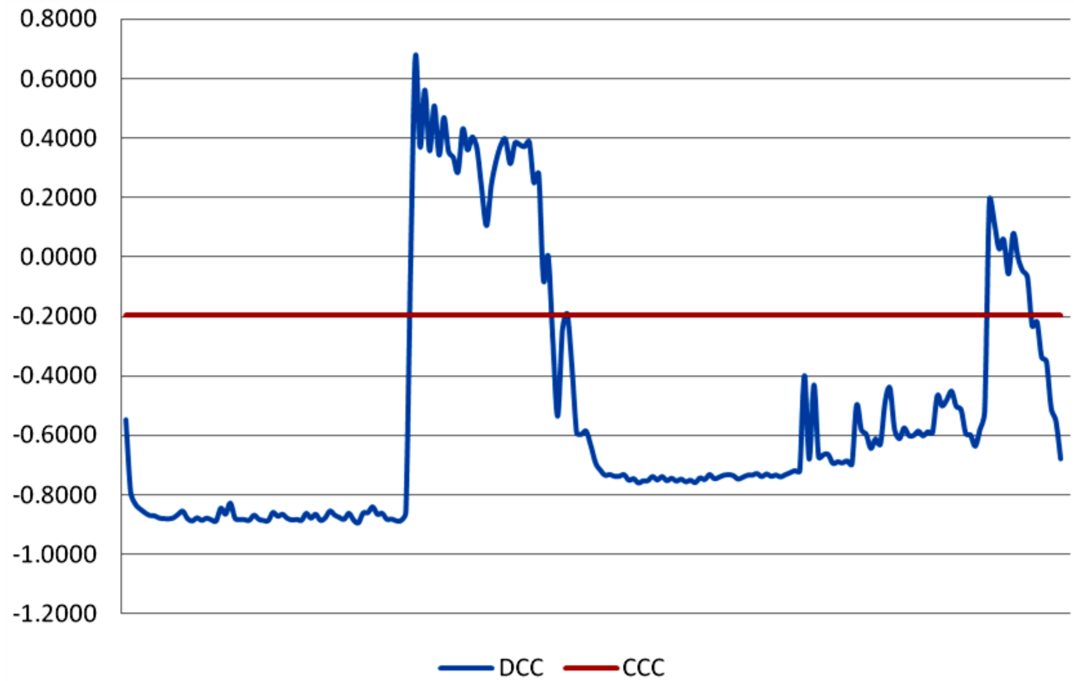

Figure 2: Dynamic correlations between *oil* and *ex* estimated from the DCC(1,1) MGARCH model (first subsample)

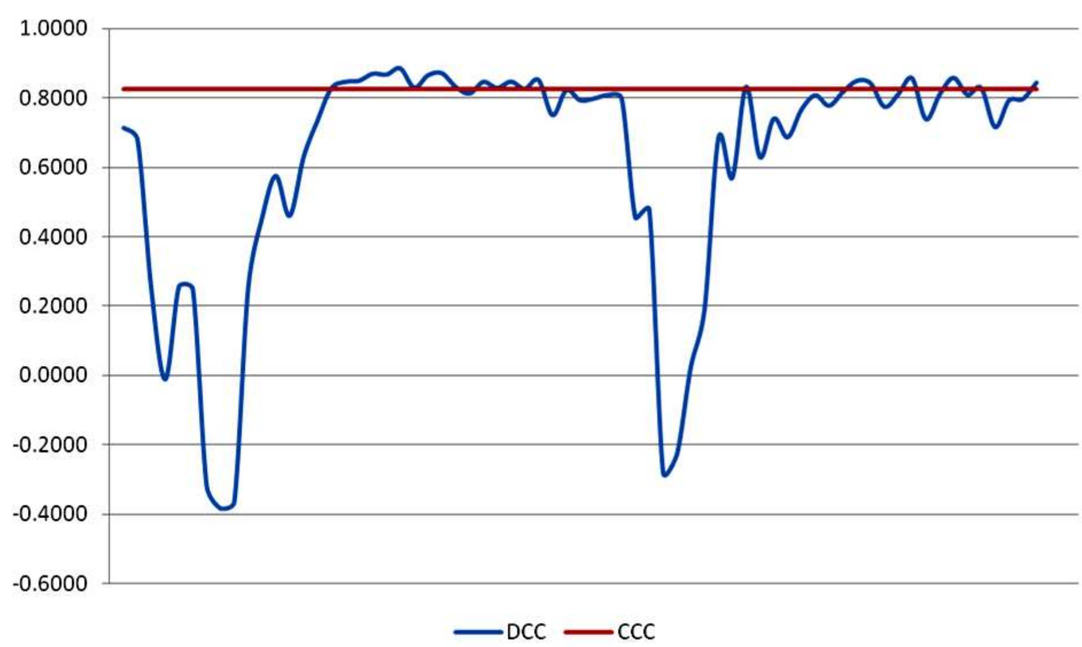

Figure 3: Dynamic correlations between *oil* and *ex* estimated from the DCC(1,1) MGARCH model (second subsample)

The values of correlation in the first subsample are between -0.9 and 0.7, which is a significantly higher range than the value of -0.194 in case of CCC(1,1) MGARCH. For the second subsample, the values of correlation are between -0.4 and 0.9, and value of correlation for CCC(1,1) MGARC, i.e. 0.827 lies almost at the boundary of the bandwidth. These two figures give a comprehensible picture of the dynamic correlation between *oil* and *ex*. Therefore, we can conclude that there is time-varying correlation between oil import and exchange rate.

4. Discussion

By far, this study analyzes the nexus between oil import and dollar-rupee exchange rate for India by means of monthly data for the period of April, 1992 to March, 2014, and it demonstrates a time-varying property of the nexus. In order to analyze it, VAR and MGARCH models have been applied and following are the major findings of the study.

Firstly, there is a major structural break in the dataset, and that is the period of global financial crisis of 2008. Therefore, the analysis is carried out on segregated data set. Moreover, the residuals of the VAR(1) model demonstrate the presence of multivariate ARCH effect. This has led us towards the further analysis of the interaction between oil import and exchange rate following multivariate GARCH models.

Secondly, this study considered two model specifications, namely constant conditional correlation (CCC) and dynamic conditional correlation (DCC) models, and this was done to check the time varying nature of the correlation. CCC model estimations revealed that there can be a strong presence of time varying correlation among the two series, and that led us towards the DCC model estimation. DCC model estimation results indicate that the residuals of VAR(1) model follow a conditional correlation structure. Single lag implementations in both of the series revealed the time varying correlations, which was not possible following univariate GARCH frameworks. The correlations before financial crisis were between -0.9 and 0.7, and were between -0.4 and 0.9 after the financial crisis.

Now, from a theoretical perspective it can be easily understood that the balance of payment condition, followed by the strength of the domestic currency of a nation, cannot be influenced only by global oil price shocks, as both of the aforementioned aspects are also influenced by the crude oil importing behavior of that nation. Following the trail of Chen and Chen (2007), it can be stated that too much dependency on crude oil import can worsen the balance of payment and strength of domestic currency of any nation, and empirical substantiation of this statement in the context of an oil importing nation is the primary focus of this paper. No major reduction in crude oil import has been worsening the balance of payment condition of India since the currency crisis in 1991, and the situation has not changed much even after 22 years. In this kind of a scenario, it is quite obvious that the oil price shocks will have a direct impact on the exchange rate. In order to dig deeper into the situation, it is needed to disintegrate the demand and supply side aspects, so that the impact of crude oil import for the case of a developing and oil importing nation can be understood. This disintegrated analysis is the foundation of our paper, where we intend to look into the nexus between crude oil import and exchange rate for India, subsequent to the currency crisis in 1991.

5. Conclusion and Policy Implications

Taking the indication from Cerra and Saxena (2002), the results obtained from this study can show the impact of oil import on trade account balance, thereby, worsening the exchange rate, and as indirectly indicated by Kumar and Jain (2010), this issue can crop up major balance of payment related concerns in India. With the detection of the Bombay High field in 1973, India was able to handle the crude oil crisis in 1970s, and subsequent to that it has always been tried by the government of India to look for opportunities across the country for exploration of domestic crude oil by means of the five-year plans. However, the domestic crude oil production has never been able to surpass the oil and oil product imports, and as a consequence, most of the export earnings are channelized towards importing crude oil, in order to sustain the industrial growth. Though the gross value of crude oil import fell in 1980s, the reduction was attributed to fall in the global oil price, and not the volume of import. Moreover, subsidies on the petroleum products have worsened the situation by manipulating the demand among retail consumers, and this is reflected on the increasing volume of crude oil imports, which has been reinstated by the results obtained in this study. As Ghosh (2006) identifies the long run sustained derived demand of petroleum products for fueling economic growth, our results complement the results of aforementioned studies. The present economic scenario in India possibly calls for removal of these subsidies, so that the conservative energy policy can be forcefully replaced by renewable energy policy. Moreover, the importing behavior, which is presently being followed by India, can be restricted by import substitution policies or by invention of alternate sources of energy. Presently, renewable energy resources constitute more than 30 percent of India's major energy contribution, and the "*Saffron Revolution*" initiated by newly formed government is actually pushing the economy towards exploration of new renewable energy sources, which can possibly replace the increased import volume of crude oil.

Saying this, we also need to prescribe the policy level solutions to ensure that the economic and ecological sustainability of the nation can be ensured. If we look into the situation from both these perspectives, then policy implications emerge out. Straightway implementation of import substitution policies for crude oil might hamper the industrial growth to a huge extent, and therefore, it should be done in a phased manner. The renewable energy sources should be provided to the households at a subsidized rate, and the price difference can be recovered from the industrial sector in the form of economic rent on crude oil. This will bring forth disincentives for the industries to continue the consumption of crude oil. Implementation of this phased substitution policy will be not only be sustainable, but will also comply with the inclusive growth paradigm of India. Now, this policy will have several consequences: (a) phased implementation of the substitution policy will not only strengthen the economy at the household levels, but also will encourage them to utilize the renewable energy sources for their daily subsistence, (b) the continuous disincentives to the industrial sector for using the crude oil will force them to shift towards the usage of renewable energy resources, and this will ensure ecological sustainability without harming the industrial growth, and (c) gradual import substitution will not only ensure the outflow of foreign currency reserves, but also will ensure the economic growth to be intrinsically fuelled. In this way, the economic and ecological sustainability might be ensured.

Subsequent to the currency crisis in 1991, it can be clearly observed from our result that the behavior of crude oil import has not been reviewed seriously by the policy makers of India until the present government. Taking into account the present economic scenario in India, it can be seen that the current account deficit is gradually mounting up over the last five years, and dollar-rupee exchange rate is facing gradual depreciation. In such an economic condition, it is necessary to review the economic policies regarding import of crude oil, as the amount of net crude oil import is nearing 7 percent of the GDP. The policy prescriptions provided by us might tackle this situation to a great extent. Future study on this aspect can be taken up considering the impact of India’s oil importing behavior on the financial market indices, taking the internationally diversified group of investors into account.

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