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Crisis and Calm: Analysing Oil Price Volatility and Exchange Rate Dynamics in India

Riny Raju[1]Dr. Raju G[2]

Abstract

This study examines the volatility of oil prices and its impact on exchange rate dynamics in India across three distinct periods: the financial crisis period (2008-2009), post financial crisis period (2009-2020), and the COVID-19 pandemic period (2020-2023). Using daily data and employing Multivariate GARCH models, the intricate relationship between oil prices and the USD-INR exchange rate is analysed. The findings reveal significant regime-dependent variations in volatility persistence and asymmetric effects. During the financial crisis and pandemic, oil price shocks notably influenced exchange rate volatility, whereas the post-crisis period exhibited relatively smoother dynamics. These insights highlight the critical need for dynamic policy responses to manage exchange rate stability amid global economic fluctuations.

Keywords*: oil price volatility, exchange rate dynamics, multivariate GARCH models, impulse response function, asymmetric effects.*

JEL Classification: *F31, Q43, C32*

Introduction

The relationship between oil prices and exchange rates is crucial for understanding the dynamics of global economies. It holds particular significance for countries like India, where the reliance on crude oil imports shapes various economic activities. Crude oil, predominantly traded in US Dollars, serves as a key factor influencing currency valuations. Hence, fluctuations in oil prices can trigger substantial movements in exchange rates, thereby impacting a nation's terms of trade. Amano and Van Norden (1998) present a model that captures the relationship between oil prices and exchange rates. Their model theorises two sectors, one dealing with tradable goods and the other with non-tradable goods. Researchers such as Rafiq et al. (2009) have extensively analysed the impact of oil price shocks on various macroeconomic variables, including output, inflation, employment, investment, and exchange rates. Zhang et al. (2008) and Chen and Chen (2007) provide further insights into the long-run and short-run effects of oil prices on exchange rates, emphasizing the relationship between the two variables. In the context of India, Ghosh (2011) empirically examines the relationship between oil prices and exchange rates, highlighting the impact of oil price returns on the depreciation of the Indian currency vis-à-vis the US dollar.

Against this backdrop, this study aims to investigate the volatility of oil prices and its implications for exchange rate dynamics in India across three distinct regimes: the financial crisis period (Regime 1), the post-crisis period (Regime 2), and the COVID-19 pandemic period (Regime 3). By examining these regimes, the study seeks to provide comprehensive insights into the evolving relationship between oil prices and exchange rates, thereby contributing to a deeper understanding of macroeconomic dynamics in India.

1. Literature Review

Tiwari, Dar, and Bhanja (2013), as well as Ahmad et al. (2020), study about the causality between oil prices and exchange rates, employing both linear and nonlinear approaches. While Tiwari et al. find no significant linear or nonlinear causality between the two variables, Ahmad et al. suggest a bidirectional causal relationship, particularly from Brent oil prices to the USDINR exchange rate. They highlight the importance of considering wavelet analysis and volatility spillover effects for a nuanced understanding of this relationship.

Bal and Rath (2015), along with Tiwari and Albulescu (2016), explore the nonlinear causal dynamics between oil prices and exchange rates. Both studies observe bidirectional causal relationships, indicating the influence of lagged

[1] Centre for Development Studies, Thiruvananthapuram, India. Email: rinyraju1@gmail.com
[2] Professor, Economics and Finance, Xavier Institute of Management and Entrepreneurship (XIME), Bangalore, India. Email: drrajug1@gmail.com

information from oil prices on exchange rates and vice versa. They stress the significance of nonlinear Granger causality tests and structural break considerations in capturing the complexities of this relationship.

Ghosh's (2011) study focuses on extreme oil price volatility periods, offering insights into the short-term dynamics between oil prices and exchange rates in India. It underscores the impact of oil price shocks on exchange rate volatility, particularly highlighting the negative effect of oil price increases on the Indian currency. The study also suggests implications for policymakers in managing exchange rate volatility amid fluctuations in international crude oil prices.

Jain and Biswal (2016), as well as Jain and Ghosh (2013), analyze the dynamic linkages among oil prices, exchange rates, and other economic variables in India. Both studies emphasize the importance of understanding long-term relationships and employing advanced econometric techniques like ARDL bounds tests and GARCH models. They provide valuable insights into the interplay between international oil prices, exchange rates, and the Indian stock market, calling for dynamic policy responses to maintain stability in financial markets.

2. Data and Methodology

The daily data for oil prices and exchange rate (US dollar with respect to Indian Rupee) has been collected for a period of 16 years from January 1, 2008, to March 31, 2023, from finance.yahoo.com. The data was tested for structural breaks. However, due to its high volatility, identifying the breaks was very challenging. Therefore, the data was arbitrarily divided into three regimes.

- Regime 1: 2008 January- 2009 June 30 (during financial crisis)
- Regime 2: 2009 July 1- 2020 March 20 (after financial crisis)
- Regime 3: 2020 March 21- 2023 December 31(during COVID-19).

The data has been analysed using Multivariate GARCH models and Impulse Response Functions.

MV-GARCH, BEKK – Model

$$\begin{bmatrix} r_{1t} \\ r_{2t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

$$H_t = CC' + A\varepsilon_{t-1}\varepsilon'_{t-1}A' + BH_{t-1}H'_{t-1}B'$$

MV-GARCH, BEKK - With Asymmetric TGARCH

$$\begin{bmatrix} r_{1t} \\ r_{2t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

$$H_t = CC' + A\varepsilon_{t-1}\varepsilon'_{t-1}A' + BH_{t-1}H'_{t-1}B' + DU_{t-1}U'_{t-1}D'$$

MV-GARCH, VAR (1) - BEKK

$$\begin{bmatrix} r_{1t} \\ r_{2t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \gamma \begin{bmatrix} r_{1t-1} \\ r_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

$$H_t = CC' + A\varepsilon_{t-1}\varepsilon'_{t-1}A' + BH_{t-1}H'_{t-1}B'$$

MV-GARCH, VAR (1) Asymmetric BEKK

$$\begin{bmatrix} r_{1t} \\ r_{2t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \gamma \begin{bmatrix} r_{1t-1} \\ r_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

$$H_t = CC' + A\varepsilon_{t-1}\varepsilon'_{t-1}A' + BH_{t-1}H'_{t-1}B' + DU_{t-1}U'_{t-1}D'$$

MV-GARCH, VAR (1) -BEKK MGARCH -in Mean

$$\begin{bmatrix} r_{1t} \\ r_{2t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \gamma \begin{bmatrix} r_{1t-1} \\ r_{2t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} r_{1t-1} \\ r_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

$$H_t = CC' + A\varepsilon_{t-1}\varepsilon'_{t-1}A' + BH_{t-1}H'_{t-1}B'$$

MV-GARCH, VAR (1) -BEKK Threshold MGARCH -in Mean

$$\begin{bmatrix} r_{1t} \\ r_{2t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \gamma \begin{bmatrix} r_{1t-1} \\ r_{2t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} r_{1t-1} \\ r_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

$$H_t = CC' + A\varepsilon_{t-1}\varepsilon'_{t-1}A' + BH_{t-1}H'_{t-1}B' + DU_{t-1}U'_{t-1}D'$$

3. Empirical Results

3.1. Preliminary Analysis

Table 1 shows the descriptive statistics of returns for oil price and returns on USD-INR exchange rate. From Table 1, it can be seen that oil price returns have a higher (2.908716) standard deviation than USD-INR returns (0.522475), indicating that oil price is much more volatile than USD-INR exchange rate. The Jarque-Bera test rejects the normality hypothesis significantly for both oil price returns and exchange rate returns.

Table 1
Descriptive statistics

	Oil Returns	USD-INR Returns
Mean	-0.008070	0.018053
Median	0.094029	0.000000
Maximum	31.96337	6.097235
Minimum	-60.16758	-6.097235
Std. Dev.	2.908716	0.522475
Skewness	-2.052549	0.066362
Kurtosis	62.29129	21.75837
Jarque-Bera	601081.2	59880.65
Probability	0.000000	0.000000
ADF Test	-31.36496	-75.487558
Probability	0.0000	0.0001

(Source: data collected from finance.yahoo.com)

3.2. Measuring Dynamic Correlations and Volatilities Between the Returns

The MV-GARCH, BEKK – Model captures the impact of past shock on present variance (given by the A terms) and the impact of past volatility on present volatility (given by the B terms). The MV-GARCH, BEKK - With Asymmetric TGARCH model introduces asymmetry into the BEKK framework by incorporating a Threshold GARCH (TGARCH) component. The asymmetry term, D, captures different impacts of positive and negative shocks on volatility.

Table 2
MV-GARCH, BEKK – Model

	Variable	**Regime 1**	**Regime 2**	**Regime 3**
1.	Mean (OILPR)	0.174031573	-0.001478818	0.188043401***
2.	Mean (EXR)	0.040152676	0.009874429	0.013811234
3.	C (1,1)	-0.114282145	0.214462024***	0.531740038***
4.	C (2,1)	0.071202638	-0.005104771	-0.047854960
5.	C (2,2)	0.083672671	0.058232736***	0.104075644***
6.	A (1,1)	0.195289397***	0.253743568***	0.399958600***
7.	A (1,2)	0.040960652***	0.000431565	-0.017272675***
8.	A (2,1)	-1.039137207***	0.000708257	0.133755841
9.	A (2,2)	0.330710771***	0.280184644***	0.213853662***
10.	B (1,1)	0.966867113***	0.964337534***	0.905691251***
11.	B (1,2)	-0.010072723***	0.000057795	0.005749378**
12.	B (2,1)	0.308699612***	0.000758243	0.230389508
13.	B (2,2)	0.914538648***	0.955460383***	0.903016651***

*(*** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level) (Source: data collected from finance.yahoo.com)*

Table 2 shows the results from the MV-GARCH, BEKK – Model for the three regimes. Regime 1 shows significant mean returns for oil prices and high persistence in volatility for both oil prices and the exchange rate, with strong cross-term effects in volatility equations. Regime 2 is characterised by significant intercept terms in the variance equations and high persistence in volatility for both variables, with relatively smoother dynamics compared to Regime 1. Regime 3 displays significant mean returns for oil prices, significant intercepts, and high persistence in volatility, but with more pronounced initial movements in the cross-term effects compared to the other regimes.

Table 3
MV-GARCH, BEKK - With Asymmetric TGARCH

	Variable	Regime 1	Regime 2	Regime 3
1.	Mean (OILPR)	0.127913548	-0.037247474	0.102932773
2.	Mean (EXR)	0.037907057	0.008110778	0.007694719
3.	C (1,1)	0.258710378	0.179260582***	-0.089772356
4.	C (2,1)	0.014035224	-0.004863319	-0.140665957***
5.	C (2,2)	0.113266767**	0.057209637***	0.000025303
6.	A (1,1)	0.115685891*	0.090079266***	0.269833069***
7.	A (1,2)	0.047229196***	-0.006361847*	-0.019759383***
8.	A (2,1)	-1.120860706***	-0.010235683	0.623181385**
9.	A (2,2)	0.404761539***	0.308417751***	0.213053796***
10.	B (1,1)	0.950845058***	0.970886604***	0.672924018***
11.	B (1,2)	-0.010078805**	-0.000756279	0.077499788***
12.	B (2,1)	0.305855363**	0.003243542	4.974658438***
13.	B (2,2)	0.884513881***	0.945923057***	-0.600280900***
14.	D (1,1)	-0.254604492***	0.297734082***	0.199467270***
15.	D (1,2)	-0.020631612	0.010152727**	0.037481746***
16.	D (2,1)	-0.848888166	-0.018268180	-0.297234287
17.	D (2,2)	0.100941929	-0.038255969	0.156058771**

*(*** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level) (Source: data collected from finance.yahoo.com)*

Table 3 shows that in Regime 1, there is high persistence in oil price volatility with significant asymmetric effects and significant negative cross-term effects from oil price shocks to exchange rate volatility. In Regime 2, there is high persistence in volatility for both oil prices and exchange rates and positive significant asymmetric effects in oil price volatility from exchange rate shocks. In Regime 3, there is high sensitivity and persistence in oil price volatility with unusual negative persistence in exchange rate volatility and significant positive asymmetric effects in both oil price and exchange rate volatility.

3.3. Measuring the Dynamic Covariance and Linear Interdependencies Between the Series

The VAR (1) - BEKK model combines a vector autoregressive (VAR) model with the BEKK framework. The VAR component captures the linear interdependencies. MV-GARCH, VAR (1) Asymmetric BEKK captures the differing impacts of positive and negative shocks on volatility.

Table 4
MV-GARCH, VAR (1) - BEKK

	Variable	Regime 1	Regime 2	Regime 3
Mean Model (OILPR)				
1.	OILPR {1}	-0.075380390	-0.025180446	0.033767556
2.	EXR {1}	-0.080153269	-0.066068978	0.264285025

3.	Constant	0.193633756	-0.000600577	0.166097782**
Mean Model (EXR)				
4.	OILPR {1}	-0.002275725	-0.027615952***	-0.012693897***
5.	EXR {1}	-0.083274738	-0.099695739***	-0.103638644***
6.	Constant	0.042138096	0.010289888	0.019215578*
7.	C (1,1)	-0.023092639	0.212507594***	0.521523245***
8.	C (2,1)	0.110621603***	-0.006788622	-0.115844295**
9.	C (2,2)	0.016787728	0.058141899***	0.081818378
10.	A (1,1)	0.205570865***	0.252009612***	0.378810741***
11.	A (1,2)	0.042679375***	-0.001450932	-0.013881649***
12.	A (2,1)	-1.005193179***	-0.005242617	0.218727356
13.	A (2,2)	0.335228676***	0.286355597***	0.250306296***
14.	B (1,1)	0.966187588***	0.964866773***	0.908916261***
15.	B (1,2)	-0.010907672***	0.000544937	0.003092631
16.	B (2,1)	0.288227834***	0.002633356	0.720086919**
17.	B (2,2)	0.910083178***	0.953601065***	0.859618532***

*(*** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level) (Source: data collected from finance.yahoo.com)*

Table 4 indicates that in Regime 1, mean models are insignificant for both OILPR and EXR. In Regime 2, mean models are insignificant for OILPR, while significant for EXR. In Regime 3, mean models are significant for both OILPR and EXR.

Table 5

MV-GARCH, VAR (1) Asymmetric BEKK

	Variable	Regime 1	Regime 2	Regime 3
Mean Model (OILPR)				
1.	OILPR {1}	-0.080436890	-0.025982782	0.020585192
2.	EXR {1}	0.062630172	-0.061848334	0.311024638
3.	Constant	0.213898940	-0.001716151	0.191072305***
Mean Model (EXR)				
4.	OILPR {1}	-0.008282966	-0.027418267***	-0.011962979***
5.	EXR {1}	-0.118630471**	-0.095046806***	-0.123907739***
6.	Constant	0.041942323	0.001286796	0.003772287
7.	C (1,1)	0.271589803	0.138891526***	0.500007639***
8.	C (2,1)	-0.031356058	-0.004971541	0.031685166
9.	C (2,2)	0.109729587**	0.057153015***	0.090287822***
10.	A (1,1)	0.151018881**	0.085763691***	0.153580599***
11.	A (1,2)	0.027355709**	0.004177894	0.004467567
12.	A (2,1)	-0.935744217**	-0.030744986	1.145598703***
13.	A (2,2)	0.331873285***	0.298650773***	0.232925520***
14.	B (1,1)	0.965035723***	0.976226903***	0.916944370***
15.	B (1,2)	-0.009232564***	-0.000893752	0.005941506***
16.	B (2,1)	0.338432819**	0.007684617	-0.663576791
17.	B (2,2)	0.908507661***	0.948772829***	0.908949447***
18.	D (1,1)	0.204546883*	0.267081527***	0.356793835***

19.	D (1,2)	0.030074249*	0.003706039	-0.015993184***
20.	D (2,1)	0.594716700	0.013011586	0.582379186
21.	D (2,2)	-0.083049034	-0.012043820	-0.137178835*

*(*** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level) (Source: data collected from finance.yahoo.com)*

Table 5 shows that in Regime 1, lagged oil prices have a positive mean effect, while lagged exchange rates have no significant mean effect, parameters measuring volatility dynamics are significant and no significant asymmetric effects are observed. In Regime 2, neither lagged oil prices nor exchange rates have significant mean effects, parameters measuring volatility dynamics are significant and no significant asymmetric effects are observed. In Regime 3, lagged oil prices have a positive mean effect, while lagged exchange rates have a negative mean effect, parameters measuring volatility dynamics are significant and there are significant asymmetric effects suggesting asymmetric volatility dynamics.

3.4. Measuring the influence of conditional variances on the mean returns

MV-GARCH, VAR (1) -BEKK MGARCH -in Mean model incorporates the MGARCH-in-Mean component, where the conditional variances directly influence the mean returns. It models the risk-return trade-off. The MV-GARCH, VAR (1) -BEKK Threshold MGARCH -in Mean model capture the impact of asymmetry also, along with the impact of past returns, and the risk-return trade-off on the conditional variances.

Table 6

MV-GARCH, VAR (1) -BEKK MGARCH -in Mean

	Variable	Regime 1	Regime 2	Regime 3
Mean Model (OILPR)				
1.	Constant	0.215465726	-0.057336963	0.185727922
2.	OILPR {1}	-0.077807229	-0.025519396	0.020815211
3.	EXR {1}	0.030558611	-0.061617429	0.240119615
4.	HHS (1,1)	-0.047638707***	0.014664554	0.037949761***
5.	HHS (2,2)	1.041624050**	0.029452103	-2.314351318
Mean Model (EXR)				
6.	Constant	0.048762784	0.006751154	0.039221155
7.	OILPR {1}	-0.003893216	-0.027677004***	-0.011344376***
8.	EXR {1}	-0.098110906*	-0.100203108***	-0.096295925***
9.	HHS (1,1)	-0.001789853	0.000848808	-0.000392261
10.	HHS (2,2)	0.052346869	-0.003816539	-0.182019837
11.	C (1,1)	-0.157596101	0.211666556***	0.610605264***
12.	C (2,1)	-0.000978968	-0.006798875	-0.068291689*
13.	C (2,2)	0.100737042***	0.057877954***	0.116612197***
14.	A (1,1)	0.186744125***	0.252209773***	0.395815738***
15.	A (1,2)	0.048465761***	-0.001401621	-0.017842756***
16.	A (2,1)	-1.073891666***	-0.003536666	0.295749970
17.	A (2,2)	0.363088042***	0.285901571***	0.241452734***
18.	B (1,1)	0.966414146***	0.964885345***	0.896503530***
19.	B (1,2)	-0.011026132***	0.000534399	0.006639934***
20.	B (2,1)	0.298751788**	0.002217593	0.352603395
21.	B (2,2)	0.902857055***	0.953812307***	0.866354000***

*(*** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level) (Source: data collected from finance.yahoo.com)*

The BEKK MGARCH -in Mean model is shown in Table 6. From this table it can be seen that in Regime 1, there is significant negative effect of risk-return relationship on lagged oil prices volatility while there is significant positive effect of risk-return relationship on lagged exchange rates volatility. The parameters measuring volatility dynamics are significant. In Regime 2, there is no significant effect of risk-return relationship on lagged oil prices or exchange rates volatility and parameters measuring volatility dynamics are significant. In Regime 3, there is significant positive effect of risk-return relationship on lagged oil prices volatility, while there is no significant effect of risk-return relationship on lagged exchange rates volatility and the parameters measuring volatility dynamics are significant.

Table 7

MV-GARCH, VAR (1) -BEKK Threshold MGARCH -in Mean

	Variable	Regime 1	Regime 2	Regime 3
Mean Model (OILPR)				
1.	Constant	0.244439799	-0.041750553	-3.25858578**
2.	OILPR {1}	-0.080765403	-0.024986058	0.05674417
3.	EXR {1}	-0.010439365	-0.056379998	0.17577192
4.	HHS (1,1)	-0.054461613**	0.002741664	-0.14113308***
5.	HHS (2,2)	1.020199945*	-0.003401590	42.02951029***
Mean Model (EXR)				
6.	Constant	0.054086659	0.008692294	0.01064783
7.	OILPR {1}	-0.003666285	-0.027900901***	-0.01025330***
8.	EXR {1}	-0.096155371	-0.098862625***	-0.11551550***
9.	HHS (1,1)	-0.002931833	0.000189856	-0.00052902
10.	HHS (2,2)	0.068884739	-0.007826369	0.07367445
11.	C (1,1)	-0.154049652	0.180561739***	0.25448586***
12.	C (2,1)	-0.036772083	-0.003833556	0.17348878***
13.	C (2,2)	0.090775718	0.057662384***	-0.00000213
14.	A (1,1)	0.115244600*	0.085329799***	0.17221773***
15.	A (1,2)	0.052719130***	-0.005259725	0.02279430***
16.	A (2,1)	-1.138905554***	-0.021964567	1.35824060***
17.	A (2,2)	0.413862650***	0.312153574***	0.04310214
18.	B (1,1)	0.960743640***	0.971131306***	0.92699200***
19.	B (1,2)	-0.010568413***	-0.000656678	0.00570408***
20.	B (2,1)	0.306734008**	0.005610937	-0.97766782***
21.	B (2,2)	0.882236036***	0.944910208***	0.80526056***
22.	D (1,1)	0.211244628**	0.297143730***	-0.32671037***
23.	D (1,2)	0.024665858	0.007800334**	0.02145494***
24.	D (2,1)	0.668902143	-0.010799188	-0.26391633
25.	D (2,2)	-0.108710351	-0.027910084	0.08070169*

*(*** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level) (Source: data collected from finance.yahoo.com)*

Table 7 reveals that in Regime 1, there is significant negative effect of risk-return relationship on lagged oil prices volatility, while there is no significant effect of risk-return relationship on lagged exchange rates volatility. The parameters measuring volatility dynamics are significant. There is no significant asymmetry in the mean models for either oil prices or exchange rates. In Regime 2, there is significant positive effect of risk-return relationship on lagged oil prices volatility and significant negative effect of risk-return relationship on lagged exchange rates volatility. The parameters measuring volatility dynamics are significant. There is significant asymmetry in both mean models. In Regime 3, there is significant negative effect of risk-return relationship on lagged oil prices volatility, while there is no significant effect of risk-return relationship on lagged exchange rates volatility. The parameters measuring volatility dynamics are significant. There is significant asymmetry in both mean models as well as in the risk-return relationship for lagged variables.

Regime 1: 2008 January 1 - 2009 June 30 (during financial crisis)

Constant (C): In the MV-GARCH, BEKK model, the constant term is negative, indicating a negative relationship between oil prices and exchange rates during the crisis. In the MV-GARCH, BEKK - With Asymmetric TGARCH model, the constant term is positive, suggesting a different relationship compared to the symmetric model. In the MV-GARCH, VAR (1) - BEKK and MV-GARCH, VAR (1) -BEKK Threshold MGARCH -in Mean models, the constant term is negative, indicating a negative relationship.

Variance (B): The variance coefficients are consistently high and positive in all models, indicating a strong influence of variance on both oil prices and exchange rates.

Past Volatility (A): Past volatility has consistently positive coefficients across all models, suggesting persistent volatility effects.

Asymmetry (D): Asymmetry terms may or may not be present depending on the model. When present, their interpretations are complex and varied.

Regime 2: 2009 July 1 - 2020 March 20 (after financial crisis)

Constant (C): In the MV-GARCH, BEKK model, the constant term is close to zero or insignificantly different from zero, suggesting a weak or no relationship between oil prices and exchange rates. In other models, the constant term becomes positive, indicating a positive relationship between oil prices and exchange rates post-crisis.

Variance (B): The variance coefficients remain consistently high and positive in all models, indicating a strong influence of variance on both variables.

Past Volatility (A): Past volatility continues to have consistently positive coefficients across all models, showing persistent volatility effects.

Asymmetry (D): Asymmetry terms may or may not be present, and their effects, if included, vary across models.

Regime 3: 2020 March 21 - 2023 December 31 (during COVID)

Constant (C): In the MV-GARCH, BEKK model, the constant term becomes positive and significant, indicating a positive relationship between oil prices and exchange rates during the COVID period. In other models, the constant term remains positive, but its significance may vary.

Variance (B): The variance coefficients continue to be high and positive across all models, suggesting a strong influence of variance on both variables.

Past Volatility (A): Past volatility maintains consistently positive coefficients across all models, indicating persistent volatility effects.

Asymmetry (D): Asymmetry terms may or may not be present, and their effects, if included, vary across models.

3.5. Impulse response function

The Impulse Response Function is obtained from the MGARCH-in-mean model. This allows for the direct modelling of the relationship between risk and returns. It is more effective to capture the risk-return trade-off.

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Figure 1
Impulse Response Function for Regime 1

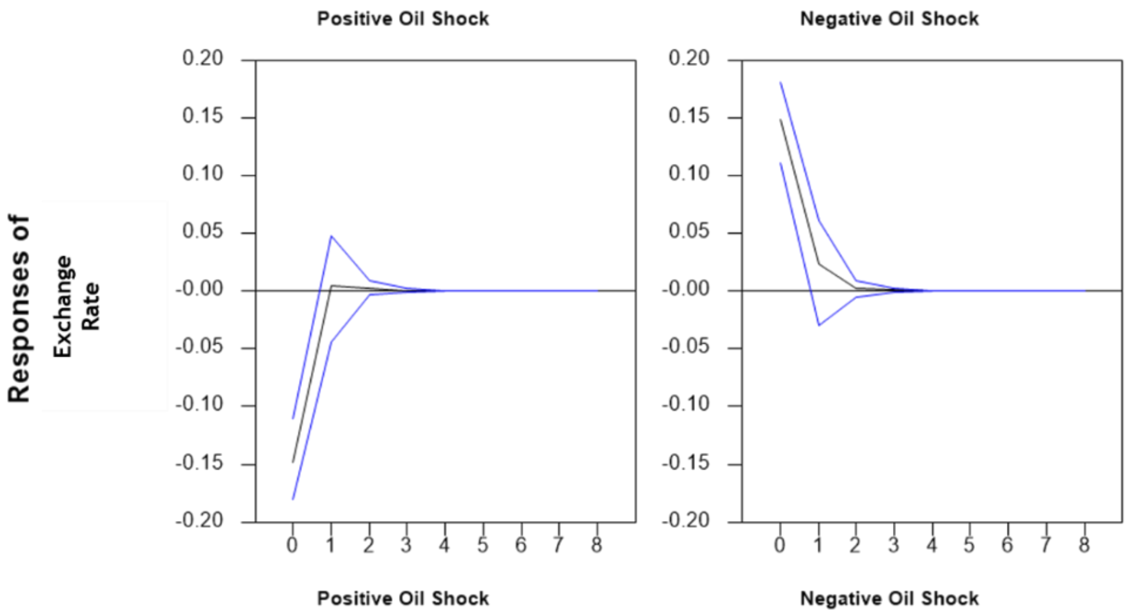


Figure 2
Impulse Response Function for Regime 2

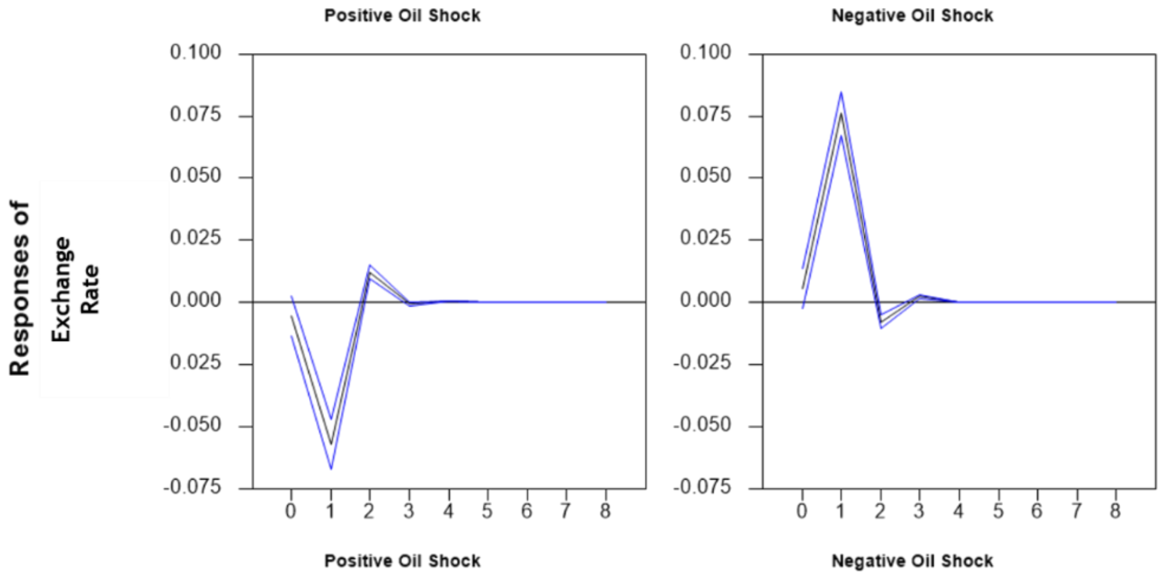
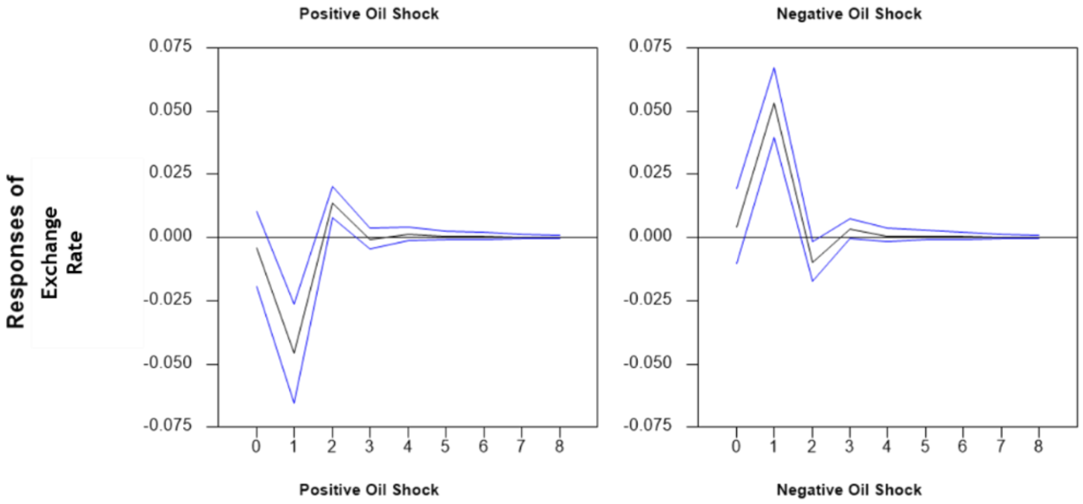


Figure 3
Impulse Response Function for Regime 3



Regime 1

- Positive oil shock: The exchange rate shows an immediate sharp depreciation following the shock. This is indicated by the negative spike right after time zero. The exchange rate then gradually returns to its original level, oscillating slightly before stabilising.
- Negative oil shock: It seems to show a similar shock with different parameter settings. The behaviour is similar with a sharp depreciation initially followed by oscillations and a return to equilibrium.

Regime 2

- Positive oil shock: The exchange rate exhibits an immediate appreciation post-shock, as indicated by the initial positive spike. However, it quickly reverses direction, showing a depreciation before gradually stabilising around the original level. This regime shows a relatively quick reversion to equilibrium.
- Negative oil shock: This IRF shows an initial appreciation followed by a depreciation and then a gradual return to the initial level. The dynamics of adjustment seem slightly smoother compared to the left panel.

Regime 3

- Positive oil shock: There is a sharp appreciation of the exchange rate immediately following the shock. The exchange rate then depreciates rapidly below the initial level before oscillating and eventually stabilising.
- Negative oil shock: The IRF shows a very similar response to the shock with an initial appreciation, followed by a rapid depreciation and oscillations before returning to equilibrium.

4. Conclusion

From the comprehensive analysis conducted on the relationship between oil price volatility and exchange rate dynamics across three distinct regimes in India, several key findings emerge, shedding light on the nuanced interplay between these variables. From the models it can be seen that the relationship between oil prices and exchange rates varies across different economic regimes. During the financial crisis (Regime 1), the relationship tends to be negative or more complex. Post-crisis (Regime 2), the relationship becomes weaker or positive. During the COVID period (Regime 3), the relationship tends to be positive, indicating potential changes in economic dynamics or policies during crises.

Across the different regimes, it is evident that the significance of oil price in explaining exchange rate movements fluctuates. While oil prices may not have been significant in explaining exchange rate fluctuations during the initial period, their significance becomes pronounced in the subsequent periods, particularly in the aftermath of the financial crisis and amidst the COVID-19 pandemic.

The analysis reveals a notable asymmetry in the volatility dynamics, implying that positive and negative shocks to oil prices and exchange rates exert differential impacts on volatility. This asymmetry underscores the complexity of the relationship between these variables and highlights the need for a nuanced understanding of their interactions. The response of exchange rates to shocks in oil prices demonstrates a significant sensitivity, with immediate and pronounced reactions observed. However, the duration and magnitude of these responses vary, indicating that while exchange rates exhibit sensitivity to changes in oil prices, the stabilization process may differ depending on the nature and direction of the shock.

The IRF shows that Regime 1 is characterised by a sharp initial depreciation of the exchange rate following the shock, with subsequent oscillations before stabilisation. The return to equilibrium is relatively slow, indicating possible persistence in the exchange rate dynamics. In Regime 2, the exchange rate initially appreciates but then quickly depreciates before returning to the original level. The adjustment process is quicker and the reversion to equilibrium is smoother compared to Regime 1. Regime 3 shows an initial appreciation followed by a sharp depreciation and then oscillations before stabilising. The dynamics are somewhat similar to Regime 2 but with more pronounced initial movements.

Economically, these findings underscore the complicated relationship between oil prices and exchange rates, with implications for policymakers, investors, and businesses. The volatility dynamics observed shows the importance of considering the differential impacts of shocks on economic variables and highlights the need for robust risk management strategies.

Policy Implications

The varying significance of oil prices across different time periods points out the dynamic nature of economic relationships and the importance of adapting analytical frameworks to evolving market conditions. Overall, the analysis provides valuable insights into the complex interplay between oil price volatility and exchange rate dynamics, offering a nuanced understanding of their implications for the Indian economy. The policy makers should take into consideration the following aspects while formulating policies.

- Prioritizing the development and implementation of robust risk management strategies.
- Strengthening the resilience of the economy to external shocks, including fluctuations in oil prices.
- Focusing on coordination and communication among central banks to ensure coherent policy responses to oil price fluctuations.

In essence, the findings suggest that while oil prices may not consistently drive exchange rate movements, they nonetheless exert significant influence, particularly in periods of economic upheaval. Understanding these dynamics is crucial for policymakers and market participants alike, as they navigate the complexities of the global economy.

Author’s Contribution

The first author, Riny Raju collected, analysed and interpreted the data, and the second author, Dr. Raju G, structured the theoretical framework.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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References

1. Ahmad, W., Prakash, R., Uddin, G. S., Chahal, R. J. K., Rahman, M. L., & Dutta, A. (2020). On the intraday dynamics of oil price and exchange rate: What can we learn from China and India? *Energy Economics, 91*(C).
2. Amano, R., & van Norden, S. (1998). Oil prices and the rise and fall of the US real exchange rate. *Journal of International Money and Finance*, 17(2), 299-316.
3. Bal, D. P., & Rath, B. N. (2019). Nonlinear causality between crude oil price and exchange rate: A comparative study of China and India - A reassessment. *Economics Bulletin, 39*(1), 592-604.

4. Chen, S.-S., & Chen, H.-C. (2007). Oil prices and real exchange rates. *Energy Economics*, 29(3), 390-404.
5. Ghosh, S. (2011). Examining crude oil price - exchange rate nexus for India during the period of extreme oil price volatility. *Applied Energy, 88*(5), 1886-1889.
6. Jain, A., & Biswal, P. C. (2016). Dynamic linkages among oil price, gold price, exchange rate, and stock market in India. *Resources Policy, 49*(C), 179-185.
7. Jain, A., & Ghosh, S. (2013). Dynamics of global oil prices, exchange rate and precious metal prices in India. *Resources Policy*, *38*(1), 88-93.
8. Rafiq, S., Salim, R., & Bloch, H. (2009). Impact of crude oil price volatility on economic activities: An empirical investigation in the Thai economy. *Resources Policy*, 34(3), 121-132.
9. Sahu, T. N., Bandopadhyay, K., & Mondal, D. (2015). Crude oil price, exchange rate and emerging stock market: Evidence from India. *Jurnal Pengurusan, 42*, 75-87.
10. Tiwari, A., & Albulescu, C. (2016). Oil price and exchange rate in India: Fresh evidence from continuous wavelet approach and asymmetric, multi-horizon Granger-causality tests. *Applied Energy, 179*(C), 272-283.
11. Tiwari, A., Dar, A., & Bhanja, N. (2013). Oil price and exchange rates: A wavelet based analysis for India. *Economic Modelling, 31*(C), 414-422.
12. Zhang, X., Lai, K. K., & Wang, S.-Y. (2008). A new approach for crude oil price analysis based on Empirical Mode Decomposition. *Energy Economics*, 30(3), 905-918.