Nonlinear Response of Fuel Price Returns to Monetary Policy : A Regime-Switching Approach

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Abstract

Purpose : The paper sought to understand the influence of call money rates and forward premiums as monetary policy stances on oil and natural gas prices in Indian markets.

Methodology : The study employed the Markov-switching dynamic regression model as a regime-switching methodology to investigate the nonlinear response of fuel price returns to monetary policy. The study considered monthly oil and natural gas prices from January 2005 to July 2019. The monthly call money rates and forward premia from January 2005 to July 2019 were extracted from the RBI database. The final data sample consisted of 175 monthly observations. The study used Stata statistical software for data analysis.

Findings : The gasoline returns showed a noteworthy correlation between call money rates and forward premia. However, according to the model fitting tests, monetary policy variables only seemed to impact oil price returns during a crisis. In the same way, for natural gas, the present return was only affected by the lag return when things were calm. Additionally, fuel returns persist longer during a crisis, a sign of increased use and a dearth of substitutes for the good.

Practical Implications : The study's conclusions have policy ramifications for monetary policy instruments like forwarding premia and calling money that can be used to influence the price of oil. Government and regulatory agencies may consider substituting natural gas for fossil fuels in the entire fuel mix, making it more environment friendly.

Originality : The study used real-time commodity (oil and natural gas) price data and policy measures (RBI call rate and forward premium) to adopt a model to examine policy intervention's effect on commodity prices in the Indian context.

Keywords : fuel price, monetary policy, call money, forward premia, regime-switching

JEL Classification Code : E32, E52, G12

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Energy is a significant subject of policy-making and governance for both developed and developing nations. Over the years, the demand for energy resources has been accentuated due to industrialization, improved modes of communication, and a better standard of living for people. Like other energy commodities, fuel prices exhibit price swings and cyclical trends. Higher oil prices have been the cause of economic recession in the United States and other developed nations (Hamilton, 2008). Therefore, it becomes imperative to understand the behavior of fuel prices to enable policymakers to make appropriate decisions.

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Emerging economies like India and China contribute to most oil demands in the 21st century (Kesicki, 2010). The existing literature on Indian and other markets investigated the impact of a particular measure of monetary policy change on oil price volatility in the market. To examine the effects of short-term monetary policy intervention on fuel prices in the Indian context, the current study is noteworthy and unique since it focuses on the call money rate and forward premium (calculated as an excess of forward price from spot price). Since the present trend in the market is toward risk mitigation and forward-looking, considering the call money rate and forward premium as a monetary policy intervention, the study is complementary to the existing body of knowledge on the subject. It addresses the research gap with empirical data analysis.

The study's findings attempt to answer the following research questions: (a) investigating the behavior of fuel prices because their volatility will make producers and consumers more vulnerable to risk ; (b) determining whether the response of oil and natural gas prices to monetary policy actions has differed because this will have an impact on fuel allocation ; (c) The extent to which gasoline prices can be regulated and how monetary policy activities affect them ; (d) To determine if regulatory measures help lessen the uncertainty around gasoline prices, and does the impact of past monetary policy actions on spot fuel prices matter?

Review of Literature

In the academic literature, several studies explored the behavior of fuel prices and their response to policy rates. Askari and Krichene (2010) studied the relationship between oil and gas prices and monetary policy. He found that the steep rise in oil prices in the market was a response to monetary policy. While the Organization of Petroleum Exporting Countries (OPEC's) decision influenced oil prices, the impact of the monetary policy stance must be addressed. Kormilitsina (2011) argued that monetary policy was the reason behind the oil price shocks in the United States. Kasekende and Brownbridge (2011) discussed the importance of monetary policy in sub-Saharan Africa (SSA) region. The authors explained that global fuel price shocks had a persistent effect on inflation, controlled by tightening their monetary policy. Koziuk (2016) suggested that central bank autonomy can decrease the impact of international commodity shocks. In a recent study, Taghizadeh-Hesary and Yoshino (2014) explained the monetary policy stance behind increased oil prices. The expansionary monetary policy that boosted credit growth and oil consumption was mentioned in their report. Taghizadeh-Hesary and Yoshino (2016) emphasized in a different study that monetary policy has raised oil prices, with a noticeable impact on demand.

Monetary policy has been linked to a supportive stance at times of economic crisis (Thach et al., 2022). While monetary policy targeted inflation, its linkage with oil prices needed introspection. According to Salisu et al. (2017), oil prices reacted to inflation predominantly in oil-importing countries. Oil prices needed to be controlled because India has been a net importer. Central banks' interest and exchange rates impacted oil prices, two common short-term monetary policy stances. Monetary policy transmission effectiveness can be known through interest and exchange rate channels (Bicchal, 2010; Jarociński, 2010). Some earlier research (Taghizadeh-Hesary & Yoshino, 2014; Verleger, 2011) assumed that interest and exchange rates would determine fuel prices. The foundation of a country's financial system is its capital, money, and foreign exchange markets (Faniband, 2020). Interest rates and exchange rates are associated with financial markets and, ultimately, the whole financial system of a country (Syed & Tripathi, 2020). Wang and Chueh (2013) explained the dynamic transmission effect of interest rates on crude oil prices. The authors found that crude oil price volatility increased in response to the lowering of interest rates by the Federal Reserve Board. They further mentioned that interest rates positively impacted future crude oil prices. Ji (2012) identified the US dollar index as the prime factor driving crude oil prices. In the Indian context, there was a spillover impact of the US dollar on assets like gold and real estate (Mishra, 2019). However, oil and natural resources differed from gold and real estate in the Indian context (Syed et al., 2021). The Central Bank of India, Reserve of India (RBI), regularly intervenes in the foreign exchange market with effective monetary policy mechanisms for the price stability of oil and natural gas (Gupta & Ahmed, 2019). Lakshmanasamy (2021) identified the spillover effect between the exchange rate and oil prices in India. Rai and Sharma (2022) were concerned about the persistence of the exchange rate and urged that it be controlled to reduce economic instability.

Various studies have examined how interest rates affect global oil prices, but the importance of the call money rate as a monetary policy tool needs to be mentioned in prior studies. Similarly, the significance of forward premium as a policy instrument must be considered (Beckmann & Czudaj, 2013; Reboredo, 2012). These monetary tools have received little attention for fuel price regulation. The call money rate is the interest rate at which short-term fund lending occurs in the money market. Interest rates remained the most dominant channels of monetary policy transmission in India (Rajan & Yanamandra, 2015). Aleem (2010) emphasized the call money rate as a monetary policy stance and the role of banks in transmitting policy shocks to the real sector.

Similarly, studies are silent on forward premia (excess of forward rate over spot rate) as one of the monetary policy mechanisms in fuel price regulation. The forward market has benefited international traders in reducing spot exchange rate risk. In the foreign exchange market, the forward exchange rate predicts a short-term pattern of exchange rates. Mueller et al. (2017) justified that uncertainty in monetary policy was evident through exchange rate differential. Calomiris and Mamaysky (2019) suggested that in the post-crisis era, the future exchange rate differential with other currencies assumed importance with close association with central bank monetary policy actions.

We extract the research gap from these studies by adding call money and forward premia as monetary policy variables. Our study is unusual because we considered how these indicators affected fuel prices. The goal of this study is to fill this research gap by examining how these tools affect fuel prices in India as a monetary policy mechanism. The analysis revealed a novel angle in which supply and demand determine fuel costs, but monetary policy measures can limit demand.

Commodity price disparities were well-known to be detected by Markov switching models (Simo-Kengne et al., 2013). Nirmala and Deepthy (2018) detected the presence of asymmetry in the energy index of Indian commodities. Additionally, this model was used to examine how policy interventions changed the patterns of gasoline prices (Balcilar et al., 2015; Geng et al., 2016; Liang et al., 2019). A strand of literature also hinted at nonlinear modeling using Markov switching and revealed the impact of exchange rates on fuel prices (Bhar & Malliaris, 2011; Tiwari & Albulescu, 2016). This study employed the Markov switching model as a regime-switching approach in line with prior empirical literature.

The fundamental hypothesis of this research is that, in addition to supply and demand worldwide, central banks' actions send signals that affect fuel prices. To the best of our knowledge, the present analysis is the first in India to measure the responses of fuel prices to monetary policy interventions by the RBI. Our study examines call money rates and forward premia to understand the monetary policy tools controlling fuel prices.

Data and Regime Switching Method

This section deals with the data source for the study and a detailed explanation of regime switching methodology. Different research constructs are also designed in this section to investigate the linkage between fuel price returns and monetary policy variables.

Source of Data

The present research is based on the secondary data obtained from different publicly available authentic sources. The fuel price data were obtained from MCX (Multi Commodity Exchange of India Ltd.), a platform for trading commodity derivatives. Crude oil and natural gas are the two fuel commodities whose spot prices are available on MCX. The MCX platform has been used in Indian studies to get closing prices of oil and natural gas (Seth & Sidhu, 2021). To verify the current state of the market, the current study considers monthly pricing from January 2005 to July 2019 based on data availability. The study uses Stata 14.0 statistical software for data analysis. The oil prices are quoted in rupees per bbl, while natural gas is quoted in rupees per MMBtu. Since oil producers used wooden barrels to export their products in the past, oil prices are expressed in barrels or bbls. In the US, natural gas is commonly measured in MMBtu, or million British thermal units, as a measure of energy. The logarithmic returns are approximated to produce a stationary series, much like any other time series data. The following is the expression for the return estimation equation:

$$F_t = \text{Ln}\,(P_t) - \text{Ln}\,(P_{t-1}) \ldots\ldots (1)$$

where,

P_t is the fuel price measured in the specified units at month t.

F_t is the fuel price return in general, which is represented as OIL_t for crude oil returns and NG_t for natural gas returns. Ln is the natural logarithm.

The monthly call money rates ($CallMoney_t$) and forward premia ($ForwardPremia_t$) from January 2005 to July 2019 are extracted from the RBI database. The final data sample consists of 175 monthly observations.

Regime Switching Methodology

The study employs the Markov-switching dynamic regression model as a regime-switching methodology to investigate the nonlinear response of fuel price returns to monetary policy. Two-state Markov-switching dynamic regression models have been used in recent works on energy price modeling for monthly and annual datasets (Sarkodie et al., 2019; Temkeng & Fofack, 2021). According to Zhu et al. (2017), the Markov-switching dynamic regression model can identify macroeconomic and energy variables' dynamic and switching patterns while providing flexibility for an instantaneous transition between classified states.

The model can be expressed as follows:

$$Y_t = ø_t + \alpha\mu_t + X_t\beta_s + €_t$$

Here, Y_t is the response variable, $ø_t$ is the intercept dependent on states, X_t and μ_t are the exogenous predictors, β_s is the coefficient dependent on state, and $€_t$ is the error term with a state-dependent variance σ^2 and a zero mean. Here, α is the coefficient independent of states.

The two-state models for fuel returns may assume that the transition of the response variable is between risky and stable states.

St represents the state variable for the regime, where $ø_t$ is denoted as a function of St :

$$ø_t = 0, \text{ if } St = 0$$

$$ø_t = 1, \text{ if } St = 1.$$

In a Markov process, St follows a Markov chain estimated as the probability of transition between two states identified by $p\ i/j$. Here, $p\ i/j$ is defined as:

$$p\ i/j = P(St = j \mid St - 1 = i), \text{ where } i = 1 \text{ and } j = 2.$$

Therefore, the chances of moving to the next state depend on the previous state. Since the system has to be in one of the states, this can be expressed as $\sum_{i=0}^{N-1} p\ i/j = 1$.

The complete matrix of transition probabilities (P) is represented as $P = (p\ i/j)$, with the summation of conditional probabilities equal to one. Hence, the matrix, in its simplest form, can be written as:

$$P = \begin{pmatrix} p11 & p21 \\ p12 & p22 \end{pmatrix}$$

Where, $p11$ = chances of persistence in state 1.

$p22$ = chances of persistence in state 2.

$p12$ = transition probability from state 1 to state 2.

$p21$ = transition probability from state 1 to state 2.

Research Equation

A simple regime-switching model applying Markov-switching dynamic regression for detecting persistence can be expressed as mentioned below:

$$Fuel_t = ø_t + \alpha\mu_t + \Omega Fuel_{t-1} + €_t \ \ldots\ldots \ (2)$$

Here, $Fuel_{t-1}$ is the previous period fuel return, and Ω is the coefficient of lagged fuel returns.

Two additional equations are constructed to find the association of fuel prices with monetary policy variables. The second equation considers, along with lagged fuel returns, the impact of call money rate and forward premia on the fuel returns. This is written as follows:

$$F_t = ø_t + \alpha\mu_t + \Omega Fuel_{t-1} + CallMoney_t\, \beta 1_s + ForwardPremia_t\ \beta 2_s + €_t \ \ldots\ldots\ldots\ (3)$$

$CallMoney_t$ and $ForwardPremia_t$ represent the call money and forward premia variables, respectively. $\beta 1_s$ and $\beta 2_s$ are the state-dependent coefficients.

The third equation analyzes whether the past period's monetary policy indicators influence the current period's fuel returns. This can be expressed as follows:

$$F_t = ø_t + \alpha\mu_t + \ \Omega Fuel_{t-1} + CallMoney_{t-1}\ \beta 1_s + ForwardPremia_{t-1}\ \beta 2_s + €_t \ \ldots\ldots\ (4)$$

Model Selection Criteria

The study uses the Akaike Information criteria (AIC) and Schwarz Bayesian Information criterion (BIC) to identify the best-fitted model. These criteria estimate the deviations of the fitted model from the actual observations. The three models from the above equations are compared based on these information values. The model with a minimum value of AIC and Schwarz BIC is selected as the most appropriate model.

Study Hypotheses

The following hypotheses evolved from the study:

- **H01 :** Fuel prices are not influenced by historical price actions. (Null)

- **Ha1 :** Historical fuel price returns significantly affect spot fuel price returns. (Alternate)
- **H02 :** Fuel prices are persistent across different states. (Null)
- **Ha2 :** Fuel prices do not exhibit persistence across different states. (Alternate)
- **H03 :** Call money and forward premia cannot influence spot fuel prices. (Null)
- **Ha3 :** Call money and forward premia significantly predict spot fuel prices. (Alternate)
- **H04 :** Forward premia and call money are insignificant predictors of future fuel prices. (Null)
- **Ha4 :** Forward premia and call money can significantly predict future fuel price actions. (Alternate)

Analysis and Results

Fuel price returns by month are shown in Figures 1 and 2. The numbers clearly show different regimes for returns on oil and natural gas. Significant volatility clusters were observed in fuel prices. However, the returns were

Figure 1. ***Crude Oil (OIL) Price Monthly Returns***

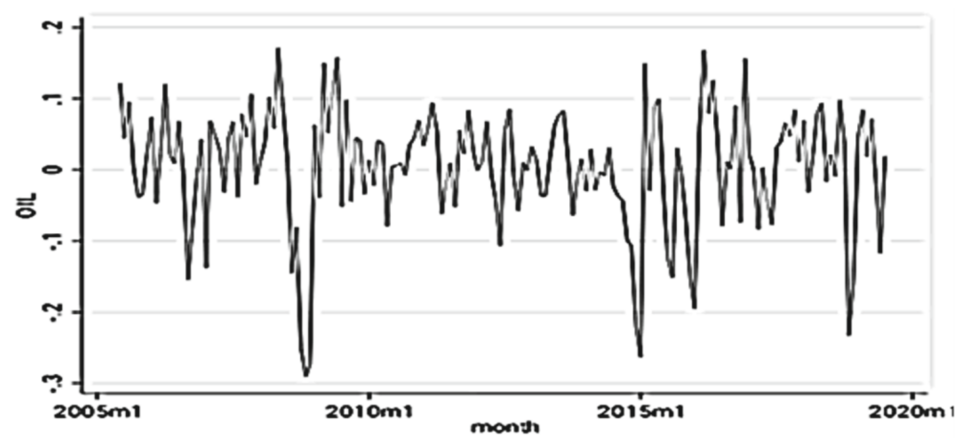
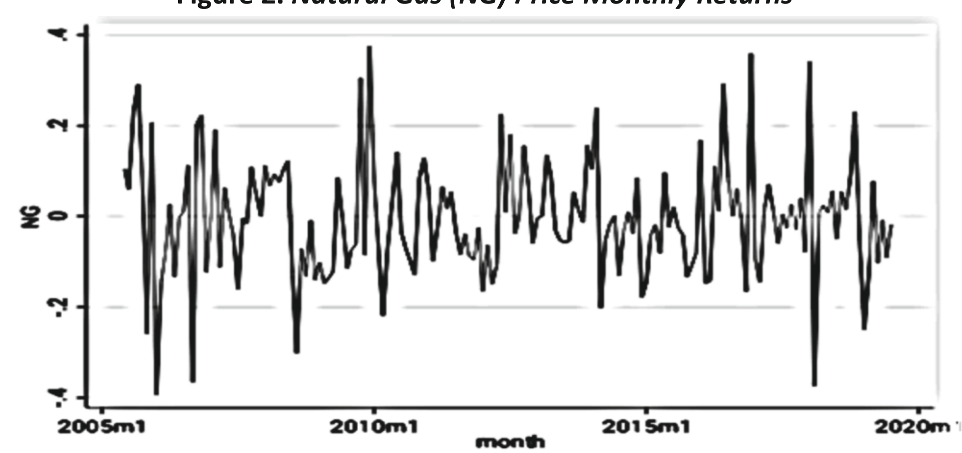


Figure 2. ***Natural Gas (NG) Price Monthly Returns***



characterized by severity and tranquil states. The fluctuations in oil returns were higher than in natural gas during the global recession (2008–2009).

Table 1 reports the Equation (2) results wherein past fuel returns are highly significant with current returns. The volatility of fuel returns is also more significant in the higher regime, as seen from the standard deviation (σ) values. The oil returns show that the estimated coefficients are more significant in regime 1 than regime 2, while it is the opposite for natural gas. This indicates a stabilizing effect for oil prices during a tranquil state while a destabilizing effect during a severe state during a period of rising prices. The historical returns of natural gas are positively correlated with lag returns in a calm environment, suggesting that a spike in price causes subsequent increases in price trends. Furthermore, the historical fuel returns for natural gas under regime 2 have no bearing on the current fuel return. As a result, we can propose that, in regime 2, in contrast to oil price returns, where previous returns determine current levels, certain other factors might affect natural gas returns.

The estimated duration in the low oil regime is shorter than in the higher regime. For natural gas, the anticipated duration in the low regime is greater than that in the high regime. Similarly, oil has a higher transition probability from state 1 to state 2 than natural gas. This implies that compared to natural gas, oil prices are more likely to fluctuate between high and severe states and to spend more time in high regimes.

Table 2 displays the results of Equation (3), explaining the significance of monetary policy indicators' effect on fuel returns. During the low regime, a higher call money rate is significantly associated with lower oil returns but has a positive significance with oil returns during the high regime period. Since a higher call money rate can be an outcome of a liquidity squeeze, during the tranquil period, the increase in interest rate has a favorable effect of lowering the oil returns. Therefore, when the central bank tightens monetary policy through call money rates, consumers will benefit from reduced oil prices during periods of calm governance. When the central bank implements strict monetary policy, an increase in the call money rate causes an increase in oil returns, ultimately impacting consumers. On the other hand, only in the calm condition does the call money rate for natural gas have a substantial negative correlation with returns. This implies that monetary policy tools like call money rates have no impact during exceptionally high volatility in the price of natural gas.

The observations are different when forward premia acts as a monetary policy indicator. An increase in forward premia can suggest that there will be a depreciation in the value of the rupee. Interestingly, forward premia have a significant adverse effect during the tranquil period only on natural gas returns. The indicator is insignificant for oil returns and natural gas during the severity period. Therefore, the central bank policy stance through forward premia in most situations cannot control the fuel prices. Overall, it is observed that fuel returns stay for a short duration in lower regimes, and the transition probability to a higher regime is more likely than a lower regime. In

Table 1. *Results of Equation (2)*

F_t	**Oil**		**Natural Gas**	
Two states	**Regime 1**	**Regime 2**	**Regime 1**	**Regime 2**
$Fuel_{t-1}$	–0.2979***	0.6992***	0.3046**	–0.2553
p-value($Fuel_{t-1}$)	0.0000	0.0000	0.0010	0.1400
σ	0.0307	0.0779	0.0771	0.1788
p_i	0.2409	0.6891	0.8421	0.7284
d	1.3174	3.2164	6.3359	3.6821
p_{ij}	0.7590	0.3108	0.1578	0.2715
AIC	–2.3242		–1.3254	
BIC	–2.2131		–1.2143	

Table 2. *Results of Equation (3)*

F_t	Oil		Natural Gas	
Two states	**Regime 1**	**Regime 2**	**Regime 1**	**Regime 2**
$Fuel_{t-1}$	–0.7858***	–0.1563***	–0.4514***	–0.2553***
p-value ($Fuel_{t-1}$)	0.0000	0.0000	0.0000	0.0000
$\beta1_s$ (*CallMoney*)	–0.0088*	0.0074***	–0.0631***	0.0056
p-value (*CallMoney*)	0.0850	0.0050	0.0000	0.1620
$\beta2_s$ (*ForwardPremia*)	0.0050	–0.0043	0.0409***	–0.0057
p-value (*ForwardPremia*)	0.3760	0.1700	0.0000	0.2350
σ	0.7752	0.0481	0.0218	0.1170
p_i	0.5966	0.7561	0.2831	0.9392
d	2.4791	4.1013	1.3949	16.4506
p_{ij}	0.4033	0.2438	0.7168	0.0607
AIC	–2.3929		–1.2584	
BIC	–2.2077		–1.0732	

the severity regime, there is a greater likelihood of staying with fuel costs. This implies that even in a monetary policy stance in the form of call money rates and advance premiums, fuel prices are more subject to a severity regime than during a peaceful period.

Table 3 presents the results of Equation (4), wherein the study examines the effect of previous monetary policy actions on current fuel returns. The table demonstrates the relationship between current returns and natural gas's prior monetary policy position. The impact of monetary policy decisions on current returns in the oil market is only strongly correlated with higher regimes. An increase in the call money rate in the previous period is positively associated with the current level of higher oil returns during the severity period. Hence, altering the liquidity conditions through call money rates can influence future oil returns during periods of severity. In the current time,

Table 3. *Results of Equation (4)*

F_t	Oil		Natural Gas	
Two states	**Regime 1**	**Regime 2**	**Regime 1**	**Regime 2**
$Fuel_{t-1}$	–0.7780***	–0.1688***	–0.8451***	–0.0974
p-value ($Fuel_{t-1}$)	0.0000	0.0290	0.0000	0.1920
$\beta1_s$ ($CallMoney_{t-1}$)	–0.0075	0.0096***	–0.0542***	0.0070
p-value ($CallMoney_{t-1}$)	0.1330	0.0000	0.0000	0.0780
$\beta2_s$ ($ForwardPremia_{t-1}$)	0.0032	–0.0072***	0.0529***	–0.0083
p-value ($ForwardPremia_{t-1}$)	0.5520	0.0160	0.0000	0.0730
σ	0.0780	0.0471	0.0084	0.1185
p_i	0.6157	0.7836	0.4729	0.9272
d	2.6025	4.6224	1.8964	12.7420
p_{ij}	0.3842	0.2163	0.5271	0.0727
AIC	–2.4193		–1.2953	
BIC	–2.2341		–1.1101	

higher oil returns in a high regime condition are associated with a decrease in forward premia during the preceding period. This suggests that a smaller rupee appreciation in the prior era resulted in a larger oil return during the tough time. Hence, anticipating a minor increase in the exchange rate can result in higher oil prices, while a forecast of a more significant increase in the exchange rate may reduce oil prices. This may be due to the higher exchange rate forecast in the previous period reducing the demand for oil in the current period, causing a price reduction.

Model Selection

The Equation (4) output shown in Table 3 is the suitable model for oil, according to the three models based on lower AIC and BIC values. As seen from Table 3, historical price is a significant indicator of spot price. Therefore, H01 is rejected, and Ha1 is accepted for oil price prediction. The negative coefficients suggest the anti-persistence behavior of reversal more often, which means H02 is rejected and Ha2 is accepted. Since Table 3 is the most appropriate model, it indicates that current monetary policy actions cannot control oil prices. Thereby, H03 is accepted, and Ha3 is rejected. However, monetary policy actions can regulate future oil prices during a low regime, which means H04 is rejected and Ha4 is accepted. In a higher regime during increased volatility, future oil prices cannot be controlled by monetary policy actions, which means that H04 is accepted and Ha4 is rejected.

Similarly, based on lower AIC and BIC values, Equation (1) output represented by Table 1 is the appropriate model for natural gas. For regime 1, natural gas returns are influenced by historical price behavior. However, the same does not hold for regime 2. Thus, for regime 1, Ha1 is accepted, and H01 is rejected. For regime 2, Ha1 is rejected, and H01 is accepted for price prediction. In regime 1, the positive coefficients for natural gas indicate that prices persist in regime 1. Therefore, H02 is accepted, and Ha2 is rejected. In regime 2, the insignificant lagged natural gas prices suggest that H02 is rejected and Ha2 is accepted. Since Table 1 best fits natural gas, the monetary policy stance cannot regulate the spot and future gas prices. Hence, we can conclude that H03 and H04 are accepted, while Ha3 and Ha4 are rejected.

Figures 3 to 6 represent the filter probabilities for States 1 and 2 for oil and natural gas returns. The severity states fit better with the fuel returns than the tranquil state. Accordingly, the model prediction accuracy is better for

Figure 3. ***Filter Probabilities for F_t = OIL_t (State 1)***

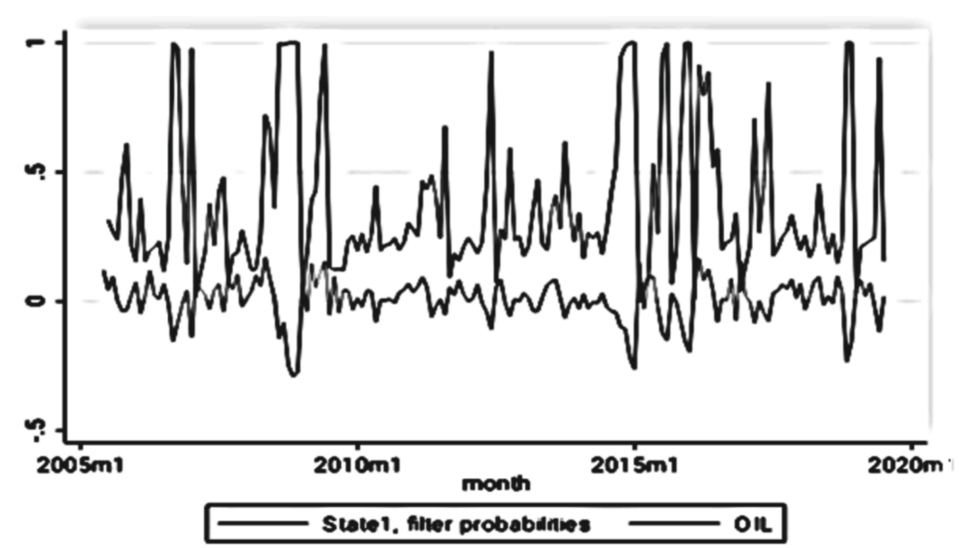


Figure 4. *Filter Probabilities for $F_t = OIL_t$ (State 2)*

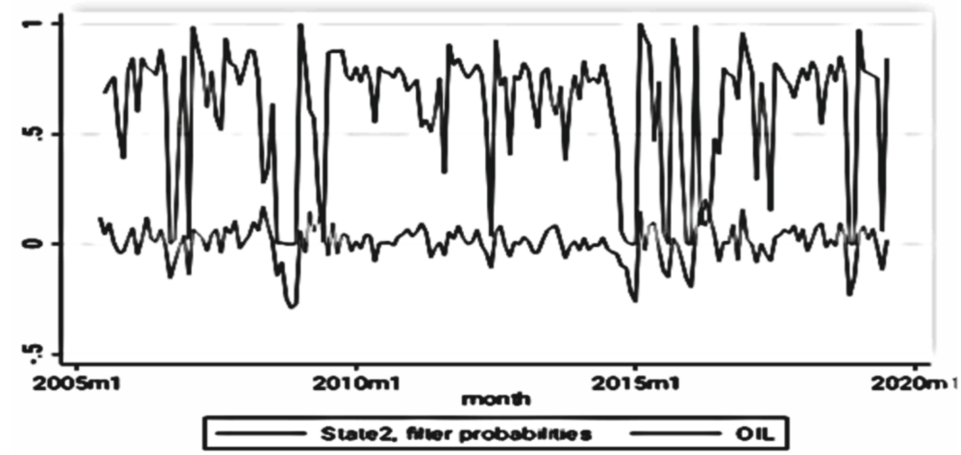


Figure 5. *Filter Probabilities for $F_t = NG_t$ (State 1)*

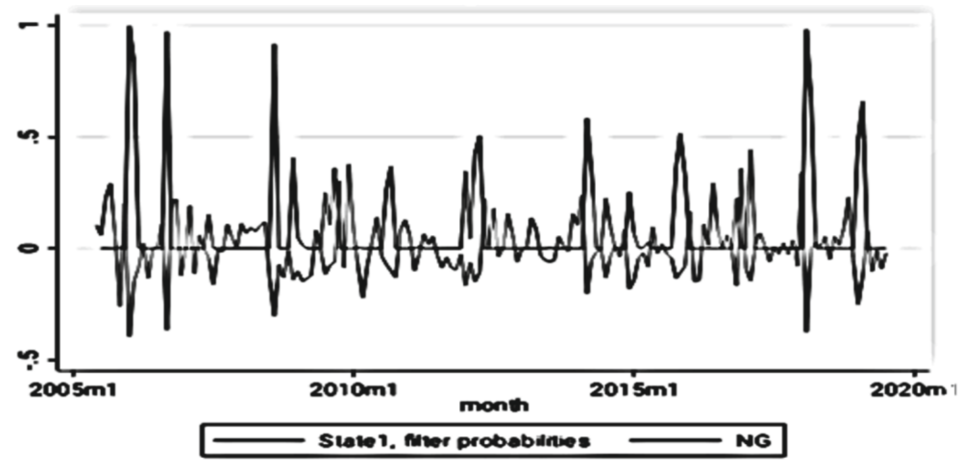
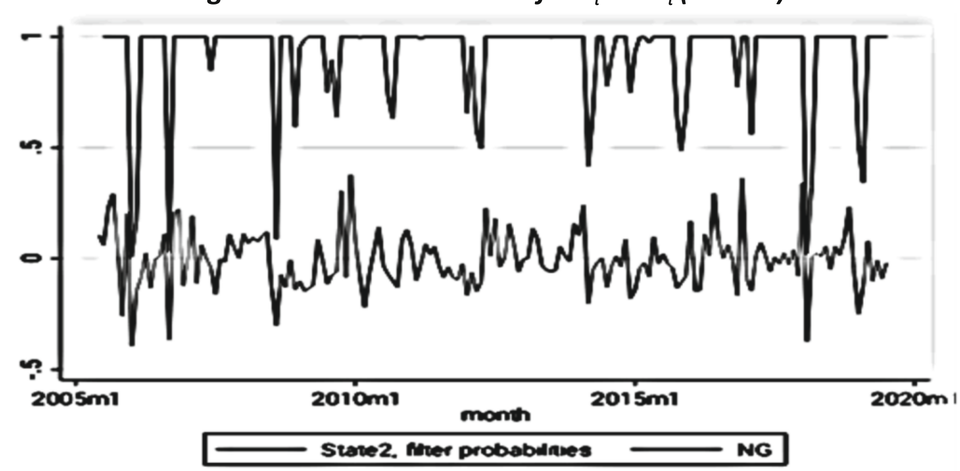


Figure 6. *Filter Probabilities for $F_t = NG_t$ (State 2)*



higher and lower regimes. It is also observed from the plots that fuel prices mostly stay in the higher regime state. This is probably due to higher demand for the commodity and the inability of consumers to substitute when the price fluctuates during the crisis period.

Conclusion and Implications

This study examines the response of fuel price returns to various monetary policy indicators represented by call money rates and forward premia. Using time series data from January 2005 to July 2019, the study applied Markov-switching dynamic regression to examine the nonlinear response of fuel returns. The two fuel commodities available on the MCX platform are oil and natural gas. According to available literature, two-state regime switching is adopted, with a lower regime assumed to be a tranquil state and a higher regime as a crisis state. The study's conclusions show that fuel prices remain that way for the longest in a crisis. Fuel prices may enter a crisis state mostly due to rising demand for use and dwindling supply of alternatives. The study's findings regarding the impact of monetary policy variables varied for natural gas and oil. The models with the lowest information criterion are deemed suitable for discussion after assessing various information criteria.

Oil prices can be controlled using monetary policy only during the crisis period. Therefore, call money rates and forward premia can sometimes be altered by the central bank to check the future oil prices. The tranquil period suggests that at times of calmer situations, there is no abrupt demand leading to price increases, which monetary policy actions can control. The model appropriately explains natural gas wherein the previous period returns lead to future returns only during the tranquil state. For a crisis state, the previous returns have an insignificant role in guiding future returns. An increase in returns during the previous period is responsible for higher returns at current levels. Natural gas is an environment-friendly alternative to fossil fuels, and regulatory support may have envisaged using natural gas in a calmer state. However, the share of natural gas in proportion to other fuels is much less, suggesting lower demand, thereby ignoring the significance of previous period prices to affect current prices at times of crisis.

The present study has multiple policy, managerial, and theoretical implications. As per the policy implications, there is a need to focus on call money rates and forward premia as monetary policy actions by central banks (RBI) to control oil prices during the crisis. Since fuel prices have greater chances to stay during the crisis period, policymakers may think of suitable measures to manage the demand and supply of fuel and increase the allocation of renewable energy resources. Government authorities can identify possibilities to maximize natural gas consumption as it is a cleaner alternative than fossil fuels. As per the managerial implications of the present research, the oil and natural gas producing and marketing companies need to change their managerial strategies to manage the inventory during different regimes, i.e., tranquil and crisis states. The present research complements the existing theoretical body of knowledge by applying the Markov-regime switching dynamic model to find the relationship between monetary policy changes and the influence of oil and natural gas prices. Most studies assume linearity in price behavior, and some do not account for the dynamic nature of fuel prices. The volatility is assumed to be constant in extant studies. Therefore, the study, in line with the approach of the regime-switching model applied in energy literature, can identify the tranquil and crisis periods through different variances with the significant role of monetary policy stance in regulating fuel prices. The study has used call money and forward premia as monetary policy indicators to assess their role in regulating fuel prices. The study's outcome is a valuable contribution to the existing body of literature on commodity markets and monetary policy, wherein implications of regulatory intervention through the demand side can be ascertained.

Limitations of the Study and Scope for Further Research

The study has undertaken a limited period of monthly data for analysis, which may not be appropriate for drawing any definitive conclusion. Therefore, the model may be used for a considerable period and shorter frequency data series to identify the trend of oil and natural gas prices. Similarly, the same model can be used for other consumer commodities traded in the future market to see the impact on prices and market inflation rate. This study has scope for future researchers in several ways. For a better understanding, a study can be conducted to include thematic indices in commodity exchange platforms. Furthermore, comparative analysis can include commodity exchanges of other emerging economies. Moreover, the sampled study period can include the effect of other asset classes on spot fuel prices.

Authors' Contribution

In addition to doing a literature study and editing the initial manuscript, Dr. Koustubh Kanti Ray participated in the final analysis. Along with helping to write the paper, he oversaw the data collection. Dr. Chandrabhanu Das was responsible for the study's design, data collecting, preliminary analysis, and paper preparation. The conclusions, implications, and findings sections of the work were co-written and discussed by both authors.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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References

Aleem, A. (2010). Transmission mechanism of monetary policy in India. *Journal of Asian Economics, 21*(2), 186–197. https://doi.org/10.1016/j.asieco.2009.10.001

Askari, H., & Krichene, N. (2010). An oil demand and supply model incorporating monetary policy. *Energy, 35*(5), 2013–2021. https://doi.org/10.1016/j.energy.2010.01.017

Balcilar, M., Gungor, H., & Hammoudeh, S. (2015). The time-varying causality between spot and futures crude oil prices: A regime switching approach. *International Review of Economics & Finance, 40*, 51–71. https://doi.org/10.1016/j.iref.2015.02.008

Beckmann, J., & Czudaj, R. (2013). Oil prices and effective dollar exchange rates. *International Review of Economics & Finance, 27*, 621–636. https://doi.org/10.1016/j.iref.2012.12.002

Bhar, R., & Malliaris, A. G. (2011). Oil prices and the impact of the financial crisis of 2007–2009. *Energy Economics, 33*(6), 1049–1054. https://doi.org/10.1016/j.eneco.2011.01.016

Bicchal, M. (2010). *Monetary policy and inflation in India: A structural VAR analysis.* Available at SSRN. https://dx.doi.org/10.2139/ssrn.1813886

Calomiris, C. W., & Mamaysky, H. (2019). *Monetary policy and exchange rate returns: Time-varying risk regimes* (NBER Working Paper No. 25714). National Bureau of Economic Research. https://doi.org/10.3386/w25714

Faniband, M. (2020). The behaviour of trading volume : Evidence from money market instruments. *Indian Journal of Finance, 14*(8–9), 69–79. https://doi.org/10.17010/ijf/2020/v14i8-9/154949

Geng, J.-B., Ji, Q., & Fan, Y. (2016). The impact of the North American shale gas revolution on regional natural gas markets: Evidence from the regime-switching model. *Energy Policy, 96,* 167–178. https://doi.org/10.1016/j.enpol.2016.05.047

Gupta, K., & Ahmed, S. (2019). Capital mobility in India : Does sterilization matter? *Indian Journal of Finance, 13*(4), 47–60. https://doi.org/10.17010/ijf/2019/v13i4/143127

Hamilton, J. D. (2008). Oil and the macroeconomy. In, *The New Palgrave Dictionary of Economics* (pp. 1–7). Palgrave Macmillan. https://doi.org/10.1057/978-1-349-95121-5_2119-1

Jarociński, M. (2010). Responses to monetary policy shocks in the east and the west of Europe: A comparison. *Journal of Applied Econometrics, 25*(5), 833–868. https://doi.org/10.1002/jae.1082

Ji, Q. (2012). System analysis approach for the identification of factors driving crude oil prices. *Computers & Industrial Engineering, 63*(3), 615–625. https://doi.org/10.1016/j.cie.2011.07.021

Kasekende, L., & Brownbridge, M. (2011). Post-crisis monetary policy frameworks in Sub-Saharan Africa. *African Development Review, 23*(2), 190–201. https://doi.org/10.1111/j.1467-8268.2011.00280.x

Kesicki, F. (2010). The third oil price surge – What's different this time? *Energy Policy, 38*(3), 1596–1606. https://doi.org/10.1016/j.enpol.2009.11.044

Kormilitsina, A. (2011). Oil price shocks and the optimality of monetary policy. *Review of Economic Dynamics, 14*(1), 199–223. https://doi.org/10.1016/j.red.2010.11.001

Koziuk, V. (2016). Independence of central banks in commodity economies. *Visnyk of the National Bank of Ukraine, 235*, 6–25. https://doi.org/10.26531/vnbu2016.235.006

Lakshmanasamy, T. (2021). The causal relationship between volatility in crude oil price, exchange rate, and stock price in India: GARCH estimation of spillover effects. *Indian Journal of Research in Capital Markets, 8*(3), 8–21. https://doi.org/10.17010/ijrcm/2021/v8i3/167954

Liang, T., Chai, J., Zhang, Y.-J., & Zhang, Z. G. (2019). Refined analysis and prediction of natural gas consumption in China. *Journal of Management Science and Engineering, 4*(2), 91–104. https://doi.org/10.1016/j.jmse.2019.07.001

Mishra, A. (2019). Foreign exchange, gold, and real estate markets in India: An analysis of return volatility and transmission. *Indian Journal of Finance, 13*(7), 50–64. https://doi.org/10.17010/ijf/2019/v13i7/145535

Mueller, P., Tahbaz-Salehi, A., & Vedolin, A. (2017). Exchange rates and monetary policy uncertainty. *The Journal of Finance, 72*(3), 1213–1252. https://doi.org/10.1111/jofi.12499

Nirmala, S., & Deepthy, K. (2018). Volatility modeling of commodity markets in India: Application of selected GARCH models. *Indian Journal of Research in Capital Markets, 5*(4), 27–37. https://doi.org/10.17010/ijrcm/2018/v5/i4/130137

Rajan, R. S., & Yanamandra, V. (2015). Effectiveness of monetary policy in India: The interest rate pass-through channel. In, *Managing the macroeconomy* (pp. 40–73). Palgrave Macmillan. https://doi.org/10.1057/9781137534149_2

Rai, S. K., & Sharma, A. K. (2022). Do lagged terms affect exchange rate volatility in India? An analysis using ARIMA Model. *Indian Journal of Finance, 16*(10), 8–23. https://doi.org/10.17010/ijf/2022/v16i10/172385

Reboredo, J. C. (2012). Modelling oil price and exchange rate co-movements. *Journal of Policy Modeling, 34*(3), 419–440. https://doi.org/10.1016/j.jpolmod.2011.10.005

Salisu, A. A., Isah, K. O., Oyewole, O. J., & Akanni, L. O. (2017). Modelling oil price-inflation nexus: The role of asymmetries. *Energy, 125,* 97–106. https://doi.org/10.1016/j.energy.2017.02.128

Sarkodie, S. A., Crentsil, A. O., & Owusu, P. A. (2019). Does energy consumption follow asymmetric behavior? An assessment of Ghana's energy sector dynamics. *Science of the Total Environment, 651*(Part 2), 2886–2898. https://doi.org/10.1016/j.scitotenv.2018.10.147

Seth, N., & Sidhu, A. (2021). Price discovery and volatility spillover for Indian energy futures market in the pre- and post-crisis periods. *Indian Journal of Finance, 15*(8), 24–39. https://doi.org/10.17010/ijf/2021/v15i8/165816

Simo-Kengne, B. D., Balcilar, M., Gupta, R., Reid, M., & Aye, G. C. (2013). Is the relationship between monetary policy and house prices asymmetric across bull and bear markets in South Africa? Evidence from a Markov-switching vector autoregressive model. *Economic Modelling, 32*, 161–171. https://doi.org/10.1016/j.econmod.2013.02.006

Syed, A. A., & Tripathi, R. (2020). Macroeconomic vulnerabilities and their effect on nonperforming loans in Indian commercial banks. *Indian Journal of Finance, 14*(2), 34–49. https://doi.org/10.17010/ijf/2020/v14i2/150555

Syed, A. A., Tripathi, R., & Deewan, J. (2021). Investigating the impact of the first and second waves of the COVID - 19 pandemic on the Indian stock and commodity markets : An ARDL analysis of gold, oil, and stock market prices. *Indian Journal of Finance, 15*(12), 8–21. https://doi.org/10.17010/ijf/2021/v15i12/167306

Taghizadeh-Hesary, F., & Yoshino, N. (2014). Monetary policies and oil price determination: An empirical analysis. *OPEC Energy Review, 38*(1), 1–20. https://doi.org/10.1111/opec.12021

Taghizadeh-Hesary, F., & Yoshino, N. (2016). Which side of the economy is affected more by oil prices: Supply or demand? In, N. Yoshino & F. Taghizadeh-Hesary (eds.), *Monetary policy and the oil market* (pp. 29–53). ADB Institute Series on Development Economics. Springer. https://doi.org/10.1007/978-4-431-55797-5_3

Temkeng, S. D., & Fofack, A. D. (2021). A Markov-switching dynamic regression analysis of the asymmetries related to the determinants of US crude oil production between 1982 and 2019. *Petroleum Science, 18*(2), 679–686. https://doi.org/10.1007/s12182-021-00549-y

Thach, N. N., Linh, N. T., Hac, L. D., Ngoc, L. T., & Hai, D. H. (2022). Specific macro factors affecting economic growth during the COVID-19 pandemic: Evidence from EAGLEs. *Indian Journal of Finance, 16*(3), 8–27. https://doi.org/10.17010/ijf/2022/v16i3/168700

Tiwari, A. K., & Albulescu, C. T. (2016). Oil price and exchange rate in India: Fresh evidence from continuous wavelet approach and asymmetric, multi-horizon Granger-causality tests. *Applied Energy, 179,* 272–283. https://doi.org/10.1016/j.apenergy.2016.06.139

Verleger, P. K. (2011). The margin, currency, and the price of oil. *Business Economics, 46*(2), 71–82. https://doi.org/10.1057/be.2011.3

Wang, Y. S., & Chueh, Y. L. (2013). Dynamic transmission effects between the interest rate, the US dollar, and gold and crude oil prices. *Economic Modelling, 30,* 792–798. https://doi.org/10.1016/j.econmod.2012.09.052

Zhu, H., Su, X., You, W., & Ren, Y. (2017). Asymmetric effects of oil price shocks on stock returns: Evidence from a two-stage Markov regime-switching approach. *Applied Economics, 49*(25), 2491–2507. https://doi.org/10.1080/00036846.2016.1240351

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