

## Dynamic regime switching behaviour between cash and futures market: A case of interest rates in India

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**Abstract.** *This study examines the Markov dynamic regime switching behaviour between cash and futures market in respect to interest rate in India. The study uses daily data of volumes, weighted average price, weighted average yield for cash market and total values, open interest, settlement price from 21st January 2014 to 30th October 2014. We a contract i.e. 883GS2023 of NSE has been used for our analysis. All data are sourced from Clearing Corporation of India Ltd. (CCIL) and National Stock Exchange (NSE). We have run regime switching regression to capture the switching behaviour in bull as well as bear state of cash to future and future to cash in six different equations. This model also captures the estimated probability and estimated duration to continue in bull and bear state and does not require to test stationarity or conversion of data into any normalised form. We find switching behaviour in both cash is regime switching the future as well as future is regime switching the cash market and the estimated probability differs from 70% to 97% in different cases. The estimated duration to continue in an existing state has also been captured in 6 different equations.*

**Keywords:** Govt. Securities, Interest Rate Futures (IRF), Markov Dynamic Regime Switching Model.

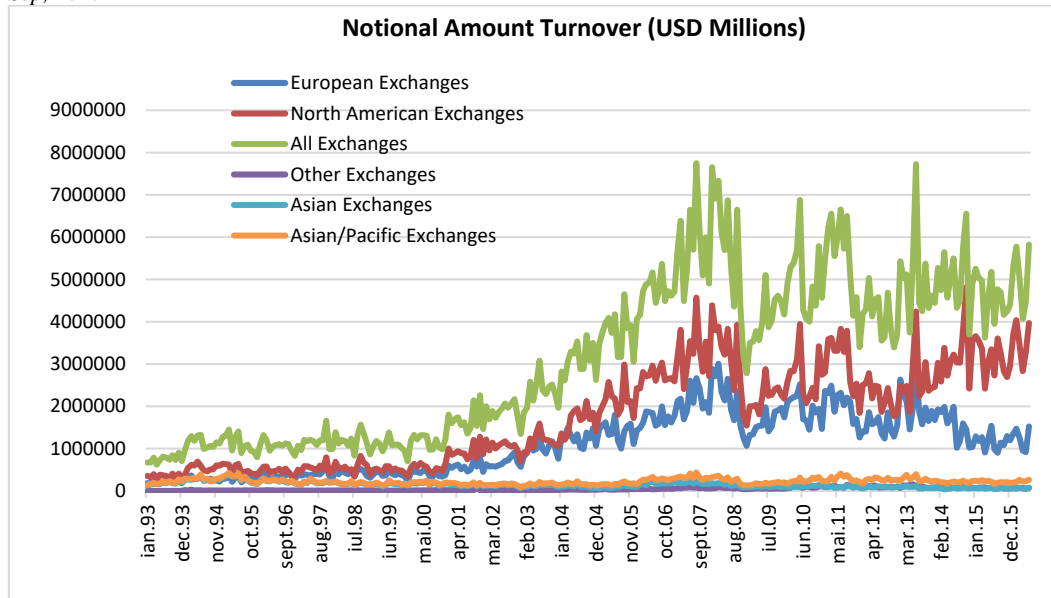
**JEL Classification:** C58, G12, G13.

## Introduction

Investors use interest rate derivative to hedge against interest rate risk. Among all derivative instruments, Interest Rate Futures (IRF) are the most popular derivative products available in the market across globe (see Figure 1 and Figure 2). Chicago Mercantile Exchange (CME) is the first exchange introduced IRF in the year 1981. This product is popular in developed markets compared to developing markets. In India, IRF has failed when it was introduced in 2003 as well as in 2009. Again it was introduced in the year 2014 for the third time (MSEI formerly MCX-SX introduced on 20th January 2014, NSE on 21st January 2014 and BSE on 28th January 2014), and this time the trading volume in the NSE was observed high among all the three exchanges (Panda and Thiripalraju, 2015). In India the underlying for the interest rate futures contract are the treasury securities. As per the regulatory provisions the interest rate future contracts on exchange platform are allowed on the liquid treasury securities in the maturity range of 5 years, 10 years and 15 years and also on 91 days treasury securities.

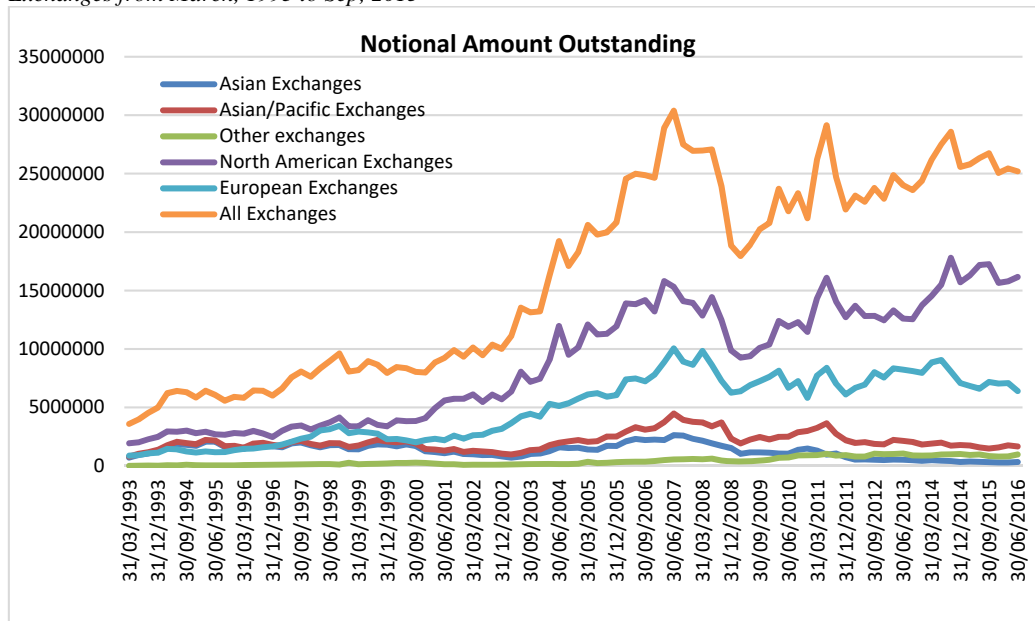
A perennial issue among investors, policy makers and market participants is whether future market leads cash market or cash market leads futures market? Although several empirical studies exists to understand the behaviour of equity/commodity/index/ currency cash and futures market, but there is no focus or less focus in the literature on the interest rate futures in Indian context. Empirical studies found that the futures market leads cash market (Oellermann and Farris, 1985; Oellermann et al., 1989; Chaihetphon and Pavabutr, 2010; Kumar and Arora, 2011 and Arora and Kumar, 2013). In case of equity cash and futures market empirical results found that the futures market leads cash market (Chan, 1992; Raju and Karande, 2003; Gupta and Singh, 2007 and Gupta and Singh, 2009). This study is an attempt to understand the regime switching behaviour of interest rate cash and futures market in India. Panda and Thiripalraju (2015) evaluated the rise and fall of interest rate futures (IRF) in Indian derivative market presenting three different cases like 2003, 2009 and 2014. The study used trend analysis of 2014 IRFs for three different exchanges like BSE, NSE and MCX-SX results found that NSE IRFs volume was higher than BSE and MCX\_SX in the Indian derivative market. Sahoo and Panda (2016) found interest rate cash market price leads the futures market but the future settlement price has impact on the yield of the underlying security by considering the most liquid contract of NSE.

**Figure 1.** Notional Amount Turnover (USD Millions) of Interest Rate Derivative Contracts from Jan, 1993 to Sep, 2015



Source: Bank for International Settlement (BIS).

**Figure 2.** Notional Amount Outstanding (OI) (USD Millions) of Interest Rate Derivative contracts of All Exchanges from March, 1993 to Sep, 2015



Source: Bank for International Settlement (BIS).

Most of the studies are based on interest rate futures relating to developed markets. Possibly usage concentration of interest rate derivative is more in developed countries in comparison to developing countries.

## Review

In a study, Poon et al. (1998) found that the suspension of trading in Shanghai Treasury bond futures had a positive impact on the market liquidity of both A and B shares traded on both Shanghai and Shenzhen Stock Exchanges. Brewer et al. (2000) found a positive relationship between usage of interest rate derivatives by banks and the growth in bank lending's. Kuttner (2000) found a strong relationship between surprise policy actions and market interest rates, but response to anticipated policy actions is small. Choi and Finnerty (2006) depicted a strong correlation among the interest rates of T-Bonds and the fund rate. Zhou (2007) found Fed affecting the interest rates market through a policy of changing in the funds rate target by a fixed amount for the foreseeable future. Hyde (2007) found the sensitivity of stock returns at the industry level to interest rate risk was observed mainly in Germany and France. Purnanandam (2007) finds banks which use derivatives for interest rate risk management are more comfortable during the events of external shocks. Debasish (2009) finds no significant volatility Spill-over from futures to spot market on NSE Nifty. Park and Choi (2011) finds interest rate sensitivity of US property/liability insurer stock returns to be time varying and is closely related to the underwriting cycle or performance of the insurance industry. In Indian case there exist two studies to the best of our knowledge. Those are, Panda and Thiripalraju (2015) evaluate the rise and fall of interest rate futures (IRF) in Indian derivative market pertaining three different cases like 2003, 2009 and 2014 and find NSE IRFs volume is higher in the Indian derivative market. Sahoo and Panda (2016) examine the price discovery process in the interest rate cash and futures market for India. The study employ correlation, regression and AR (1) GARCH (1, 1) spillover model to capture the spillover effect between cash and futures market. The study finds, in most of the cases cash market leads the futures market.

Based on the above literature, we find most of the research on interest rate derivatives have been done in developed markets. But in case of emerging markets like India the study on IRF are very few and none of them have attempted to capture switching behaviour of cash and futures market. The objective of this study is to measure the regime switching behaviour between interest rate cash and futures market by using Markov Regime Switching model.

## Data and model

**Data.** For our analysis we have considered the most liquid treasury security in the 10 year maturity horizon i.e. 883 GS 2023 (GS = Government Securities). We sourced all futures market data from National Stock Exchange (NSE) and all cash market data from Clearing Corporation of India Ltd. (CCIL). The period of our study covers from 21<sup>st</sup> January 2014 to 30<sup>th</sup> October 2014 with total of 182 daily observations (trading days). We considered three variables from the futures market such as daily settlement price, value/volume of contracts traded and open interest and three variables from the cash market such as weighted average price, total volume and weighted average yield for our analysis.

**Model.** Regime switching models match the tendency of financial markets which often changes its behaviour and the new behaviour associated with financial variables that persists for longer period after this change. The reasons behind popularity of regime

switching model in financial modelling are as follows. First, the idea of regime is natural and intuitive. Second, these models parsimoniously capture stylized behaviour of many financial return series including Fat tails, persistently occurring periods of turbulence followed by periods of low volatility (ARCH Effects), skewness and time-varying correlations. Finally, regime switching models are capable to capture non-linear stylized dynamics of asset returns in a framework based on linear specifications, or conditionally normal or log normal distributions within as regime (Ang and Diego, 2011).

The regime switching models in interest rate have been used by several researchers since 1988. Hamilton (1988), Sola and Driffill (1994), Gray (1996).

### Markov switching dynamic regression model

The Markov Switching model or regime switching model was proposed by Hamilton (1989) in his work on business cycle recession and expansions and the regime naturally captured economic activity cycles around a long term trend. This model characterizes the time series behaviour in different regimes of the selected variables involving multiple equations. This model captures more complex dynamics of the variables allowing them to switch between these regimes. The model control the switching behaviour by an unobservable state variable that follows first order Markov chain process and it explains the correlated data which exhibits dissimilar dynamic patterns during various time periods.

$$\text{State 1: } y_t = \mu_1 + \varepsilon_t \quad (1)$$

$$\text{State 2: } y_t = \mu_2 + \varepsilon_t \quad (2)$$

Where,  $\mu_1, \mu_2$  are the intercepts of state 1 and state 2 equations respectively and  $\varepsilon_t$  is the white noise term with variance  $\sigma^2$ . If the  $s_t$  is the timing of switches then the equations is expressed as follows:

$$y_t = s_t \mu_1 + (1 - s_t) \mu_2 + \varepsilon_t \quad (3)$$

Where,  $s_t$  is 1 if the process state is one other wise 2. It is difficult to infer the process state by knowing the intercept. This model allows the parameters to change over the states. Markov-switching dynamic regression model with state dependent intercept is expressed as follows:

$$y_t = \mu_{s_t} + \varepsilon_t \quad (4)$$

If  $s_t = 1$ , then  $\mu_{s_t} = \mu_1$ , if  $s_t = 2$ , then  $\mu_{s_t} = \mu_2$ , where  $\mu_{s_t}$  is an intercept parameter. The transition probabilities are of great interest and it can be expressed as  $p_{s, s+1}$  in Markov Switching regression. In two states process,  $P_{11}$  denotes the probability of remaining in state 1 in the next period, given that the state is 1 at current period. If the value is close to 1 then it is expected to stay in state 1 for a long time or process is said to be persistent.

Markov-Switching Dynamic Regression with exogenous variables is expressed as follows:

$$y_t = \mu_{s_t} + X_t \alpha + Z_t \beta_{s_t} + \varepsilon_t \quad (5)$$

Where,  $\mu_{s_t}$  is a time dependent intercept,  $y_t$  is a dependent variable,  $X_t$  is a vector of exogenous variables with state invariant parameter  $\alpha$ ,  $Z_t$  is a vector of exogenous variable

with state dependent variable  $\beta_{st}$ . Here  $X_t$  and  $Z_t$  can include lag of dependent variable  $y_t$ . The error term  $\varepsilon_s$  is independent and identically distributed with mean zero and error variance  $\sigma^2$ .

Transition probability from one state to other can be expressed in K x K matrix

$$P = \begin{bmatrix} p_{11} & \dots & p_{1k} \\ \vdots & \ddots & \vdots \\ p_{1k} & \dots & p_{kk} \end{bmatrix}$$

The probability of the state  $s_t$  is equal to  $j$ , where  $j = \{1, \dots, k-1\}$ , is dependent on the most recent realized value of  $s_{t-1}$  and can be expressed as

$$\Pr (s_t = j \mid s_{t-1} = i) = p_{ij}$$

$P$  is non-negative and sum of each column equal to 1.

$$p_{ij} = \frac{\exp(-q_{ij})}{1 + \exp(-q_{i1}) + \dots + \exp(-q_{ij})}$$

$$p_{ik} = \frac{1}{1 + \exp(-q_{i1}) + \dots + \exp(-q_{ij})}$$

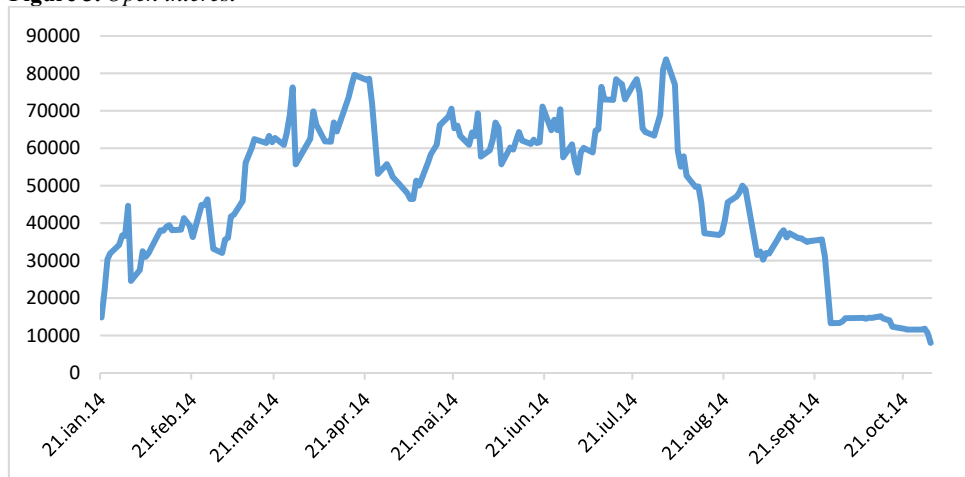
Where  $j \in (1, \dots, k-1)$  and transmitted parameter  $q$  can be computed as

$$q_{ij} = - \left( \frac{p_{ij}}{p_{ik}} \right)$$

### Empirical result

The regime switching behaviour from cash to futures and futures to cash markets are given below.

**Figure 3.** Open interest



From Figure 3 of open interest, we find January and June periods were characterized by periods of high prices while other periods displaying moderate to low prices. Thus, two regime dynamic regression models seem to be reasonable. The Markov dynamic regression model also supported two regimes for the selected data.

The estimates of the two states dynamic regression model results are presented in the following table.

**Table 1.** Markov switching dynamic regression model: dependent variable-open interest

Variable	State1			State2		
	Coefficient	SE	P value	Coefficient	SE	P value
Total volume	5.512324	.3765475	0.000	-2.949145	.5336494	0.000
Wtdavg price	1773.28	5680.941	0.755	66578.06	1426.745	0.000
Mean	133274	586473.8	0.820	6536314	143350.5	0.000
Sigma	37149.71	1440.332				
P11	.9712535	.0066312				
P12	.0287465	.0066312				
P21	.0394168	.0072161				
P22	.9605832	.0072161				
State1 expected duration	90.3317					
State2 expected duration	80.1928					

Maximization algorithm has been used to estimate the Markov Regime Switching Dynamic model. The results in Table 1 reported the information about the regimes transition probabilities and its persistence.

The state 1 is associated with lower mean 133274 compared to state 2's mean value, which is 6536314. State 1 is low volatile state with low mean and state 2 is high volatile state with high mean. So, state 1 represent a bull market situation and state 2 can be considered as bear market situation. The two states dynamic regression model exhibit dissimilar dynamics across unobserved regimes using state dependent variables. The estimated coefficients in both the regimes are statistically significant and positive.

The result also suggests that total traded volume is significant and positive in state 1 that is bull market conditions. But total traded volume and weighted average prices are significant and positive during state2, that is bear market conditions. The regime switching probability matrix shows that the estimated probability that open interest in state 1 is 97% for the next period and assuming that the process is in state 1 in the current period. P12 is the estimated probability that the open interest rate shift to state 2 from the current state 1. The estimated probability value is 3%. P22 is the estimated probability of open interest rate to continue in state 2 in the next period and the estimated value is 0.96, and P21 indicates that the probability of shifting from state 2 to state 1 is 4%, assuming that the process is in state 1. The results infer that the state 1 and state 2 are highly persistent with 96% and 97% probabilities respectively.

Results also estimated the expected duration for these two states. The state 1, less volatile state is expected to continue for 90 days and state 2 which is high volatile state is expected to continue for 80 days.

The below Figure 4 presents the predicted values for the two states i.e. state 1 and state 2. These predicted values are one step ahead probabilities and weighted average values of

the state specific predictions. The state one predicted values are lower than the state 2 predicted values with low mean values. Which confirms that the state 1 is low volatile price market situation.

**Figure 4.** Comparison between the state1 and state 2 one-step a head predicted values

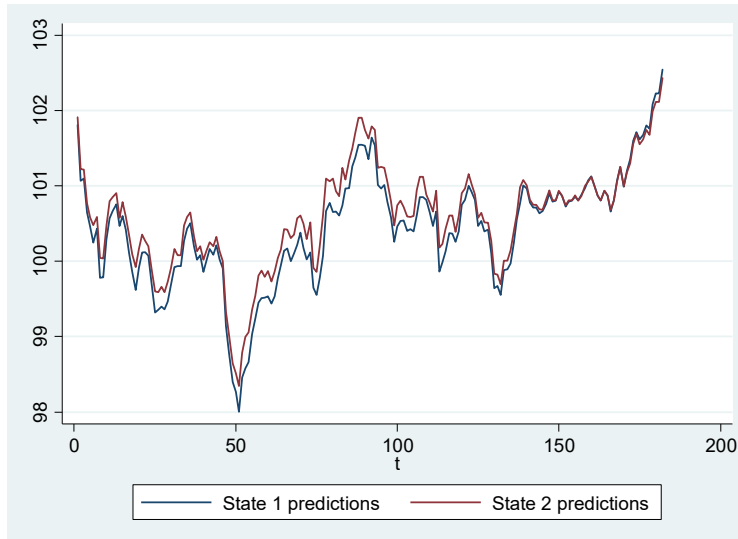
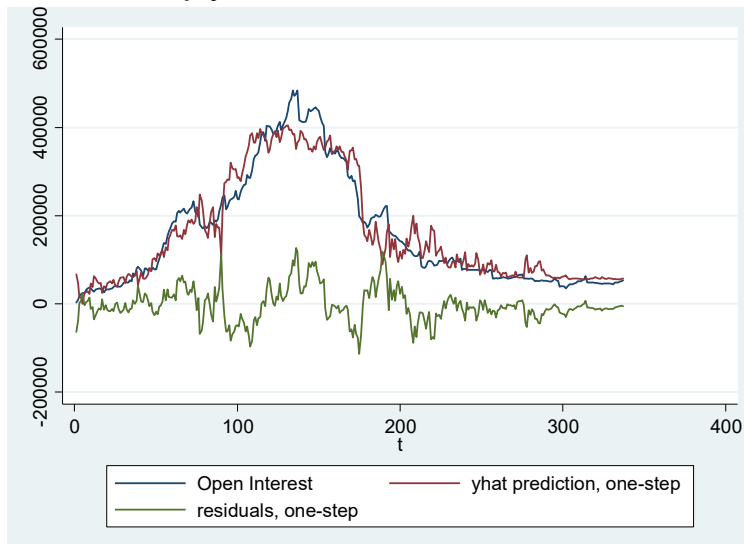


Figure 4 represents the model fitness by comparing fitted values of open interest rates.

**Figure 5.** Model fitness by comparing fitted values of open interest rates, residuals and actual values of open interest rates





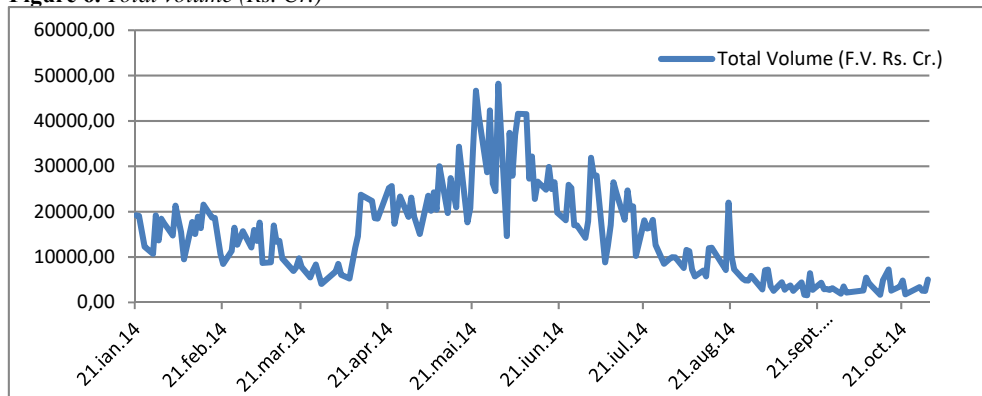
**Figure 6.** Total volume (Rs. Cr.)

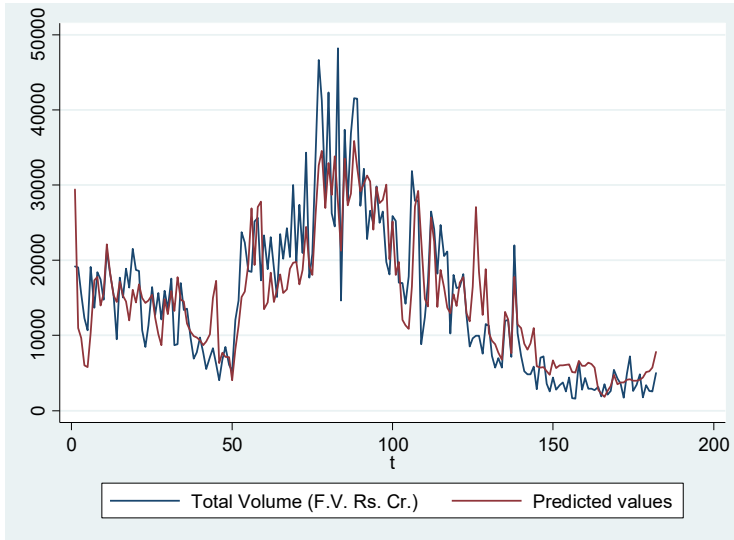
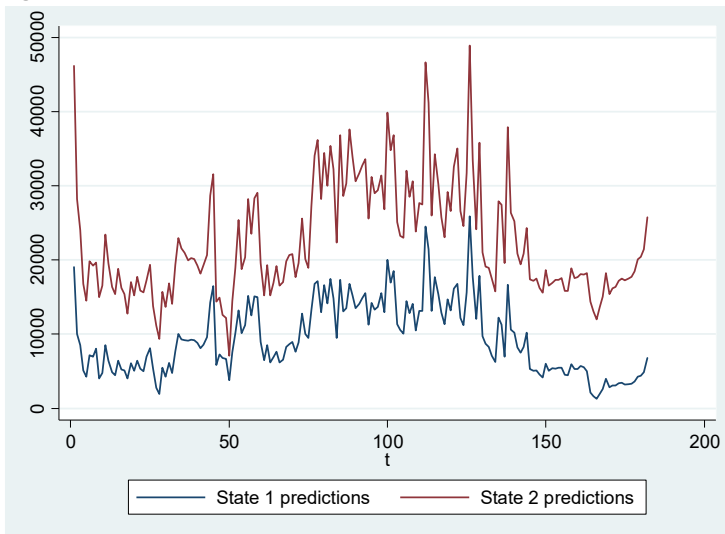
Table 2 presents regime switching behaviour of total volume. There are two states – state 1 and state 2. State 1 is associated with negative mean -225535.7 as compared to mean value of state 2 (-5590119). State 1 is high volatile state with high mean and state 2 is low volatile state with low mean. State 1 is regarded as bear market and state 2 can be regarded as bull market. Total contracts, open interest and near month settlement prices are positive and significant in both the states.

**Table 2.** Markov Switching dynamic regression model: Dependent Variable-Total Volume

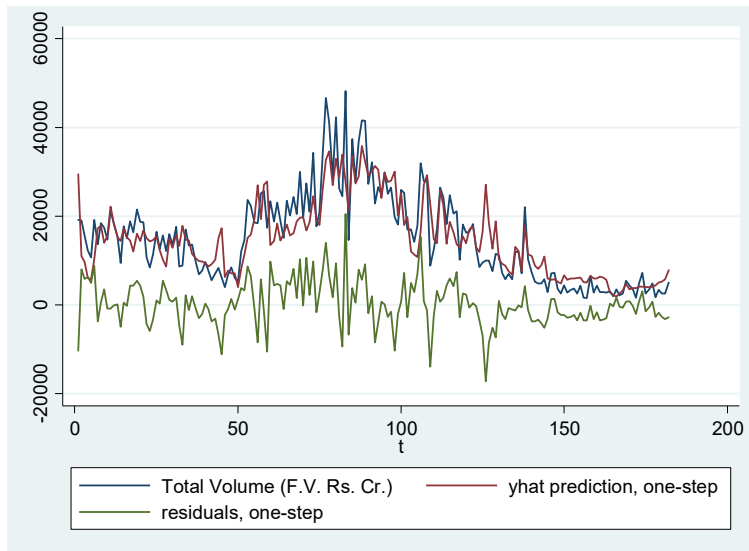
Variable	State1			State2		
	Coefficient	Standard error	P value	Coefficient	Standard error	P value
Total contracts	.0999006	.015428	0.000	.1808527	.0343266	0.000
Open interest	.1230078	.0340118	0.000	.1070402	.0605322	0.077
Near month daily settlement price	2235.634	951.7714	0.019	5658.031	749.1802	0.000
Mean	-225535.7	96733.08	0.020	-559011.9	74809.32	0.000
Sigma	4484.549	240.461				
P11	.9729385	.0159087				
P12	.0270615	.0159087				
P21	.0436271	.0226944				
P22	.9563729	.0226944				
State1 expected duration	36.95292					
State2 expected duration	22.92155					

The regime switching probability matrix indicates the estimated probability that total value in state 1 is 97% for the next period and assuming that the process is in state 1 in current period. P12 is the estimated probability that total value total value shift to state 2 from the current state 1 is 3%. The estimated probability that the total value to continue in state 2 in the next period is 96%. P21 depicts that the probability of shifting from state 2 to state 1 is 4% assuming that the process is in state 1. The result indicate the state 1 and state 2 are highly persistent with 97% and 96% probability respectively. The result also estimated that the expected duration for these two states. The state 1 which is more volatile is expected to continue for 27 days and state 2 which is less volatile is expected to continue for 5 days.

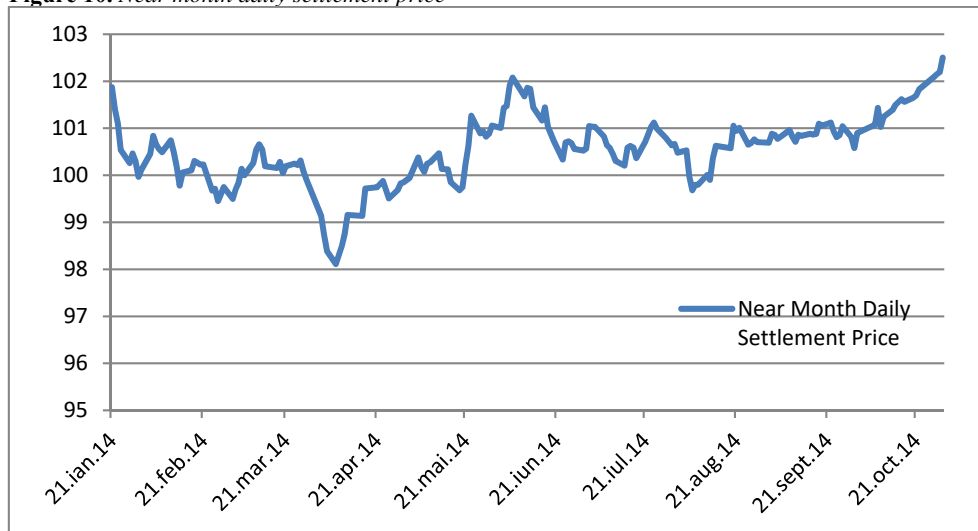
The below Figure 8 presents the predicted values for the two states i.e. state 1 and state 2. These predicted values are one step ahead probabilities and weighted average values of the state specific predictions. The state 1 predicted values are higher than the state 2 predicted values with high mean. Which confirms that the state 1 is more volatile price market situation.

**Figure 7.** Total volume and predicted values**Figure 8.** Comparison between the state1 and state 2 one-step a head predicted values

**Figure 9.** Model fitness by comparing fitted values of total volume, residuals and actual values of total volume



**Figure 10.** Near month daily settlement price

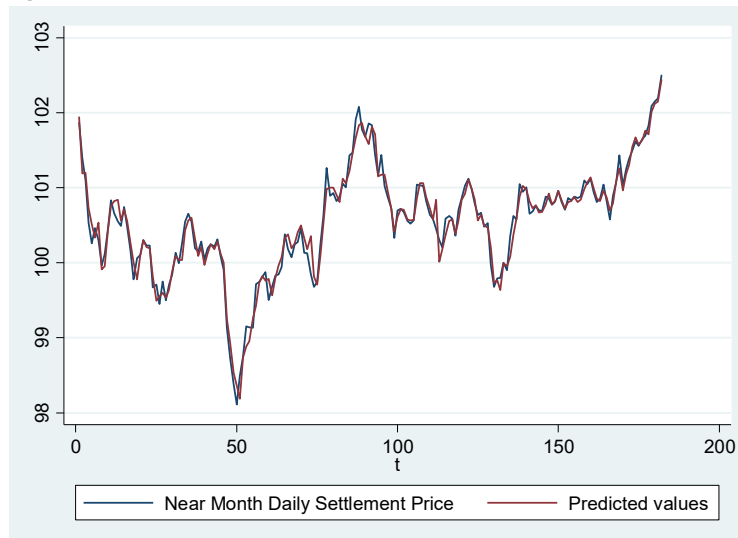


January to February and June to August is characterized by periods of high near month settlement prices and other periods are characterized by moderate to low near month settlement prices. This depicts that the application of two regime switching regression model is good. The Markov dynamic regression model also supported two regimes of the selected data. The estimates for two states dynamic regression model results are presented in Table 3.

**Table 3.** Markov Switching dynamic regression model: Dependent Variable - Near Month Settlement Price

Variable	State1			State2		
	Coefficient	Standard error	P value	Coefficient	Standard error	P value
Total volume	-.0000101	2.25e-06	0.000	1.60	9.47	0.092
Wtdavg price	1.080243	.0218325	0.000	.9814821	.0153321	0.000
Mean	-8.116148	2.198124	0.000	1.814773	1.539941	0.239
Sigma	.1006614	.0063092				
P11	.6880125	.1074249				
P12	.3119875	.1074249				
P21	.1231902	.0498823				
P22	.8768098	.0498823				
State1 expected duration	3.205257					
State2 expected duration	8.117526					

The results of information about the regimes transition probabilities and its persistence has been presented in Table 3. There are two states – state 1 and state 2. State 1 is associated with negative mean of -8.116 as compared to mean value of state 2 of 1.815. State 1 is low volatile state with low mean and state 2 is high volatile state with high mean. State 1 is regarded as bull market and state two can be regarded as bear market. The two states dynamic regression model exhibit dissimilar dynamics across unobserved regimes using state dependent variables. The estimated coefficient in both the variables are statistically significant. Result depicts total volume is negative and significant in bull market that is State 1 but weighted average price is significant and positive in this state. Total volume and weighted average price are positive and significant in bear market that is in state 2.

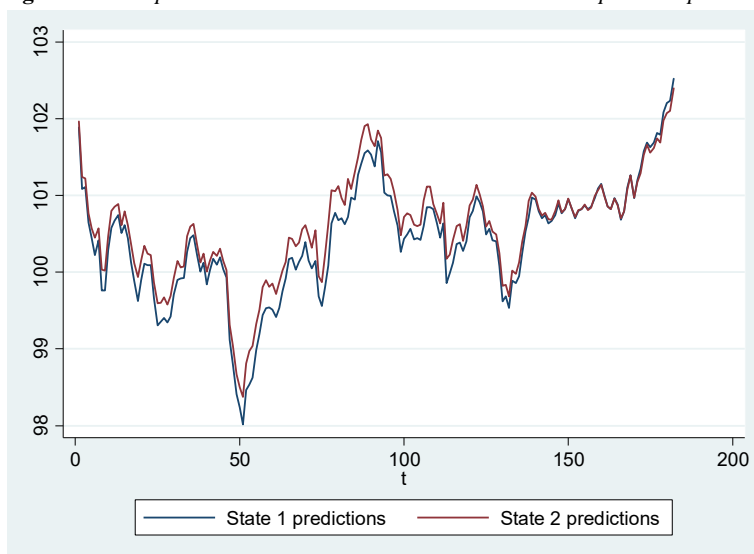
**Figure 11.** Comparison of near month settlement price and its predicted value

The regime switching probability matrix indicates the estimated probability that total value is in state 1 is 69% for the next period and assuming that the process is in state 1 in current period. P12 is the estimated probability that total value total value shift to state 2 from the current state 1 is 31%. The estimated probability that the total value to continue in state 2 in the next period is 88%. P21 depicts that the probability of shifting from state 2 to state 1 is

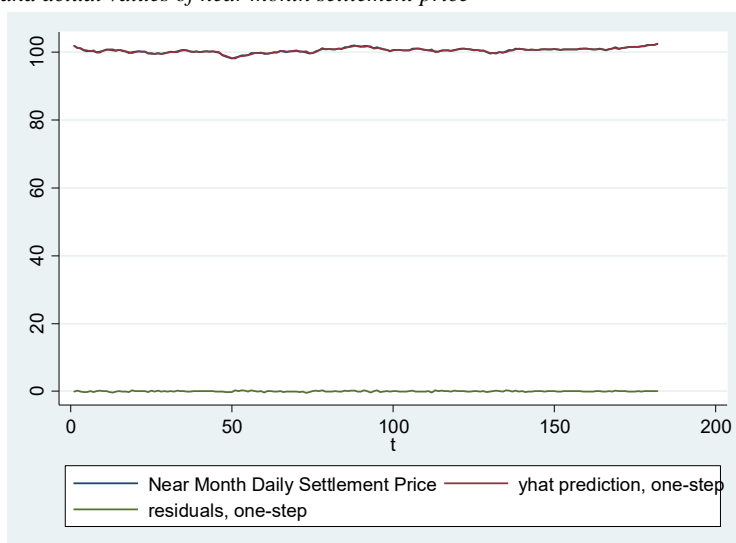
12% assuming that the process is in state 1. The result indicate the state 1 and state 2 are highly persistent with 69% and 88% probability respectively. The result also estimated that the expected duration for these two states. The state 1 which is less volatile is expected to continue for 3 days and state 2 which is more volatile is expected to continue for 8 days.

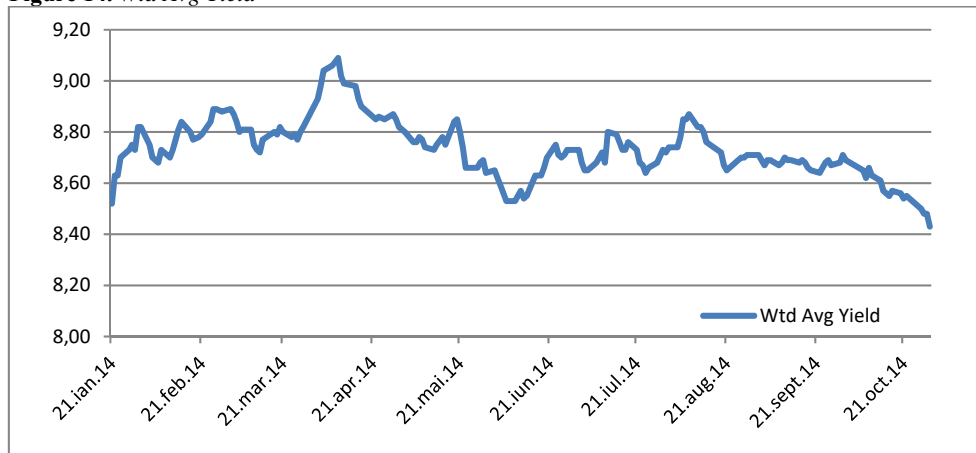
The below Figure 12 presents the predicted values for the two states i.e. state 1 and state 2. These predicated values are one step ahead probabilities and weighted average values of the state specific predictions. The state 1 predicated values are lower than the state 2 predicted values with low mean. Which confirms that the state 1 is less volatile price market situation.

**Figure 12.** Comparison between the state1 and state 2 one-step a head predicted values



**Figure 13.** Model fitness by comparing fitted values of total volume, residuals and actual values of near month settlement price



**Figure 14.** *Wtd Avg Yield*

January to May is characterized by periods of high near month settlement prices and other periods are characterized by moderate to low near month settlement prices. This depicts that the application of two regime switching regression model is good. The Markov dynamic regression model also supported two regimes of the selected data.

**Table 4.** *Markov switching dynamic regression model: dependent variable - Wtd Avg Yield*

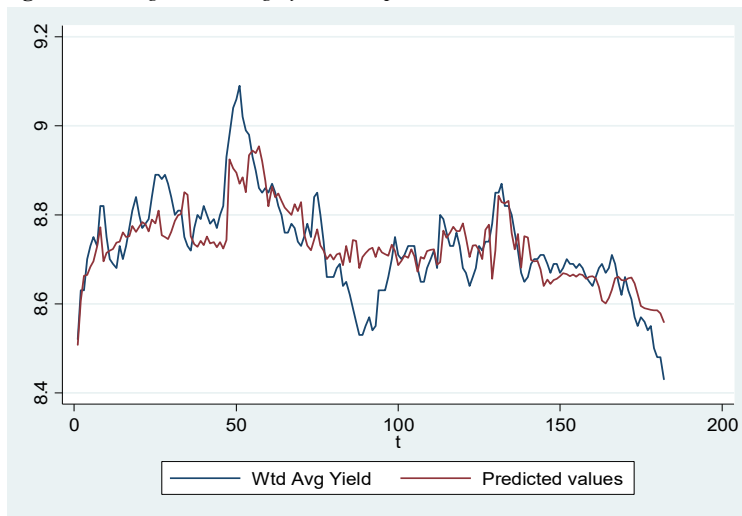
Variable	State1			State2		
	Coefficient	Standard error	P value	Coefficient	Standard error	P value
Open interest	3.15	5.68e-07	0.000	5.49	.561	0.000
Total value	-.0000337	.0000135	0.013	-.0000452	.0000166	0.006
Mean	8.544127	.026838	0.000	8.596584	.0244119	0.000
Sigma	.0655273	.0036401				
P11	.9664406	.0176092				
P12	.0335594	.0176092				
P21	.0527145	.0278579				
P22	.9472855	.0278579				
State1 expected duration	29.79795					
State2 expected duration	18.97011					

The results of information about the regimes transition probabilities and its persistence has been presented in Table 4. There are two states – state 1 and state 2. State 1 is associated with positive mean of 8.54 as compared to mean value of state 2 of 8.60. The mean value of these two states are slightly different. State 1 is low volatile state with low mean and state 2 is high volatile state with high mean. State 1 is regarded as bull market and state two can be regarded as bear market. The two states dynamic regression model exhibit dissimilar dynamics across unobserved regimes using state dependent variables. Result depicts total value is negative and significant in bull market as well as in bear market that is State 1 and state 2, but open interest is significant and positive in these two states.

The regime switching probability matrix indicates the estimated probability that weighted average yield is in state 1 is 97% for the next period and assuming that the process is in state 1 in current period. P12 is the estimated probability that total value total value shift to state 2 from the current state 1 is 3%. The estimated probability that the total value to

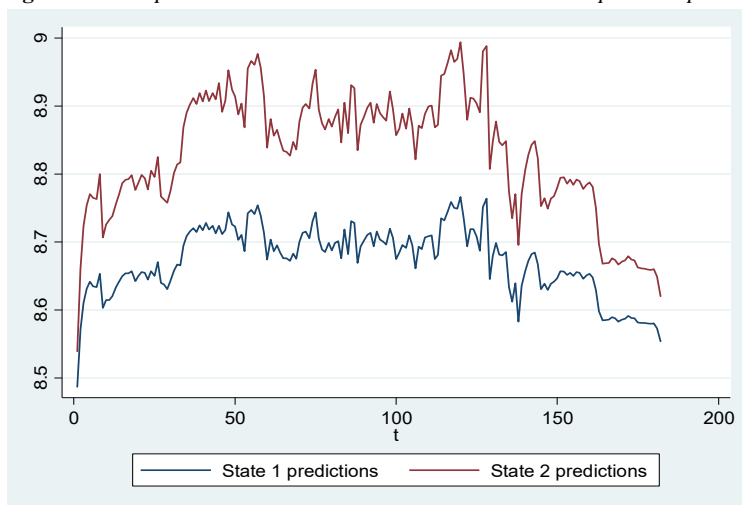
continue in state 2 in the next period is 95%. P21 depicts that the probability of shifting from state 2 to state 1 is 5% assuming that the process is in state 1. The result indicate the state 1 and state 2 are highly persistent with 97% and 95% probability respectively. The result also estimated that the expected duration for these two states. The state 1 which is less volatile is expected to continue for 30 days and state 2 which is more volatile is expected to continue for 19 days.

**Figure 15.** Weighted average yield and predicted values

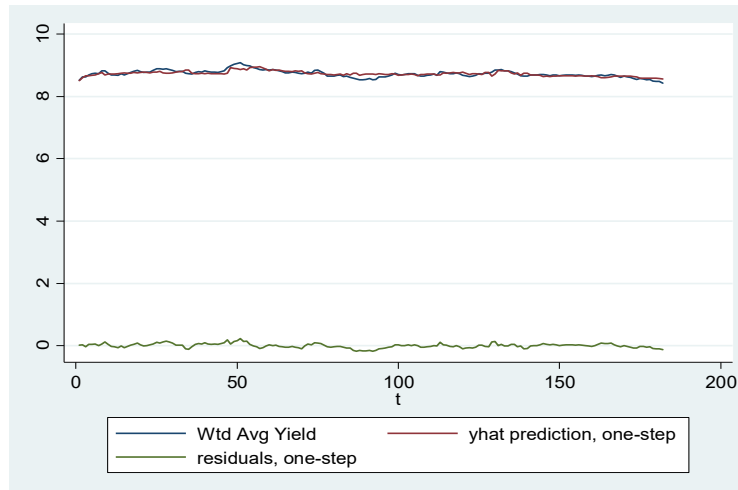


The below Figure 16 presents the predicted values for the two states i.e. state 1 and state 2. These predicted values are one step ahead probabilities and weighted average values of the state specific predictions. The state 1 predicted values are lower than the state 2 predicted values with low mean. Which confirms that the state 1 is less volatile weighted average yield market situation.

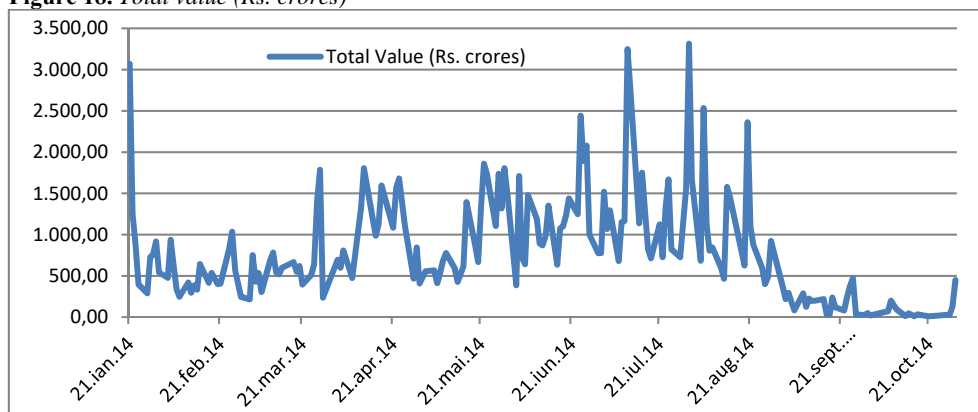
**Figure 16.** Comparison between the state1 and state 2 one-step a head predicted values



**Figure 17.** Model fitness by comparing fitted values of weighted average yield, residuals and actual values of weighted average yield



**Figure 18.** Total value (Rs. crores)



The period from March to August are characterized by high values while rest of the periods are display moderate to low prices. For this reason two regime dynamic regression model is suitable. The estimated results of two dimensions regime switching models are presented in Table 5.

**Table 5.** Markov switching dynamic regression model: dependent variable - total value

Variable	State1			State2		
	Coefficient	Standard error	P value	Coefficient	Standard error	P value
Total volume	.0346815	.0027543	0.000	.0730763	.0178753	0.000
Wtdavg price	-111.1784	45.07733	0.013	391.9498	185.2423	0.034
Mean	11342.86	4541.815	0.014	-38667.74	18379.46	0.035
Sigma	353.091	20.2935				
P11	.9626766	.0171197				
P12	.0373234	.0171197				
P21	.1989945	.118086				
P22	.8010055	.118086				
State1 expected duration	26.79286					
State2 expected duration	5.025264					



The results of information about the regimes transition probabilities and its persistence has been presented in Table 5. There are two states – state 1 and state 2. State 1 is associated with high positive mean 11342.86 as compared to mean value of state 2 (-38667.74). State 1 is high volatile state with high mean and state 2 is low volatile state with low mean. State 1 is regarded as bear market and state two can be regarded as bull market. The two states dynamic regression model exhibit dissimilar dynamics across unobserved regimes using state dependent variables. The estimated coefficient in both the variables are statistically significant. Result depicts total volume is positive and significant in bear market that is State 1 but weighted average price is significant and negative in this state. Total volume and weighted average price are positive and significant in bull market that is in state 2.

The regime switching probability matrix indicates the estimated probability that total value is in state 1 is 96% for the next period and assuming that the process is in state 1 in current period. P12 is the estimated probability that total value total value shift to state 2 from the current state 1 is 4%. The estimated probability that the total value to continue in state 2 in the next period is 80%. P21 depicts that the probability of shifting from state 2 to state 1 is 20% assuming that the process is in state 1. The result indicate the state 1 and state 2 are highly persistent with 96% and 80% probability respectively. The result also estimated that the expected duration for these two states. The state 1 which is more volatile is expected to continue for 27 days and state 2 which is less volatile is expected to continue for 5 days.

**Figure 19.** Total values and its predicted values

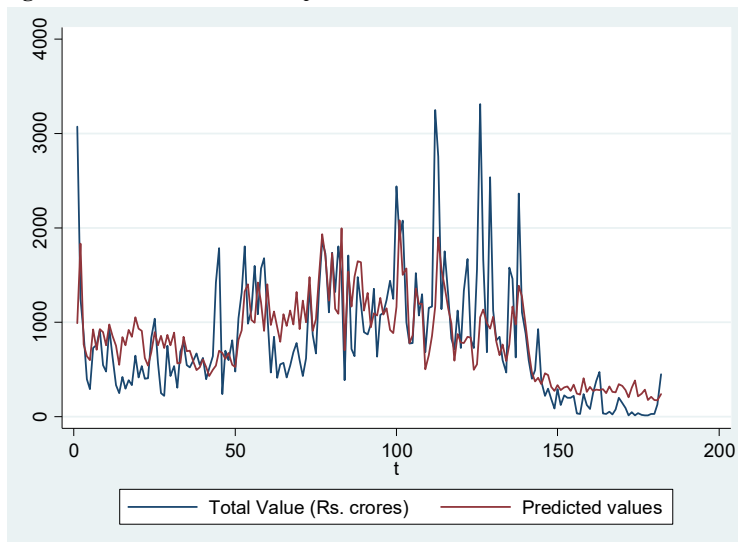
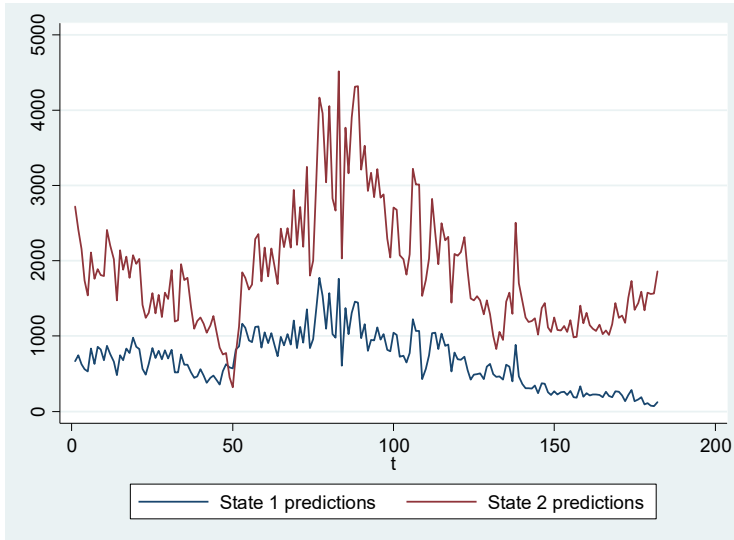
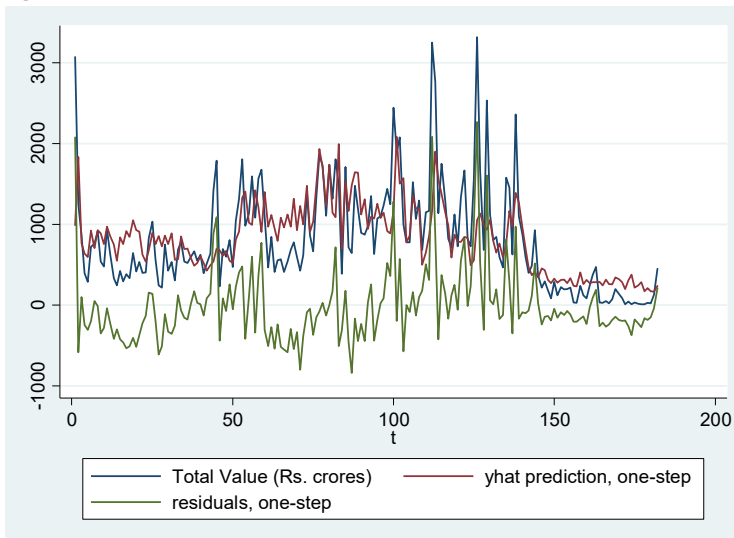
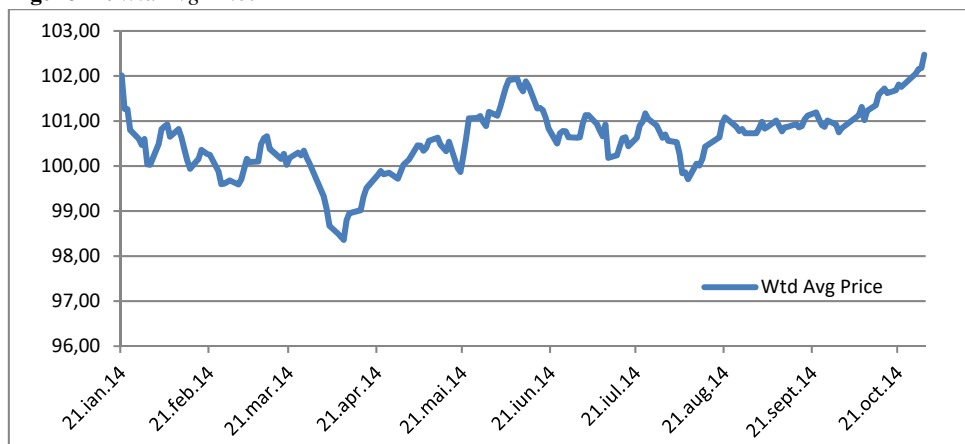


Figure 19 presents the predicted values for the two states i.e. state 1 and state 2. These predicted values are one step ahead probabilities and weighted average values of the state specific predictions. The state 1 predicted values are higher than the state 2 predicted values with high mean. Which confirms that the state 1 is more volatile price market situation. The model fits very well.

**Figure 20.** Comparison between the state1 and state 2 one-step ahead predicted values**Figure 21.** Model fitness by comparing fitted values of total value, residuals and actual values total value

**Figure 22.** *Wtd Avg Price*

From Figure 22, it is very clear that the series is exhibiting high volatility for few periods and for some periods it is showing low volatility. This depicts that the application of two regime switching regression model is good. The Markov dynamic regression model also supported two regimes of the selected data.

**Table 6.** *Markov Switching Dynamic Regression Model: Dependent Variable- Weighted Average Price*

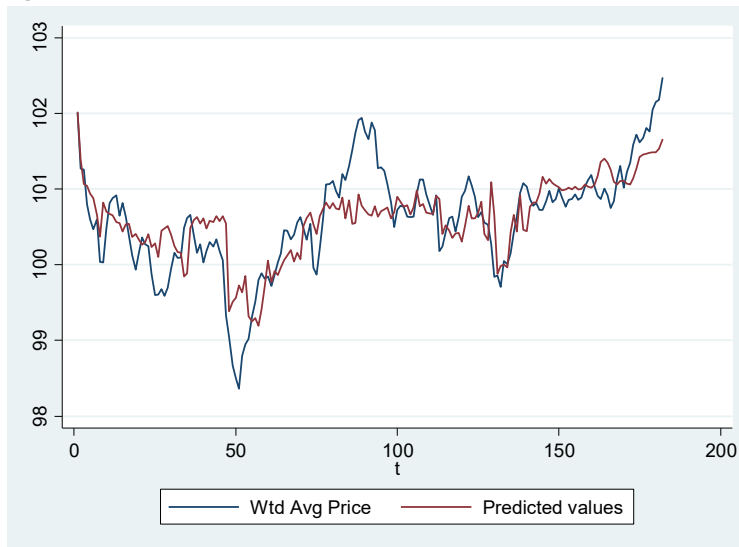
Variable	State1			State2		
	Coefficient	SE	P value	Coefficient	Standard error	P value
openinterest	-.0000348	.77e-06	0.000	-.000019	3.94e-06	0.000
totalvalue	.0002918	.0001095	0.008	.0002175	.0000844	0.010
Mean	101.4514	.1660495	0.000	101.736	.1973601	0.000
Sigma	.4192832	.0237948				
P11	.9460557	.0290047				
P12	.0539443	.0290047				
P21	.0325782	.0181579				
P22	.9674218	.0181579				
State1 expected duration	18.53764					
State2 expected duration	30.69537					

The results of information about the regimes transition probabilities and its persistence has been presented in Table 6. There are two states – state 1 and state 2. State 1 is associated with positive mean of 101.5 as compared to mean value of state 2 of 101.8. The mean value of these two states are slightly different. State 1 is low volatile state with low mean and state 2 is high volatile state with high mean. State 1 is regarded as bull market and state two can be regarded as bear market. The two states dynamic regression model exhibit dissimilar dynamics across unobserved regimes using state dependent variables. Result depicts open interest is negative and significant in bull market as well as in bear market that is State 1 and state 2 but the coefficients are very low. Total value is significant and positive in these two states.

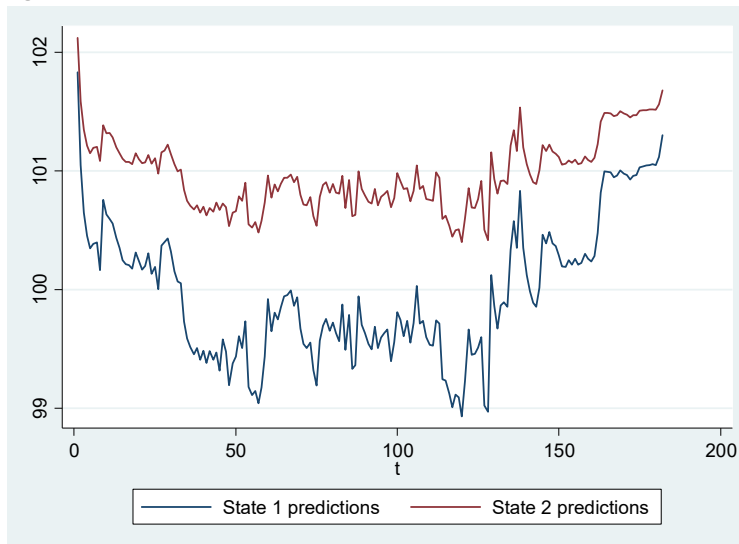
The regime switching probability matrix indicates the estimated probability that weighted average price is in state 1 is 95% for the next period and assuming that the process is in state 1 in current period. P12 is the estimated probability that weighted average price shift to state 2 from the current state 1 is 5%. The estimated probability that the weighted average price to continue in state 2 in the next period is 97%. P21 depicts that the

probability of shifting from state 2 to state 1 is 5% assuming that the process is in state 1. The result indicate the state 1 and state 2 are highly persistent with 97% and 95% probability respectively. The result also estimated that the expected duration for these two states. The state 1 which is less volatile is expected to continue for 30 days and state 2 which is more volatile is expected to continue for 19 days.

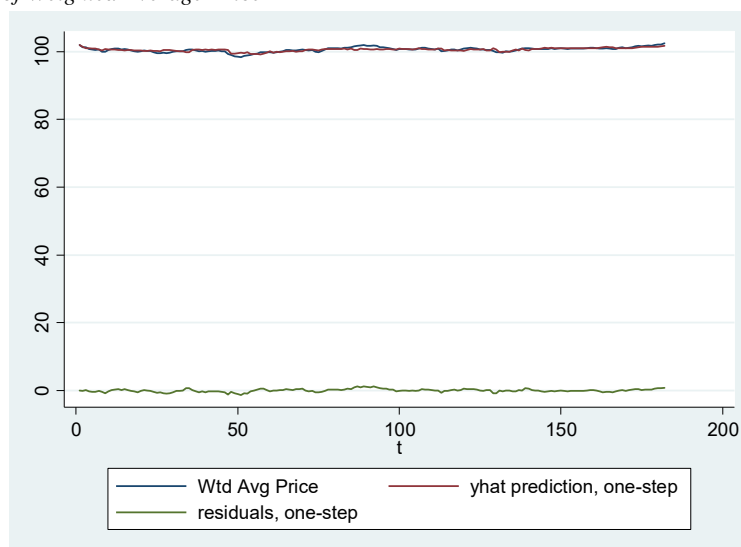
**Figure 23.** Weighted Average Price and its Predicted Values



**Figure 24.** Comparison between the state1 and state 2 one-step a head predicted values



**Figure 25.** Model fitness by comparing fitted values of Weighted Average Price, residuals and Actual values of Weighted Average Price



## Conclusion

Study relating to interest rate futures and cash market in India are a few. In this study we use daily data for interest rate cash market like- volumes, weighted average price, weighted average yield and for futures market - total values, open interest, settlement price from 21<sup>st</sup> January 2014 to 30<sup>th</sup> October 2014. We consider the most liquid and having longer period contract i. e. 840GS2024 of NSE for our analysis. All data are sourced from Clearing Corporation of India Ltd. (CCIL) and National Stock Exchange (NSE). We run regime switching regression to capture the switching behavior in bull as well as bear state of cash to future and future to cash in six different equations. This model also captures the estimated probability and estimated duration to continue in bull and bear state and does not require to test stationarity or to convert data into any normalise form. We find both cash is regime switching the future and future is regime switching the cash market and the estimated probability differs from 70% to 97% in different cases. The estimated duration to continue in an existing state has been captured in 6 different equations. This result will help investors of interest rate cash and futures in India.

## References

- Arora, S. and Kumar, N., 2013. Role of Futures market in price discovery. *Decision*, 40(3): 165-179
- Beg, A.R.M.B.A. and Anwar, S., 2012. Detecting Volatility Persistence in GARCH models in the presence of the Leverage Effect. *Quantitative Finance*, 14(12), pp. 2205-2213.
- Bollerslev, T., 1986. Generalised Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics*, 31(3), pp. 307-327.
- Brewer, III E., Minton, B.A. and Moser, J., 2000. Interest-rate derivatives and bank lending. *Journal of Banking and Finance*. 24, pp. 353-379.

- Chaihetphon, P. and Pavabutr, P., 2010. Price discovery in Indian gold futures market. *Journal of Economics and Finance*, 34(4), pp. 455-467
- Chan, K., 1992. A further analysis of the lead-lag relationship between the cash market and stock index futures market. *Review of Financial Studies*, 5(1), pp. 123-152
- Choi, H. and Finnerty, J., 2006. Impact study on the interest rate futures market. *The Quarterly Review of Economics and Finance*. 46, pp. 495-512.
- Debasish, S.S., 2009. Effect of futures trading on spot-price volatility: evidence for NSE Nifty using GARCH. *The Journal of Risk Finance*. 10(1), pp. 67-77.
- Dickey, D.A., and Fuller, W.A., 1979. Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*. 74(366), pp. 427-431.
- Engle, R.F., 2004. Risk and Volatility: Econometric Models and Financial Practice. *American Economic Review*. 94(3), pp. 405-420.
- Granger, C.W.J., 1969. Investigating Causal Relations by Econometric Models and Cross-Spectral Methods. *Econometrica*. 37(3), pp. 424-438.
- Granger, C.W.J., 1980. Testing for Causality: A personal Viewpoint. *Journal of Economic Dynamics and Control*. 2 (4) pp. 329-352.
- Gupta, K. and Singh, B., 2007. An examination of price discovery and hedging efficiency of Indian equity futures market. 10th Indian Institute of Capital Markets conference paper. Available at SSRN: <<http://ssrn.com/abstract=962002> or <http://dx.doi.org/10.2139/ssrn.962002>>
- Gupta, K. and Singh, B., 2009. Price discovery and arbitrage efficiency of Indian equity futures and cash markets. *NSE Research Paper*. <[www.nseindia.com/content/research/res\\_paper\\_final185.pdf](http://www.nseindia.com/content/research/res_paper_final185.pdf)>. Accessed on 23rd February 2016.
- Hyde, S., 2007. The response of industry stock returns to market, exchange rate and interest rate risks. *Managerial Finance*. 33(9), pp. 693-709.
- Kumar, N. and Arora, S., 2011. Price discovery in precious metals market: a study of gold. *International Journal of Financial management*, 1(1), pp. 49-58.
- Kuttner, K.N., 2001. Monetary policy surprises and interest rates: Evidence from the Fed funds futures market. *Journal of Monetary Economics*. 47(3), pp. 523-544.
- Oellermann, M.C. and Farris, P.L., 1985. Futures or cash: which market leads live beef cattle prices? *Journal of Futures Market*, 5(4), pp. 529-538.
- Panda, P., and Thiripalraju, M., 2015. Rise and fall of Interest Rate Futures in Indian Derivative Market. *International Journal of Financial Management*, 5(1), pp. 57-58.
- Park, J. and Choi, B.P., 2011. Interest rate sensitivity of US property/liability insurer stock returns. *Managerial Finance*. 37(2), pp. 34-150.
- Phillips, P.C.B., and Perron, P., 1988. Testing for a Unit Root in Time Series Regression. *Biometrika*, 75(2), pp. 335-346.
- Poon, W.P.H., Firth, M. and Fung, H.G., 1998. The spill-over's effects of the trading suspension of the Treasury bond futures market in China. *Journal of International Financial Markets, Institutions and Money*. 8(2), pp. 205-218.
- Purnanandam, A., 2007. Interest rate derivatives at commercial banks: An empirical investigation. *Journal of Monetary Economics*. 54(6): 1769-1808.
- Raju, M.T. and Karande, K., 2003. Price discovery and volatility on NSE futures market. *Securities and Exchange Board of India Working Paper Series No. 7*. <[http://www.sebi.gov.in/cms/sebi\\_data/attachdocs/1293096997650.pdf](http://www.sebi.gov.in/cms/sebi_data/attachdocs/1293096997650.pdf)>. Accessed on 23rd February 2016.
- Sahoo, H.R. and Panda, P., 2016 Interest Rate: Futures and Cash Market Spill-over's in India. *Research Bulletin*, The Institute of Cost Accountants of India. 42(1), pp. 118-128.
- Zhou, S., 2007. The dynamic relationship between the federal funds rate and the Eurodollar rates under interest-rate targeting. *Journal of Economic Studies*. 34(2), pp. 90-1021.