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THE BEHAVIOR OF OPTION'S IMPLIED VOLATILITY INDEX: A CASE OF INDIA VIX

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Abstract. The aim of this paper is to investigate the behavior of implied volatility in the form of day-of-the-week, year-of-the-month and surround the expiration of options. The persistence of volatility is modeled in ARCH/GARCH type framework. The empirical results have shown significant effects of the day-of-the-week, month-of-the-year and day of options expiration. The positive significant Monday effect explains that India VIX rises significantly on the initial days of the market opening, and the significant negative Wednesday effect shows that expected stock market volatility fall through Wednesday-Friday. Moreover, the study reveals the fact on options expiration, the evidence shows that India VIX fall significantly on the day of expiration of European call and put options. The March and December months have reported significant negative impact on the volatility index. Certainly, this kind of results holds practical implication for volatility traders, and helps to the market participant in hedging and pricing of options.

Keywords: implied volatility, India VIX, IVIX, day-of-the-week, options expiration, month-of-the-year, seasonal anomalies.

JEL Classification: G11, G14.

Introduction

Implied volatility is the inversion of the Black-Scholes option pricing model, and it is the function of options' traded price; time-to-expiration; risk-free-rate-of-interest and dividend yield; strike price and spot price of underlying. Under the rational expectation and market efficiency, implied volatility is the expectation of the future stock market volatility. The market participant trade into options to hedge the market holdings and risk management, hence the expectation of the investors gauged into the price of options (call/put) and the same traded price used to calculate the implied volatility. Therefore, implied volatility is the best estimate of future realized return volatility (Christensen, Prabhala 1998; Hansen 2001; Shaikh, Padhi 2013, 2014a, 2014b) for 30 days horizon (one month option).

The information content of implied volatility as the market's expected volatility has motivated to construct the volatility index, which is often referred as the "Investor's-fear-gauge-index" (Whaley 2000). The Chicago Board of Options Exchange (CBOE) has started calculating implied volatility index since 1993 known as VIX. The VIX is the premier barometer of the investor's sentiment and the market volatility. The CBOE has calculated more than 19 volatility indices apart from VIX, which means the 30-day implied volatility of different securities. The volatility indices are the key measures of market expectation in near-term calculated based on the listed option prices. From 2003, CBOE has started calculating VIX based on S&P 500 stock index, and also calculate volatility of volatility index (i.e. VVIX) based on the options written on VIX index.

The National Stock Exchange (NSE) of India limited has started trading in options from 2001 based on the S&P CNX Nifty equity index. India's first volatility index has been started and calculated since November 2007, and this volatility index is available to the public on real time basis. India VIX signifies the investors sentiment in near-term for

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the next 30 calendar days. India VIX (2007) uses the same methodology as developed by CBOE for VIX (2003) methodology. The market participant, analyst and academician have been intrigued by the volatility index; the reason is that stock indices and implied volatility indices are negatively correlated. The high level of implied volatility index signifies towards oversold market condition. The correlation between stock index and volatility index hovers in the rage of –0.70 to –0.90.

Unlike the previous studies on the seasonal anomalies in term of stock returns, exchange rate and fixed income securities, the aim of our study is to analyze the behavior of implied volatility in the emerging market like India. The seasonality of India VIX (herein after IVIX) has been assessed like day-of-the-week, month-of-the-year and options expiration effects.

There are quite good number of attempts (e.g. Dzikevičius, Stabužytė 2012; Martinkute-Kauliene 2013; Shaikh, Padhi 2013; Padhi, Shaikh 2014) that deals with the market efficiency, sensitivity of options and forecasting, investor sentiment and information content of option prices. However, we do not find any study that deals with the option volatility and stylized nature of implied volatility on Indian derivatives market; hence, this is an attempt in this direction to fill-up the gap. Moreover, recent studies (e.g. Žilinskij, Rutkauskas 2012; Lukaševičius *et al.* 2013; Evrim-Mandaci *et al.* 2013; Stádník 2013; Vilkancas 2014; Shaikh, Padhi 2014a, 2014b, 2014c) deal on the firm's performance and potential return on investment; dynamics of stock price cycle; determinants of stock market dynamics in advanced and emerging economics; random walk and stock prices; portfolio optimization with respect to omega function; volatility index and forecasting performance of emerging market's volatility index. The studies are in association with the various issues on the stock market development and portfolio optimization, our study identifies the gap on the emerging market volatility index in terms of behavior of volatility index as the expected volatility of the future stock market realized volatility.

The formal studies of seasonal anomalies are accessible in the works (e.g. Schwert 1989, 1990; French 1980; Gibbons, Hess 1981; Keim, Stambaugh 1984; Fleming *et al.* 1995). These studies well document the seasonality of stock index returns and conclude the presence of seasonal anomalies. Some of the earlier studies (e.g. Cross 1973; Jaffe, Westerfield 1985; Aggarwal, Rivoli 1989; Lakonishok, Levi 1982; Balaban *et al.* 2001) analyze the day-of-the-week effects and their empirical results has shown Monday and Friday effects. Particularly, these studies report significant negative returns on Monday, and Friday returns remain highest as compare to other days.

The month of the year anomalies found in the works (e.g. Rozeff, Kinney 1976; Gultekin, M. N., Gultekin, N. B. 1983; Keim 1983; Lakonishok, Smidt 1984; Jones *et al.* 1987; Ariel 1987; Tong 1992; Pandey 2002), the January effect happens due to several reasons indentified like, it occurs due to tax-motivated transaction, market participants intends to reduce their tax expenses by closing their bad positions, returns realized on small and large firms. Moreover, the literature evidences on the day-of-the-week and options expiration effects are come up in the studies (e.g. Fleming *et al.* 1995; Dowling, Muthuswamy 2005, Frijns *et al.* 2010). More recently, Fleming *et al.* (1995) describes how implied volatility index has been calculated, moreover they explain the behaviour of implied volatility over seven years of period in the form of day-of-week and on the options expiration. Their study strongly suggests the presence of seasonality and intertemporal relation between implied volatility and stock index returns. In particular, they find an inverse and asymmetric relation among future stock market volatility and stock returns. Dowling and Muthuswamy (2005) examine the properties of Australian implied volatility index (AVIX) in the form of seasonality and the information content of AVIX as the predictor of future volatility. They find strong seasonal anomalies and contemporaneous asymmetric relation between AVIX and stock returns. Similarly, Frijns *et al.* (2010) revisits the study of Dowling and Muthuswamy (2005) and supports the previous work for the more recent period from 2002 to 2006. A great amount of literature we have been explored in the previous paragraph but very limited studies are based on the seasonal anomalies of implied volatility index, hence, this study is an attempt in this direction.

The aim of this paper is to explain the seasonal anomalies in the form of implied volatility index (India VIX). The statistical properties have shown the presence of seasonal pattern like day-of-the-week and options expiration effects. Moreover, month of the year effects is also apparent. The empirical model has been framed in the form of simple OLS and ARCH/GARCH type framework. The autocorrelation and ARCH-test reports significant presence of autocorrelation and heteroscedasticity in the residuals, consequently the regression models have been estimated using AR-GARCH (1,1) specification. The empirical results show significant positive Monday effect on the expected market volatility, and significant negative impact of the day of the options expiration. In additions, there are some strong evidences on month-of-the-year effect like March, May and December effects.

The rest of the paper proceed as: Section 1 deals with the data and methodology and empirical model, Section 2 reports the empirical results and last section ends with our conclusions.

1. Data sources and empirical model

Our data sources consist of daily close of India VIX retrieved from the National Stock Exchange of India (NSE)

website. The data points rages from November 1, 2007 to April 30, 2013, that has resulted into 1361 trading days. The returns on the volatility index has been obtained as one day contemporaneous continuously compounded logarithmic returns $R_t^{IVIX} = ln\left(IVIX_t\right) - ln\left(IVIX_{t-1}\right)$.

To isolate the effects of day-of-the-week, expiration of the options and month-of-the-year on expected stock market volatility, a dummy ordinary least squares (DOLS) by allowing an AR term (i.e. AR-DOLS) has been structured as follows.

The regression model based on the day-of-the-week anomalies is expressed:

$$R_t^{IVIX} = \sum_{i=1}^{5}\delta_i D_{it} + \gamma R_{t-1}^{IVIX} + \varepsilon_t^{IVIX}, \qquad (1)$$

where: D_{it} = 1, if Monday;
= 0, otherwise
i = 1: Monday, Tuesday, Wednesday, Thursday and Friday, and the behaviour of expected stock market volatility surround the cycle of one month options expiration is written,

$$R_t^{IVIX} = \sum_{j=-2}^{2}\varphi_j D_{jt} + \gamma R_{t-1}^{IVIX} + \varepsilon_t^{IVIX}, \qquad (2)$$

where: D_{jt} = 1, the day of option expiration (i.e. last Thursday of the month)
= 0, otherwise
j = –2, –1, 0, 1, 2.
By combining the Eqs (1) and (2),

$$R_t^{IVIX} = \sum_{i=1}^{5}\delta_i D_{it} + \sum_{j=-2}^{2}\varphi_j D_{jt} + \gamma R_{t-1}^{IVIX} + \varepsilon_t^{IVIX}. \quad (3)$$

Apart from the Eq. (3) we also develop the regression model that account for the month-of-the-year effects on the implied volatility,

$$R_t^{IVIX} = \sum_{k=1}^{12}\pi_k D_{kt} + \gamma R_{t-1}^{IVIX} + \varepsilon_t^{IVIX}, \qquad (4)$$

where: D_{kt} = 1, January;
= 0, otherwise
k = January, February, ..., December.

The Eqs (3) and (4) have been estimated by taking into accounts the problem of autocorrelation and heteroscedasticity. The Lagrange's Multiplier LM-test has shown significant presence of heteroscedasticity, hence the estimation framework is expressed in ARCH/GARCH. The AR-GARCH (1,1) model is structured as,

$$\sigma_t^2 = \theta_0 + \theta_1\varepsilon_t^{IVIX^2} + \theta_2\sigma_{t-1}^2, \qquad (5)$$

where: θ_1 and $\theta_2 > 0$ and $\theta_1 + \theta_2 \leq 1$.

The literature explains that the assumption of Gaussian (Normal) distribution for the errors may not be appropriate for the GARCH model. Thus, for GARCH models Generalized Error Distribution (GED) has been assumed. Where $\varepsilon_t^{VIX} / \omega_{t-1} \sim$ GED $(0, \sigma_t^2, \upsilon)$.

1.1. Hypotheses of the models:

(i) Day-of-the-week effects: if day-of-the-week anomalies holds in the Indian capital market than the slopes δ_i should be statistically different from zero. Previous studies on stock returns anomalies found out significant negative Monday effect, hence in our model (the volatility index) the slope of Monday should appear positive and statistically significant.

(ii) Options-expiration-effects: Fleming *et al.* (1995) analyzes the behavior of expected market volatility surround options expiration. It is expected that on the day of options expiration, market positions are cleared and ambiguity regarding the market also get resolved, and investors become certain about the market condition. Hence, the slope φ_j on the day of options expiration should appear negative and statistically significant.

(iii) Month-of-the-year effects: if India VIX behaves systematically and hold an important pattern based on the months, than the slopes π_k should be different from zero and remain significant. Generally speaking at the end of the year investors clear their market positions, hence it is expected that December and January months should have significant impact on the expected stock market volatility. Moreover, the corporate results are due in the month of July (Q1), October (Q2), January (Q3) and April (Q4), hence the ambiguity of corporate performance get resolved in these months, consequently the slope for these months should appear negative as on these months VIX reaches its normal level.

1.2. Statistical properties of India VIX

In this section some of the statistical properties of implied volatility index have been presented based on the seasonality and options expiration cycle.

Table 1 reports the summary statistics of daily closing of India VIX and its returns. The summary statistics shows the mean, maximum, minimum and standard deviation of the India VIX. In additions, the measures of autocorrelation and autoregressive conditional heteroscedasticity are calculated up to three lags. The analysis has been reported for full sample, calendar year wise and normal period. Now starting with the Panel A, the average close of IVIX for the whole sample period found to be 27.74%, while for the normal period it is calculated 21.11%. The average range of IVIX for the calendar years appears between 21.82% (2010) to 39.34% (2008). The measure of central tendency speaks that implied volatility was remain quite normal during the year 2010–13. Generally it is believed that the reading of VIX between 15 to 30% is good for the market performance of the future realized volatility. The average close of the

years 2008–09 violates the normal range of VIX, it is due to the extreme nature of stock market happened on the counter part of global financial crises took place during 2008–09. The maximum and minimum values of IVIX to be observed 85.13% and 13.04% for the full sample, while for normal period it is 37.19% and 13.04%. The standard deviation of the entire sample (11.14) is more than the normal (4.70) period, and the range of volatility of volatility for the calendar years appears between 4.20 (2012) to 11.43 (2008). The empirical results are reported for the entire sample and low volatility (normal) period based on these statistical properties.

Panel B of the Table 1 shows the statistical measures of returns (IVIX). The stock index and volatility index are negatively correlated, hence the average returns on VIX expected to be negative. The means score of India VIX returns for full and normal period appears respectively –0.0621% and 0–0.560%. The average return of the calendar years ranges between –0.2510% (2009) to 0.2250% (2008). The volatility of the returns is found to be 7.39% for the entire data points and 5.16% for the low volatility period. Once again, the volatility of the volatility index remains higher for the calendar years 2008 and 2009, which appears more than 10%. There are some evidences of autocorrelation and heteroscedasticity in the returns of India VIX, hence in the empirical model an AR term has been added to resolve the autocorrelation problem, and the resulted residuals are modelled in ARCH/GARCH framework to control the heteroscedasticity.

Table 2 summarizes the behavior of India VIX based on the day-of-the-week and options expiration. The average close of the India VIX on Monday (28.18%) is remain higher as compare to other days, and the corresponding IVIX return on Monday also observed to be positive (2.06%), that implies implied volatility becomes more volatile on the market opening (see Fig. 1). The standard deviation of the IVIX close and returns appears respectively 11.76 and 8.48, which is higher than the other day's volatility. The descriptive statistic on the options expiration and surround the expiration cycle (i.e. Thursday, the last week of the respective months) the average close and returns to be recorded respectively 27.47% and –2.76%, this numbers explains that India VIX on the day of options expiration remains more normal and falls significantly. The patterns surround the options expiration show that VIX increases prior to the expiration and keeps on falling after the scheduled expiration. The volatility of the volatility also confirms these patterns.

Table 3 explains the changes in the India VIX based on the month-of-the-year (also see Fig. 1). The Panel A and B shows the descriptive statistics for VIX close and corresponding returns. The average highest VIX close calculated for

Table 1. Summary statistics on India VIX

Panel A	VIX Close						
Statistics	Full sample	2008	2009	20010	2011	2012	Normal period
Mean	27.7433	39.3363	38.1386	21.8155	23.8358	19.7230	21.1084
Maximum	85.1300	85.1300	83.7100	34.3700	37.1900	28.9200	37.1900
Minimum	13.0400	23.2500	22.6900	15.2200	16.7300	13.0400	13.0400
S.D.	11.1430	11.4284	9.4200	3.8141	4.3453	4.1978	4.7003
Observations	1361	246	243	252	247	251	832
Panel B	VIX return						
Statistics	Full sample	2008	2009	20010	2011	2012	Normal period
Mean (× 100)	–0.0621	0.2250	–0.2510	–0.1410	0.2021	–0.2401	–0.0560
S.D.	0.0739	0.1020	0.1026	0.0538	0.0588	0.0446	0.0516
ρ_1	–0.230[a]	–0.245[a]	–0.377[a]	–0.092	–0.008	–0.121[c]	–0.061[c]
ρ_2	0.000[a]	–0.056[a]	0.007[a]	0.084	0.042	0.033	0.054[c]
ρ_3	–0.062[a]	–0.061[a]	–0.042[a]	–0.023	–0.206[b]	–0.010	–0.092[a]
ARCH(1)	240.07[a]	32.51[a]	44.57[a]	0.00	20.02[a]	0.02	30.51[a]
ARCH(2)	246.00[a]	40.88[a]	45.09[a]	1.66	20.71[a]	6.57[b]	39.72[a]
ARCH(3)	247.48[a]	41.93[a]	44.88[a]	1.81	22.36[a]	6.71[c]	41.14[a]
Observations	1360	245	242	251	246	250	831

Note: Table 1 shows the descriptive statistics for daily close of India VIX and VIX returns. The sample period consists of 11/07/2007 to 04/30/2013. The autocorrelation coefficient ρ is calculated upto lag three and the ARCH-LM test is also reported upto three lags. Significant at [a]1%, [b]5%, [c]10%.

Table 2. Summary statistics based on seasonality and options expiration

Panel A Day-of-the-week					
Statistics	VIX close				
	Mon	Tues	Wed	Thu	Fri
Mean	28.18	27.89	28.09	26.99	27.51
SD	11.76	11.36	11.04	10.33	11.21
Observations	273	275	272	266	275
Panel B Day-of-the-week					
Statistics	VIX return				
	Mon	Tues	Wed	Thu	Fri
Mean (x 100)	–0.64	–0.73	–0.38	–0.63	–0.64
SD (x 100)	7.59	7.43	6.15	6.74	7.59
Observations	273	275	272	266	275
Panel C VIX close surround options expiration					
Statistic	Days surround expiration				
	–2	–1	0	+1	+2
Mean	28.61	28.29	27.47	26.71	26.97
SD	11.91	11.39	10.97	10.06	10.67
Panel D VIX return surround options expiration					
Statistic	Days surround expiration				
	–2	–1	0	+1	+2
Mean (x 100)	–1.14	–1.39	–2.76	–2.14	–0.57
SD (x 100)	9.19	8.66	7.46	6.75	7.37
Observations	132	66	66	66	132

Table 3. Summary statistics based on month-of-the-year

Panel A Month-of-the-year												
Statistics	VIX close											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	26.91	29.79	25.90	25.50	29.94	28.08	27.04	27.13	26.13	28.25	31.02	27.27
Maximum	54.41	50.65	44.44	57.88	83.71	62.05	61.73	63.58	39.56	70.27	85.13	55.26
Minimum	13.23	13.76	13.07	13.88	16.82	16.73	16.01	15.64	14.76	13.04	13.66	13.63
SD	11.16	10.24	8.23	10.86	12.06	9.53	10.40	10.39	7.32	13.08	16.08	10.64
Panel B Month-of-the-year												
Statistics	VIX return											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean (x 100)	0.67	–0.09	–0.46	–0.44	0.36	–0.20	–0.06	–0.05	0.21	0.10	–0.04	–0.71
Maximum	0.25	0.21	0.27	0.27	0.52	0.40	0.46	0.50	0.20	0.39	0.20	0.11
Minimum	–0.29	–0.22	–0.27	–0.23	–0.65	–0.23	–0.47	–0.29	–0.11	–0.19	–0.28	–0.17
SD (x 100)	6.25	6.05	6.58	7.00	11.23	7.75	8.82	9.86	5.64	7.03	6.38	4.80
Observations	127	120	122	115	105	108	111	105	103	101	120	124

the month of May and November are respectively 29.94% and 31.02%, and the average corresponding returns found to be respectively 0.36% and 0.04%. This signifies that for the whole sample the May and November months appears to be more volatile for the investors. The SD's of the respective months also appear to be high as compare to other months. More particularly, the months July (Q1), October (Q2), January (Q3) and April (Q4) are the months in which the quarterly corporate results are scheduled to be announced, we can observe that the average return on VIX recorded negative for the April and July. This signifies that VIX index is an efficient investor's fear gauge index that reflects the corporate announcements. On the other hand, we record positive returns on the India VIX for other months, plausible reason could be, more uncertainty about the future corporate results and other domestic economic factors.

2. Empirical results and discussion

This section presents the empirical results obtained on the behavior of India VIX in the form of day-of-the-week, options expiration and month-of-the-year effects. The empirical results are presented using Eqs (3) and (4) based on AR–DOLS and AR–GARCH framework. The results are organized for entire data points and normal/low volatile period.

Table 4 reports the AR–DOLS/AR–GARCH estimates for the seasonal anomalies of India VIX, in which we test the day-of-the-week and options expiration effects. The results are presented in four columns, the column (1) and (2) show the output on AR–DOLS and AR–GARCH for the full sample and column (3) and (4) for low volatile normal period. The column (1) shows significant positive Monday effect and negative options expiration effect. The slope of Monday effect appears 0.0235 (2.35%) and remains statistically significant at 1% level of significance. We do not find significant changes on India VIX on other trading days. When we fit AR–GARCH (1,1) the slope of Monday calculated positive 2.44%, this signifies that on the market opening the IVIX increases by 2.44%, hence investors can plan their profitable strategy through volatility trading. The practical implication of this phenomenon explains that (i) a rise in the VIX level implies the "fear" among the investors on Monday, hence the options seller can make profit by selling the options at high rate of premium (ii) the market uncertainty experienced

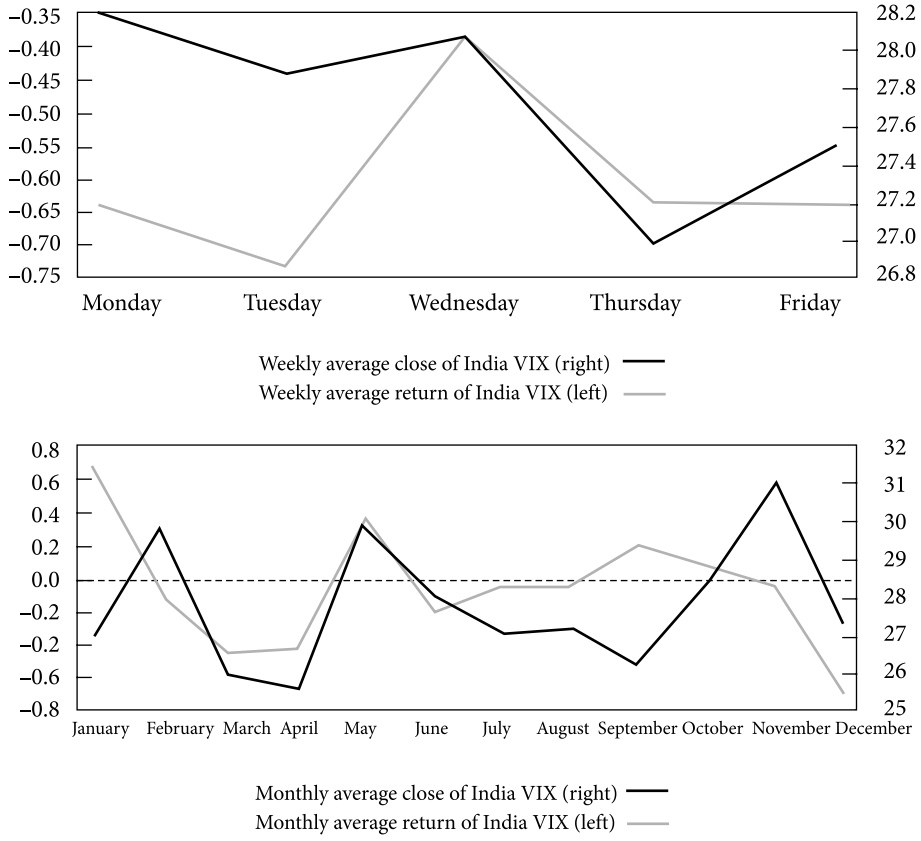

Fig. 1. Seasonality of India VIX

Note: Fig. 1 speaks about the seasonality of India VIX based on the day-of-the-week and month-of-the-year. The figure shows the plot of average weekly and monthly close of India VIX and corresponding VIX returns.

by the investors in holidays (i.e. SAT–SUN) get reflected on the Monday, and due to market uncertainty investors bid higher premium for the call/put options, ultimately it results into rises of volatility of Black–Scholes model.

The AR–GARCH (1,1) for Tuesday shows significant negative impact on India VIX, the estimated slope (–0.129) explain that after Monday, once the market continuous its business VIX keeps on falling as the market uncertainty resolved , and keeps on falling through Tuesday–Wednesday–Friday, but not significantly. At this point we can conclude that India VIX hold day-of-the-week effects pattern unlike previous studies have shown Monday significant negative effect on stock indices. More particularly, the markets' expected volatility rises significantly on the market opening and falls significantly on the other days. The similar kinds of results are also obtained for the normal period as shown in columns (3) and (4).

Table 4 also reports the behaviour of expected stock market volatility surround the expiration of one–month European options, which are cash, settled. Generally it is believed that market participant buys options to hedge their market holding, market players buy one month options to protect their portfolio in near term. The European options can be exercised only on the day of scheduled expiration; hence, investor exercises their right to buy/sell of the underlying if the trade is profitable. The estimate of the slope $\varphi_0 = -0.032$, which is negative and statistically significant at 1% level. The result signifies that on the day of options expiration India VIX falls significantly by 3.2%. This happen due to positions cleared by the investors and they take new market positions on the next trading day. The slope of AR–GARCH (1,1) also appears statistically significant, and the results on the normal period are also identical with the full sample. We do not find any significant movement in the India VIX before and after, from the day of options expiration. The AR–GARCH parameters appears highly statically significant that implies that volatility persist in the returns of expected stock market volatility index. The LB–Q(12) statistic speaks that results are not suffering from autocorrelation. Finally, at this stage we can conclude that India VIX holds some seasonal anomalies like day-of-the-week and options expiration effects. This kind of predictive elements can helpful to the volatility traders for the risk management and profitable trade from the trading of options.

Table 4. OLS/GARCH estimation of day-of-the-week and options expiration

Variables	Full sample AR–DOLS		Full sample AR–GARCH (1,1)		Normal period AR–DOLS		Normal period AR–GARCH (1,1)	
	(1)		(2)		(3)		(4)	
	Estimate	p –value	Estimate	p –value	Estimate	p –value	Estimate	p –value
	0.0235	**0.0000**	**0.0244**	**0.0000**	**0.0230**	**0.0000**	**0.0256**	**0.0000**
δ_2	–0.0051	0.2910	**–0.0129**	**0.0000**	**–0.0105**	**0.0131**	**–0.0152**	**0.0000**
δ_3	–0.0052	0.2847	–0.0040	0.1722	–0.0029	0.5029	–0.0026	0.5023
δ_4	0.0044	0.3889	0.0026	0.3822	0.0007	0.8801	–0.0010	0.7816
δ_5	–0.0012	0.8014	–0.0039	0.1898	0.0012	0.7838	–0.0006	0.8743
φ_{-2}	–0.0076	0.4363	–0.0048	0.4322	–0.0065	0.4550	–0.0101	0.1273
φ_{-1}	–0.0011	0.9405	0.0037	0.6802	0.0176	0.1587	0.0143	0.1394
φ_0	**–0.0320**	**0.0020**	**–0.0264**	**0.0001**	**–0.0276**	**0.0026**	**–0.0228**	**0.0041**
φ_{+1}	–0.0106	0.4954	–0.0020	0.8304	0.0141	0.2665	0.0057	0.5846
φ_{+2}	–0.0105	0.2859	–0.0141	0.0284	**–0.0249**	**0.0049**	**–0.0198**	**0.0063**
γ	**–0.2411**	**0.0000**	–0.0644	0.0168	–0.0525	0.1331	–0.0410	0.2370
θ_1			**0.2841**	**0.0000**			**0.0851**	**0.0011**
θ_2			**0.5038**	**0.0000**			**0.8659**	**0.0000**
Adj. R^2	0.08		0.05		0.05		0.04	
LB–Q(12)			17.41(0.096)				16.68(0.121)	
LB–Q^2(12)			7.76(0.745)				8.16(0.699)	

Note: Table 4 reports the estimation of Eq. (3). $R_t^{IVIX} = \sum_{i=a}^{5} \delta_i D_{it} + \sum_{j=-2}^{2} \varphi_j D_{jt} + \gamma R_{t-1}^{IVIX} + \varepsilon_t^{IVIX}$. Where $D_{it} = 1$, if Monday, otherwise zero; $i = 1$, Monday, Tuesday, Wednesday, Thursday and Friday. Where $D_{jt} = 1$, the day of option expiration, otherwise zero; $j = -2$, –1, – 0, 1, 2. The value with bold letter signifies statistically significant at 1%, 5% and 10% level of significance. The LB–Q(12) and LB–Q^2(12) explain that residual are free from autocorrelation. Where $\varepsilon_t^{VIX} / \omega_{t-1} \sim$ GED $(0, \sigma_t^2, \upsilon)$.

Table 5 shows the results on month-of-the-year anomalies, the evidences show significant March, May, June and December effects. The column (1) reports the AR–DOLS results in which only December months appears with negative significant slope. The column (2) reveals the slope of March –0.0085 (0.85%) and for the December it is –0.0087 (0.87%), both the slopes are statistically significant at 5% level. While the slope of May appear with positive value 0.0092(0.92%), and significant at 5% level. These are the prima facie evidences of seasonal anomalies in the form of month-of-the-year effects on the expected stock market volatility. One can explain that India VIX rises significantly in the month of May and fall significantly during March and December.

Generally, the market participants are uncertain about the corporate earning declared quarterly (i.e. during July (Q1), October (Q2), January (Q3) and April (Q4)). Hence, the slope of the months (July, October, January and April) should appear negative and for the rest of the months it should be positive. The slopes with negative sign are April, July and October (for normal period) but not statistically significant, this indicates corporate scheduled announcements determine the expected level of implied volatility. In particular, the slope with negative sign are (March, April, June, September, October, November, and December) but only March and December appear statistically significant, this implies before declaration of corporate earnings, results for the quarter 3 and 4 matter for the investment decisions. The market participants take into account the Q3 and Q4 results in their assets valuation that is reflected in the expected market volatility. The rest of the months (January, February, May, July and August) appears with positive slopes, only May shows significant positive impact on IVIX, the plausible reason could be investors remain more uncertain about their investment during the May month, hence they buy more and more hedge funds (options) to protect their portfolio, consequently VIX level increases. We do not find any significant results for the low volatility period only except to the October month.

Finally, the empirical results have supported the presence of seasonal anomalies in the expected stock market volatility.

Table 5. AR–DOLS/AR–GARCH estimation based on month-of-the-year

Variables	Full sample AR–DOLS		Full sample AR–GARCH (1,1)		Normal period AR–DOLS		Normal period AR–GARCH (1,1)	
	(1)		(2)		(3)		(4)	
	Estimate	p –value	Estimate	p –value	Estimate	p –value	Estimate	p –value
π_1	0.0071	0.1742	0.0017	0.6368	0.0027	0.6014	0.0004	0.9284
π_2	–0.0007	0.8955	0.0029	0.4536	0.0024	0.6545	0.0047	0.2769
π_3	**–0.0052**	**0.3281**	**–0.0085**	**0.0265**	–0.0056	0.2838	–0.0055	0.2417
π_4	–0.0036	0.5099	–0.0039	0.3259	–0.0040	0.4602	–0.0051	0.2854
π_5	**0.0038**	**0.5097**	**0.0092**	**0.0279**	0.0071	0.2371	0.0053	0.3161
π_6	–0.0025	0.6594	–0.0063	0.1032	–0.0065	0.2780	–0.0068	0.2224
π_7	–0.0006	0.9188	0.0029	0.4523	–0.0035	0.5529	–0.0034	0.4909
π_8	–0.0008	0.8921	0.0006	0.8861	0.0045	0.4534	0.0012	0.8301
π_9	0.0022	0.7045	–0.0022	0.6161	0.0061	0.3176	0.0034	0.5613
π_{10}	0.0010	0.8606	–0.0053	0.1996	–0.0088	0.1531	**–0.0093**	**0.1024**
π_{11}	–0.0003	0.9556	–0.0041	0.2859	0.0034	0.5822	0.0043	0.3911
π_{12}	**–0.0073**	**0.1086**	**–0.0087**	**0.0178**	–0.0035	0.5594	–0.0047	0.3970
γ	**–0.2341**	**0.0000**	**–0.0994**	**0.0002**	**–0.0737**	**0.0349**	**–0.0788**	**0.0257**
θ_1			**0.2508**	**0.0000**			**0.0747**	**0.0035**
θ_2			**0.5169**	**0.0000**			**0.8598**	**0.0000**
Adj. R^2	0.05		0.03		0.05		0.07	
LB–Q(12)			19.97(0.050)				24.61(0.013)	
LB–Q^2(12)			8.09(0.705)				6.84(0.812)	

Note: Table 5 report the estimation of Eq. (4): $R_t^{IVIX} = \sum_{k=1}^{12} \pi_k D_{kt} + \gamma R_{t-1}^{IVIX} + \varepsilon_t^{IVIX}$, where: D_{kt} = 1, January, otherwise zero; k = January, February, ..., December.

The value with bold letter signifies statistically significant at 1%, 5% and 10% level of significance. The LB–Q(12) and LB–Q^2(12) explain that residual are free from autocorrelation. Where: $\varepsilon_t^{VIX} / \omega_{t-1} \sim$ GED $(0, \sigma_t^2, \upsilon)$.

Unlike the previous studies, volatility index also holds the seasonal component in the form of day-of-the-week, options expiration and month-of-the-year effects. Our empirical evidences have shown significant impact of seasonal anomalies on the India VIX. This kind of predictive pattern can help to the volatility traders, policy makers and financial institutions for potential investment and financing decisions.

Conclusions

This study demonstrates the seasonal anomalies of the emerging market's volatility index in the form of day-of-the-week, options expiration and month-of-the-year effects based on India VIX. To the best of our knowledge, this is the first attempt in the emerging markets like India that analyzes the behavior of volatility index based on seasonality. The results have been presented based on simple dummy OLS and conditional volatility GARCH framework.

The important finding of the study has shown significant positive Monday effect on the expected stock market volatility. The average VIX close of the Monday is recorded 28.18% with positive return 2.06%. The slope of the Monday appears positive 2.44%, which signifies on the initial market opening VIX rises significantly by 2.44%, and it fall significantly on Wednesday. Unlike the previous studies, India VIX also shows the positive Monday effects. Moreover, our findings reports significant negative impact of the day of options expiration, the India VIX falls by 2.64% on the Thursday (the last week of the month). Most interesting evidence on the month-of-the-year effect reveals that March and December have significant negative impact on the India VIX, while the month May reports positive impact. There are some evidences of the effects of quarterly announcement of corporate earnings on the India VIX. The practical implications of the empirical evidence are definitely helpful to the volatility traders who trade in the options. The seasonal anomalies of the India VIX provide an insight for the pricing of future options. We strongly believe that the India VIX is the gauge of the investors' expectation about the future market volatility, hence the NSE can introduce some more volatility products like futures and options on India VIX and this will allow more liquidity in the derivative market.

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