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Article

Stylized patterns in implied volatility indices and stock market returns: A cross country analysis across developed and emerging markets

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FINANCIAL ECONOMICS | RESEARCH ARTICLE

Stylized patterns in implied volatility indices and stock market returns: A cross country analysis across developed and emerging markets

Jalaj Pathak^{1*} and Soumya G. Deb¹

Abstract: Purpose: This paper examines the associative and causal relationship between changes in the implied volatility index (VIX) and stock market returns, with data from 15 countries representing both developed and emerging economies.¹ We also examine the dynamic variation, if any in the nature of the relationship across bull and bear market swings in these markets. **Design/Methodology/Approach:** We use daily time series data between January 2013 to July 2019, on VIX and stock index from these countries and employ regression and causality models to explore the nature of the relationship between VIX and stock market movements. We also explore differential patterns, if any, across the countries and bull and bear market cycles in each of these countries. We substantiate our results from the main analysis using a series of robustness tests. **Findings:** For most countries, we find strong evidence of a negative and asymmetric relationship between the stock market and VIX movement, irrespective of the bear and bull market cycles. We also find that this relation is asymmetric in nature i.e. volatility spikes are more in market downturns than during market upswings. We find strong evidence of the “leverage hypothesis” explaining this asymmetric relation for all countries across all market cycles. We also find weak evidence of reverse causality i.e VIX changes to market

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Jalaj Pathak is a 3rd-year Ph.D. student in the F&A area at the IIM, Bangalore and is interested in measures of volatility and its effects on different aspects i.e. market level as well as company level. The variables of interest with respect to association or causal are price and volume. He would also like to delve into qualitative measures of volatility, such as texts. Converting the same to a numerical measure and analyzing its impact.

Dr. Soumya G Deb holds a Ph.D. (FPM) from IIM-Calcutta and is currently Associate Professor at IIM Sambalpur. He is an active researcher and has several publications in nationally and internationally reputed journals. His research interests are in the areas of Mutual funds, Corporate Finance, Investments and Portfolio Management, Asset Pricing, Causality and Volatility in Financial markets, etc. He is also a reviewer in several reputed journals published by SAGE, Springer, Emerald, Elsevier.

PUBLIC INTEREST STATEMENT

The article analysis the relationship between volatility and stock index and finds that the returns are causing VIX except for the case of developing nations in a bear market cycle. The article also states that the relationship is asymmetric, i.e. there more to lose in a market downturn than to gain in case of an index increase. Thus, the investors can use this information to safeguard as well as increase their wealth in the stock market. This can be done by timing their inflows with respect to the above specified relationship. Also, since the investments are done across the globe in today's the fact that the analysis is done with respect to both developed and developing markets would further increase the importance of the same.

movements as per the “*volatility feedback hypothesis*” holding during bear periods only in developed countries. We suspect that two important pre-conditions of volatility feedback hypothesis to hold, namely volatility persistence and contemporaneous positive volatility return relation might not be holding. We do not find any significant changes in these patterns across bull and bear market cycles. **Value:** These results indicate that investors can effectively use signals imminent in VIX movements, to determine potential entry and exit points both in emerging as well as developed markets. This should provide them an additional tool in addition to standard analysis approaches before allocating resources in a particular market.

Subjects: Credit & Credit Institutions; Investment & Securities; Risk Management

Keywords: VIX; Leverage hypothesis; Volatility feedback hypothesis; emerging markets
JEL: C12; C15; C21; C53.

1. Introduction

This paper examines the association of “implied volatility indices” (VIX henceforth) and stock market returns, in 15 countries representing developed and emerging markets under bull and bear market conditions. The fundamental relation between risk and return has been extensively examined over the past four decades (Blay & Markowitz, 2013), because of its obvious applications in designing trading strategies, quantifying and managing risks, and forecasting economic conditions. Returns and volatility are typically found to be negatively related and this relation is asymmetric in nature i.e. more prominent for negative returns (Bekaert & Wu, 2000; Black, 1976; Christie, 1982; French, Schwert, & Stambaugh, 1987). The nature of this relation is therefore expected to change across different market cycles (bull and bear) and more so across different markets with different levels of maturity (emerging and developed). This study draws its principal motivation from these considerations.

1.1. What is VIX?

Numerous sophisticated models including the generalized autoregressive conditional heteroscedasticity (GARCH) family models and other stochastic volatility models are developed over the last few decades to measure and predict market volatilities. However, given the inadequacy of even the most advanced models to truly reflect market sentiment and investor expectations regarding future economic fundamentals, using only historical data, (Han, Kutan, & Ryu, 2015), an alternative class of volatility estimation models is often proposed. The volatility estimates proposed by these models are based on current market prices of tradable financial assets (like options) with the assumption that they contain all available information (assuming market efficiency) and reflect market sentiment and expectations of market participants. The volatilities estimated through these models are called “*implied*” volatilities’ and expressed by VIX in most countries. VIX is an index computed on a real-time basis throughout each trading day. The only meaningful difference with a standard index (like DJIA for eg), is that it measures volatility and not price. VIX was introduced in 1993 with two purposes in mind (Whaley, 2008). *First*, it was intended to provide a benchmark of expected short-term market volatility. To facilitate comparisons of the then-current VIX level with historical levels, minute-by-minute values were computed using index option prices. *Second*, VIX was intended to provide an index upon which futures and options contracts on volatility could be written. VIX estimates are believed to be not only forward-looking but also having clear advantages over historical volatilities in capturing market conditions and forecasting future states (Giot & Laurent, 2007; Ryu, 2012).

1.2. VIX and market return relationship—background theories

A fully consistent economic theory is yet to be developed to explain the volatility-return relationship. Empirical research (Black, 1976; Bollerslev, Kretschmer, Pigorsch, & Tauchen, 2007; Campbell & Hentschel, 1992; Fleming, Ostdiek, & Whaley, 1995; Giot, 2005; Poterba & Summers, 1986)

typically shows a negative relation between realized stock market returns and VIX movements. More specifically, the association between market returns and changes in VIX exhibits an asymmetric relationship i.e the magnitude of volatility shocks is higher (lower) in a down (up) market. Two popular hypotheses associated with this observed negative return-volatility relationship are the “leverage hypothesis” and the “volatility feedback hypothesis”. The leverage hypothesis states that in down market cycles, a fall in the value of a firm’s stock causes the debt to equity ratio to rise which in turn leads the shareholders who bear the residual risk of the firm, to perceive their future cash flow stream as being relatively riskier. This feature was first documented by Black (1976) and Christie (1982). The “volatility feedback hypothesis” first documented by Poterba and Summers (1986), on the other hand, postulates that positive shocks to volatility cause negative returns. This hypothesis posits that expected future stock returns must increase when volatility increases. The current stock prices should then fall to adjust to this change in future expectations. Thus, an increase in expected volatility causes negative returns now. The volatility feedback hypothesis relies on the existence of time-varying risk premiums as the link between returns and changes in volatility. In summary, thus, the leverage hypothesis asserts that return shocks lead to changes in conditional volatility, while the volatility feedback effect theory assumes that return shocks can be caused by changes in conditional volatility through a time-varying risk premium.

A lot of empirical research is in place, studying which of the two theories best explains the existence of a negative relation between returns and volatility and the evidence is mostly mixed in nature. For example early studies like Christie (1982), Schwert (1989), Nelson (1991), Gallant, Rossi, and Touchen (1992), Campbell and Kyle (1993) and Engle and Ng (1993) finds support to the leverage effect, while others like Poterba and Summers (1986), French et al. (1987); Campbell and Hentschel (1992) finds evidence some towards the volatility feedback effect. These later studies posit that the magnitude of the impact of a decrease in stock prices on volatility is too large to be explained by financial leverage fluctuations alone. In more recent times, Bekaert and Wu (2000) report similar findings and posit that the volatility feedback hypothesis is more likely to generate an asymmetric response than would the leverage effect by using the Japanese stock market data. Figlewski and Wang (2001), Bollerslev, Litvinova, and Tauchen (2006), Dennis, Mayhew, and Stivers (2006) extend these results and also distinguish between strong and weak forms of the asymmetric relation. The strong form relates to a negative relation of returns with volatility, while the weak form says the negative relation exists for returns and expected volatility, after controlling for the absolute return shock and volatility innovation. Dufour and Taamouti (2010) and Dufour, Garcia, and Taamouti (2012) bring in an interesting insight as to which of these two effects is likely to get manifested under what conditions. They analyze high-frequency observations on S&P 500 Index futures contracts, the associated realized volatilities and implied volatilities. Using only returns and realized volatility, they find a strong dynamic leverage effect. On the other hand, when implied volatility is considered, volatility feedback becomes apparent, whereas the leverage effect is almost the same. These results can be explained by the fact that volatility feedback effect works through implied volatility which contains important information on future volatility, through its nonlinear relation with option prices which are themselves forward-looking. is almost the same. These results can be explained by the fact that volatility feedback effect works through implied volatility which contains important information on future volatility, through its nonlinear relation with option prices which are themselves forward-looking.

There is also a *behavioral finance explanation*, of the return-VIX asymmetric relationship which becomes particularly relevant for exploring short term association between the variables. This draws primarily from the behavioral theory of loss-aversion (Kahneman & Tversky, 1979) in which the impact of losses is higher than gains. Low (2004) attempts to explain the strong negative contemporaneous asymmetric return-implied volatility relation between OEX returns and VXO changes using the loss aversion perspective. Finucane et al (2000), and Dennis et al. (2006), lend support to this argument. Bollen and Whaley (2004), Shefrin (2005), explain the negative return-VIX relation in terms of “representativeness”, “affect”, and “extrapolation bias” from behavioral finance theory. They propose that the common use of heuristics to make decisions can be easily extended to explain the negative

return versus VIX relation. This view is consistent with the common perception that investors and dealers of options get extra cautious and bid up put prices during market downturns due to the fear arising out of the experience (representativeness) for downside protection against additional future losses. Hibbert, T DAIGLER, & Brice, (2008) posit that the leverage and volatility feedback hypotheses, which are based on fundamental factors of the firm, should reflect more on the longer-term lagged effect between return and volatility, or vice versa.

Very recently some empirical works extended the previous studies in general equity markets to other markets like *currency markets* (Daigler, Hibbert, & Pavlova, 2014) and *real estates* (Hung & Glascock, 2010; Jirasakuldech, Campbell, & Emekter, 2009; Yang, Zhou, & Leung, 2012; Zhou, 2016; Zhou & Nicholson, 2015). An interesting observation in the volatility return relation for the currency market is the weakness in the asymmetry. This is assigned primarily to the two-sided nature of exchange rates, namely, a positive return shock to one currency is a negative shock for the other. The evidence in the real estate market shows that both leverage and volatility feedback effects are at work but the leverage effect dominates the volatility feedback effect. Zhou (2016), reports that both effects are nonlinear in nature—a feature matching the tendency of the financial market to often change its behavior.

1.3. Contributions of this study

Our study is different from some of the previous ones and contributes to the existing literature in the following ways:

- (i) unlike a majority of previous studies mentioned above, which employ weekly and monthly data, in line with Hibbert et al., (2008), we do a detailed analysis of the “short term” association between market returns and VIX by using daily data. Monthly or weekly data cannot deal with holidays and their lead/lag relationships. Given that our principal goal is an “early detection” of changes in data trends, daily data is believed to be superior and quicker at reacting to level shifts and changes in trends, versus waiting a week/month to observe the new data.
- (ii) Most of the previous studies have restricted their data from within a single country. However, it is quite possible that the association between VIX and market movements is dynamic and varying cross-sectionally across various markets, depending on their maturity levels. We, therefore, do not limit our analysis to a single country but carry out a ‘cross country’ analysis with data from 15 countries: 10 of them (Australia, Canada, France, Germany, Hong Kong, Japan, South Korea, Switzerland, UK, and the USA) representing the developed markets while five (Brazil, India, Russia, China, and South Africa) representing developing or emerging markets.
- (iii) The dynamic variation in the association of VIX and market movements across various market swings (bull and bear) remains unexplored to date. This study tries to explore that issue. We divide our study period into bull and bear market cycles (in line with methodologies adopted by Fabozzi and Francis, 1979; Wiggins, 1992 and Bhardwaj and Brooks, 1993) and carry out the entire analysis separately over bull market cycles and bear market cycles. Our results show that there is a strong negative and statistically significant relationship between stock market returns and VIX movements. This is true, in general, across most countries irrespective of the bear and bull market cycles. We also find evidence that this relationship is asymmetric in nature i.e. the change in VIX is more during market downturns than during market up-cycles. We find strong evidence of leverage hypothesis holding i.e causality flowing from the market return to VIX, for all countries, independent of market cycles. Additionally, we also find that for developed countries, there is evidence of bi-directional causality between market returns and VIX. For the emerging markets, the leverage hypothesis seems to be explaining the causal flow between market returns and VIX better.

These results indicate that investors can effectively use signals imminent in VIX movements, to determine potential entry and exit points both in emerging as well as developed markets. The

findings of this study, therefore, can have significant implications for all stakeholders in these markets, including investors, portfolio managers, and policymakers.

The remaining part of the paper is organized as follows: Section II talks about the data and discusses the methodology, section III, presents the results and inferences followed by the conclusion, references, and tables.

2. Data, hypotheses formulation, and methodology

2.1. Sample construction

We use daily time-series data from January 2013 to July 2019, for stock indices and VIX from 15 countries: 10 of them (Australia, Canada, France, Germany, Hong Kong, Japan, South Korea, Switzerland, UK and USA) representing the developed markets while five (Brazil, India, Russia, China and South Africa) representing developing or emerging markets. The data is collected from Bloomberg. We initially start with a larger set of countries representing developed as well as emerging markets following MSCI country classification.¹ However, our final sample consists of only those countries which have at least close to 1500 observations or more for both stock index as well as VIX. However, our final sample consists of the intersection of data for all countries and indices (both return and VIX Index). This leads to 1000 observations for each country. The respective market indices and VIX used in each country, along with the time period, a proxy for risk-free rate considered in each country are shown in Table 1 below.

This study uses the relative VIX changes (ΔVIX) and market returns which are estimated as follows:

- (i) We measure the changes in the VIX by using log returns from the value of the VIX (V) on a specific moment in time (t).

Table 1. This table shows the countries used in this study along with respective market indices, VIX, a proxy for risk-free rate considered for each

Country	Stock Index	Risk Index	Risk-Free Rate
Australia	AS 51	AS/SP 200 VIX INDEX	Aus Bank Bill Short Term Rates 3 Month
Brazil	BOVESPA	CBOE BRAZIL VOL INDEX	3 Month Bond
Canada	TSX	CAD VOL INDEX	3 Month Bond
France	CAC 40	CAC 40 VOL INDEX	3 Month Bond
Germany	DAX	VDAX—DAX NEW VOL INDEX	3 Month Bond
Hong Kong	HSI	HSI VOL INDEX	3 Month Bond
India	NIFTY 50	INDIA VIX	3 Month Bond
Indonesia	JCI	INDONESIA VIX	Bank Of Jakarta Offer Rate 3 M
Japan	NIKKEI	NIKKIE VOL INDEX	3 Month Bond
South Africa	JSE	JSE VOL INDEX	Bank Agreed 3 M Rate
South Korea	KOSPI	KOSPI 200 VOL INDEX	3 Month CD
Switzerland	SMI	SMI VOL INDEX	3 Month Bond
China	HSCEI Index	VXFXI Index	3 Month Bond
UK	UKX Index	VFTSE Index	3 Month Bond
USA	SP 500	US VIX	3 Month Bond

$$\Delta VIX_t = \log\left(\frac{VIX_t}{VIX_{t-1}}\right) \quad (1)$$

(i) stock market return (r) for a specific stock market index (i) at a given moment in time (t) is estimated as follows:

$$r_t = \log\left(\frac{P_t}{P_{t-1}}\right) \quad (2)$$

2.2. VIX and return: expected association and theory

The values of VIX are typically computed by using the prices of the index options visible in the market. Based on the bid-ask prices of the index (the lower the spread, the better it is) of index options contracts, the annualized implied volatility is calculated. The figure generated indicates the expected market volatility over a specified number of days in the future. The VIX is also known as the *fear index* (Whaley, 2000). An investor who is bullish on the market buys a call option, and the bearish one buys a put option. When the investors' faith in the market falls, they tend to buy put options (a bearish position taken in the belief that markets will fall) to either catch the downfall or hedge their portfolios. Also, in such a scenario, the bulls too are skeptical to buy into equity or futures and resort to buying call options (a bullish position taken in the belief that the markets will rise). This increases the options' premium, and consequently, the VIX rises. On the other hand, when the market participants are confident about the bull run, they tend to write/sell put options and prefer futures over call options, resulting in a lower option premium and, thereby, a lower VIX.

2.3. Identifying bull and bear market cycles in each country

We identify the respective bull and bear periods within each country, based on standard approaches previously used in literature. The studies suggesting classification of markets into bull or bear market periods, either compare the market index to a critical threshold value to separate "up"- from "down"-market periods, or they use a trend-based scheme to classify markets as "bull" or "bear" (Woodward and Anderson, 2009). The "up"- and "down"-market scheme dichotomizes the market by comparing the market index to a critical threshold value. In this study, we adopt three approaches used by Wiggins (1992),² for classifying the study period in each country into bull and bear market cycles. Wiggins (1992) defines substantial up (down) months as months in which the excess return on the market portfolio is greater (less) than zero and thereby separate the market into periods when the market is substantially up, substantially down, or neither. Thus, for each country, daily log returns are calculated for Market Index as well as VIX Index, monthly returns are calculated from the same. Every month is classified as bull/bear and all the bull/bear months for developed/developing are clubbed together for further analysis across developed/developing.

Table 2 below shows the total number of observations, observations during bull months and observations during bear months.

2.4. Hypothesis formulation

As mentioned in the previous section large amount of empirical studies (Black, 1976; Bollerslev et al., 2007; Campbell & Hentschel, 1992; Fleming et al., 1995; Giot, 2005; Poterba & Summers, 1986) report a negative relation between realized stock market returns and VIX movements i.e when market falls, VIX rises and vice versa. As we do use a large data set across country analysis across emerging and developed markets we formulate our first hypothesis (for our overall pooled data) as follows:

Hypothesis 1: Market movement and VIX movement are negatively associated with each other.

Bollerslev et al. (2006) state that "one of the striking empirical regularities to emerge from the burgeoning literature on volatility modeling over the past two decades concerns the apparent

Table 2. The table shows the total number of observations, observations during the bull months taken together and that during the bear months taken together. Bull and bear months are defined based on three classification approaches as detailed in the text. Here we provide the information for only one of them (Bhardwaj and Brooks, 1993 for the sake of brevity). The period chosen for each country is 2013 to 2019 which is approximately 1250 daily observations for each country. However, we use a common time length for each country, hence only the intersection of trading days across each country is used which comes out to be 1000

Country	Country Status	Start Time	End Time	Total daily observations	No of bull Months	No of bear Months
Australia	Developed	22-01-2013	26-06-2019	1000	41	37
Brazil	Emerging	22-01-2013	26-06-2019	1000	37	41
Canada	Developed	22-01-2013	26-06-2019	1000	51	27
France	Developed	22-01-2013	26-06-2019	1000	41	37
Germany	Developed	22-01-2013	26-06-2019	1000	44	34
Hong Kong	Developed	22-01-2013	26-06-2019	1000	39	39
India	Emerging	22-01-2013	26-06-2019	1000	39	39
Russia	Emerging	22-01-2013	26-06-2019	1000	39	39
Japan	Developed	22-01-2013	26-06-2019	1000	45	33
South Africa	Emerging	22-01-2013	26-06-2019	1000	43	35
South Korea	Developed	22-01-2013	26-06-2019	1000	38	40
Switzerland	Developed	22-01-2013	26-06-2019	1000	45	33
China	Emerging	22-01-2013	26-06-2019	1000	41	37
UK	Developed	22-01-2013	26-06-2019	1000	42	36
USA	Developed	22-01-2013	26-06-2019	1000	53	25

asymmetry in the relationship between equity market returns and volatility. Anecdotal evidence like the heightened volatility following the October 1987 stock market crash and the more recent turmoil following Russia's default and the Long-Term Capital Management (LTCM) debacle in September 1998, as well as the relatively low volatility accompanying the rapid run-up in prices during the recent tech bubble, are all consistent with this asymmetry". Some studies (Bekaert & Wu, 2000; Wu, 2001) explore the association between market returns and VIX changes and report asymmetry i.e they show that the magnitude of volatility shocks is higher (lower) in a down (up) market. Bekaert and Wu (2000), posit that the volatility feedback hypothesis is more likely to generate an asymmetric response than would the leverage effect by using the Japanese stock market. Bekaert and Wu (2000) and Dennis et al. (2006) also distinguish between strong and weak forms of the asymmetric relation. Low (2004) characterizes the nature of the asymmetric risk-return relation as a form of loss aversion. He posits, that extreme price plunges correlate strongly with rapid increases in risk. Extreme price rises correlate with relatively subdued decreases in risk which that fear strikes quickly but exuberance builds slowly. He uses a regression model to investigate the nonlinear contemporaneous relation between percentage changes in the VIX and the S&P 100 returns and reports a higher R^2 for the downside-return partition than the upside-return partition. With our updated extensive dataset, this question of asymmetry becomes an important one and we formulate our next hypothesis as follows:

Hypothesis 2: The relationship between market movement and VIX movement is asymmetric in nature.

As discussed in section 2 above, Black (1976), Christie (1982), first proposed the leverage hypothesis which posits that in down market cycles, a fall in the value of a firm's stock causes the debt to equity ratio to rise which in turn leads the shareholders who bear the residual risk of the firm, to perceive their future cash flow stream as being relatively riskier. Empirical evidence on leverage effect can also be found in Nelson (1991), Gallant et al. (1992), Campbell and Kyle (1993) and Engle and Ng (1993). Bollerslev et al. (2006), French et al. (1987), Campbell and Hentschel (1992), posit that if volatility is priced, an anticipated increase in volatility would raise the required rate of return, in turn necessitating an immediate stock-price decline to allow for higher future returns. Therefore, the causality underlying the volatility feedback effect runs from volatility to prices, as opposed to the leverage effect that hinges on the reverse causal relationship. Thus, if causality runs from RM to VIX, leverage hypothesis should be holding, while a reverse causal flow indicates evidence of volatility feedback hypothesis. Given this we formulate our next hypothesis as follows:

Hypothesis 3: Causality flows from market movements to VIX and not the other way around.

It is quite possible that the association between VIX and market movements is dynamic and varying cross-sectionally across various markets, depending on their maturity levels. Also, it is quite possible, that the market's understanding of risk and return might change across different market swings. One of the important objectives of this study is to explore differential patterns across different markets (emerging and developed) and different market cycles (bull and bear) w.r.t the above-mentioned hypotheses. We thus formulate our next two hypotheses as follows:

Hypothesis 4: There are significant differences w.r.t hypotheses 1, 2 and 3 above for emerging and developed markets.

Hypothesis 5: There are significant differences w.r.t hypotheses 1, 2 and 3 above for bull and bear markets.

2.5. Correlation analysis

A preliminary test of hypothesis 1 above is undertaken by looking at the correlation coefficients between daily VIX percentage changes and daily stock market returns for all countries. A negative correlation should validate hypothesis 1. Table 3 presents and discusses the results of the correlation analysis in the next section.

2.6. Pooled regression models

To further substantiate our findings from correlation analysis and to specifically test hypothesis 2 (asymmetric relation) we adopt the following simple regression model:

$$\Delta VIX_t = aR_t + b \cdot DR + \gamma RM_t \cdot DR + e_t \quad (3)$$

Where, DR is a dummy variable, which takes value, $DR = 1$ if $RM_t \leq 0$, and 0 otherwise. RM_t and ΔVIX_t specify respectively percentage market return and percentage change in VIX at time t .

A negative α and γ would imply higher values of VIX corresponding to negative returns which should substantiate hypothesis 2 above.³

The analysis is repeated for all countries, developed countries and emerging countries after pooling the data for these cross-sectional clusters. It is then repeated for overall periods, bull periods, and bear periods within these cross-sectional clusters. The results are presented in Table 4.

Table 3. Correlation coefficients between Return and VIX

	Overall	Bull	Bear
All countries	−0.41***	−0.78***	−0.81***
Emerging countries			
All emerging	−0.39***	−0.31***	−0.40***
Brazil	−0.4***	−0.61***	−0.39***
India	−0.56***	−0.48***	−0.57***
Russia	−0.34***	−0.21***	−0.35***
South Africa	−0.53***	−0.74***	−0.52***
China	−0.33***	−0.24***	−0.42***
Developed countries			
All developed	−0.44***	−0.44***	−0.44***
Australia	−0.65***	−0.61***	−0.66***
Canada	−0.94***	−0.87***	−0.94***
France	−0.31***	−0.69***	−0.31***
Germany	−0.73***	−0.5***	−0.75***
Hong Kong	−0.59***	−0.81***	−0.58***
Japan	−0.53***	−0.38***	−0.55***
South Korea	−0.62***	−0.61***	−0.62***
Switzerland	−0.92***	−0.93***	−0.92***
UK	−0.70***	−0.65***	−0.74***
USA	−0.78***	−0.78***	−0.79***

This table shows the Correlation coefficients between daily VIX changes (%) and daily market returns (%). The correlation coefficients are generated across emerging and developed markets for overall periods, bull periods and bear periods. *** implies 1% significant, ** implies significant at 5% and * implies significant at 10%

Table 4. This table shows the pooled regression results based on the following model (on 1% winsorized sample)

	α	β	γ
All countries	-1.481***	0	-2.865***
Developed	-2.124***	0	-3.171***
Developed Bull	-1.955***	0.007*	-3.209***
Developed Bear	-2.268***	0	-3.208***
Developing	-0.824***	-0.008***	-2.447***
Developing Bull	-0.432***	0	-2.520***
Developing Bear	-1.101***	-0.013***	-2.406***

Model 1: $RVIX_{t+} = \alpha R_t + \beta^* DR + \gamma R_t^* DR + e_t$

Cells in the table indicate b values with significance. *** implies 1% significant, ** implies significant at 5% and * implies significant at 10%

2.7. Exploring the asymmetric relation: threshold GARCH (TGARCH) analysis

In addition to the above pooled regression model, we also use TGARCH (Zakoian, 1994) model to check for asymmetry in the relationship between VIX and returns. The following model is used for the same:

$$\sigma_t^2 = \omega + \sum_{i=1}^q \alpha_i e_{t-i}^2 + \gamma e_{t-1}^2 d_{t-1} + \sum_{j=1}^p \beta_j \sigma_{t-j}^2 \quad (4)$$

The variable d_{t-1} is the dummy variable which is equal to 1 when e_{t-1}^2 is less than 0 and 1 otherwise. Thus, if the variable γ is positive and significant it shows that the relationship between VIX and return is asymmetric i.e. higher in case of negative returns.

The analysis is done for the pooled sample for all countries and also repeated for all individual countries as well as developed and developing groups across bull and bear markets.

The results are presented in Table 5.

2.8. Causality tests

To test hypothesis 3 above, we employ a Granger (non) causality test between ΔVIX and market movement across emerging and developed markets in bull and bear market cycles. We first do a stationarity check of all the time series data we have and find that the index values, as well as ΔVIX series, are both non-stationary at level. We thus work out the ΔVIX and RM values as discussed above and find that these are all stationary for all countries and all market cycles. We then employ the standard Granger (non) causality test between ΔVIX and RM series. Traditionally Granger (1969) causality is employed to test for the causal relationship between two variables. This test states that, if past values of a variable y significantly contribute to forecast the future value of another variable x then y is said to Granger cause x . Conversely, if past values of x statistically improve the prediction of y , then we can conclude that x Granger causes y . The test for our case is based on the following models:

$$\Delta VIX_t = \beta_0 + \sum_{k=1}^M \beta_k \Delta VIX_{t-k} + \sum_{l=1}^N \alpha_l RM_{t-l} + u_t \quad (4)$$

$$RM_t = \gamma_0 + \sum_{k=1}^M \delta_k \Delta VIX_{t-k} + \sum_{l=1}^N \gamma_l RM_{t-l} + v_t \quad (5)$$

Where, ΔVIX and RM are the two variables we explained above, u_t and v_t are mutually uncorrelated error terms, t denotes the time period and “ k ” and “ l ” are the numbers of lags. The null hypothesis

Table 5. TGARCH analysis for asymmetry

	All countries	Developed Overall	Developed Bull	Developed Bear	Emerging Overall	Emerging bull	Emerging Bear
Γ	0.9999*	0.1793***	0.2897	0.2258	1*	0.2874	0.9999 ***

The numbers in the cells indicate the coefficient for γ . *** implies significant at 1%, ** implies significance at 5% and * implies significance at 10% respectively.

is $\alpha_l = 0$ for all l 's and $\delta_k = 0$ for all k 's versus the alternative hypothesis that $\alpha_l \neq 0$ and $\delta_k \neq 0$ for at least some l 's and k 's. If the coefficients α_l s are statistically significant but δ_k 's are not, then RM causes VIX . In the reverse case, VIX causes RM . But if both α_l and δ_k are significant, then causality runs both ways. Once again as we carry out causality tests separately for the overall data, for emerging and developed groups, and bull or bear market cycles, the results should provide interesting insights vis-à-vis hypotheses 3,4 and 5 above. The results are reported in Table 6 and discussed in the next section.

2.9. Analysis of a winsorized sample

Winsorizing or winsorization, first proposed by Charles P. Winsor, is the transformation of statistics by limiting extreme values in the statistical data to reduce the effect of possibly spurious outliers (Tukey, 1962). In our case, it is possible that the results we obtain are driven by a few very large or small changes in post-investment performance by a small number of firms. Hence the patterns that we observe could be a result of a handful of large outliers rather than generic trends. To address such possibilities, we run all our models (regression as well as causality models) after dropping all sample points with market returns in the top 1% or bottom 1% of the entire range.

2.10. Robustness tests

To check the robustness of results obtained from the main analysis we carry out a couple of robustness tests as follows:

2.10.1. Robustness test 1: using alternate classification schemes of bull and bear periods for each country

It is possible that the results we obtain, particularly w.r.t the market cycles (bull and bear) are biased because of the choice of a particular scheme of classification that we followed Wiggins (1992). So as a check of the robustness of our results, we adopt two more approaches to classify our study period into bull and bear periods. The approaches are those used by i) Fabozzi and Francis (1977,1979) and ii) Bhardwaj and Brooks (1993). Fabozzi and Francis (1977,1979), defines up (down) months as months when the market return is greater (less) than 1.5 times its standard deviation, while Bhardwaj and Brooks (1993) use the median return on the market portfolio as the demarcating value.

2.10.2. Robustness test 2: using 5% winsorized sample

We discussed above the reasons for using a 1% winsorized sample to eliminate the extreme outliers from our sample. As a robustness check, we use a 5% winsorized sample as well and carry out all our analyses to further weed out more outliers from our sample without significantly enhancing the chances of information loss.

We discuss the robustness test results in the following section.

3. Results

Table 3 below reports the correlation coefficients between VIX changes (ΔVIX_t) and market returns (RM_t). As we can see, there is evidence of a strong negative correlation between ΔVIX_t RM_t . The pattern is strong and robust for the overall period, during bull periods as well as during bear periods. Cross sectionally speaking, the pattern is robust for all countries on the average, for

Table 6. Granger causality test results

	All countries	Developed Overall	Developed Bull	Developed Bear	Emerging Overall	Emerging bear	Emerging Bear
Fabozzi							
Return on VIX	0.0003***	0.0002***	0.0022***	0.0005***	0.4005	0.4442	0.4162
VIX on Return	0.0006***	0.000***	0.0001***	0.65398	0.0038***	0.0001***	0.6323

Numbers in the cells indicate the p-values of the test statistic. *** implies significant at 1% and ** implies significance at 5% respectively.

developed countries and emerging countries, barring a few exceptions (Switzerland and Canada). All correlation coefficients are statistically significant at 1%. These findings give us the initial hint that there is a negative association between ΔVIX and RM and hence lend support to hypothesis 1.

Table 4 reports the regression results from the model (1) above. We observe the following patterns here: i) The association between RM and ΔVIX is negative, as all the α s are negative and significant. This is true for all countries, developed as well as developing countries. ii) The γ are also negative and significant. This implies that the association between VIX and market returns is asymmetric in nature i.e VIX rise during market downturns are more compared to VIX falls during market rises. This shows that the volatility during market downswings is much more compared to that of the upswings. This substantiates hypothesis 2 above and is in line with previous findings of Bekaert and Wu (2000); Wu (2001); Low (2004); and Dennis et al. (2006). These patterns are consistent across developed and developing nations including bull and bear markets.

The TGARCH γ coefficient is mostly positive and significant for all groups. This substantiates the results for asymmetry along with the pooled regressions results

Table 6 reports the results of Granger Causality tests using Wiggins (1992) approach for classification of bull and bear markets in each country. We have analyzed for each country individually but for the sake of brevity, we report only the aggregates group-wise results over here. We observe that there is strong evidence of unidirectional causal flow (market movement to VIX changes) for all countries irrespective of bull or bear swings. There is partial evidence of causal flow in the reverse direction i.e from VIX changes to market movements for developed countries, during bear periods. In summary, we can say there is strong evidence of leverage hypothesis holding for all countries and all periods and weak evidence of feedback hypothesis also holding only for developed countries.

3.1. Robustness test results

Tables 7, 8, 9 and 10 present the results of the robustness test. Tables 7 and 8 show the results of the regression models to test negative and asymmetric relationships between returns and volatility with alternate schemes of bull-bear period classification and 5% winsorized sample respectively. We find these results are almost similar to our findings from the main analysis i.e market movements and VIX movements are negatively and asymmetrically related to each other. The asymmetric relation gets enhanced (marginally) for developed markets and during negative market movements happening within an overall bear period. Tables 9 and 10 show the results of causality tests using alternate schemes of bull-bear period classification and 5% winsorized sample respectively. Here also, we find that results from the main analysis are more or less substantiated. We find there is strong evidence of leverage hypothesis holding for all countries and all periods and weak evidence of feedback hypothesis also holding only for developed countries.

The country-wise asymmetry results are mostly in line with the results of the developed and developing market across bull and bear cycles. The return, as well as the interaction coefficient, are negative and significant individually as well as across bull and bear cycles. The same can be seen in the case of TGARCH analysis.

With respect to causality also the results are mostly in line with the earlier results of returns granger causing risk in most cases, especially in case of overall and the bull market and some cases of reverse causality in case of bear markets.

4. Discussion of results

We find strong evidence in support of hypotheses 1 and 2 above. Correlation tests and pooled regression models (even after weeding out extreme outliers) show that return and volatility are negatively associated with each other, and the association is asymmetric in nature i.e volatility peaks during negative market movements are higher compared to drops during positive market movements. This asymmetric nature of the association is further ratified by the results of the

Table 7. Robustness test 1: Regression models on alternate bull-bear classification schemes

	α	β	γ
Bhardawaj and Brooks (1993) classification			
All countries	-1.481***	0.002	-2.865***
Developed	-2.124***	0.003	-3.171***
Developed Bull	-1.949***	0.008*	-3.038***
Developed Bear	-2.251***	-0.001	-3.346***
Developing	-0.824***	-0.008***	-2.447***
Developing Bull	-0.528***	-0.002	-2.465***
Developing Bear	-1.022***	-0.012***	-2.450***
Fabozzi and Francis (1977,1979) classification			
All countries	-1.481***	0.002	-2.865***
Developed	-2.124***	0.003	-3.171***
Developed Bull	-0.852***	0.021***	-2.286***
Developed Bear	-2.380***	0.0003	-3.108***
Developing	-0.824***	-0.008***	-2.447***
Developing Bull	-0.573*	-0.002	-1.810***
Developing Bear	-0.853***	-0.008***	-2.480***

This table shows the pooled regression results based on the following model (using alternate classification schemes of bull-bear periods)

$$RVIX_t = \alpha R_t + \beta \Delta R_t + \gamma R_t \Delta R_t + \epsilon_t$$

Cells in the table indicate b values with significance. *** implies 1% significant, ** implies significant at 5% and * implies significant at 10%

Table 8. Robustness test 2: Regression models on 5% winsorized sample

5% winsorized sample			
	α	β	γ
All countries	-1.562***	0.002**	-1.950***
Developed	-2.248***	0.002	-2.318***
Developed Bull	-2.093***	0.002	-2.707***
Developed Bear	-2.332***	0.001	-2.009***
Developing	-0.915***	-0.003	-1.466***
Developing Bull	-0.769***	-0.001	-1.524***
Developing Bear	-1.060***	-0.005**	-1.396***

This table shows the pooled regression results based on the following model using a 5% winsorized sample (instead of our originally used 1%)

$$RVIX_t = \alpha R_t + \beta \Delta R_t + \gamma R_t \Delta R_t + \epsilon_t$$

Cells in the table indicate b values with significance. *** implies 1% significant, ** implies significant at 5% and * implies significant at 10%

T-GARCH analysis. With respect to our hypothesis 3 above, we find strong evidence of causal flow from market movements to VIX i.e. leverage hypothesis holds for our overall data. To test hypotheses 4 and 5 we repeat the analysis within sub-samples based on market cycles (bull and bear) and level of maturity of the market (developed versus emerging). We do not find any significant differences in either associative or causal relation between volatility and returns across bull and bear market cycles (hypothesis 5). Hence the market's perception of volatility and return and hence the nature of the association between them does not change significantly across bull and bear market swings. However, we find marginal differences across developed and emerging markets (hypothesis 4). Although the evidence towards leverage hypothesis holding is strong and

Table 9. Robustness test 1: Causality tests with alternate approaches for bull-bear market classification

	All countries	Developed Overall	Developed Bull	Developed Bear	Emerging Overall	Emerging bull	Emerging Bear
Bhardwaj							
Return on VIX	0.0003***	0.0002***	0.0193**	0.0000***	0.4005	0.3186	0.3272
VIX on Return	0.0006***	0.0000***	0.0002***	0.5001	0.00389	0.0000***	0.5965
Fabozzi and Francis							
Return on VIX	0.0003***	0.0002***	0.2047	0.0002***	0.4005	0.0481**	0.7533
VIX on Return	0.0006***	0.0000***	0.4088	0.0000***	0.0038***	0.5523	0.0014

Numbers in the cells indicate the p-values of the test statistic of Granger causality tests. *** implies significant at 1%, ** implies significance at 5% and * implies significance at 10% respectively.

Table 10. Robustness test 2: Causality tests with 5% winsorized sample

	All countries	Developed Overall	Developed Bull	Developed Bear	Emerging Overall	Emerging bull	Emerging Bear
Return on VIX	0.0000***	0.0000***	0.0000***	0.0000***	0.0002***	0.0067***	0.0047***
VIX on Return	0.0000***	0.0005***	0.0014***	0.06563*	0.0000***	0.0000***	0.0157**

Numbers in the cells indicate the p-values of the test statistic of Granger causality tests. *** implies significant at 1%, ** implies significance at 5% and * implies significance at 10% respectively.

Table 11. TGARCH Analysis for Asymmetry Winsorized

	All countries	Developed Overall	Developed Bull	Developed Bear	Emerging Overall	Emerging bull	Emerging Bear
Γ	0.2271	-0.1238	0.2053*	0.4156	0.9996	-0.8258***	0.1752

The numbers in the cells indicate the coefficient for γ . *** implies significant at 1%, ** implies significance at 5% and * implies significance at 10% respectively.

ubiquitous across both developed and emerging markets in bull as well as bear market swings, we find weak evidence of the reverse causality holding only for the developed markets but not for the emerging markets. Our principal results are quite stable in nature and remain more or less unaltered even through a country-level analysis and through a couple of robustness tests as well. In summary, we find evidence of a negative and asymmetric association between volatility and market movements in all countries across all market swings with causality flowing from market movements to volatility (leverage hypothesis holding). We find weak evidence of causal flow from volatility to market movements (volatility feedback) mostly in developed countries.

Which of the two effects (leverage versus volatility feedback) explain the asymmetric nature of volatility return association, remains a contentious issue in finance research. As noted in Bekaert and Wu (2000) for the volatility feedback theory to hold, one of the primary conditions is the persistence of volatility i.e. a large realization of news, positive or negative, increasing both current and future volatility. The second basic requirement of the feedback hypothesis is a positive intertemporal relationship between expected return and conditional variance, such that increased conditional variance raises expected returns and lowers current stock prices. However, such an association only holds in general equilibrium settings under restrictive assumptions. (Backus & Gregory, 1993). Moreover, findings in several empirical research (Glosten, Jagannathan, & Runkle, 1993; Nelson, 1991; Turner, Startz, & Nelson, 1989) challenges this premise. That we find weak evidence of volatility feedback theory and find it holding only for developed countries and strong evidence of the alternate leverage hypothesis could be further re-emphasizing the doubts about the positive intertemporal relationship between expected return and conditional variance holding at all.

5. Summary and conclusion

This paper examines the association of implied volatility indices (VIX) on stock market returns, with data from 13 countries representing developed and emerging markets. We use an extensive daily time series data between January 2013 to December 2018, on VIX and stock index from nine developed markets (Australia, Canada, France, Germany, Hong Kong, Japan, South Korea, Switzerland, USA) and four emerging markets (Brazil, India, Russia and South Africa). This leads to 769 observations for each country for each Index. We employ regression and causality models on this data to explore the nature of the association between VIX and stock market movement. We also explore differential patterns, if any, across the countries and bull and bear market cycles in each of these countries.

Table 12. Asymmetry analysis Countrywise

		Return	DR	Return*DR	Constant	Observations	Adjusted R2
VIX	Australia	-2.597***	0.003	-5.229***	-0.015***	999	0.478
	Brazil	-0.617**	-0.005	-2.736***	-0.011**	999	0.195
	Canada	0.762***	-0.0005**	-0.065***	0.0002	999	0.879
	China	-0.038	-0.007	-2.845***	-0.011***	999	0.18
	France	-4.264***	0.003	-1.578	0.006	999	0.094
	Germany	-2.468***	0.016***	-2.998***	-0.016***	999	0.566
	Hong Kong	-1.104***	-0.008*	-4.448***	-0.013***	999	0.433
	India	-1.618***	-0.012**	-3.489***	-0.004	999	0.365
	Japan	-1.550***	0.018***	-1.788***	-0.008***	999	0.316
	Russia	-1.609***	-0.021***	-2.084***	0.005	999	0.133
	South Africa	-1.176***	-0.001	-0.776***	-0.002	999	0.293
	South Korea	-2.449***	0.001	-3.886***	-0.011***	999	0.412
	Switzerland	0.711***	0.0002	0.082***	0.001***	999	0.854
	UK	-5.094***	-0.022***	-5.064***	-0.002	999	0.533
	USA	-6.651***	0.005	-4.304***	0.006**	999	0.642

The numbers in the cells indicate the coefficient. *** implies significant at 1%, ** implies significance at 5% and * implies significance at 10% respectively.

Table 13. Asymmetry analysis Countrywise Bull

	Return	DR	Return*DR	Constant	Observations	Adjusted R2
VIX						
Australia	-1.761***	0.011	-5.748***	-0.020***	521	0.407
Brazil	-0.690**	0.007	-1.574***	-0.010**	444	0.29
Canada	0.774***	-0.0004*	-0.103***	0.00003	657	0.874
China	1.075***	-0.009	-4.585***	-0.018***	528	0.212
France	-4.741**	0.002	-0.27	0.019	487	0.033
Germany	-2.365***	0.027***	-2.518***	-0.019***	558	0.501
Hong Kong	0.096	-0.002	-5.783***	-0.021***	493	0.397
India	-1.663***	0.002	-2.119***	-0.005	502	0.31
Japan	-2.433***	0.002	-0.791**	0.004	573	0.303
Russia	-1.013**	-0.01	-1.945***	-0.001	509	0.091
South Africa	-1.348***	-0.006	-1.164***	0.0004	555	0.295
South Korea	-2.047***	0.004	-4.857***	-0.012**	508	0.482
Switzerland	0.688***	-0.0001	0.114***	0.001***	590	0.85
UK	-4.811***	-0.011	-5.455***	-0.007	497	0.46
USA	-9.773***	0.004	-0.382	0.013***	683	0.62

The numbers in the cells indicate the coefficient. *** implies significant at 1%, ** implies significance at 5% and * implies significance at 10% respectively.

Table 14. Asymmetry analysis countrywise bear

	Return	DR	Return*DR	Constant	Observations	Adjusted R2
VIX						
Australia	-3.591***	-0.007	-4.619***	-0.009*	474	0.576
Brazil	-0.591	-0.011	-3.209***	-0.012	551	0.181
Canada	0.748***	-0.001*	-0.025	0.0005	338	0.884
China	-0.969***	-0.005	-1.359***	-0.006	467	0.2
France	-3.711***	0.009	-2.639***	-0.009	508	0.585
Germany	-2.590***	0.001	-3.541***	-0.012***	437	0.659
Hong Kong	-1.739***	-0.011*	-3.677***	-0.010**	502	0.487
India	-1.604***	-0.021***	-4.436***	-0.003	493	0.425
Japan	-3.445***	-0.008	1.997***	0.008*	422	0.279
Russia	-2.289***	-0.032***	-2.136***	0.011	486	0.18
South Africa	-1.043***	0.004	-0.499	-0.004	440	0.312
South Korea	-2.673***	0.001	-2.571***	-0.010**	487	0.319
Switzerland	0.739***	0.001	0.05	0.001*	405	0.859
UK	-5.206***	-0.033***	-4.985***	0.002	498	0.597
USA	-7.293***	-0.0002	0.264	0.007	312	0.647

The numbers in the cells indicate the coefficient. *** implies significance at 1%, ** implies significance at 5% and * implies significance at 10% respectively.

Table 15. Causality analysis country wise

Country	Return on VIX			VIX on Return		
	Overall	Bull	Bear	Overall	Bull	Bear
Australia	0.6119	0.8281	0.0344**	0.0066***	0.0217**	0.0946*
Brazil	0.0640*	0.8438	0.5998	0.5756	0.6395	0.0430**
Canada	0.1244	0.1204	0.9784	0.1158	0.1238	0.9549
China	0.0005***	0.6387	0.675	0.7639	0.0054***	0.0005***
France	0.6908	0.6741	0.0437**	0.0027***	0.4769	0.6368
Germany	0.0132**	0.0734*	0.1634	0.3821	0.3975	0.8986
Hong Kong	0.0307**	0.0135**	0.3759	0.0717*	0.2893	0.0917*
India	0.3857	0.1426	0.0061***	0.0459**	0.9309	0.4169
Japan	0.7642	0.1055	0.1111	0.0421**	0.7628	0.8577
Russia	0.8027	0.4133	0.3758	0.0211**	0.0802*	0.1962
South Africa	0.3288	0.1227	0.3206	0.5982	0.1191	0.1195
South Korea	0.8262	0.0121**	0.0454**	0.447	0.2042	0.4372
Switzerland	0.0827*	0.3105	0.5635	0.1581	0.2001	0.4972
UK	0.0090***	0.0035***	0.3947	0.0122**	0.0251**	0.7744
USA	0.3241	0.0046***	0.5752	0.9568	0.0942*	0.0225**

The numbers in the cells indicate the coefficient for the p-value. *** implies significant at 1%, ** implies significance at 5% and * implies significance at 10% respectively.

Table 16. Causality analysis country wise

Country	Return on VIX		
	Overall	Bull	Bear
Australia	0.8241***	-0.2208	0.2198
Brazil	0.7879**	0.0159	-0.4478
Canada	1***	-0.4328*	-0.5124***
China	0.6487***	-0.4133	0.0238
France	0.8791***	0.05	-0.7729***
Germany	0.9038***	0.012	-0.4137*
Hong Kong	1***	-0.2949	-0.3201
India	1***	-0.4248*	-0.8946*
Japan	0.6961***	-0.6703***	-0.371**
Russia	0.4708***	-0.1987	-0.079
South Africa	1***	-0.0897	-0.5942***
South Korea	1***	1	-0.6709**
Switzerland	1***	-0.2564	-0.4784**
UK	0.9402***	-0.8051	-0.7178***
USA	0.8731***	-0.303**	-0.5079**

The numbers in the cells indicate the coefficient for p-value. *** implies significant at 1%, ** implies significance at 5% and * implies significance at 10% respectively.

Our results show that there is a strong negative and statistically significant relationship between stock market return and VIX movements, which is consistent with previous studies employing traditional regression models (Fleming et al., 1995; and Whaley 2009, among others). This negative relation exhibits asymmetry i.e magnitude of an increase in volatility in down markets is higher than the magnitude of the decline in volatility in up markets. We also observe that there is strong

evidence of causal flow from market movement to VIX changes (i.e leverage hypothesis holding) for all countries irrespective of bull or bear swings. This is in line with previous results reported in Black (1976), Christie (1982), Nelson (1991), Gallant et al. (1992), Campbell and Kyle (1993) and Engle and Ng (1993). We find weak evidence of reverse causality (VIX changes to market movements indicating feedback hypothesis holding) for developed countries, particularly during bear periods. Bekaert and Wu (2000), posits that for the volatility feedback theory to hold, two conditions must be satisfied: persistence in volatility and a positive contemporaneous association between volatility and return. However, it is well documented such an association only holds in general equilibrium settings under restrictive assumptions. (Backus & Gregory, 1993). Moreover, empirical research (Glosten et al., 1993; Nelson, 1991; Turner et al., 1989) also challenges this premise. That we find weak evidence of volatility feedback theory and strong evidence of the alternate leverage hypothesis further re-emphasizes the doubts about these conditions holding.

Overall, our results indicate that investors can effectively use signals imminent in VIX movements, for risk prediction and hedging. They can use information in VIX movements to determine potential entry and exit points both in emerging as well as developed markets. Informed traders and speculators in some markets may use the advance negative signal of higher VIX to time short-selling stocks and realizing gains (or minimizing losses) on their stocks before prices actually drop (Sarwar, 2012). For example, since VIX reflects the price of portfolio insurance (Whaley, 2009), the significant time lag between the closing and opening of US and European markets vis-a-vis Asian markets provides potential timing opportunities during high VIX days for informed portfolio and risk managers in the later markets to trade in portfolio insurance products (e.g., options, swaps, and forward contracts) before their prices actually rise (Sarwar, 2012). These results imply that VIX can be used as an effective tool for risk management. Derivative products based on the volatility index can be designed and used as a tool for portfolio insurance against the worst declines. Derivatives on volatility can potentially provide the investors an opportunity to invest in a separate asset class thereby augmenting the current set of investment opportunities and enhancing diversification benefits. In summary, the findings of this study can have significant implications for all stakeholders in these markets, including investors, portfolio managers, and policymakers.

Despite our best efforts, for the sake of brevity, some potential limitations could not be addressed within this study itself which could be addressed in separate endeavors in the future. Since the stock market return is used as one of the key variables, there may exist many variables and factors that could be considered as leading economic indicators, such as the CCI (consumer confidence index) and could be used as the predictive power of stock market returns. Because those variables are not included in the analysis the models may be subject to problems of the omitted variable bias. The models used may be subject to problems of endogeneity because one or more of the explanatory variables VIX and/or RM could be jointly determined by some other variables. For example (Govt. Bond Yields). This is possible, because during periods of temporary economic declines and consequent negative returns in equity markets investors might flee to safe havens like commodities (gold) or Govt. bond markets leading to declining in bond yields. To overcome and address this problem, future studies can use the government bond yield as an instrumental variable estimator. Future studies can also include other measures of volatility, like gross volatility (standard deviation of daily returns), or conditional volatility (measures generated out of GARCH type models) to test whether these findings still hold.

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Notes

1. Dr. Soumya G Deb holds a Ph.D. (FPM) from IIM-Calcutta and is currently Associate Professor at IIM Sambalpur.

Jalaj Pathak is a 3rd-year Ph.D. student in the F&A area at the IIM, Bangalore. We would like to thank Prof. Sankarshan Basu, Prof. Srinivasan Rangan and Prof. Shashidhar Murthy for their valuable comments and feedback. Also, we would like to thank Nikhil Vidhani for his immense help with respect to research design and analysis.

2. <https://www.msci.com/market-classification>.
3. The other two methods used are Fabozzi and Francis (1977,1979) and Bhardwaj and Brooks (1993). The same is explained in detailed in the Robustness section.
4. The beta in the equation is the coefficient of Dummy of Return (DR) which is included as it is there in the interaction term. It is not taken into consideration in case of asymmetry discussion as it only affects the intercept and not the slope.

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