# Some Preliminary Examination of Predictive Ability of India VIX[1]


## *Abstract*

Earlier studies establish a positive relationship between volatility index (VIX) and the stock index returns. These studies are mainly restricted to developed markets and the research in this regard in emerging market is scarce. We intend to fill up this gap and in the process extend our study for examining direct and cross-sectional relationship of India VIX in relation to three important parameters, viz., stock beta, market-to-book value of equity and market capitalization. Using multiple regression analysis, we find that India VIX has a positive and significant relationship with the returns of the value-weighted portfolios sorted on the basis of beta, market-to-book value of equity and market capitalization. We further examine the behavior of India VIX in the presence of market-to-book value of equity and market capitalization as controlling variables and document that India VIX yields a positive and significant relationship with the portfolio returns in those cases also. These results suggest India VIX is a distinct risk factor, capable of predicting the pricing mechanism of the market.



Key words: Volatility Index, stock beta, market to book value, market capitalization

JEL Classification: G1, G11



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[1] "VIX" is a trademark of Chicago Board Options Exchange, Incorporated ("CBOE") and Standard & Poor's has granted a license to NSE, with permission from CBOE, to use such mark in the name of the India VIX and for purposes relating to the India VIX.

# Some Preliminary Examination of Predictive Ability of India VIX

## Introduction

In the backdrop of the meltdown in the financial sector worldwide, the importance of a volatility index has assumed great importance . The financial derivatives which exposed the fragility of the financial management system worldwide, underscores the fact that the regulatory measures are partially ineffective, when attempting to regulate the market without understanding the ferocity of the destructive power unleashed by these instruments on the established financial system. Although the stock markets generate wealth of information on these issues, which help the regulatory authorities to monitor the health of the financial system and to prescribe corrective measures, yet the defense of the financial system remained vulnerable to the dysfunctional forces generated by these unregulated or exotic derivatives, which remain beyond the control of the regulators. Researchers have developed various indicators for examining dynamics of market forces and their inter- relationship. One such recently introduced information measure is volatility index. Introduced in US in 1993 as CBOE Volatility Index (VIX), it was constructed on the basis of S&P 100 (OEX) stock index option. Subsequently in 2003, VIX is computed from S&P 500 (SPX) index option and is identified as VXO. The volatility index is also introduced in several developed and emerging markets. It is a measure of market expectation of volatility over a short-term period and indicates the implied volatility as well as implied risk of the stock market. As such the volatility index offers a clue to the investors to buy and sell in the market. Although in the developed markets there are impressive numbers of research studies in VIX, it is in the area of emerging markets where dearth of studies is observed. One plausible reason is due to recent introduction of measure of VIX in those markets and as a result data for investigation are small which may not be suitable for the intended research study. In the Asian continent the Indian derivative market is expanding at a high rate. In fact the Indian market, which is an emerging market, is growing at around 100% and occupies a position next only to Korea Stock Exchange in the year 2009 (World Federation of Exchange Website). Accordingly, it would be of interest to understand the behavioral aspect of India VIX. ( For a detailed discussion on India VIX and its construction, please see National Stock Exchange of India website: www.nseindia.com).

**A Brief Survey of Earlier Research Studies**

The research activities in the interpretation and understanding of the underlying characteristics of VIX are wide. In previous research studies, VIX has been referred to as a measure of implied volatility and also a measure of investor's anxiety (Whaley 2000) , as high levels of VIX signal high degree of market uncertainty. As a result, VIX may be regarded as a signaling device triggering buy / sell decisions by the investors. Fleming, et, al. (1995) examine time series properties of the CBOE old volatility index VIX (now VXO) and find that large negative contemporaneous relation with significant asymmetry between changes in VIX and stock index returns. Whaley (2000) reports negative relationship between weekly changes in VIX and S & P 100 returns. Also a recent account of VIX, tracing its history and purpose is due to Whaley (2009).

It is generally believed that high VIX signals bottoming out of the market and indicates oversold positions. Consequently, in anticipation of price rise as an aftermath of high VIX, the investors can go long in the market. The relation of high VIX with oversold market position is investigated by Giot (2005). He documents a negative and statistically significant relationship between the returns of the S & P 100 and Nasdaq 100 Stock Indexes and their corresponding implied volatility indexes VIX and VXN. He also finds asymmetric return with respect to S & P 100 Index. Negative stock index returns are more associated than positive returns with greater changes in VIX. The asymmetric return is found to be relatively weak for Nasdaq 100 when compared to S & P 100 index. The inference that we could draw from the result is that very high levels of VIX could signal attractive opportunities for buying. This inference, however, contradicts the notion of market efficiency. An alternative explanation is that VIX may be regarded as a systematic risk factor. A number of researchers also find that the market price of volatility risk is negative [ Jackwerth and Rubeinstien (1996), Coval and Shumway (2001)]. In other words risk averse investors may find high levels of VIX as a signal of high risk premium due to negative correlation between price and volatility. Hedge funds returns are also central to some studies. A contemporary addition to studies relating to the portfolio returns in respect of hedge funds is a study by Das and Moran (2005). They document negative correlation of VIX with respect to hedge fund returns. Issues involving volatility risk premium and innovations in VIX are subject matter of various other contemporary studies. For example, Ang and others (2006) find that stocks that have higher sensitivity to innovations in VIX have lower returns. The study points out a negative volatility risk premium. Coval and Shumway ( 2001) find a negative volatility risk premium. Copeland and Copeland (1999) have examined VIX vis-à-vis BARRA's indices (value and growth stocks), S&P 500 futures (large stocks), and Value Line futures (small stocks) and find that the large and value stocks earn high returns post-high VIX. Guo and Whitelaw (2006) document, that the market returns are positively related to implied volatilities in time-series analysis. Banerjee, Doran and Peterson (2007) examine the relationship of innovation of VIX in portfolios sorted on book-to-market equity, size and beta. They find VIX related variables have strong predictive ability even in control models containing Fama and French (1993) and Carhart (1997) factors. In the course of forming our methodology we are also motivated by Fama and French (1992) arguments on the variables that we have chosen, viz, beta, market-to-book value and market capitalization. Fama and French (1992) establish "two easily measured variables, size and book-to-market equity, combine to capture the cross-sectional variation in average stock returns associated with market β, size, leverage, book-to-market equity, and earnings-price ratios….." (Fama, E.F. and French, K.R.: "The cross-section of expected stock returns", *The Journal of Finance*, Vol. XLVII, No.2, June, 1992, p.427). However, the contemporary researchers downplay the argument and consider book value a historical element while the market value reflects information on the present discounted value of future cash flows. In other words, book-to-market value seems to provide meaningless information. On the other hand Fama and French (1992) argue that book-to-market ratio along with size (market capitalization), earning-price ratio, debt-equity are more readily associated with expected stock return. Since no counter evidence has been documented to contradict Fama and French (1992) works and the results are with some reservations are still valid, we use some of these factors in our construction of regression equations.

**Research Objective and Methodology**

In this study, we want to expand the earlier studies in Indian context and our aim is to study predictive behavior of the India VIX, drawing inferences from the result obtained. This study contributes in following way. First it examines the India VIX from the point of behavioral finance and second it provides valuable information to the traders and investors for using volatility index as a tool for predicting the market.

We wish to examine, predictive behavior of India VIX under three different characteristics. These parameters are beta, size (market capitalization) and market-to-book value of equity. Earlier studies have established significant relationship between Volatility Index (VIX) and future market returns. Accordingly, beta becomes an important grouping characteristic to find out the underlying relationship, like whether high beta firms have different relationship with India VIX when compared to low beta firms. We also select size (market capitalization) and market-to-book value of equity as two more grouping characteristics, since these are attributes that are observed to affect investors' decision. Given the above overview, we construct six portfolios on the following criteria:

1. Portfolios sorted from Nifty Index firms on the basis of high beta and low beta. The high beta firms are Nifty index firms with beta falling at 60% or above percentile, while low beta firms are those betas falling at 30% or less percentile.

2. Portfolios sorted from Nifty Index firms with high and low market-to-book equity ratio. The break-point between high and low ratio is chosen on the basis of 60%

and above percentile for high M/E ratio, while 30% and less percentile for low M/E firms.

3. Portfolios sorted from Nifty Index firms on the basis of size, i.e., market capitalization with break-point of large size at 60% and above percentile, while small size at 30% and less percentile.

We calculate the return of the above 6 portfolios on 30-day (calendar days) holding period. The holding time period coincides with forecast horizon of India VIX. We regress it with the following equation to find out overall impact of India VIX:

$$R_{pit}^{30} = \alpha_t + \beta_{pit} \ \ln v_t + \varepsilon \qquad (1)$$

where $R_{pit}^{30}$ is the **log return** of the sorted portfolio *i* on a 30-day holding period at time *t*, while $v_t$ is the volatility index at time *t*. The regression coefficient $\beta_{pit}$ represents the effect on portfolio returns by the India VIX.

Second, we put market-to-book value of equity and size (market capitalization) to examine cross-sectional relationship of India VIX with portfolio returns. The book value of the individual stock is calculated as the net-worth of the firm divided by the number of equity shares outstanding, as reported in the balance sheet, while market value of the share is taken as the closing value of the stock reported in the National Stock Exchange of India on daily basis. The following equations are used to examine the underlying relationship:

With market-to-book characteristics the equation is:

$$R_{pit}^{30} = \alpha_t + \beta_{pit} \ \ln v_t + \gamma_{pit} \ln(M/E)_{pit} + \varepsilon \qquad (2)$$

where $(M/E)_{pit}$, is the ratio of market-to-book value of the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\gamma_{pit}$ is the regression coefficient representing the cross-sectional effect on relationship of (M/E) on the portfolio returns.

With size (market capitalization) characteristics the equation becomes:

$$R_{pit}^{30} = \alpha_t + \beta_{pit} \ \ln v_t + \delta_{pit} \ln(MC)_{pit} + \varepsilon \qquad (3)$$

where $(MC)_{pit}$ , is the market capitalizations of the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\delta_{pit}$ is the regression coefficient representing the cross-sectional effect on relationship of (MC) on the portfolio returns.

We additionally try to capture the cross-sectional relationship of VIX with market-to-book and size (market capitalization) characteristics and we use the following equation:

$$R_{pit}^{30} = \alpha_t + \beta_{pit} \ln v_t + \gamma_{pit} \ln(M/E)_{pit} + \delta_{pit} \ln(MC)_{pit} + \varepsilon \qquad (4)$$

If India VIX is a predictor of portfolio return, βs' should be significant and should also be in spite of the presence of size and market-to-book factors. The above examination will reveal relationship of directional movement of India VIX.

In second stage we wish to repeat the same experiment on 45-day holding period for further assessing the forecasting power of VIX. The consideration of the 45-day holding period is important since in earlier studies it has been found that VIX is mean reverting around 45-day period (Bannerjee, P.S. and others (2006)). Mean reversion is a mathematical concept that underlies the stock prices will tend to move towards the average price over time. Hence if the mean reversion process is linked to predictive ability of VIX, its behavior is expected to reveal whether the investor is attracted towards using VIX to predict the future stock returns or that the investor would primarily base his decision on mean reversion criterion. The 30-day holding period corresponds the period on which VIX is constructed, while 45-day period coincides with mean reversion. Any significant difference of results between the two is expected to reveal whether investors are more attracted towards VIX. In other words, the result would reveal whether VIX has systematic higher predictive power over 45-day period vis-à-vis 30-day period.

Accordingly, set of our equations will be:

For examination of behavior of beta sorted portfolio:

$$R_{pit}^{45} = \alpha_t + \beta_{pit}\ \ln v_t + \varepsilon \tag{5}$$

where $R_{pit}^{45}$ is the **log return** of the sorted portfolio *i* on a 45-day holding period at time *t*.

For examination of market-to-book characteristics vis-à-vis behaviour of India VIX:

$$R_{pit}^{45} = \alpha_t + \beta_{pit}\ \ln v_t + \gamma_{pit}\ \ln(M/E)_{pit} + \varepsilon \tag{6}$$

With size (market capitalization) characteristics:

$$R_{pit}^{45} = \alpha_t + \beta_{pit}\ \ln v_t + \delta_{pit}\ \ln(MC)_{pit} + \varepsilon \tag{7}$$

Finally for finding out cross-sectional relationship of VIX with market-to-book and size (market capitalization) characteristics, we use the following regression equation:

$$R_{pit}^{45} = \alpha_t + \beta_{pit}\ \ln v_t + \gamma_{pit}\ \ln(M/E)_{pit} + \delta_{pit}\ \ln(MC)_{pit} + \varepsilon \tag{8}$$

The primary aim and contribution of this study is to bring forth the nature of relationships between Nifty constituents and India VIX and the analysis is expected to bring out valuable insight on the further use of India VIX in the stock market analysis.

**Data**

The data on constituent firms of Nifty 50 (closing values) and India VIX (closing values) are collected over the period between November 1, 2007 and November 30, 2009 on daily basis, from National Stock Exchange of India (NSE) website. The portfolio is selected by first finding out the individual beta of the firms constituting the Nifty Index, while market capitalization and market-to-book equity are calculated from the data available in the NSE India and individual firm's websites. Specifically, we calculate the market value of equity as on 31st March of the year t and use it for forming the portfolio based on market capitalization for the year t (i.e., from 1st April year t-1 to 31st March year t, in order to coincide with accounting year of the firms), with the appropriate cut-off percentiles. The same procedure is followed for calculation of beta and market to book value of the equity. We form the value-weighted portfolios on yearly basis after sorting 50 constituent firms of the Indian Nifty index by dividing them into upper 60th percentile and lower 30th percentile and calculate the daily value-weighted portfolio returns on 30-calendar day and 45-calendar day holding period basis for the entire period.

**Results**

The log returns characteristics (returns and their standard deviations) of the various portfolios are given in table – 1. Except for the low beta sorted portfolio and 30-day holding period return of high beta sorted portfolio, all the other portfolios yield negative returns. The negative returns are higher for 45-day holding period when compared to the returns of 30-day holding period. The behavior of return series is expected as the period is witnessing recession and drastic fall of stock market returns world-wide. As expected high beta portfolios have high standard deviations. We also present the correlation coefficients of returns of various portfolios with respect to log of VIX in table – 2. Since the correlation is positive, it appears that the VIX is positively related to various portfolio returns.

We now test the VIX series about its stationarity. The ADF test statistic yields - 4.0777, which rejects the hypothesis of existence of unit root in the series. In addition, we test the stationarity of all the regression residuals and we find that they are stationary and the D-W statistic is 2.00 or very close to 2.00. Under such circumstances, the degree of bias in the regression coefficients will be very small so that the regression results are acceptable. In addition, we examine the presence of multicollinarity among the independent variables. For the purpose, we compute the variance inflation factor (VIF), which is found to be a little more than one and accordingly we reject the existence of multicollinarity among the independent variables. In addition, we find constant terms are significant in the regression equations, suggesting presence of some explanatory factors not captured by the data or the model.

The regression analysis shows that the India VIX has a positive statistically significant impact on the portfolio returns. As the India VIX can be regarded as idiosyncratic risk measure, we observe that the impact of India VIX on the portfolio returns is significant and high, when India VIX is used as the only independent variable in the regression. The results are presented in table – 3. The high beta sorted portfolios have shown larger significant impact than the other portfolios. Since the beta is a measure of risk, high beta portfolios returns would have higher impact. It is also observed that the impact is relatively higher on 45-day return (0.472) as compared to 30-day return (0.034). For other portfolios, impact of India VIX is lowest (0.009) for high market capitalization (MC) sorted portfolio, while the impact is highest (0.0663) for low MC sorted portfolio. In other words, investors tend to discount India VIX information for larger MC firms, while have a propensity to use India VIX information for smaller MC firms. The India VIX is also an important risk measure for the investors basing their judgment on market to book value (M/E) parameter. The high and low M/E portfolios yield asymmetric but significant coefficients for the India VIX, when 30-day (0.0301 and 0.0291 respectively) and 45-day (0.046 and 0.0439 respectively) return periods are considered. In a sense it affirms the findings of Giot (2005) that the VIX has the greatest forecasting power for 60-day period.

Next we introduce a second independent variable. i.e., log of market to book (M/E) value of equity. The impact of India VIX is found to be lower for both high and low portfolios, as compared to the impact of India VIX on the same portfolios, without the variable (M/E). The results are tabulated in table – 4. However, the impact remains positive and significant. The higher impact (0.25) is again confined to high beta sorted portfolio. It is further observed that portfolios selected on market capitalization have mixed impact of India VIX. The low portfolios (30-day and 45-day) have higher impact (0.0321 and 0.0449 respectively) in respect of other categories of portfolios. We have earlier reported that India VIX is considered as an important risk factor for smaller firms and this evidence further establishes it.

We also introduce log of market capitalization as another independent variable to examine the effect of India VIX on portfolio returns. The results are shown in table – 5. Since the investors discount India VIX information for large (MC) firms, the effect of India VIX on the portfolio returns turns out to be lowest ( 0.0053 and 0.02336 respectively for 30-day and 45-day respectively) compared to all other categories of portfolios. Once again we find that since the investors usually value India VIX information for the low (MC) firms, the impact of India VIX is found to be relatively high for low (MC) portfolios. The regression coefficient for 30-day return horizon is 0.0187 and 0.019 for low beta and low (M/E) portfolios, while it is 0.02336 for (MC) portfolio. Similar inference can be drawn in the case for 45-day holding period return. The regression coefficient for low (MC) portfolio is 0.0308, while for beta and (M/E) sorted portfolios these are 0.0259 and 0.0266 respectively.

We now introduce both the variables (M./E) and (MC) in addition to India VIX, in order to examine cross-sectional impact of India VIX. If India VIX is a predictor of portfolio returns, its regression coefficient should be positive and significant, in spite of the presence of above two independent variables, which are expected to influence investors' investment strategy. The regression results are presented in table - 6. It may be observed that for all the portfolios, the regression coefficients of India VIX are positive and significant, thereby establishing our above hypothesis. As expected, the coefficients of India VIX are found to be lowest for high (MC) portfolio.

**Conclusion**

Earlier studies establish a positive relationship between volatility index (VIX) and the stock index returns. These studies are mainly restricted to developed market and the research in this regard in emerging market is scarce. We intend to fill up this gap and in the process extend our study for examining direct and cross-sectional relationship of India VIX in relation to three important parameters, viz., stock beta, market to book value and market capitalization. These parameters are important traits in behavioral finance, influencing investors' decision. For the purpose, we built up six portfolios on the basis of above three parameters, dividing into two distinct parts, viz., lower percentile and upper percentile and compute their returns for 30-day and 45-day holding periods. We then document that India VIX has a positive and significant relationship with the returns of these portfolios. We further examine the behavior of India VIX in the presence of two parameters, i.e., market to book value and market capitalization, individually and jointly. In all cases, India VIX yields a positive and significant relationship with the portfolio returns. The relationship is found to be larger for 45-day holding period return when compared to 30-day period. The above evidence points to the fact that India VIX has higher predictive accuracy for 45-day period. In sum, the results suggest India VIX can be regarded as a distinct risk factor that could assist an investor to understand the price discovery mechanism.

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**Table - 1**

**Descriptive Statistics**

The table below shows the mean log return and standard deviations of the portfolios formed on the basis of beta, market value to book value of equity (M/E) and the market capitalization (MC), during the period between 1st November, 2007 and 30th November, 2009.

| **Portfolio** | **Low Beta** | | **High Beta** | |
|---|---|---|---|---|
| | **30-day** | **45-day** | **30-day** | **45-day** |
| **Mean** | **0.000294** | **0.000526** | **0.002621** | **-0.019377** |
| **Standard Deviation** | **0.010672** | **0.013601** | **0.017860** | **0.219421** |

| **Portfolio** | **Low M/E** | | **High M/E** | |
|---|---|---|---|---|
| | **30-day** | **45-day** | **30-day** | **45-day** |
| **Mean** | **-0.000640** | **-0.001072** | **-0.002794** | **-0.004245** |
| **Standard Deviation** | **0.015004** | **0.018540** | **0.015784** | **0.020016** |

| **Portfolio** | **Low MC** | | **High MC** | |
|---|---|---|---|---|
| | **30-day** | **45-day** | **30-day** | **45-day** |
| **Mean** | **-0.003112** | **-0.004842** | **-0.000436** | **-0.000678** |
| **Standard Deviation** | **0.023671** | **0.029503** | **0.004148** | **0.005215** |

**Table - 2**

**Correlation of Log VIX with respect to various log return series**

| Return Series | High Portfolio Log VIX | Low Portfolio Log VIX |
|---|---|---|
| BETARTN30 | 0.294873 | 0.387137 |
| BETARTN45 | 0.325600 | 0.432820 |
| M/ERTN30 | 0.300095 | 0.302594 |
| M/ERTN45 | 0.348225 | 0.358387 |
| MCRTN30 | 0.324875 | 0.291984 |
| MCRTN45 | 0.384536 | 0.339770 |

**BETARTN30 : Log return of beta sorted portfolio for 30-day holding period**

**BETARTN45 : Log return of beta sorted portfolio for 45-day holding period**

**M/ERTN30 : Log return of M/E sorted portfolio for 30-day holding period**

**M/ERTN45 : Log return of M/E sorted portfolio for 45-day holding period**

**MCRTN30 : Log return of MC sorted portfolio for 30-day holding period**

**MCRTN45 : Log return of MC sorted portfolio for 45-day holding period**

**Table - 3**

The table below shows the regression results in respect of six sorted portfolios. The regression equations are:

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit} \ lnv_t + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit} \ lnv_t + \varepsilon,}$$

where $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **Beta sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $v_t$ is the volatility index at time *t*. The regression coefficient $\beta_{pit}$ represents the effect on portfolio returns by the India VIX.

| **Portfolio** | **Low Beta** | | | | **High Beta** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\boldsymbol{\beta_{pit}}$ | **0.026** | **5.803** | **0.0389** | **5.43** | **0.034** | **4.709** | **0.472** | **4.62** |

**All coefficients are significant at 1% level.**

**Table - 3 (C0ntd.)**

Following results are the regression output in respect of **market to book value (M/E) sorted portfolio.**

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit}\ \ln v_t + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit}\ \ln v_t + \varepsilon,}$$

where $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **M/E sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $v_t$ is the volatility index at time *t*. The regression coefficient $\beta_{pit}$ represents the effect on portfolio returns by the India VIX.

| **Portfolio** | **Low M/E** | | | | **High M/E** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\beta_{pit}$ | **0.0291** | **6.84** | **0.0439** | **5.633** | **0.0301** | **4.678** | **0.046** | **5.022** |

**All coefficients are significant at 1% level.**

**Table - 3 (C0ntd.)**

Following results are the regression output in respect of **market capitalization sorted portfolio.**

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit} \ lnv_t + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit} \ lnv_t + \varepsilon,}$$

where $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **Market Capitalization (MC) sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $v_t$ is the volatility index at time *t*. The regression coefficient $\beta_{pit}$ represents the effect on portfolio returns by the India VIX.

| **Portfolio** | **Low MC** | | | | **High MC** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\boldsymbol{\beta_{pit}}$ | **0.0443** | **4.71** | **.0663** | **4.71** | **0.009** | **4.99** | **0.013** | **5.37** |

**All coefficients are significant at 1% level.**

**Table - 4**

The table below shows the regression results in respect of sorted portfolios for the additional independent variable market to book value of equity. The regression equations are:

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit}\ lnv_t + \gamma_{pit}\ ln(M/E)_{pit} + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit}\ lnv_t + \gamma_{pit}\ ln(M/E)_{pit} + \varepsilon,}$$

where $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **Beta sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $(M/E)_{pit}$ , is the ratio of **market-to-book value of** the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\beta_{pit}$ and $\gamma_{pit}$ are the regression coefficients representing the cross-sectional effect on relationship on the portfolio returns.

| **Portfolio** | **Low Beta** | | | | **High Beta** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\beta_{pit}$ | **0.0214** | **6.76** | **0.306** | **6.64** | **0.021** | **6.697** | **0.25** | **7.27** |
| $\gamma_{pit}$ | **-0.0136** | **-4.99** | **-0.025** | **-7.13** | **-0.032** | **-5.79** | **-0.531** | **-8.67** |

**All t-statistic are significant at 1% level**

**Table – 4 (Contd.)**

Following results are the regression output in respect of independent variable of market capitalization:

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit}\ lnv_t + \gamma_{pit}\ ln(MC)_{pit} + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit}\ lnv_t + \gamma_{pit}\ ln(MC)_{pit} + \varepsilon,}$$

where, $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **Beta sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $(MC)_{pit}$, is the ratio of **market capitalization** of the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\beta_{pit}$ and $\gamma_{pit}$ are the regression coefficients representing the cross-sectional effect on relationship on the portfolio returns.

| **Portfolio** | **Low Beta** | | | | **High Beta** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\beta_{pit}$ | **0.0187** | **7.823** | **0.0259** | **8.07** | **0.0202** | **6.29** | **0.227** | **6.41** |
| $\gamma_{pit}$ | **-0.0144** | **-7.43** | **-0.0251** | **-10.61** | **-0.0458** | **-5.57** | **-0.825** | **-8.44** |

**All are t-statistic are significant at 1% level**

**Table – 4 (Contd.)**

The following table shows the cross-sectional relationship of VIX with market-to-book and size (market capitalization) characteristics through the use of following equations:

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit}\, lnv_t + \gamma_{pit}\, ln(M/E)_{pit} + \delta_{pit}\, ln(MC)_{pit} + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit}\, lnv_t + \gamma_{pit}\, ln(M/E)_{pit} + \delta_{pit}\, ln(MC)_{pit} + \varepsilon}$$

where $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **Beta sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $(M/E)_{pit}$ , is the ratio of **market to book value** and (MC) is the **market capitalization** of the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\beta_{pit}$, $\gamma_{pit}$ and $\delta_{pit}$ are the regression coefficients representing the cross-sectional effect on relationship on the portfolio returns.

| **Portfolio** | **Low Beta** | | | | **High Beta** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\beta_{pit}$ | **0.0183** | **7.58** | **0.0247** | **7.92** | **0.0235** | **5.89** | **0.252** | **6.86** |
| $\gamma_{pit}$ | **0.0237** | **3.38** | **0.0376** | **4.27** | **-0.059** | **-3.64** | **-0.547** | **-3.38** |
| $\delta_{pit}$ | **-0.0311** | **-5.89** | **-0.518** | **7.91** | **0.0457** | **1.92*** | **0.0265** | **0.103*** |

***not significant**

**All other t-statistic are significant at 1% level**

**Table - 5**

The table below shows the regression results in respect of sorted portfolios for the additional independent variable market to book value of equity. The regression equations are:

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit}\ lnv_t + \gamma_{pit}\ ln(M/E)_{pit} + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit}\ lnv_t + \gamma_{pit}\ ln(M/E)_{pit} + \varepsilon,}$$

where $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **market to book value (M/E) sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $(M/E)_{pit}$, is the ratio of **market-to-book value of** the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\beta_{pit}$ and $\gamma_{pit}$ are the regression coefficients representing the cross-sectional effect on relationship on the portfolio returns.

| **Portfolio** | **Low M/E** | | | | **High M/E** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\beta_{pit}$ | **0.021** | **6.76** | **0.031** | **8.37** | **0.0173** | **6.826** | **0.245** | **8.09** |
| $\gamma_{pit}$ | **-0.0237** | **-5.58** | **-0.04** | **-8.05** | **-0.0312** | **-6.21** | **-0.0518** | **-9.24** |

**All t-statistic are significant at 1% level**

**Table – 5 (Contd.)**

Following results are the regression output in respect of independent variable of market capitalization:

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit}\ lnv_t + \gamma_{pit}\ ln(MC)_{pit} + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit}\ lnv_t + \gamma_{pit}\ ln(MC)_{pit} + \varepsilon,}$$

where, $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **market to book value (M/E) sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $(MC)_{pit}$ , is the **market capitalization** of the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\beta_{pit}$ and $\gamma_{pit}$ are the regression coefficients representing the cross-sectional effect on relationship on the portfolio returns.

| **Portfolio** | **Low M/E** | | | | **High M/E** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\beta_{pit}$ | **0.019** | **7.45** | **0.0259** | **8.07** | **0.0174** | **6.38** | **0.0235** | **7.51** |
| $\gamma_{pit}$ | **-0.02** | **-6.44** | **-0.0251** | **-10.61** | **-0.0428** | **-5.78** | **-0.0759** | **-8.77** |

**All t-statistic are significant at 1% level**

**Table – 5 (C0ntd.)**

The following table shows the cross-sectional relationship of VIX with market-to-book and size (market capitalization) characteristics through the use of following equations:

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit} \ln v_t + \gamma_{pit} \ln(M/E)_{pit} + \delta_{pit} \ln(MC)_{pit} + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit} \ln v_t + \gamma_{pit} \ln(M/E)_{pit} + \delta_{pit} \ln(MC)_{pit} + \varepsilon}$$

where, $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **market to book value (M/E) sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $(M/E)_{pit}$ , is the ratio of **market to book value** and (MC) is the **market capitalization** of the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\beta_{pit}$, $\gamma_{pit}$ and $\delta_{pit}$ are the regression coefficients representing the cross-sectional effect on relationship on the portfolio returns.

| **Portfolio** | **Low M/E** | | | | **High M/E** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\beta_{pit}$ | **0.019** | **7.53** | **0.0264** | **8.82** | **0.0216** | **5.85** | **0.0277** | **8.36** |
| $\gamma_{pit}$ | **0.0005** | **0.045*** | **0 .006** | **0.415*** | **-0.0767** | **-5.2** | **-0.0918** | **-6.15** |
| $\delta_{pit}$ | **-0.0202** | **-2.54**** | **-0.0374** | **-3.89** | **0.0669** | **3.02** | **-0.0374** | **3.02** |

***not significant**

****significant at 5% level**

**All other t-statistic are significant at 1% level**

**Table - 6**

The table below shows the regression results in respect of sorted portfolios for the additional independent variable market to book value of equity. The regression equations are:

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit}\ lnv_t + \gamma_{pit}\ ln(M/E)_{pit} + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit}\ lnv_t + \gamma_{pit}\ ln(M/E)_{pit} + \varepsilon,}$$

where, $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **market capitalization (MC) sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $(M/E)_{pit}$, is the ratio of **market-to-book value of** the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\beta_{pit}$ and $\gamma_{pit}$ are the regression coefficients representing the cross-sectional effect on relationship on the portfolio returns.

| **Portfolio** | **Low MC** | | | | **High MC** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\beta_{pit}$ | **0.0321** | **6.53** | **0.031** | **8.37** | **0.0173** | **6.83** | **0.245** | **8.09** |
| $\gamma_{pit}$ | **-0.0356** | **-4.02** | **-0.04** | **-8.05** | **-0.0312** | **-6.21** | **-0.052** | **-9.24** |

**All t-statistic are significant at 1% level**

**Table – 6 (C0ntd.)**

Following results are the regression output in respect of independent variable of market capitalization:

$$\mathbf{R_{pit}^{30} = \alpha_t + \beta_{pit}\ \ln v_t + \gamma_{pit}\ \ln(MC)_{pit} + \varepsilon}$$

**and**

$$\mathbf{R_{pit}^{45} = \alpha_t + \beta_{pit}\ \ln v_t + \gamma_{pit}\ \ln(MC)_{pit} + \varepsilon,}$$

where $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **market capitalization (MC) sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $(MC)_{pit}$ , is the ratio of **market capitalization** of the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\beta_{pit}$ and $\gamma_{pit}$ are the regression coefficients representing the cross-sectional effect on relationship on the portfolio returns.

| **Portfolio** | **Low MC** | | | | **High MC** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\beta_{pit}$ | **0.0234** | **6.42** | **0.008** | **9.46** | **0.0053** | **7.36** | **0.0368** | **7.92** |
| $\gamma_{pit}$ | **-0.0412** | **-5.66** | **-0.019** | **-9.83** | **-0.0114** | **-6.82** | **-0.0685** | **-8.89** |

**All are significant at 1% level**

**Table – 6 (Contd.)**

The following table shows the cross-sectional relationship of VIX with market-to-book and size (market capitalization) characteristics through the use of following equations:

$$R_{pit}^{30} = \alpha_t + \beta_{pit} \ln v_t + \gamma_{pit} \ln(M/E)_{pit} + \delta_{pit} \ln(MC)_{pit} + \varepsilon$$

**and**

$$R_{pit}^{45} = \alpha_t + \beta_{pit} \ln v_t + \gamma_{pit} \ln(M/E)_{pit} + \delta_{pit} \ln(MC)_{pit} + \varepsilon$$

where $R_{pit}^{30}$ and $R_{pit}^{45}$ are the **log return** of the **market capitalization (MC) sorted portfolio** *i* on a 30-day and 45-day holding period at time *t*, while $(M/E)_{pit}$, is the ratio of **market to book value** and (MC) is the **market capitalization** of the portfolio *i* sorted on the basis of high and low categories, at time *t*, while $\beta_{pit}$, $\gamma_{pit}$ and $\delta_{pit}$ are the regression coefficients representing the cross-sectional effect on relationship on the portfolio returns.

| **Portfolio** | **Low MC** | | | | **High MC** | | | |
|---|---|---|---|---|---|---|---|---|
| | **30-day** | **t-stat** | **45-day** | **t-stat** | **30-day** | **t-stat** | **45-day** | **t-stat** |
| $\beta_{pit}$ | **0.022** | **6.302** | **0.0266** | **5.64** | **0.0056** | **6.83** | **0.0079** | **9.34** |
| $\gamma_{pit}$ | **0.09** | **5.47** | **0.1325** | **6.69** | **-0.0057** | **-1.619*** | **-0.0041** | **-1.079*** |
| $\delta_{pit}$ | **-0.105** | **-7.303** | **-0.1626** | **-10.67** | **0.0026** | **-0.484*** | **-0.0124** | **-2.02**** |

***not significant ;**

****significant at 5% level ;**

**All other t-statistic are significant at 1% level**