TESTING OF CAPITAL ASSET PRICING MODEL: AN APPLICATION OF FAMA MACBETH APPROACH IN INDIAN EQUITY MARKET

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Abstract
The present study examines the Capital Asset Pricing Model (CAPM) for the Indian stock market using monthly stock returns from 278 companies of BSE 500 Index listed on the Bombay stock exchange for the period of January 1996 to December 2009. The findings of this study are not substantiating the theory's basic result that higher risk (beta) is associated with higher levels of return. The theory's prediction for the intercept is that it should equal zero and the slope should equal the excess returns on the market portfolio. The results of the study lead to negate the above hypotheses and offer evidence against the CAPM. The tests conducted to examine the nonlinearity of the relationship between return and betas bolster the hypothesis that the expected return-beta relationship is linear. Additionally, this study investigates whether the CAPM adequately captures all-important determinants of returns including the residual variance of stocks. The results exhibit that residual risk has effect on the expected returns of portfolios.

Key words: CAPM, portfolio returns, beta, risk free rate, systematic risk
JEL Classification: F23, G15

Testing Capital Asset Pricing Model: Empirical Evidences from Indian Equity Market

1. Introduction

Capital market plays an important role in the development of an economy and is an integral part of financial system. In the capital market, the manner in which securities are priced is core issue and it has attracted the attention of researchers for long. Investment in securities requires the study of risk-return relationship which performs a central role in pricing of securities consequently helps in making judicious investment decision making and performance appraisal. The capital asset pricing model (CAPM) of Sharpe (1964), Lintner (1965) and Mossin (1968) marks the birth of asset pricing theory. The major result of the model is a statement of the relation between the expected risk premiums on individual assets and their "systematic risk." This relationship says that the expected excess return on any asset is directly proportional to its "systematic risk." If empirically true, the relation given by capital asset pricing model has wide-ranging implications for problems in capital budgeting, cost benefit analysis, portfolio selection, and for other economic problems requiring knowledge of the relation between risk and return. Almost five decades later, the CAPM is still widely used in applications, such as estimating the cost of capital for firms and evaluating the performance of managed portfolios. It is the centerpiece of many investment and financial market courses. Indeed, it is often the only asset pricing model taught in these courses. There is still a great debate on the empirical validity of CAPM in finance literature. Therefore an attempt is made to see if systematic risk beta as independent variable can explain the cross-sectional variation in security returns in the Indian capital market. The present study aims to test the standard form of CAPM in Indian context. The study is organized in four parts. Part 1 is the introduction; part 2 reviews some of the empirical evidences on CAPM; part 3 deals with objectives, hypotheses, data and methodology; part 4 focuses on the analysis of the results; part 5 presents the summary and conclusions.

2. Review of Literature

The empirical results regarding capital asset pricing model in finance literature are categorized into single factor CAPM and multifactor CAPM. Initially the studies (Lintner, 1965; Douglas, 1969) on CAPM were mainly based on individual security returns and highlighted the risk-return relationship. Their empirical results were not encouraging. Miller and Scholes (1972) exhibited some statistical problems when using individual securities' returns in testing the validity of the CAPM. Most studies subsequently overcame this problem by using portfolio returns. Black, Jensen and Scholes (1972) formed portfolios of all the stocks of the New York Stock Exchange over the period 1931-1965, and reported a linear relationship between the average excess portfolio return and the beta, and for high beta portfolios(low beta portfolios) the intercept tends to be negative (positive).Extending the work of Black, Jensen and Scholes (1972) study, Fama and MacBeth (1973) highlighted the evidence (i) of a larger intercept term than the risk-free rate, (ii) that the linear relationship between the average return and the beta holds and (iii) that the linear relationship holds well when the data covers a long time period. Subsequent studies, however, provide weak empirical evidence on these relationships. See, for example, Fama and French (1992), He and Ng (1994), Davis (1994) and Miles and Timmermann (1996). The mixed empirical findings on the return-beta relationship prompted a number of responses: (i) Roll (1977) concluded that the single-factor CAPM could not accepted until the portfolio used as a market proxy was inefficient. Even very small deviations from efficiency can produce an insignificant relationship between risk and expected returns (Roll and Ross, 1994; Kandel and Stambaugh, 1995). (ii) Kothari, Shanken and Sloan (1995) highlighted the survivorship bias in the data used to test the validity of the asset pricing model specifications. (iii) Bos and Newbold (1984), Faff, Lee and Fry (1992), Brooks, Faff and Lee (1994) and Faff and Brooks (1998), exhibited the unstabiltiy of beta.(iv) There are several model specification issues: For example, (a) Kan and Zhang (1999) focused on a time-varying risk premium, (b) Jagannathan and Wang (1996) showed that specifying a broader market portfolio can affect the results and (c) Clare, Priestley and Thomas (1998) argued that failing to take into account possible correlations between idiosyncratic returns may have an impact on the results. A growing number of studies found that the cross-sectional variation in average security returns cannot be explained by the market beta alone and showed that fundamental variables such as size (Banz, 1981), ratio of book-to-market value (Rosenberg, Reid and Lanstein, 1985; Chan, Hamao and Lakonishok, 1991), macroeconomic variables and the price to earnings ratio (Basu, 1983) account for a sizeable portion of the cross-sectional variation in expected returns. Fama and French (1995) observed that the two non-market risk factors SMB (the difference between the return on a portfolio of small stocks and the return on a portfolio of large stocks) and HML (the difference between the return on a portfolio of high-book-to-market stocks and the return on a portfolio of low-book-to-market stocks) are useful factors when explaining a cross-section of equity returns. Chung, Johnson and Schill (2001) observed that as higher-order systematic co-moments are included in the cross-sectional regressions for portfolio returns, the SMB and HML generally become insignificant. Therefore, they argued that SMB and HML are good proxies for higher-order co-moments. Groenewold and Fraser (1997) examined the validity of these models for Australian data and compared the performance of the empirical version of APT and the CAPM. They concluded that APT outperforms the CAPM in terms of within-sample explanatory power. Recently, several studies investigated the effect of good and bad news (leverage effects), as measured by positive and negative returns on beta. See, for example, Braun, Nelson and Sunier (1995) (BNS hereafter) and Cho and Engle (1999) (CE hereafter). BNS examined the variability of beta using bivariate Exponential GARCH (EGARCH) models allowing market volatility, portfolio-specific volatility and beta to respond asymmetrically to positive and negative market and portfolio returns. CE, on the other hand, incorporated a two-beta model with an EGARCH variance specification and daily stock returns of individual firms. CE concluded that news asymmetrically affects the betas while the BNS study that used monthly data on portfolios did not uncover this relationship. While many studies have been conducted on CAPM across the world, there is little research in the Indian context. Studies by Varma (1988), Yalwar (1988), and Srinivasan (1988) have generally corroborated the CAPM theory in India, while Gupta and Sehgal (1993), Madhusoodanan (1997), Ansari (2000), and Rao (2004) have exhibited the empirical results against the validity of CAPM in Indian markets. Interestingly some of the studies for example Mohanty (1998; 2002), and Connon and Sehgal (2003) have yielded evidences in favour of Factors models. On the whole the empirical results regarding CAPM discussed in this section lead to mixed conclusions. Some the studies advocate multifactor models due to failure of market beta alone to explain cross-sectional variation in security returns and others highlighted the methodological issues in testing CAPM. The present study is confined to testing the standard form of CAPM in Indian equity market.

3. Objectives of the study

The objective of this paper is to examine whether the CAPM holds true in Indian stock market i.e.:

- To examine whether a higher/lower risk stocks yield higher/lower expected rate of return.
- To examine whether the expected rate of return is linearly related with the stock beta,

i.e. its systematic risk.

- To examine whether the non-systemic risk affects the portfolios' returns.

Data Selection

The study uses monthly adjusted closing stock prices for the sampled 278 companies of BSE 500 index listed on the Bombay Stock Exchange for the period of January 1996 to December 2009. The BSE 500 index represents the 93 percent of BSE's total market capitalisation and 74 per cent of BSE's total turnover. The data were obtained from the Prowess database of CMIE. The monthly closing values of the BSE Sensex Index are used as a proxy for the market portfolio. Furthermore, the yield on 91-days treasury bills of government of India is incorporated as risk free return. The returns on sample scrips and market index are calculated as follows:

$$R_{it} = LN(P_{it}/P_{it-1})$$

Where,

P_{it} = price for the share of a share i at time t.

P_{it-1} = price for the share of a share i at time t-1.

$$R_{mt} = LN(I_t/I_{t-1})$$

Where,

I_t = daily value for the market index at time t.

I_{t-1} = daily value for the market index at time t-1.

Procedure of CAPM testing

The study covers the period from January 1996 to December 2009. Since the purpose of this study is to test the prediction of CAPM, the methodology of Fama and Macbeth (1973) is employed. We start with the first portfolio formation period, 1996-98 (36 months) to estimate the beta of the individual securities and ranked securities by beta and construct 1-20 portfolios. In initial estimation period we calculate the monthly returns for each of 36 months of 1999-01 for 20 portfolios estimated. The same procedure is adopted for next portfolio formation period. (See Table 1).

Table 1
Portfolio formation, Estimation and Testing Period

	Periods 1	2	3
Portfolio formation period	1996-98	1999-01	2002-04
Initial estimation period	1999-01	2002-04	2005-07
Testing Period	2002-04	2005-07	2008-09
No. of Securities	278	278	278

Fama and Macbeth used a time series test of the CAPM. The test is based on the time series regressions of excess portfolio return on excess market return, which can be express by the equation below:

$$R_{it} - R_{mt} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + \varepsilon_{it} \qquad (1)$$

Where:

R_{it} is the rate of return on asset i (or portfolio) at time t,

R_{ft} is the risk-free rate at time t,

R_{mt} is the rate of return on the market portfolio at time t.

β_i is the beta of stock i.

ε_{it} is the random disturbance term in the regression equation.

The equation (1) can be also expressed by:

$$r_{it} = \alpha_{it} + \beta_{it}\, rmt + \varepsilon_{it} \qquad (2)$$

Where:

$R_{it} - R_{mt} = r_{it}$ is the excess return of stock i;

$R_{mt} - R_{ft} = r_{mt}$ is the average risk premium.

The intercept is the difference between the estimated expected return by time series average and the expected return predicted by CAPM. If CAPM describes expected returns and a correct market portfolio proxy is selected, the regression intercepts of all portfolios (or assets) are zero.

- The first step is to estimate a beta coefficient for each stock using their monthly returns. The beta is estimated by regressing each stock's monthly return against the market index (BSE Sensex) according to the equation (1). Based on the estimated betas the sample 278 stocks are divided into 20 portfolios; each comprised 28 stocks based on their betas except portfolio no. 10 and 11 which include 26 stocks each. The first portfolio-portfolio 1 has the 28 highest betas and the last portfolio-portfolio 20 has the 20 lowest betas. Combining these sample scrips into portfolios diversify away most of the firm-specific part of returns thereby enhancing the precision of the estimates of beta and the expected rate of return on the portfolios.
- The second step is to calculate the portfolios' betas using the following equation:

$$r_{pt} = \alpha_p + \beta_p r_{mt} + \varepsilon_{pt} \qquad (3)$$

Where:

r_{pt} is the average excess portfolio return at time t,

β_p is the estimated portfolio beta.

ε_{pt} is random disturbance term.

· The third step is to estimate the ex-post Security Market Line (SML) for testing period by regressing the portfolio returns against the portfolio betas. If we view $E(R_i) = R_f + \beta_i([E(R]_m) - R_f)$ as the Security Market Line (SML), we can estimate γ_0, γ_1 in the following equation and use the estimated beta from the last step;

$$r_p = \gamma_0 + \gamma_1 \beta_p + \varepsilon_p \qquad (4)$$

Where:

r_p is the average excess return on a portfolio p,

β_p is beta of portfolio p,

ε_p is the is random disturbance term

If the CAPM is true, γ_0 should be equal to zero and the slope of SML γ_1, is the market portfolio's average risk premium.

To test for nonlinearity between total portfolio returns and betas we use the following equation:

$$r_p = \gamma_0 + \gamma_1 \beta_p + \gamma_2 \beta_p^2 + \varepsilon_p \qquad (5)$$

If the CAPM hypothesis is true; i.e., portfolios' returns and its betas are linear related with each other, γ_2 should be equal to zero.

Finally, we examine whether the expected excess return on securities are determined only by systematic risk and are independent of the nonsystematic risk, as measured by the residuals variance $\sigma^2(\varepsilon_p)$;

$$r_p = \gamma_0 + \gamma_1 \beta_p + \gamma_2 \beta_p^2 + \gamma_3 \sigma^2(\varepsilon_p) + \varepsilon_p \qquad (6)$$

Where:

γ_2 measures the potential nonlinearity of the return,

γ_3 measures the explanatory power of non-systemic risk.

$\sigma^2(\varepsilon_p)$ measures the residual variance of portfolio return.

If the CAPM hypothesis is true, ?3 should be equal to zero.

In order to test CAPM, nonlinearity and effect of nonsystematic risk on portfolio returns equation 4, 5 and equation 6 are also estimated for each month of 2002-04. The same procedure is adopted for the remaining two study periods. Thus total 96 estimates of γ_0, γ_1, γ_2 and γ_3 are obtained and the following t test is used to check their statistical significance.

$$t(\overline{Y}_j) = \frac{\overline{Y}_j}{\frac{S(\overline{Y}_j)}{\sqrt{n}}}$$

4. Empirical results and discussions

The initial part of the methodology for testing the CAPM required the estimation of betas for individual sample stocks by using observations on monthly returns for a sequence of dates. Valuable remarks can be derived from the results of this procedure, for the scrips used in this study. The range of estimated individual stocks beta has the minimum value of -0.55 and the maximum value of 2.33 with a standard deviation of 0.40 (Table 2). Majority of the estimated beta coefficients for individual stocks were statistically significant at a 95% level. The study argues that certain hypotheses can be tested irrespective of whether one believes in the validity of the simple CAPM or in any other version of the theory. Firstly, the theory points that higher systematic risk (beta) is associated with a higher level of return. However, the results of the study do not bolster this hypothesis. It is evident from the Table 3 and scatter plots (Figure 1 to 4) that higher beta portfolios were not associated with higher returns. Portfolio 1 for example, the highest beta portfolio (ß = 1.773), yielded 0.23 per cent average excess monthly return. In contrast, portfolio 20, the lowest beta portfolio (ß = 0.7795) produced 2.6 per cent average excess monthly return during the whole study period. Nevertheless, the similar results regarding the risk-return relationship are obtained for the three sub-periods. These contradicting results can be partially explained by the significant fluctuations of stock returns over the period examined (Table 3). In order to test the CAPM hypothesis, it is essential to find the counterparts to the theoretical values that must be used in the CAPM equation. In this study the yield on the 91 days Treasury bill is used as an approximation of the risk-free return. For the market portfolio return (R_m), the BSE SENSEX Share index is taken as the proxy for the market portfolio. The basic equation used was Equation 4, where γ_0 is the expected excess return on a zero beta portfolio and γ_1 is the risk premium, the difference between the expected rate of return on the market and a zero beta portfolio. The inclusion of an intercept term in the estimation of SML is an approach for allowing for the possibility that the CAPM does not hold true. The CAPM considers that the intercept is zero for every asset. Hence, a positive value of intercept term can lead to rejection of this hypothesis. In order to diversify away most of the firm-specific part of returns, thereby enhancing the precision of the beta estimates, Black et al (1972) combined the securities into portfolios. The same approach is followed in the study because it mitigates the statistical problems that arise from measurement errors in individual beta estimates. These portfolios were created for several reasons: (i) the random influences on individual scrips tend to be higher compared to those on suitably constructed portfolios and (ii) the tests for the intercept are easier to implement for portfolios because by construction their estimated coefficients are less likely to be correlated with one another than the shares of individual companies. The results of this study appeared to be inconsistent with the zero beta version of the CAPM because the intercept of the SML was although lower than the interest rate on risk free-asset yet positive (Table 3 and 4). In the estimation of SML, the CAPM's prediction for γ_0 is that it should be equal to zero. The calculated value of the intercept was 0.043 (Table 4) and significantly different from zero (t value = 4.67). Hence, based on the intercept criterion alone the CAPM hypothesis can not be accepted. According to CAPM the SML slope should equal the excess return on the market portfolio. The average excess monthly return on the market portfolio was 0.76 percent while the estimated SML slope was - 0.020 (Table 4) and significantly different from zero (t value = -2.42). For testing the effect of time the study period was broken into three sub-periods and in all the three periods the estimated SML slope was negative. Hence, the latter result also indicated evidence against the CAPM (Table 3 and 4) in Indian capital market during the study period. In order to test for nonlinearity between total portfolio returns and betas, a cross-section regression was run between average portfolio returns, calculated portfolio betas, and the square of betas (Equation 5). Results regarding this exhibited that the intercept (Table 5, 0.093) of the equation was significant and lower than the risk-free interest rate , γ_1 (-0.12) was negative and significantly different from zero while γ_2 , the coefficient of the square beta was very small (0.053 with a t-value not greater than 2). Almost similar results were obtained for the sub-periods and thus consistent with the hypothesis that the expected return-beta relationship is linear (Table 4) except the second study period. The study could not generate enough evidence to negate the hypothesis of linear relationship between the expected return and beta. According to the CAPM, expected returns vary across assets only because the assets' betas are different. Hence, one way to investigate whether CAPM adequately captures all-important aspects of the risk-return tradeoff is to test whether other asset-specific characteristics can contribute to the cross-sectional differences in average returns that cannot be attributed to cross-sectional differences in beta. To accomplish this, the residual variance of portfolio returns was added as an additional explanatory variable (Equation 6). The coefficient of the residual variance of portfolio returns γ_3 was 0.220 (Table 6) and statistically different from zero. The similar results were noticed during the second sub-period. It is therefore safe to conclude that residual risk has some affect on the expected return of a security. Thus, when portfolios were used instead of individual stocks, residual risk appeared to be important an important factor. On the whole the analysis on the entire study period did not yield strong evidence in favor of the CAPM yet the study exhibited evidence consistent with the hypothesis that the expected return-beta relationship is linear. Furthermore, the residual risk of portfolios had effect on the expected return.

5. Conclusions

The study tested the validity of the CAPM for the Indian stock market. The study used monthly stock returns from 278 companies of BSE 500 index listed on the Bombay stock exchange from January 1996 to December 2009.The findings of the study were not supportive of the theory's basic hypothesis that higher risk (beta)is associated with a higher level of return. In order to diversify away most of the firm-specific part of returns thereby enhancing the precision of the beta estimates, the securities combined into portfolios to mitigate the statistical problems that arise from measurement errors in individual beta estimates. The results obtained provided credence to the linear structure of the CAPM equation being a good explanation of security returns. The CAPM's prediction for the intercept is that it should be equal to zero and the slope should equal the excess returns on the market portfolio. The findings of the study contradicted the above hypothesis and indicated evidence against the CAPM. The inclusion of the square of the beta coefficient to test for nonlinearity in the relationship between returns and betas indicated the linear relationship between the expected return and beta. Additionally, the tests conducted to investigate whether the CAPM adequately captures all-important aspects of reality by including the residual variance of stocks indicated that the residual risk had effect on the expected return on portfolios. The results of the tests conducted on sample data for the period of January1996 to

December 2009 do not appear to clearly reject the CAPM. In the light of above findings, it can be concluded that beta was not sufficient to determine the expected returns on securities/portfolios. The empirical findings of this paper would be useful to financial analysts in Indian capital market. Further research on the combinations of market factors, macroeconomic factors and firms' specific factors can be carried out to solve the CAPM puzzle.

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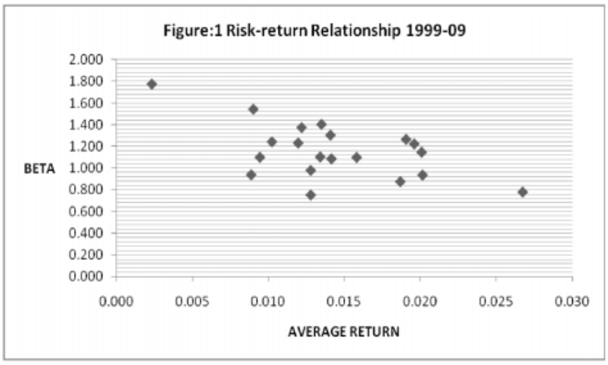
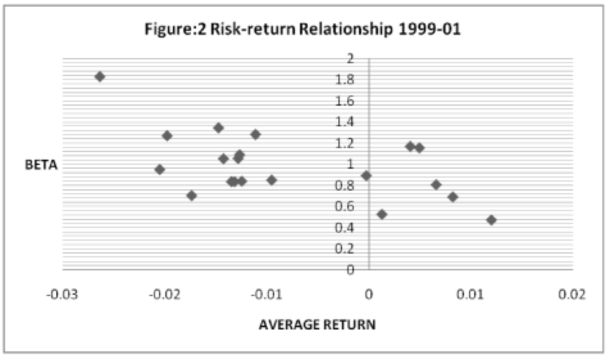
Table: 2 Summary Statistics of Beta of Sample Stocks

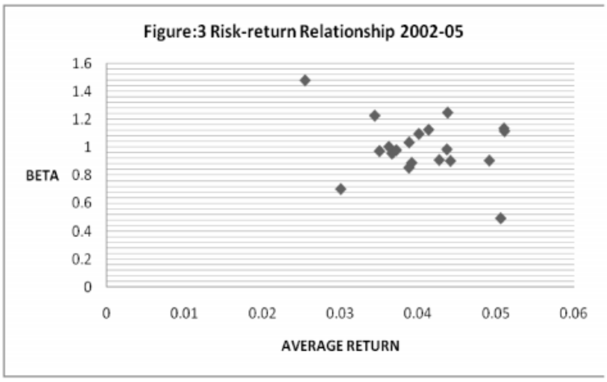
Source: Computed from Eviews 6 Student Version

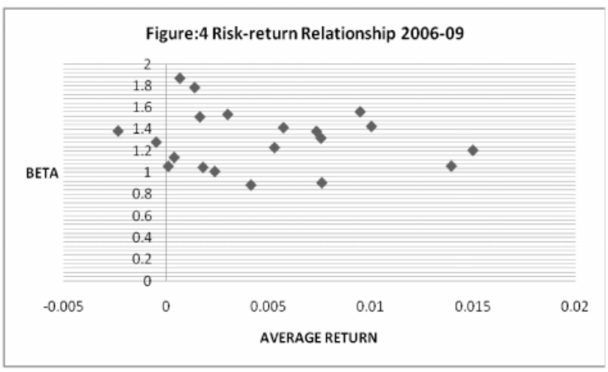
Table: 3 Average excess portfolio returns and betas

Source: Computed from Eviews 6 Student Version









Source: Computed from Eviews 6 Student Version

Table: 4

$r_p = \gamma_0 + \gamma_1\beta_p + \varepsilon_p$ **(Fama-MacBeth)**

		Mean	Std.	Std.	t	Sig.	Lower	Upper
WHOLE	γ_0	0.043**	0.009	0.090	4.679	0.000	0.025	0.061
	γ_1	-0.020*	0.008	0.081	-	0.017	-0.036	-0.004
I TEST	γ_0	0.057**	0.016	0.097	3.502	0.001	0.024	0.089
	γ_1	-0.018	0.010	0.062	-	0.091	-0.039	0.003
II TEST	γ_0	0.062**	0.015	0.089	4.148	0.000	0.031	0.092
	γ_1	-	0.009	0.052	-	0.009	-0.041	-0.006
III	γ_0	-0.005	0.013	0.063	-	0.706	-0.032	0.022
	γ_1	-0.017	0.027	0.130	-	0.528	-0.072	0.038

Source: Computed from Eviews 6 Student Version
Note: * significant at 5 percent level of significance,
** significant at 10 percent level of significance

Table: 5

$r_p = \gamma_0 + \gamma_1\beta_p + \gamma_2\beta_p^2 + \varepsilon_p$ **(Fama-MacBeth)**

		Mean	Std.	Std.	t	Sig.	Lower	Upper
WHOLE	γ_0	0.093**	0.030	0.293	3.108	0.002	0.034	0.152
	γ_1	-0.125*	0.055	0.541	-	0.026	-0.235	-0.015
	γ_2	0.053	0.028	0.270	1.918	0.058	-0.002	0.108
I TEST	γ_0	0.066	0.041	0.245	1.621	0.114	-0.017	0.149
	γ_1	-0.039	0.076	0.458	-	0.612	-0.194	0.116
	γ_2	0.011	0.038	0.230	0.287	0.776	-0.067	0.089
II TEST	γ_0	0.171**	0.043	0.255	4.028	0.000	0.085	0.258
	γ_1	-	0.078	0.467	-	0.002	-0.413	-0.097
	γ_2	0.116**	0.037	0.224	3.117	0.004	0.041	0.192
III	γ_0	0.016	0.078	0.384	0.200	0.843	-0.147	0.178
	γ_1	-0.059	0.147	0.718	-	0.693	-0.362	0.245
	γ_2	0.021	0.075	0.366	0.275	0.786	-0.134	0.175

Source: Computed from Eviews 6 Student Version
Note: * significant at 5 percent level of significance,
** significant at 10 percent level of significance

Table: 6

$r_p = \gamma_0 + \gamma_1\beta_p + \gamma_2\beta_p^2 + \gamma_3\sigma^2(\varepsilon_p) + \varepsilon_p$

(Fama-MacBeth)

		Mean	Std. Error	Std. Deviation	t	Sig. (2-tailed)	Lower	Upper
WHOLE PERIOD	γ_0	0.072*	0.029	0.286	2.477	0.015	0.014	0.130
	γ_1	-0.108	0.056	0.548	- 1.935	0.056	-0.219	0.003
	γ_2	0.042	0.028	0.270	1.520	0.132	-0.013	0.097
	γ_3	0.220*	0.109	1.067	2.023	0.046	0.004	0.437
I TEST PERIOD	γ_0	0.035	0.041	0.247	0.863	0.394	-0.048	0.119
	γ_1	-0.028	0.076	0.458	- 0.369	0.714	-0.183	0.127
	γ_2	0.005	0.038	0.229	0.129	0.898	-0.073	0.083
	γ_3	0.360	0.183	1.096	1.971	0.057	-0.011	0.731
II TEST PERIOD	γ_0	0.055	0.075	0.365	0.740	0.467	-0.099	0.209
	γ_1	-0.186*	0.082	0.491	- 2.274	0.029	-0.352	-0.020
	γ_2	0.074	0.040	0.241	1.839	0.074	-0.008	0.155
	γ_3	0.398**	0.127	0.761	3.135	0.003	0.140	0.655
III TEST PERIOD	γ_0	0.120**	0.044	0.263	2.746	0.009	0.031	0.209
	γ_1	0.398**	0.127	0.761	3.135	0.003	0.140	0.655
	γ_2	-0.112	0.149	0.731	- 0.749	0.461	-0.420	0.197
	γ_3	0.050	0.073	0.360	0.678	0.505	-0.102	0.202

Source: Computed from Eviews 6 Student Version
Note: * significant at 5 percent level of significance,
** significant at 10 percent level of significance