

An Empirical Test of Capital Asset Pricing Model with reference to S&P BSE Sensex Index

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ABSTRACT

Capital Asset Pricing Model (CAPM) relates expected returns from an asset and portfolio to its systematic risk (Market risk). The CAPM proposes that excess rate of return on an asset is directly proportional to its covariance (Beta) with the market return. CAPM is a widely used asset pricing model for investment analysis, whereas in late twentieth various other theories contradicted the model. Numerous studies have been conducted to test the validity of CAPM in developed markets. Besides, there are limited studies conducted for testing the CAPM in developing markets. The present study is an empirical analysis of CAPM in Indian stock market with reference to S&P BSE Sensex Index for the period of Jan 2011 to Dec 2015.

The empirical analysis conducted in the study fails to substantiate the theory. The result negates the hypothesis that the beta is the only factor that determines the return from the asset. The hypothesis of CAPM, that the assets returns are linearly related to the betas of the assets and the only risk that influence the return is the systematic risk is not established. The empirical findings of the study concludes that CAPM is not valid in S&P BSE Sensex index.

1. Introduction

The traditional investment mantra followed by the smart investor is "Do not put all your eggs in one basket, essence diversify your investment. The intuitively smart investor knows the benefits of diversification. It was Harry Markowitz how did a first formal attempt to show why and how diversification reduces risk. Harry Markowitz in 1950 proposed portfolio theory that explains how risk-averse investors can build portfolios to optimize or maximize expected return based on a given level of market risk (Chandra, 2008). Taking off from Markowitz, William Sharpe did the significant contribution in the portfolio investment theories through developing Capital Asset Pricing Model (CAPM). CAPM predicts the relationship between the risk of an asset and its expected return. The capital asset pricing model (CAPM) extends capital market theory in a way that allows investors to evaluate the risk-return trade-off for both diversified portfolios and individual securities (Reilly & Brown, 2012).

The model basically answers two questions, one what is the relationship between risk and return for an efficient portfolio? And what is the relationship between risk and return of individual security? The model has become popular owing to its utility to producing a benchmark for evaluating various investment and ability to forecast the return expected from an asset. CAPM has emerged a centerpiece of modern financial investment theories and has been in use for estimating the cost of capital for firms and evaluating the performance of portfolios. The model has led the foundation of establishing the new branch of study, financial economics, and William Sharpe awarded the Nobel Prize in economics for his contribution.

Capital Asset Pricing Model (CAPM) depicts the risk-return relationships based on historical data. The capital market theory extends portfolio theory by developing a model for pricing all risky assets. The CAPM will allow you to determine the required rate of return for any risky asset (Reilly & Brown, 2012). The risk associated with any security can be classified into two types one is the systematic risk (Market risk) and next is the unsystematic risk (fundamental risk). Market risk of security arises from changes in economics wide factors like change in GDP growth rate, change in government spending, interest rate structure, inflation rate etc. The investor can not totally avoid the influence of these factors. The systematic risk is the degree to which security returns, or portfolio returns, are related to market moves (Hagin, 2004). Unsystematic risk arises from the factors that are associated with the returns of a specific company's security such as the development of a new product, a strike in the company, or the emergence of new competitors. This risk is reducible through diversifying the investment portfolio (Chandra, 2008).

The CAPM postulate that the diversifiable risk can be eliminated, there is no reward for bearing it. The capital-market system rewards only systematic risk (Hagin, 2004). The systematic risk is measured by β . The β coefficient tells us how much systematic risk of a particular asset has relative to a portfolio that contains all assets in the economy. The portfolio that contains all assets in the economy is called a market portfolio (Ansari, 2000). The CAPM implies that the expected excess rate of return on an asset is directly proportional to its covariance with the market return (DeFusco, McLeavey, Pinto, & Runkle, 2007).

2. Literature Review

The Capital Asset pricing model is the foundation of all asset pricing theories and widely used for estimating the required rate of return by the investors. Across the globe, various studies have been conducted for empirically testing the model and test shows mixed results.

(Fama&MacBeth, 1973) The study tests the relationship between average return and risk for the New York Stock Exchange. The study supports the CAPM and stated that there is a positive trade-off between return and risk. The study proposes a linear relationship between risk & return and there is no unsystematic risk that affects the portfolio average return.

(Andor, 1999) Tested the CAPM in the Hungarian Capital Markets. For the study monthly data of 17 Hungarian companies listed on the Budapest Stock Exchange (BSE) for the period, 31st July 1991 to 1st June 1999 was used. The regression result showed the relationship between the company's beta and their average returns. The study has concluded that the CAPM acceptably described the Hungarian Capital Market.

(Rahman, Baten, & Ashraf-UI- Ala, 2006)The study was conducted to assess whether CAPM is a good indicator of asset pricing in Bangladesh for the period of 1999-2003. The study is based on Fama-French (1992) methodology on five variables- Stock market return, Beta, Book to market value, Size (Market capitalization) and Size (Sales). The study results support the CAPM and show that the variables considered under the study have a significant relationship with stock return.

(Chan, Hamao, &Lakonishok, 1991)The study assesses the relationship between returns on Japanese stocks from 1971 to 1988 to four variables, they are earnings yield, size, book to market ratio, and cash flow yield. The sample includes both manufacturing and nonmanufacturing firms, companies from both the Tokyo Stock Exchange and also delisted securities. The findings reveal a significant relationship between these variables and the expected returns in the Japanese market. Out of the four variables considered, the book to market ratio and cash flow yield have the most significant positive impact on expected returns.

(Basu, 1977) The entitled Investment Performance of Common Stocks in Relation to Their Price-Earnings Ratios: a Test of the Efficient Market Hypothesis, tests the idea that price-earnings ratios contain information regarding the future performance of an asset. This information is known to the market, therefore the asset should not earn any unexplained returns. It proposes the phenomenon that the CAPM is not properly specified due to an omission of some risk factors.

(Roll, 1977) Has claimed that empirically testing of CAPM is infeasible because of incomplete knowledge of the true market portfolio. To form a true market portfolio, all assets such as financial, real as well as human and not just equity stocks need to be included, which is a difficult proposition.

(Banz, 1980)The study examined the empirical relationship between the return and the total market value of NYSE

common stocks. It was found that smaller firms have had higher risk-adjusted returns, on average, than larger firms. This 'size effect' has been in existence for at least forty years and is evidence that the capital asset pricing model is mis-specified.

(Bhandari, 1988) has used the sample from the New York Stock Exchange showed that there is a positive relationship exists between the expected common stock returns and the ratio of debt to equity, even after controlling for the beta and firm size. Through evidence, it is concluded that beta was the only factor required to explain an asset's expected return but the expected common stock returns are positively related to the ratio of debt.

(Fama& French, 2004)Has stated that CAPM has never been an empirical success. Research has uncovered the fact that variables like size, various price ratios, and momentum influence the average returns provided by beta. There is sufficient evidence to invalidate most applications of the CAPM. But empirical work depicts the relation between beta and the average return is flatter than CAPM. Besides, CAPM paves the way for an introduction to the fundamental concepts of portfolio theory and asset pricing, to move forward toward more complicated models ICAPM.

(Ansari, 2000) has done an empirical assessment of the model in India. The study concludes that game is not lost for CAPM, the evidence is not sufficient to drop the use of CAPM however, one must recognize and understand its limitations while using it.

(Choudhary&Choudhary, 2010) 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. Besides the study supports the assumption of excess returns and the linear structure of the CAPM equation. The results depict that residual risk has no effect on the expected returns of portfolios.

(Basu& Deepak, 2010) The study examines the applicability of CAPM to India. For the study 10 portfolios, covering 50 stocks, over a 5-year period from 1 January 2003 to 1 February 2008 from NSE were selected. The results concluded that CAPM is not a suitable descriptor of asset prices in India over the chosen sample period.

(Shrivastav, 2017)The stock return of 15 companies listed on National Stock Exchange (NSE) has been analyzed for a period of 5 years from January 2006 to December 2010. For testing, the validity of CAPM Cross-sectional and Portfolio analysis were the two methods were adopted. In both the cases, the findings did not support the CAPM's basic hypothesis that higher risk (beta) is associated with a higher level of return. Also, the zero intercept hypothesis of CAPM was negated. The finding of the study empirically concluded that CAPM is not valid in Indian capital market.

(Bajpaia & Sharma, 2015) The study is conducted for a period of 10 years from January 2004-December 2013 and the data is daily data for 10 years. Rolling regression is applied to a rolling sample of three years where a window of three years keeps moving for a quarter. Further, the model developed for the second stage regression is a constrained model, in which the intercept term is assumed to be zero. A comparison between the developed model and the traditional model has been made. The results show that CAPM is very much significant in the Indian equity market and the model developed in this study, performs better than the traditional model.

CAPM is a widely used asset pricing model, however, in the late twentieth century, the model started losing its glory as various other theories contradicted the model. The new asset pricing models proposed that it is not only the beta that determines the returns of assets, there are various other factors that influence risk-return relationships and those factors should also be taken into account. This ambiguity in financial literature has made the empirical analysis of CAPM a thrust area for financial researchers. There are numerous studies, conducted to test the validity of CAPM in developed markets. Besides, there are limited studies conducted for testing the CAPM in developing markets. There is a need for empirically testing the validity of CAPM in the different time period to understand the behaviour of asset pricing in the Indian market. The present study is an empirical analysis of CAPM in Bombay stock exchange, for the BSE Sensex companies.

3. Research Methodology

In this section of the paper, the research methodology adopted for the study in terms of samples, the source of data and analytical tools used for the study is discussed.

Data: The study considers the period of 5 years from 1 January 2013 to 31 December 2015. The data collected for the study is discussed below.

Individual Securities: The study has been carried out based on BSE Sensex companies that were part of the index from 1 January 2013 to 31 December 2015.

Market Proxy: The BSE Sensex index has been taken as the market proxy. The BSE Sensex index comprises of 30 stocks. Weekly returns of the BSE Sensex is been considered as market return under the study.

Risk-free return Proxy: For risk-free return, 91-days Treasury bill rates have been taken as a risk-free return proxy.

Source of the data: The required data on stocks and indices was collected from Centre for Monitoring Indian Economy (CMIE) database, PROWESS, the Bombay Stock Exchange (BSE) website, and the Yahoo! Finance website. For the risk-free rate, 91-day Treasury bill rates for the same period were collected from tradingeconomics.com.

The methodology adopted for the study:

Return calculation: For the purpose of the study, weekly data has been used for all variables. This is because, daily

data, though better for estimating risk-return relationships, is very noisy and, monthly data, owing to the longer duration distorts the risk-return relationships. Thus, weekly data has been considered as it suits best the purpose of the study.

Following steps were used to empirically analysis CAPM model.

Step 1: Weekly stock return data was collected for the study. Such a high-frequency long duration data may show non-stationarity. To resolve the issue of non-stationary of data the first order logarithmic difference of all the companies and the market proxy were taken. In other words, the log returns were calculated with the following formula:

Equation No. (1)

$$r_{t+1} = \ln\left(\frac{P_{t+1}}{P_t}\right) = \ln(P_{t+1}) - \ln(P_t)$$

Where r_{t+1} is the simple return, P_{t+1} is the value of the index or price at the time $t+1$ and P_t is the price or the value of the index at the time period t .

Step 2: Next step was to compute the excess return for various stock and market proxy. Excess return means return earn above the risk-free return by the investor. It was calculated by deducting the risk-free return from the actual return.

Step 3: It was followed by estimating the beta of 30 stocks. To estimate the beta of each stock weekly risk-free stock returns were regressed on weekly risk-free market returns. The regression equation is as follows:

Equation No. 2

$$R_{it} - R_{ft} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + e_{it}$$

Here R_{it} is weekly returns of the particular stock, R_{ft} is weekly returns of the risk-free security and R_{mt} is the returns on the market proxy for the week and e_{it} is the residual term.

Step 4: Estimated beta was used for portfolio formation. The thirty stocks under the study were arranged ascendingly based on their beta. This was done to achieve diversification and thus reduce any errors that might occur due to the presence of unsystematic risk.

Then 10 portfolios were formed by taking 03 securities in each of the portfolios starting from the highest beta stocks to lowest beta stock.

Step 5: After this weekly excess portfolio returns were estimated by taking the simple average of the return of the stocks constituent in each portfolio.

Steps 6: The portfolio beta was estimated. To estimate the portfolio beta weekly risk-free portfolio returns of each

portfolio regressed on the excess return of the market portfolio by using the following equation:

Equation No. 3

$$Z_{pt} = \alpha_p + \beta_p Z_{mt} + e_{pt}$$

Where, Z_{pt} is the excess monthly return of the portfolio, β_p is the beta of the portfolio, Z_{mt} is the excess monthly return of the market portfolio and e_{pt} is the residual term.

This step has given 10 betas of each 10 portfolios.

Step 7: The next step is to estimate the security market line (SML) to test the CAPM in BSE Sensex index companies. SML is estimated by using cross-sectional regression in which the portfolio returns were regressed on portfolio betas. Cross-sectional regression formula is as follows:

Equation No. 4

$$Z_{pt} = \lambda_0 + \lambda_1 \beta_p + e_{pt}$$

Where Z_{pt} is the average of excess return of portfolios over risk-free rate for 10 years period, λ_0 is the intercept, β_p is the beta of the portfolio computed in the previous step, λ_1 is the market risk premium which is the regression coefficient for this equation and e_{pt} is the residual term. Criteria for If CAPM holds, the value of λ_0 should be zero and λ_1 should be positive.

Step 8: The CAPM postulates that the assets returns are linearly related to the betas of the assets. In this step, the non-linearity of the model is assessed. The following equation was used to perform the non-linearity test:

Equation No. 5

$$Z_{pt} = \lambda_0 + \lambda_1 \beta_p + \lambda_2 \beta_p^2 + e_{pt}$$

Here, β_p^2 is the square of the beta of portfolios. If CAPM holds, the value of λ_2 should be zero.

Step 9: Another important assumption of The CAPM is that the only risk which is relevant is the systematic risk which is represented by beta. At this stage impact of non-systematic risk is measured.

For it, another variable the variance of the residuals of portfolio p is added. The regression equation is as follows:

Equation No. 6

$$Z_{pt} = \lambda_0 + \lambda_1 \beta_p + \lambda_2 \beta_p^2 + \lambda_3 RV_p + e_{pt}$$

Here, RV_p refers to the variance of the residuals of portfolio p. If CAPM holds, the value of λ_3 should be zero.

Hypotheses:

By adopting the above steps hypothesis relating to the conformity of CAPM were tested. For CAPM to hold true, the following hypothesis should be satisfied.

$\lambda_0 = 0$, as any excess return earned should be zero for a zero-beta portfolio.

$\lambda_1 > 0$, as there should be a positive reward for risk taken.

$\lambda_2 = 0$, as the security market line, should represent a linear relationship

$\lambda_3 = 0$, as a residual risk which can be diversified away, should not affect return.

4. Data Analysis

This section discusses the results of empirical data analysis of BSE Sensex index stocks. The CAPM model is tested in eight stages. Through using time series data obtained, the weekly risk-free return of individual stock was calculated and the beta of an individual stock was determined by the regressing risk-free return of each stock on market proxy (BSE Sensex index) risk-free return by using regression equation No. 2.

Table No.1 shows that the beta coefficients for all individual stocks are statistically significant at 1 percent level. Besides intercept term is significant only for 5 stock at 5 percent level of significance. The estimated beta of each stock was used for portfolio formation as per the methodology stated in step four, and the portfolios' betas were estimated by regressing portfolio excess return on market excess return. By using the cross-sectional regression equation it is tested whether the risk premium indicated by the beta is positive and significant or not.

Table No.1 shows the intercept, Beta and weekly returns of each stock

Company	Intercept	Beta	Return
Yes Bank	0.317	1.631**	0.49475
Larsen & Toubro Ltd.	-0.085	1.345**	0.062056
Axis Bank	0.197	1.326**	0.342269
ICICI Bank	0.131	1.318**	0.274648
Indusind Bank	0.421*	1.294**	0.562695
State Bank Of India	0.085	1.27**	0.223637
Vedanta	-0.596*	1.215**	-0.46351

Tata Steel Ltd	-0.411	1.199**	-0.31028
Tata Motors DVR	0.244	1.141**	0.36868
Tata Motors Ltd	0.135	1.119**	0.25761
Adani Ports	0.119	1.112**	0.240411
HDFC Bank	0.149	1.094**	0.268356
Kotak Bank	0.348*	1.091**	0.467304
Reliance Industries	-0.096	1.091**	0.022648
HDFC Bank	0.248*	1.057**	0.363042
Maruti Suzuki	0.374	1.045**	0.487945
ONGC	-0.115	1.04**	-0.00152
Mahindra & Mahindra	0.155	0.953**	0.258541
Coal India	0.024	0.912**	0.123583
Power Grid Corporation Of India	0.084	0.884**	0.180706
Bajaj-Auto	0.207	0.825**	0.297248
Infosys	0.272	0.816**	0.361023
ASIAN Paints	0.478*	0.81**	0.566781
Bharti Airtel	-0.076	0.792**	0.010153
ITC	0.212	0.775**	0.296763
Sun Pharmaceutical	0.393	0.761**	0.475552
Wipro	0.051	0.733**	0.13143
HERO Motocorp	0.121	0.724**	0.200356
TCS	0.27	0.709**	0.347756
Hindustan Unilever	0.349	0.694**	0.425145

Note: * means significance at 5% level of significance and ** means that it is significant at 1% level.

Table no. 2 shows that the beta coefficients for all the portfolios are statistically significant at 1 percent level. Besides intercept term of the portfolio is only significant for portfolio P5, P8, P9, and P10. It is also inferred that high beta doesn't indicate high average returns.

Table No.2 Average excess return of the portfolio and Beta, Beta Square and Variance of residuals of the Portfolio

	Return	R	R Square	Intercept	Beta	Beta square	RV
P1	0.300	0.873	0.763	0.14	1.434 ***	2.056	7.32
P2	0.354	0.883	0.780	0.21	1.294***	1.674	5.41
P3	-0.135	0.791	0.626	-0.26	1.185 ***	1.404	9.61
P4	0.255	0.880	0.774	0.134	1.108***	1.228	4.11
P5	0.284	0.925	0.856	0.166*	1.08 ***	1.166	2.24
P6	0.248	0.861	0.742	0.138	1.013 ***	1.026	4.08
P7	0.201	0.838	0.703	0.105	0.874***	0.764	3.69
P8	0.313	0.810	0.655	0.225*	0.806***	0.650	3.91
P9	0.301	0.799	0.639	0.219*	0.756***	0.572	3.70
P10	0.324	0.797	0.635	0.25**	0.709 ***	0.503	3.31

Test of Beta:

The result of excess portfolio returns regressed on the beta of the portfolio are presented in table no. 3.

Table No.2 Regression result of Beta Test

	Regression Result	T –Statistics	Probability
Intercept λ_0	.352	1.651	.137

Market Risk Premium λ_1	-.105	-.518	.619
R-Squared	.032		

The regression results depict that the intercept term is not zero and not significant. It violates the CAPM postulation that portfolios return are only determined by the beta coefficient. The negative market risk premium is against the CAPM proposition and stock return is a reward for market risk. It is inferred that the market risk premium is not the only factor that determines the return in the BSE Sensex index stocks.

Test of Non-linearity:

Another important hypothesis of CAPM is that the assets returns are linearly related to the betas of the assets. This means that the term like Beta square if substituted beta should not yield better explanatory power.

Table No. 4 Regression Result for Test of Non-linearity

	Regression Result	T Statistics	Probability
Intercept λ_0	1.457	1.446	.191
Market Risk Premium λ_1	-2.311	-1.168	.281
Beta Square λ_2	1.049	1.121	.299
R-Squared	.180		

The regression result from table no. 4 states that the intercept term λ_0 , is not zero and insignificant, the market risk premium λ_1 is negative and insignificant and Beta Square λ_2 is not zero and insignificant. Altogether the regression result infers that CAPM does not hold.

Test of Non-systematic risk

CAPM claims that only risk that influences the return is the systematic risk. There is no unsystematic risk. The impact of non-systematic risk is measured by adding another variable the variance of the residuals of portfolio, for it the regression equation No. 6 is used.

Table No. 5. Regression Equation result of Non-systematic risk assessment.

	Regression Result	T –Statistics	Probability
Intercept λ_0	1.880	4.605	.004
Market Risk Premium λ_1	-2.905	-3.650	.011
Beta Square λ_2	1.519	3.981	.007
Variance of the residuals λ_3	-.070	-6.156	.001
R-Squared	.888		

The results indicate that intercept λ_0 , Market Risk Premium λ_1 , Beta Square λ_2 , the variance of the residuals λ_3 , are significantly different from zero at 5 percent level of significance. Thus all evidence is against the CAPM postulations. It is inferred that the CAPM model is not applicable to Indian stock market, specifically to BSE Sensex index based companies.

5. Conclusion

In this paper validity of CAPM was empirically tested in Indian stock market with reference to S&P BSE Sensex Index for the period of Jan 2011 to Dec 2015. The regression results violate the CAPM postulation that portfolio returns are only determined by the beta coefficient. The hypothesis of CAPM that the assets returns are linearly related to the betas of the assets and the only risk that influence the return is the systematic risk is also not established. The study findings are on the lines of other previous studies by Bajpai & Sharma (2015), Chaudhary (2017) and Shrivastav (2017) etc. Within the limited scope of the study based on the empirical evidence, it is

concluded that CAPM propositions do not hold true in Indian stock market, specifically for S&P BSE Sensex Indexed stocks for the specified period. Besides it has to be noted the view of Richard Roll (1977) that CAPM is not testable because true market portfolio cannot be measured as it may include all assets such as financial, real as well as human and not just equity stocks. The inability of CAPM to predict the Indian stock market proposes the need for further studies to predict the behavior of Indian stock market with using not only various other asset pricing models but using behavior asset pricing model approach.

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