Testing the Validity of Capital Asset Pricing Model (CAPM) in the Indian Stock Market

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Abstract

The capital asset pricing model (CAPM) is one of the most significant concepts in the financial investment literature which serves as a basis for the modern portfolio theories. The applicability of this model in deciding the asset prices has been rigorously tested by researchers over the years. However, the most significant studies in this regard have been conducted in context of a developed stock market and ,therefore, testing this model in context of a developing country like India may provide interesting results. The volatility in the Indian stock markets is quite high due to the under-developed financial sector. It drives a rational investor to study the applicability and effectiveness of the asset pricing models in such volatile markets. This paper aimed to test the theoretical assumptions of the CAPM in the context of the Indian stock market. This study was conducted by using data from top 30 stocks of Bombay Stock Exchange (BSE) constituting the Sensex. The results of the study indicated that in the given time frame, the CAPM is not valid in the Indian context. It also questions the robustness of CAPM and advocates for the inclusion of other factors along with beta (systematic risk) in the model, which also may have a significant impact in determining the asset prices and construction of efficient portfolios.

Keywords : **risk, returns, stock market, portfolio**

JEL Classification : G11, G12, G120

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The relationship between risk and returns is vital for investments in the financial markets in general and especially in capital markets because returns are more volatile and the risk of losing money is higher compared to that in the money market. In the investment literature, risk is a measure of variability of returns. It is the chance of an investment's actual returns being different from the investor's expected returns. This indicates the possibility of losing some or all of one's investments in a flash. Risk is different for different investors. Investors may be risk averse, or risk takers, while some may react moderately to risk (risk neutral). In general, investors aim for the highest possible returns from an investment with minimum possible risk. This objective for higher returns and lower risk can be addressed by the risk return trade-off. This trade-off indicates that higher the risk, higher will be the probability of getting greater returns. An investor, then, would require a positive compensation for bearing higher risk. This makes it essential to understand the relationship of risk with returns, particularly with expected returns. This compelling need to ascertain the risk- return relationship and estimate the cost of equity forms the basis of developing asset pricing models such as the capital asset pricing model (CAPM).

CAPM was developed in the mid-1960s and became popular because of its simplicity and ease of application. This model explains the relationship between the risk and returns of an asset. The model assumes that the portfolio returns are a linear function of the excess returns for systematic risk undertaken, that is, coefficient of market returns, which is denoted by beta. CAPM holds true under the following assumptions :

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(i) All investors are rational and risk-averse. Therefore, they aim to maximize their economic utilities (asset quantities are given and fixed).

(ii) Investors are broadly diversified across a range of investments.

(iii) They are price takers, that is, they cannot influence prices as they have homogeneous expectations.

(iv) Investors are free to lend and borrow unlimited amounts of funds under the risk free rate of interest.

(v) There are no transaction or taxation costs.

(vi) All investors assume all information is available at the same time to all investors.

The assumptions mentioned above seem far from reality, but most of these assumptions can be relaxed to represent reality as a financial theory. The mathematical expression (Sharpe, 1964) of the model is as follows:

$$R_{it} = R_{ft} + \beta_i R_{mt} + u_t$$

where,
R_{it} is the return on portfolio *i* at time *t,*
R_{ft} is the return on the risk-free asset at time *t,*
R_{mt} is the market return at time *t,*
u_t is the stochastic error term at time *t.*

This model suggests that systematic risk is only a risk factor which affects the returns of an asset. Therefore, it is also called a single factor model. The relationship between risk and returns that is predicted by this model may be represented graphically and the line showing returns for a given level of risk is called the security market line (SML).

This study attempts to test the validity of the model in the Indian context because a limited number of studies concerning the Indian stock market have been conducted which too have provided conflicting results. The results of some of these studies led us to believe that CAPM is not a robust model in guiding investors to make informed decisions regarding financial portfolios. Therefore, investors find themselves vulnerable while adopting this model in such situations. Moreover, the underlying assumption of this model of beta being the only factor affecting the portfolio returns is also tested.

Literature Review

CAPM was first introduced by Sharpe (1964), Linter (1965), and Mossin (1966). It was accepted by the financial analysts straightway because of its simplicity and ease of use. Since the inception of CAPM, various studies have been conducted to test its validity. Interestingly, the results of these tests are mixed in response.

Most of the earlier studies conducted by Blume (1970) ; Jensen, Black, and Scholes (1972) ; and Fama and MacBeth (1973) supported the CAPM and found out the evidences of assets' returns being a linear function of the systematic risk (Beta). Later on, many studies have questioned the validity of CAPM. For instance, Banz (1981) depicted that there is a relationship between the stock returns and market capitalization. Similarly, Bhandari (1988) examined the effect of the debt-equity ratio on the returns of the risky assets and rejected the presence of the security market line, though he found that there was a positive relationship between risk and returns. Fama and French (1993) suggested that systematic risk is not the only factor that influenced the returns of the risky asset, but there are many additional factors also, such as market capitalization and book to market ratio.

Most of the studies of empirical testing of CAPM have been carried out in the United States market, while there

are very few studies which have been conducted in the context of developing countries such as India. Interestingly, there are variations in the findings of these studies too.

Yalwar (1988), Varma (1988), Ansari (2000), and Dhankar and Kumar (2007) found out that CAPM is applicable in the context of the Indian stock market. However, Gupta and Sehgal (1993) and Madhusoodanan (1997) are researchers who have denied the applicability of CAPM in the Indian context. In recent studies, Basu and Chawla (2010) denied the applicability of the CAPM model. They took the BSE Sensex data for 5 years of the top 30 companies of the index. They concluded that the CAPM model is not an appropriate model for determining the asset prices and we should look for more advanced model for this purpose. Dash and Rishika (2011) compared the arbitrary pricing model (APM) with the CAPM and found out that in context of the Indian capital market, the CAPM provides more robust results than APM. Bajpai and Sharma (2015) found out that CAPM can be estimated by removing the intercept term from the model. Using the intercept term in the CAPM leads to a total failure of the model in the context of the Indian equity market.

Objective of the Study

The objective of this exercise is to test the validity of the capital asset pricing model in the context of the Indian stock market, in this case, the Bombay Stock Exchange (BSE).

Dataset and Methodological Approach

This study has been carried out by considering the data of the top 30 companies of BSE - which constitutes the Sensex - for a period of 2 years from April 1, 2014 to March 31, 2016. The selection of the companies to be included in the study is strictly according to the Sensex as on April 1, 2014. Since the index is being formed on the basis of market capitalization, therefore, the selected stocks are well traded stocks. Moreover, there are diverse industries to which these stocks belong to. The data were collected from the databases of BSE, Bloomberg, and Yahoo Finance websites. The yields of 2-year government bond is taken as a proxy of risk free rate of returns. The data represents daily price closes of different stocks because daily prices are best suited for calculating the returns of the stock and subsequently, its beta value. In the second stage of the model, weekly prices are also captured through data sources to calculate portfolio returns, beta, and residual variances.

Based on the review of literature, the approach that most of the studies adopted to test the CAPM is the two stage regression methodology. Jensen et al. (1972) took up this methodology where they first conducted a time series regression to estimate the values of beta and based on this, they formed portfolio of securities. They divided the entire time period (December 1931 to March 1965) into sub - periods and then calculated the least square estimates of systematic risk and unsystematic risk for each of the period. Fama and Macbeth (1973) also tested CAPM by conducting a two stage regression. In the first stage, a set of regressions equal to the number of portfolios was conducted. In second stage, another set of regressions equal to the number of time periods was conducted. Observing the methodologies that were adopted in the studies which were conducted in the Indian context, one can find a similar approach. Bajpai and Sharma (2015) conducted their study on NSE CNX -500 index by taking a similar two stage regression methodology, where they first estimated the beta for individual stocks followed by formation of portfolios and then regressing risk premium on beta of the portfolio for different sub periods.

In spite of having the same methodology and similar estimation model, in this study, the time period is not being divided into sub periods. Moreover, there is an alternate model with no intercept term which is tested considering the notion of CAPM being a zero intercept model. Firstly, the daily returns of the individual stocks were calculated using the daily closing prices of the stocks. The following formula was used to calculate the daily returns :

$$Daily\ Return = \frac{(Present\ Close - Previous\ Close)}{Previous\ Close} * 100$$

Beta of the stocks were calculated by regressing daily returns of the stock on the daily returns of the market. The following equation was used to calculate beta:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_t$$

On the basis of the beta values, the stocks were then arranged in a descending order, and six portfolios were formed taking first five stocks in first portfolio having highest beta values and next three in second portfolio, and so on. Now, we have the first portfolio with stocks having highest beta values and the last having the lowest beta

Table 1. Formation of Portfolios on the Basis of Beta Values

Rank	Stock	Beta	Portfolio No.
1	Vedanta Ltd.	1.9	I
2	Hindalco Industries Ltd.	1.57	
3	Tata Steel Ltd.	1.51	
4	Axis Bank Ltd.	1.5	
5	Tata Motors Ltd.	1.48	
6	State Bank of India	1.44	II
7	Bharat Heavy Electricals Ltd.	1.39	
8	ICICI Bank Ltd.	1.39	
9	Larsen and turbo Ltd.	1.27	
10	Oil and Natural Gas Corp of India	1.24	
11	Housing development & Finance Corp	1.19	III
12	Reliance Industries Ltd.	1.14	
13	Gail India Ltd	1.12	
14	Mahindra and Mahindra Ltd.	0.92	
15	NTPC	0.9	
16	Coal India Ltd.	0.89	IV
17	Maruti Udhyog ltd	0.88	
18	Cipla Ltd.	0.87	
19	HDFC Bank Ltd.	0.85	
20	Hero Motor Corp	0.83	
21	Bajaj Automobiles Corp	0.74	V
22	Sun Pharmaceuticals Ltd.	0.71	
23	ITC Ltd.	0.7	
24	Infosys technologies Ltd.	0.63	
25	Lupin Ltd.	0.63	
26	Dr. Reddy's Lab Ltd.	0.62	VI
27	Bharti Airtel Ltd.	0.61	
28	Wipro Ltd.	0.55	
29	Tata Consultancy Services Ltd.	0.54	
30	Hindustan Uniliver Ltd.	0.08	

values. This was done to eliminate any error due to the presence of unsystematic risk (Table 1). Having formed the portfolios, portfolio returns, portfolio beta, and residual variance were calculated using weekly data. Portfolio returns were calculated by averaging out the returns of individual stocks in a particular portfolio assuming equal weights for each stock constituting the portfolio. Portfolio beta and residual variances were calculated by regressing portfolio returns on market returns. The excess returns or risk premium was calculated for each of the portfolio by adjusting the risk free returns from the portfolio returns.

Portfolio returns were regressed on portfolio beta, beta-squared, and residual variances to test the statistical significance of the regression coefficients using *t*-test. The following regression model was used:

$$R^* = \alpha_1\beta_{it} + \alpha_2\beta_{it}^2 + \alpha_3 RV_{it} + \varepsilon_t$$

where,
R^* is the risk premium, that is, difference between R_{it} and R_{ft} (R_{it} is the return on portfolio i at time t and R_{ft} is the return on the risk-free asset at time t),
β_{it} is the beta of portfolio i at time t, representing the systematic risk,
β_{it}^2 is the beta of portfolio i at time t, representing non-linearity of returns,
RV_{it} is the residual variance of portfolio i at time t, representing unsystematic risk,
ε_t is the stochastic error term at time t.

For the validity of CAPM, the hypotheses that should be satisfied at the 5% level of significance are :
Excess returns should be zero because it is zero intercept portfolio (intercept must be statistically insignificant), $\alpha_1 > 0$ (there should be positive returns for risk taken and must be statistically significant), $\alpha_2 = 0$ (a linear security market line), $\alpha_3 = 0$ (unsystematic risk can be diversified and should not affect the returns).

Analysis and Results

The Table 2 shows the results obtained by estimating the regression equation. The results indicate that the intercept term is significantly different from zero in all six cases, which is against the validity of CAPM as it is

Table 2. Regression Results of Estimating the Equation : $R_i - R_f = \alpha_0 + \alpha_1\beta_i + \alpha_2\beta_i^2 + \alpha_3 RV_i + \varepsilon$

Estimated Standardized Coefficients and *p*-values at 5% level of significance							
Portfolio No.	**Constant**	**β**	**β^2**	***RV***	***R^2***	***DW***	***F*-Stat (Probability)**
I	-7.263	-0.040	0.038	0.662	43.9%	1.97	0.001
	(0.000)	(0.825)	(0.831)	(0.000)			
II	-7.073	-0.116	0.133	0.517	26.5%	1.96	0.020
	(0.000)	(0.665)	(0.619)	(0.000)			
III	-6.995	0.113	-0.082	0.580	34.2%	1.96	0.000
	(0.000)	(0.954)	(0.966)	(0.000)			
IV	-6.738	0.064	-0.031	0.533	28.6%	1.97	0.046
	(0.000)	(0.884)	(0.944)	(0.000)			
V	-6.588	0.012	0.025	0.939	58.4%	1.96	0.030
	(0.000)	(0.971)	(0.940)	(0.000)			
VI	-6.877	-0.022	0.045	0.790	42.2%	1.96	0.000
	(0.000)	(0.955)	(0.907)	(0.000)			

Table 3. Regression Results of Estimating the Equation: $R_i - R_f = \alpha_1\beta_i + \alpha_2\beta_i^2 + \alpha_3 RV_i + \varepsilon$

Portfolio No.	β	β^2	*RV*
I	-0.261	0.146	0.360
	(0.240)	(0.509)	(0.000)
II	-1.058	0.870	0.272
	(0.000)	(0.001)	(0.003)
III	-2.775	2.691	0.464
	(0.229)	(0.244)	(0.025)
IV	-1.627	1.509	0.218
	(0.001)	(0.000)	(0.020)
V	0.203	0.124	0.485
	(0.810)	(0.883)	(0.000)
VI	0.327	0.412	0.230
	(0.588)	(0.495)	(0.020)

assumed to be a zero intercept model. The coefficient of beta is positive in four out of six cases, but it is insignificant in all the cases, which again questions the theoretical foundations of CAPM by invalidating the claim that portfolio returns are affected by the systematic risk (beta). However, the coefficients of beta-squared are insignificant in all the cases, indicating that the SML is linear, and thereby validating the model. The coefficient of residual variance is significant in all the cases which suggests that the unsystematic risk is affecting the portfolio returns. It is against the validity of CAPM because the model considers only the systematic risk in estimating the expected returns of a portfolio. Therefore, the assumed hypotheses that holds true for the validity of CAPM is rejected based on very strong evidences. R^2 in most cases are on the lower side and significant in all six cases as depicted by the *F*-statistic of the respective cases, which suggests the overall fit of the model. Lower values of R^2 are suggesting that the independent variable beta alone is not able to explain all the variations in dependent variable excess return on portfolio. The Durbin-Watson (DW) statistic indicates that there is no problem of autocorrelation in any of the cases as the values are very much close to 2.

Results of the Model Without Intercept : Since CAPM is considered as a model without the intercept term, that is, the zero intercept model, therefore, it is appropriate to test this model by eliminating the intercept term as well. However, the results are still not supporting the hypotheses which hold the validity of CAPM as it is rejected in all six cases (Table 3).

Conclusion, Implications, Limitations of the Study, and Scope for Further Research

The findings of this study indicate that CAPM does not hold true in the context of the Indian Stock market for the selected time frame. The results of the study question the theories and assumptions that form the foundations of CAPM. Even with the model having no intercept, the results are overwhelmingly against the theory of CAPM. However, this study has the following limitations: (a) the theoretical assumptions of the model are not fully met, (b) a limited sample size of 30 companies was considered for the study for a limited time period of 2 years only.

R^2 values are very low, which suggests that beta alone is not sufficient to explain all the variations in excess portfolio returns, but there can be other factors as well such as market capitalization, net profit ratio, and book to market ratio, which can be included in the model while determining the portfolio returns. However, a model

including the aforesaid factors is not tested and requires further research. This study advocates the fact that the validity of CAPM concerning developing and more volatile capital markets is highly questionable as the results of this study and many other studies conducted in developing countries in context go against the theory of this model. Hence, there is strong need to upgrade or replace the existing CAPM with a model which captures the variable/s causing the changes in asset prices in a more effective way.

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