An Empirical Test of CAPM—The Case of Indian Stock Market*

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A deluge of tests have been conducted on asset pricing models in literature, more so on the Capital Asset Pricing Model (CAPM), to ascertain their validity, efficiency and efficacy in different markets in explaining asset prices. Such tests have been either individual in nature wherein any one model has been studied or comparative in nature where one model has been compared with another. Many studies have also resulted in the development of new models or extensions to the existing theory. However, majority of the aforementioned tests have been undertaken in developed markets, resulting in a dearth of such tests in emerging markets like India where the risk–return relationship gains more significance. A growing, emerging market is always less analyzed but more volatile and thus, more interesting. The article, thus, applies the fundamental CAPM theory to India.

This study examines 10 portfolios, covering 50 stocks, over a 5-year period—from 1 January 2003 to 1 February 2008—to verify the efficiency and efficacy of the model and finds that CAPM fails completely in the Indian context. The intercept term, which is expected to be zero, is found to be significant for all 10 portfolios. The study also finds a negative relationship between beta and excess returns indicating an inefficient capital market. Moreover, residual variance, representing unsystematic risk, is also found significant in certain cases. Moreover, the regressions show poor explanatory power. Thus, it can be concluded that CAPM is not a suitable descriptor of asset prices in India over the chosen sample period.

Keywords: Capital asset pricing model, Asset pricing, Portfolio returns, Beta, Systematic risk, Linearity, Market efficiency

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Introduction

The risk–return trade-off has long been an area of significant research. In the investing world, risk is defined as the chance that an investment's actual return is different from the investor's expected return. This implies the possibility of losing some or all of one's investments at the blink of an eye, if one is not comfortable with the investments made. While some can handle a financial skydive without batting an eyelid, others are terrified to climb the financial ladder without an adequate safety net. Thus, to be comfortable, an investor needs to understand this risk–return balance.

The risk–return trade-off is the balance between a rational investor's desire for the highest possible return and lowest possible risk. This implies that taking higher risk would make available the possibility for higher returns. An investor, then, would require a positive compensation for bearing risk. This makes it crucial to understand the relationship between risk and return, particularly expected return.

This compelling need to ascertain the risk–return relationship and estimate the cost of equity became the cornerstone of developing asset pricing models, which aim at understanding the prices of claims with uncertain payments.

The Capital Asset Pricing Model (CAPM), developed in the 1960s, was a true revolution in financial theory. CAPM helps determine the theoretically required rate of return and, therefore, the price of an asset when added to a well-diversified portfolio and predicts that the expected return on an asset equals the risk-free rate plus a risk premium, that is, it is linearly related to systematic risk, measured by the asset's beta. This model has been primarily applied to: (*a*) active and passive portfolio management in establishing benchmarks for measuring the performance of active investments and (*b*) infer the market capitalization interest rate, that is, the risk adjusted discount rate.

It is a ceteris paribus model and holds valid only under the following assumptions:

- Investors are risk averse individuals who aim at maximizing the expected utility of their wealth. They also have the same time horizon.
- Investors are price takers (no single investor can affect the price of a stock) and have homogenous expectation about asset returns that have a joint normal distribution.
- Investors can borrow or lend money at the risk-free rate of return.
- The quantities of assets are fixed. All assets are marketable and perfectly divisible.
- Asset markets are frictionless and information is costless and simultaneously available to all investors.
- There are no market imperfections such as taxes, no transaction costs or no restrictions on short selling.

Thus, CAPM assumes that all stocks are equally sensitive to any news in the economy and exhibits vulnerability in looking for a benchmark for the purpose of comparing the ex-post performance and ex-ante returns on real and financial investments. While the aforementioned assumptions seem far from reality, as a financial theory, it may be considered to represent reality reasonably well as most of these assumptions can be relaxed.

The CAPM argues that these assumptions imply that the tangency portfolio will be a value-weighted mix of all the assets in the world and is actually based on an elegant equilibrium argument. It begins with the assertion that all risky assets in the world are a part of the global wealth portfolio and all the investors in the world collectively hold all these assets. Here, each portfolio would have a weight as given by the relative asset values of the companies and then, each investor's portfolio weight becomes exactly proportional to the percentage that a company represents of the world's assets. When the model was developed, this capital-weighted portfolio of global wealth found a solution in the United States S&P 500 index, which is a capital-weighted portfolio of the country's largest stocks. In the 1960s, United States was the world's largest market and the index, thus, seemed to be a fair approximation of the global assets and was claimed a representative of the tangency portfolio, but as the market gained significance, this approximation became flawed.

While CAPM found a massive following among investors and researchers and is a theoretical solution to the identification of a tangency portfolio, any theory like CAPM would be strictly valid only if its assumptions were true, but the model's assumptions itself question the validity of the model. What then requires to be understood is, given so many unrealistic assumptions, does this model really fit reality? Is CAPM valid beyond the US where it was first established, particularly in emerging markets, which display different characteristics and tendencies while gaining importance in the minds of global investors?

Thus, this article attempts to test CAPM in the Indian context, primarily, since the test of any asset pricing model has not been extensively conducted in this market (Ansari 2000) and also because India, today, with its economic growth appears to be a likely and emerging market to study. Also, given the continued bull run since 2003, coupled with 6 of the top 10 single day losses in the history of the Bombay Stock Exchange (BSE) Sensex in the 2002–07 period, volatility and growth in the Indian stock markets have surged and this makes the Indian market more interesting to study as asset pricing has become crucial for a comfortable risk–return trade-off.

The rest of this article is organized as follows. The section 'Literature Survey' probes some of the existing literature to assess the impact of previous studies and their results on the chosen subject. The next section states the objective of this study, with the following one describing the data used for study. The section 'Methodology' briefly explains the methodology of research and the preprocessing of data required for study, while the section 'Model Estimation and Analysis' elucidates the estimated model and analyzes the results obtained thereon. The last section contains the concluding remarks and the possible impact of the study on further research in the same field.

Literature Survey

Empirical tests of asset pricing models have been undertaken for over three decades, more often than not, with limited conclusive ability. Within this context, CAPM helped lay the foundation for further models that addressed the risk–return trade-off. First introduced by Sharpe (1964), Lintner (1965) and Mossin (1966), this model gained immediate acceptance because of its simplicity, commonsense notion and ease of use. At the centre of this theory is the security market line which indicates that an investor is rewarded for the systematic or non-diversifiable portion of risk, as represented by beta and higher this risk, higher the expected returns. Despite its simplicity, numerous criticisms arose against the model as people began to empirically test it.

In the late 1960s, many practitioners, taking advantage of their superior computing power at that time, tried to put CAPM to work by investing in higher beta stocks but were ultimately disappointed. Academicians then had just started to test the model's validity. Most of the articles like by Blume (1968) and Fama et al. (1969) were promising in their support for CAPM. Further formal studies in the early 1970s, Black et al. (1972), Blume and Friend (1973) and Fama and MacBeth (1973), found positive results for the model but this euphoria was shortlived as most of the later empirical studies like Roll (1977), Basu (1977, 1983), Banz (1981), Bhandari (1988) and Fama and French (1992) rejected the existence of the security market line. While these tests accepted that there did exist a positive relation between risk and return, it was found to be too flat. The intercept term was found to be greater than the risk-free rate and the coefficient of beta was found to be less than the average excess market return. These results were confirmed in both cross-sectional and time series tests. Further studies like Sauer and Murphy (1992) in the German market and Limmack and Ward (1990) in the UK market also found that CAPM was a good indicator of asset pricing. Fama and French (1996), on the other hand, found compelling evidence that beta did not suffice in explaining expected returns.

These tests were primarily conducted in the US market and soon such tests gained significance even in developing or emerging markets. Srinivasan (1988), in a study on the Indian market, found that CAPM was valid but a much larger sample was required to draw inferences. Yalwar (1988) and Varma (1988) also found results supportive of the CAPM as against Manjunatha and Mallikarjunappa (2006), which questioned the models validity in Indian markets. For Gupta and Sehgal (1993), CAPM was found to be an unsuitable descriptor of asset pricing in India during the study period as it did not show a linear risk–return relationship as well as identified volatility and a more regulated Indian capital market as the possible reasons for the same. It found a positive but weak risk–return relation. Madhusoodanan (1997) tested the model on 120 scrips in India and found no positive relationship between beta and return. The author found that the most risky portfolio actually yielded the minimum return while the least risky portfolio yielded a comparatively higher return and suggested that a low beta strategy would be more rewarding in the Indian context. This study was not only disturbing for CAPM but also for the efficiency of the Indian capital market. Another study in the same year, Sehgal (1997) reported that CAPM was not a suitable asset pricing model in India and found the slope to be negative but insignificant for the total period under consideration implying the absence of any significant relationship between beta and return.

Early twenty-first century saw an alternative methodology for testing CAPM in the Philippine Equity Markets in Ocampo (2004) and helped revive the ability of beta in explaining asset returns. Though the article failed to prove the validity of CAPM in the market studied, it provided evidence for the role of beta in explaining returns in the Philippines market. In 2006, Yang and Xu (2006) tested CAPM in the Chinese stock market and found that while expected returns and beta exhibited a linear relationship, the hypotheses for the intercept and the slope did not hold, thereby, concluding that the model did not give a valid description of the Chinese market. Another study in the same year, in the Greek Securities Market in Michailidis et al. (2006) concluded that the tests provide evidence against the CAPM. A test in Turkey in Gürsoy and Rejepova (2007) found no meaningful relationship between beta coefficients and ex-post risk premiums under the Fama and MacBeth approach but found strong beta-risk premium relationships with the Pettengill et al. (1995) methodology. Moreover, the intercept hypothesis was accepted only in two of the five sub-periods, hence, concluding that the article did not prove the validity of the model in Turkish conditions. Another study, Dhankar and Kumar (2007) in India, again found support for CAPM in establishing a trade-off between risk and return and validating the efficient market hypothesis in the Indian context.

While many of these rejections of the CAPM model can be attributed to the lack of conformance of actual conditions with the assumptions of theory, the inability of empirical studies to validate the model resulted in the search for alternative models, like Arbitrage Pricing Theory or Three Factor Model, to explain asset pricing.

Thus, there appears to be no consensus in the literature regarding the validity of the model and its ability to explain the returns and estimate the cost of equity capital, more so in emerging markets. This has been the motivation behind this study and has been undertaken under a deductive approach while following the philosophy of positivism, to test the effectiveness and efficiency of the model in an emerging market like India.

Objective

The objective of this article is to test the validity of the CAPM for the Indian stock market.

Data

The study has been carried out based on S&P CNX Nifty companies that were part of the index from 1 January 2003 to 1 February 2008. Nifty stocks represented about 54 per cent of the total market capitalization as on 31 December 2007 and accounted for 21 sectors of the economy. These companies are well traded and belong to diverse industry groups. While the aforementioned index consists of 50 stocks, other scrips that were replaced on or after 1 January 2003 were also included in the study. The list included 69 companies. The final list was reduced to 50 companies owing to the unavailability of data for 19 companies for the entire period under consideration.

The S&P CNX 500 has been taken as the market proxy being India's first broad-based benchmark. It represents more than 90 per cent of the total market capitalization and accounts for 72 industry indices. The required data on stocks and indices was collected from Centre for Monitoring Indian Economy (CMIE) database, PROWESS, the National Stock Exchange (NSE) website and the Yahoo! Finance website. For the risk-free rate, 91-day Treasury bill rates have been taken as a proxy.

The required data was collected from CMIE Database Economic Intelligence.

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.

Methodology

The steps followed in carrying out the research, explained briefly, are as follows:

- For the market index (S&P CNX 500) and each of the 50 stocks, daily returns through natural logarithm of price relatives were calculated, followed by the calculation of weekly returns, from one Wednesday to the next to ensure no impact of effects like day-of-the-week and weekend.
- This was followed by estimating beta for each of the 50 stocks by regressing the weekly stock returns on the weekly market returns.
- The stocks were then arranged in descending order of beta and grouped into 10 portfolios of 5 stocks each such that portfolio 1 contains the first 5 stocks representing the 5 highest beta values and portfolio 10 contains the last 5 stocks representing the 5 lowest beta values. This was done to achieve diversification and thus reduce any errors that might occur due to the presence of unsystematic risk as done in Amanulla et al. (1998) (Refer Annexure 1).
- Finally, using daily returns, portfolio returns, portfolio beta and residual variance were calculated for each portfolio at weekly intervals resulting in 256 observations for each of the variables for each of the weeks.

Model Estimation and Analysis

According to the model, returns can be explained through the following regression:

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

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

The above regression, interpreted according to CAPM's theory, implies that returns are a linear function of the risk-free rate and a risk premium for systematic risk undertaken, as measured by the coefficient of market return. Thus, beta is supposed to be the only factor influencing excess portfolio returns, that is, portfolio returns as reduced by the risk-free rate. This suggests that the validity of this theory depends on: (*a*) a positive linear relationship between beta and excess returns and (*b*) sole dependence of excess returns on systematic risk as measured by beta.

This model was thus, tested using the following regression:

$$R_{it} - R_{ft} = \gamma_0 + \gamma_1 \beta_{it} + \gamma_2 \beta_{it}^2 + \gamma_3 RV_{it} + \varepsilon_t$$

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
β_{it} is the beta of portfolio i at time t, representing systematic risk
β_{it}^2 is the beta of portfolio i at time t squared, 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 this purpose, the excess weekly portfolio returns were regressed on beta, beta-squared and residual variance, as obtained from the data preprocessing stage, to test the statistical significance of the coefficients using the standard t test. For CAPM to hold true, the following hypothesis should be satisfied.

- $\gamma_0 = 0$, as any excess return earned should be zero for a zero-beta portfolio
- $\gamma_1 > 0$, as there should be a positive price for risk taken
- $\gamma_2 = 0$, as the security market line should represent a linear relationship
- $\gamma_3 = 0$, as residual risk which can be diversified away should not affect return

The regression model was estimated using OLS method and tests of significance were carried out at 5 per cent level using the following framework:

- The intercept term, the coefficient of beta-squared and the residual variance have been hypothesized as not being statistically different from zero, and therefore a two-tailed test is appropriate.
- The coefficient of beta should be positive and thus, significant, as explained above, and therefore a one-tailed test is used.

The results obtained by estimating the regression equation are presented in Table 1. The results indicate that for all the 10 portfolios, the intercept term is significantly different from zero, the coefficient of beta-squared is significant in five cases and the coefficient of residual variance is significant in four cases. These are against the validity of CAPM.

Further, the coefficient of beta falters in 9 out of the 10 portfolios, the coefficient of beta is found to be negative but it is insignificant in 6 of these cases. Overall, the beta coefficients are found insignificant in 7 of the 10 cases. These results again question the validity of CAPM and its risk–return theory in the context of Indian stock market. Also, the R^2 values in the 10 regressions presented in Table 1 varies from 1.55 per cent to 7.78 per cent which is very low, although significant in six cases as indicated by the p value corresponding to its F statistic. There is also a problem of first degree autocorrelation in the case of two regressions as evident from the Durbin-Watson (DW) statistic.

Thus, the above results reveal that, in the Indian context, CAPM fails to adequately explain the excess portfolio returns earned. For each of the regressions, CAPM performs below expectations with respect to the signs and significance of the coefficients while displaying very low R-squared values across all 10 portfolios. As demonstrated by empirical evidence, application of this model has yielded varied results under different market conditions over varying sample periods. Accordingly, this analysis helps in finding further evidence for CAPM's downfall in explaining excess returns in emerging market.

Table 1
The Estimates of Regression Equation

$$R_i - R_f = \gamma_0 + \gamma_1\beta_i + \gamma_2\beta_i^2 + \gamma_3 RV_i + \varepsilon$$

Portfolio No.	*Coefficient/ p-value*	*Estimated Coefficients and p-value of corresponding t statistics of* Constant	β	β^2	*RV*	R^2	*DW*	*F-Stat (Prob)*
I	Coefficient	–0.0448	–0.0154	0.0029	125.4248	4.55%	1.92	0.0083
	p-value	0.0000	0.1329	0.3897	0.0023			
II	Coefficient	–0.0300	–0.0247	0.0101	–164.7290	4.53%	1.87	0.0085
	p-value	0.0007	0.0667	0.0897	0.0020			
III	Coefficient	–0.0469	–0.0122	0.0064	107.9075	2.68%	1.76	0.0763
	p-value	0.0000	0.1394	0.0497	0.0677			
IV	Coefficient	–0.0396	–0.0082	0.0017	–126.3216	3.62%	1.84	0.0254
	p-value	0.0000	0.2457	0.0341	0.0898			
V	Coefficient	–0.0378	–0.0223	0.0107	–70.0073	2.71%	1.77	0.0741
	p-value	0.0000	0.0305	0.0268	0.1332			
VI	Coefficient	–0.0447	–0.0062	0.0012	–9.7707	1.89%	1.78	0.185
	p-value	0.0000	0.0944	0.3152	0.8042			
VII	Coefficient	–0.0544	0.0032	0.0008	–19.7523	1.54%	1.9	0.2408
	p-value	0.0000	0.5543	0.5176	0.4016			
VIII	Coefficient	–0.0439	–0.0043	0.0036	–152.5200	7.78%	1.93	0.0001
	p-value	0.0000	0.4473	0.0666	0.0001			
IX	Coefficient	–0.0511	–0.0074	0.0010	–114.5246	4.74%	1.54	0.0066
	p-value	0.0000	0.3154	0.0334	0.0138			
X	Coefficient	–0.0552	–0.0037	0.0062	12.8368	3.75%	1.59	0.0219
	p-value	0.0000	0.3831	0.0054	0.7616			

Source: Authors' own.
Note: *p*-values are for two-tailed tests.

Conclusion

This article finds that CAPM performs below expectations and questions the theories that form its foundation. It helps in concluding that CAPM is really more dead than alive, and needs to be replaced with a model that captures the variables causing the changes in asset prices more effectively. A negative relation between beta and returns for 90 per cent of the portfolios also casts doubts on the efficiency of the Indian capital markets.

Though the failure of CAPM can be attributed to various other factors, including an imperfect market proxy, tax effects and different borrowing and lending rates, these factors only question the testability of the model, which many, in favour of CAPM, claim is the real reason behind its failure across markets. This argument would reduce CAPM to a hollow theory, futile for a practitioner. This implies that either CAPM as a model is only a theory that cannot be tested or is a testable theory that fails miserably, either way the model becomes useless as an asset pricing tool. It also questions beta as an efficient measure of risk and is perhaps why share prices can still not be predicted. The only good this model then serves is as a popular benchmark which also sets the base for other asset pricing models and its contribution in understanding other concepts like active portfolio management and performance evaluation.

While, overall, this article provides adequate evidence to judge the effectiveness and efficiency of the model in the Indian context, the study was limited by: (*a*) its inability to meet the theoretical assumptions of all the models and (*b*) the restricted sample size of 50 scrips. While this study is successful in invalidating the model, further research could be attempted to test the validity of other asset pricing models in the Indian markets to find a feasible alternative. A comparative study of asset pricing models could also be attempted for a more thorough analysis. The efficiency of the Indian markets, today, could also be verified to draw a clearer conclusion about the CAPM theory and the risk–return trade-off.

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ANNEXURE 1

Final 10 Portfolios on the Basis of Beta Values

Portfolio No.	*Company*	*Beta*	*Ranking*
I	Steel Authority of India Ltd.	1.471928244	1
	Tata Steel Ltd.	1.267770388	2
	Tata Communications Ltd.	1.258670634	3
	Oriental Bank of Commerce	1.21633837	4
	Shipping Corpn. of India Ltd.	1.210769354	5
II	Reliance Energy Ltd.	1.193484298	6
	Oil & Natural Gas Corpn. Ltd.	1.142889351	7
	Mahanagar Telephone Nigam Ltd.	1.136908415	8
	Punjab National Bank	1.121746953	9
	Tata Power Co. Ltd.	1.120710927	10
III	Bharat Heavy Electricals Ltd.	1.101889114	11
	GAIL (India) Ltd.	1.099147709	12
	National Aluminium Co. Ltd.	1.067015989	13
	Tata Motors Ltd.	1.062645475	14
	Unitech Ltd.	1.047761525	15
IV	Siemens Ltd.	1.044074025	16
	State Bank of India	1.036399922	17
	Hindustan Petroleum Corpn. Ltd.	1.022898636	18
	Mahindra & Mahindra Ltd.	1.015354395	19
	Hindalco Industries Ltd.	0.9935118	20
V	ACC Ltd.	0.970760031	21
	Zee Entertainment Enterprises Ltd.	0.96177779	22
	Tata Tea Ltd.	0.958779217	23
	Reliance Industries Ltd.	0.947745496	24
	Grasim Industries Ltd.	0.946133049	25
VI	Tata Chemicals Ltd.	0.936972064	26
	Indian Hotels Co. Ltd.	0.923953693	27
	ICICI Bank Ltd.	0.915463607	28
	Bharat Petroleum Corpn. Ltd.	0.895158713	29
	Bharti Airtel Ltd.	0.866325117	30
VII	ABB Ltd.	0.818513025	31
	Wipro Ltd.	0.811303937	32
	HCL Technologies Ltd.	0.808151718	33
	Satyam Computer Services Ltd.	0.792694193	34
	HDFC Bank Ltd.	0.791111893	35

(*Annexure 1 continued*)

(*Annexure 1 continued*)

Portfolio No.	*Company*	*Beta*	*Ranking*
VIII	Dabur India Ltd.	0.781745796	36
	Ambuja Cements Ltd.	0.780920867	37
	Housing Development Finance Corpn. Ltd.	0.76862713	38
	Hero Honda Motors Ltd.	0.755834289	39
	Hindustan Unilever Ltd.	0.724869669	40
IX	Cipla Ltd.	0.712920141	41
	Infosys Technologies Ltd.	0.670749664	42
	ITC Ltd.	0.666932923	43
	Ranbaxy Laboratories Ltd.	0.665344126	44
	Bajaj Auto Ltd.	0.662430222	45
X	Dr Reddy's Laboratories Ltd.	0.615332878	46
	Glaxosmithkline Pharmaceuticals Ltd.	0.608884638	47
	Sun Pharmaceutical Inds. Ltd.	0.586040174	48
	Glaxosmithkline Consumer Healthcare Ltd.	0.502334872	49
	Britannia Industries Ltd.	0.375621689	50