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Capital Asset Pricing Model: A Review of Theory, Evidence and Applications

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Abstract: Capital Asset Pricing Model (CAPM) provides a relatively truthful forecast of the relationship that exists between the expected return and a financial risk. The core of the model is represented by the beta coefficient. The co-efficient of Beta measures the sensitivity of the financial instrument in relation to the systematic risk. The model is still widely used in various applications, such as estimating the cost of equity capital for firms, the expected return of an asset and evaluating the performance of managed portfolios. Actually, the model is used to determine a theoretically appropriate required rate of return of an asset, to make decisions about adding assets to a well-diversified portfolio. The study reviewed the theory and evidence of the Capital Asset Pricing Model (CAPM). It has exposed a rational assessment between Security Market Line (SML) and Capital Market Line (CML). Furthermore, the study showed that how the Security Market Line (SML) may be instigated from Capital Market Line (CML) and vice- versa. The different applications of CAPM Model from different points of view have been analyzed in this study.

Keywords: Exposed, Forecast, Portfolios, Systematic Risk, Sensitivity.

INTRODUCTION

The Capital Asset Pricing Model (CAPM) is the most essential model in asset pricing. The model was introduced by Jack Treynor (1962), William F. Sharpe (1964), John Lintner (1965) and Jan Mossin (1966) independently. This is based on the earlier work of Harry Markowitz on diversification and modern portfolio theory. Later on, Fischer Black (1972) developed another version of CAPM, called Black CAPM or zero-beta CAPM that does not assume the existence of a riskless asset.

The model describes the relationship between systematic risk and expected return for assets, particularly stocks. The general idea behind the model is that investors need to be compensated in two ways: time and risk. It provides an equilibrium relationship between risk and return, which helps in identifying the underpriced and overpriced assets. This equilibrium relationship is also known as the security market line (SML). The line explains the relationship between the return of asset and beta of asset *(Chong, 2013)*.

REVIEW OF LITERATURE

The capital asset pricing model (CAPM) is a model used to determine the required rate of return of an asset, to make decisions about adding assets to a well-diversified portfolio. But, the model depends on certain critical assumptions. That's why, many experts/academicians/investors have doubt regarding to the model. In this context, the different literature regarding to the present study are as follows:

Dhankar and Kumar (2007) explained that the model helps in explaining the risk return relationship in the Indian market. The model takes into account the asset's sensitivity to non-diversifiable risk (also known as systematic risk or market risk), often represented by the quantity beta (β) in the financial industry, as well as the expected return of the market and the expected return of a theoretical risk-free asset.

Yalwar (1988) and Verma (1988) supported the Capital Asset Pricing Model (CAPM) and mentioned that the model is applicable for calculation of expected return from an asset. They also point out that it is very much useful in the Indian stock market. Ansari (2000) again supported the model and reported that game is not lost for CAPM in the Indian market.

Gupta and Sehgal (1993), Ray (1994), Obaidullah (1994), Madhusoodan (1997) and Sehgal (1997) denied the applicability of CAPM in Indian stock market. They claimed that the single factor, beta, cannot explain the return generating process of assets. They also mentioned that it is based on some irrelevant assumptions and the reasons why they are criticised. The most important work of Fama and French (1992, 1993 and 1995) declined the fact that 'Beta' is the only factor which can explain the return generating process of risky assets.

Fama, French (2003), mentioned that the model is its powerfully simple logic and intuitively pleasing predictions about how to measure risk and about the relation between expected return and risk. Unfortunately, because of its simplicity, the empirical record of the model is poor - poor enough to invalidate the way it is used in applications.

Bajpai and Sharma (2014) focussed on empirical testing the model in the Indian equity market. In this study, 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.

In the late twentieth century, the CAPM started losing its popularity as various other theories/ model of asset pricing came into existence, which contradicted the model and claimed that the single factor, beta, cannot explain the return generating process of assets. There are various other factors which influence risk return relationships and those factors should also be taken into account. This kind of ambiguity prevailing in the financial literature has given the motivation to authors to review the theory, evidence and applications of the model.

The literature provides the mixed kind of evidences in support of CAPM. The major studies of empirical testing of CAPM are done in the US market. On the otherhand, developing countries have a dearth of such empirical tests of CAPM. In India too there are very few studies, which have addressed the same issue. This gap has also provided enough motivation to conduct this kind of study.

METHODOLOGY

The study of Capital Asset Pricing Model is based upon both primary as well as secondary data. Therefore, in the course of analysing the issues, a number of text and references books, Government Publications and other published and unpublished documents relating to the study have been considered. In this theory, the following methods/tactics have been used:

(A) CAPM Equation and Security Market Line (SML)

To fulfil the objectives, the equation of Capital Asset Pricing Model (CAPM) has been used in this study. The basic equation is:

$$E(R_i) = Rf + \beta_i \, [E(RM) - R_f]$$

Where $E(R_i)$ is expected return on asset *i*, R_f is the risk-free rate of return, $E(R_M)$ is expected return on market proxy and β_i is a measure of risk specific to asset *i*.

From basic equation of Capital Asset Pricing Model (CAPM), various forms of equations have also been derived. Moreover, the Security Market Line (SML) is well described from these equations.

(B) Measurement of Portfolio Beta

The standardized measure of systematic risk, popularly called as beta (ßi). This beta (bi) is the ratio of covariance between the asset return and market return and the variance of market return.The beta can be calculated as:

$$\beta_i = \frac{\sigma_{iM}}{\sigma_M^2}$$

Where, market portfolio is σ_{im} and the market risk is σ_M

The model calculates the expected return of an asset based on its beta and expected market returns. The beta can also be calculated on the basis of correlation between market risk and stock and variance of market risk. In this context, the equation of beta is as follows:

Beta coefficient, $$\beta_i = \frac{Cov(R_A, R_M)}{\sigma_M^2}$$

Here, $Cov(R_A, R_M) = \dfrac{\sum\left(R_A - \overline{R_A}\right)\left(R_M - \overline{R_M}\right)}{n-1}$, and, $\sigma_M^2 = \dfrac{\sum\left(R_M - \overline{R_M}\right)^2}{n-1}$

Where, R_A is return on stock and R_M Return on market portfolio.

Beta is important because it measures the risk of an investment that cannot be reduced by diversification. The significance of Beta has described as per its different values. On the basis of Beta Coefficient, a comparative analysis has made among thirty Indian companies. The formula used for that:

Beta = Co-variance (SENSEX, Stock)/Variance (SENSEX)

(C) Derivation of CML from SML

For efficient a portfolio, the relationship between risk and return is depicted by the straight line called the Capital Market Line (CML). The CML has shown by using the following equation:

$$E(R_j) = R_f + \lambda\sigma_j$$

Where $E(R_j)$ the expected return on portfolio j, R_f is the risk free rate, λ is the slope of the market line and σ_j is the standard deviation of portfolio j. The value of lambda is:

$$\lambda = \frac{E(R_M) - R_f}{\sigma_M}$$

Where λ, the slope of the CML may be regarded as the "Price of risk" in the market.

By using equation of $E(R_p)$ and λ, Capital Market Line (CML) has derived from Security Market Line (SML). Similar way, Security Market Line (SML) has derived from Capital Market Line (CML).

(D) Evidence of CAPM

For understanding the evidence of the model, Security Characteristic Lines (SCLs) and the Security Market Line (SML) have been derived. For that purpose, the following two equations are need to be analysed:

For Security Characteristic Lines (SCLs), the equation is:

$$R_{it} - R_{ft} = a_i + b_i(R_{Mt} - r_{ft}) + e_{it}$$

Where, a_i is a constant and b_i is also constant for a particular situations.

For estimating the Security Market Line (SML), the equation is:

$$\overline{R_i} = \gamma_0 + \gamma_1 b_i + e_i \quad i = 1 \ldots n$$

Where, γ_0, the intercept, should not be significantly different from the risk-free rate, $\overline{R_f}$ γ_1 the slope coefficient, should not be significantly different from $\overline{R_M - R_f}$.

For Security Characteristic Lines (SCLs), the return on security i is regressed on the return on the market portfolio, whereas for the Security Market Line (SML), the excess return on security *i* is regressed on the excess return on market portfolio and this equation is used more commonly.

As as additional evidence of CAPM, the equilibrium relationship of Arbitrage Pricing Theory (APT) has also been analysed:

$$E(R_i) = \lambda_0 + b_{i1}\lambda_1 + b_{i2}\lambda_2 + \ldots b_{ij}\lambda_j$$

Where $E(R_i)$, the expected return on asset is i, λ_0 is the expected return on an asset with zero systematic risk, b_{ij} is the sensitivity of asset i's return to the common risk factor j and λ_j is the risk premium related to the jth risk factor.

(E) CAPM: Different Applications

The model has different applications in different ways. The various applications like expected Return for a portfolio offers, CAPM in investment appraisal and Asset pricing have analysed in this study. The different application analysed by different equations and graphical representation.

(F) CAPM: Modified formula

The model has modified to include size premium and specific risk. The modification, has also explained by different equations form. In this context, David Luenberger (1997) has derived another new equation for better understanding of Capital Asset Pricing Model. In this regard, the basic equation is:

$$E(R_i) = R_f + \beta i(RP_m) + RP_s + RP_u$$

Where, $E(R_i)$ is required return on security i

R_f is risk-free rate

RP_m is general market risk premium

RP_s is risk premium for small size

RP_u is risk premium due to company-specific risk factor

On the basis of the above points, the Capital Asset Pricing Model (CAPM) have been analysed in different way and presented in a different equational form, tabular and graphical form as and where necessary.

Capital Asset Pricing Model (CAPM): A Review

The CAPM says that the only reason an investor should earn more, on average, by investing in one stock rather than another is that one stock is riskier. Not surprisingly, the model has come to dominate modern financial theory. Actually, whenever an investment is made, for example in the shares of a company listed on a stock market, there is a risk that the actual return on the investment will be different from the expected return. Investors take the risk of an investment into account when deciding on the return they wish to receive for making the investment. In this regard, the CAPM is a method of calculating the return required on an investment, based on an assessment of its risk.

In equation form, the model can be expressed as follows:

$$E(R_i) = R_f + \beta_i [E(R_M) - R_f] = R_f + \sigma_M/\sigma_M \, [(E(R_M) - R_f)/\sigma_M] \quad \text{...(1)}$$

Where $E(R_i)$ is expected return on asset i, R_f is the risk-free rate of return, $E(R_M)$ is expected return on market proxy and β_i is a measure of risk specific to asset i. Here, σ_M is the variance of return on market portfolio, and Σ_{iM} is the covariance of retunes between security i and market portfolio.

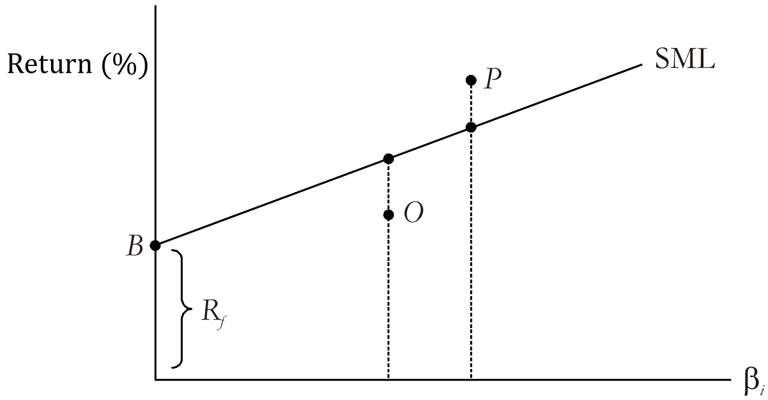
There is a linear relationship between their expected return and their covariance with the market portfolio. The relationship between expected return on asset i and expected return on market portfolio is also called the Security Market Line (SML). For SML, the equation can be expressed as like as follows:

$$E(R_i) = R_f + \left(\frac{E(R_M) - R_f}{\sigma_M^2}\right)\sigma_{iM} \quad \text{...(2)}$$

In words, Expected return on security i = Risk-free return + (Price per unit of risk) Risk

Here, the price per unit of risk is: $\frac{E(R_M) - R_f}{\sigma_M^2}$ and the measure of risk is: σ_M

The SML reflects the expected return-beta relationship. The slope of the SML indicates the market risk premium. The SML has shown in Graph 1.



Graph 1: The Security Market Line

In the Graph 1, Assets which are fairly priced plot exactly on the SML. Underpriced securities (such as *P*) plot above the SML, whereas overpriced securities (such as *O*) plot below the SML. The difference between the actual expected on a security and its fair return as per the SML is called the security's alpha (α).

In Equation (2), the risk of a security is expressed in terms of its covariance with the market portfolio; σ_{iM}. The standardized measure of systematic risk, which is popularly called beta (β), can be calculated by the following formula:

$$\beta_i = \frac{\sigma_{iM}}{\sigma_M^2} \qquad \text{...(3)}$$

Beta (β_i) reflects the slope of a linear regression relationship in which the return on security *i* is regressed on the return on the market portfolio. It is a measure of the volatility, or systematic risk, of a security or a portfolio in comparison to the market as a whole. The Beta Co-efficient may be calculated on the basis correlation ship between return on market and return on stock and variance of market risk. In this regard, Beta formula is:

Beta coefficient,

$$\beta_i = \frac{Cov\ (R_A, R_M)}{\sigma_M^2} \qquad \text{...(4)}$$

Here, $Cov\ (R_A, R_M) = \frac{\sum\left(R_A - \overline{R_A}\right)\left(R_M - \overline{R_M}\right)}{n-1}$ and, $\sigma_M^2 = \frac{\sum\left(R_M - \overline{R_M}\right)^2}{n-1}$

Where, R_A is return on stock and R_M Return on market portfolio.

Beta Significance: A comparative analysis for 30 Indian Companies

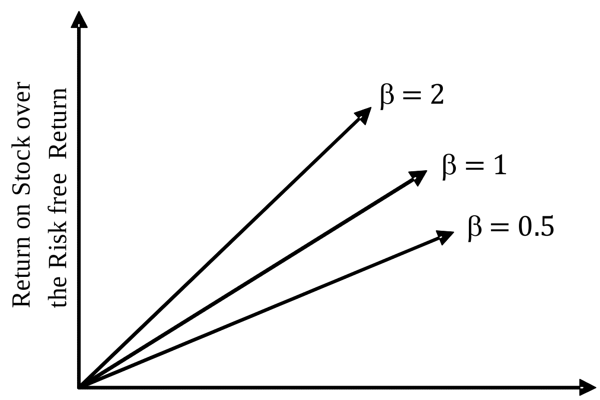
The beta value for a firm depends on the kind of products and services offered and its relationship with the overall marco-economic environment. The greater the proportion of fixed costs in the cost structures of the business, the higher the beta. The more debt a firm takes on, the higher the beta will be of the equity in that business. Normally, the significance of beta has shown in table 1:

Table 1
Significance of Beta Co-efficient (β_i)

Sl. No.	*Value*	*Nature of Risk*	*Remarks/Explanations*
1.	Beta = 1	Same level of risk	If Beta of the stock is one, then it has the same level of risk as the stock market.
2.	Beta > 1	higher level of risk	If the Beta of the stock is greater than one, then it implies higher level of risk and volatility as compared to the stock market.
3.	Beta > 0 and Beta < 1	Lower level of risk	If the Beta of the stock is less than one and greater than zero, it implies the stock prices will move with the overall market, however, the stock prices will remain less risky and volatile.

Source: CAPM Beta, Available At Http://Www.Wallstreetmojo.Com/Capm-Beta-Definition-Formula-Calculate-Beta-In-Excel/#Capmformula

On the other hand, the relationship between Return of market over risk-free rate and return on stock over the risk free return for different beta values has shown in Graph 2,



Graph 2: Return of market over risk-free rate Vs return of stock over the risk free return

From Graph 2, it is found that the relationship between Return of market over risk-free rate and return on stock over the risk free return is a straight line and passes though the origin. It is also notable that for different beta values the lines are different. Moreover, for the higher beta, the slope of the straight line is also higher.

For analysing the Beta factor, thirty Indian Companies have taken from Stock Exchanges. These all companies are listed in Bombay Stock Exchanges. The Beta Co-efficient is calculated by using covariance between SENSEX and Stock and Variance of SENSEX. In this context, the beta formula is: Beta Co-efficient = Co-variance (SENSEX, Stock)/Variance (SENSEX). Then, Beta values for Thirty Indian Companies have shown in table 2.

From the Table 2, it is found that large companies with more predictable Financial Statements and profitability will have a lower beta value. For the companies like Energy, Utilities and Banks etc, all tend to have lower beta. Most betas normally fall between 0.1 and 2.0 though negative and higher numbers are possible.

Table 2
Beta values for Thirty Indian Companies

Sl. No.	*Company*	*Beta Values*	*Sl. No.*	*Company*	*Beta Values*
1.	Housing Development Finance Corp. Ltd.	1.35	2.	Cipla Ltd.	0.93
3.	Bharat Heavy Electricals Ltd.	1.38	4.	State Bank of India	1.28
5.	Dr. Reddy's Laboratories Ltd.	0.62	6.	HDFC Bank Ltd	0.93
7.	Hero Motocorp Ltd.	0.67	8.	Infosys Ltd.	0.69
9.	Vedanta Limited	1.28	10.	Oil And Natural Gas Corporation Ltd.	1.18
11.	Reliance Industries Ltd.	1.12	12.	Tata Power Co.Ltd.	1.34
13.	Hindalco Industries Ltd.	1.44	14.	Tata Steel Ltd.	1.36
15.	Larsen and Toubro Ltd.	1.38	16.	Mahindra and Mahindra Ltd.	0.87
17.	Tata Motors Ltd.	1.41	18.	Hindustan Unilever Ltd.	0.40
19.	Itc Ltd.	0.64	20.	Wipro Ltd.	0.53
21.	Sun Pharmaceutical Industries Ltd.	0.63	22.	Gail (India) Ltd.	0.93
23.	ICICI Bank Ltd.	1.14	24.	Axis Bank Ltd.	1.83
25.	Bharti Airtel Ltd.	0.55	26.	Maruti Suzuki India Ltd.	0.81
27.	Tata Consultancy Services Ltd.	0.58	28.	Ntpc Ltd.	0.95
29.	Bajaj Auto Ltd.	0.63	30.	Coal India Ltd.	0.85

Source: Author calculation from, http://www.bseindia.com/indices/betavalues.aspx, retrieved on 07/06/2017.

It is also notable that due to uncertain economic environment, questions always remain on what is the best investment strategy. There are two kinds of stocks: Cyclical stocks and Defensive stocks. Cyclical stocks are those whose business performance and stock performance is highly correlated with the economic activities. Defensive stocks are stocks whose business activities and stock prices are not correlated with the economic activities. It is normally understood that cyclical stocks have high Beta and defensive sectors have low Beta.

CAPM: Derivation of the Security Market Line (SML) Relationship

To understand the derivation of SML Graph, the Graph 3 has considered. The graph shows the typical relationship between a single security (point *i*) and the market portfolio (*M*). The curve *iMM′* indicates all possible Rp, σ_p values obtainable by various feasible combinations of *i* and *M*. The curve *iM M′* is tangential to the capital market line $R_f MZ$ at *M*.

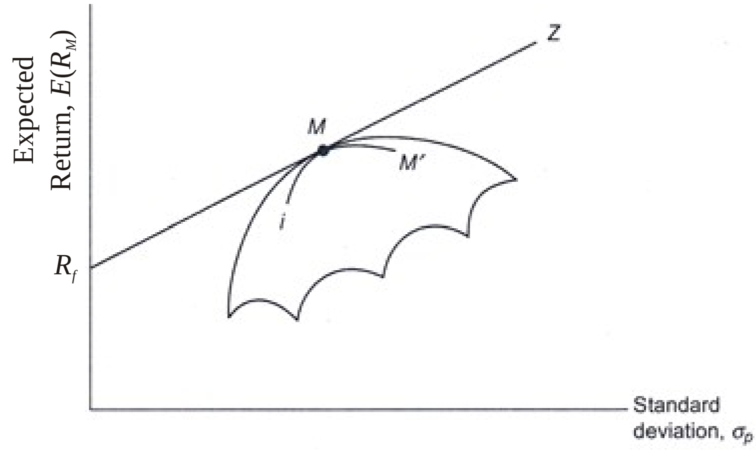
Let,

S_M is the slope of *iMM′* at point *M′*,

$E(R_i)$ is the expected return on security *i*,

$E(R_M)$ is the expected return on market portfolio, σ_M is the standard deviation of the Return on market portfolio,

σ_{iM} is the covariance of return between security *i* and market portfolio.



Graph 3: Relationship between a Security and the Market portfolio

The slope of iMM' is the derivative of $E(R_p)$ with respect to σ_p, Hence slope iMM' is $dE(R_p)/d\,\sigma_p$. Now, applying the chain Rule of differentiation,

write, $$dE(R_p)/d\sigma_p = \frac{dE(R_p)/dw_i}{d\sigma_p/dw_i} \quad ...(5)$$

Now, $E(R_p) = w_i E(R_i) + (1 - 2w_i)E(R_M)$

So, $$dE(R_p)/dw_i = E(R_i) - E(R_M) \quad ...(6)$$

Further, $\sigma_p = [w_i^2\sigma_i^2 + (1 - w_i)^2\sigma_M^2 + 2w_i(1 - w_i)\sigma_{iM}]1/2$

Hence, $$\frac{d\sigma_p}{dw_i} = \frac{w_i(\sigma_i^2 + \sigma_M^2 - -2\sigma_{iM}) + \sigma_{iM} - \sigma_M^2}{\sigma_p} \quad ...(7)$$

substituting the results (6) and (7) in equation (5), we get

$$\frac{dE(R_p)}{d\sigma_p} = \frac{(E(R_i) - E(R_M))\sigma_p}{w_i(\sigma_i^2 + \sigma_M^2 - 2\sigma_{iM}) + \sigma_{iM} - \sigma_M^2}$$

Evaluting $\frac{dE(R_p)}{d\sigma_p}$ at point M where $w_i = 0$, we get

$$\left[\frac{Ed(R_p)}{d\sigma_p}\right] = \frac{(E(R_i) - E(R_M)\sigma_M}{\sigma_{iM} - \sigma_M^2}$$

The slope of $iM\,M'$ at point M is equal to:

$$S_M = \frac{\left[E(R_i) - E(R_M)\right]\sigma_M}{\sigma_{iM} - \sigma_M^2} \quad ...8$$

Again, the slope of the CML graph is,

$$\lambda = \frac{E(R_M) - R_f}{\sigma_M}$$

Since the slope of *iMM'* at *M* is equal to the slope of the Capital Market Line, the above two equation, it can be written,

Then: $$\frac{[E(R_i)-E(R_M)]\sigma_M}{\sigma_{iM}-\sigma_M^2}=\frac{E(R_M)-R_f}{\sigma_M}$$

Simplifying and rearranging,

$$E(R_i) = R_f + \sigma_{iM}/\sigma_M\ [(E(R_M) - R_f)/\sigma_M]$$

Again, $$\beta_i = \frac{\sigma_{iM}}{\sigma_M^2}$$

Hence, $$E(R_i) = R_f + \beta_i\,[E(R_M) - R_f] \qquad ...(9)$$

This is the Security Market Line (SML).

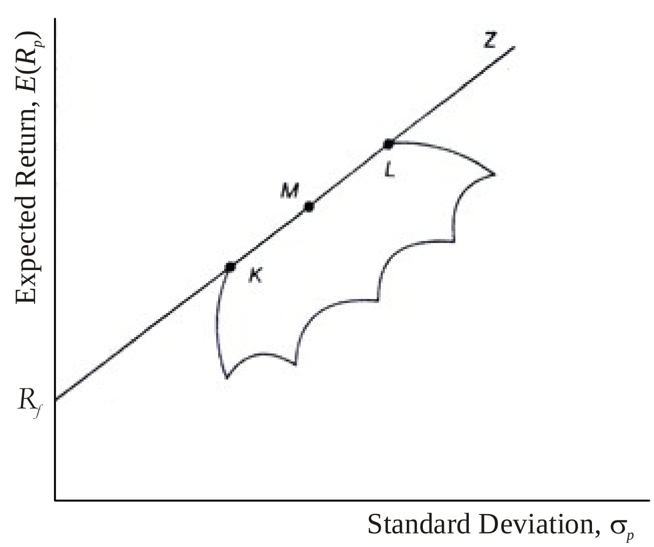
Derivation of CML from SML: A New Outlook

There is a simple linear relationship between the expected return and standard deviation (as far as efficient portfolios). The linear relationship is known as Capital Market Line (CML). Typically, the expected return and standard deviation for individual securities will be below the CML, reflecting the inefficiency of undiversified holdings. Further, such pints would be found throughout the feasible region with no well-defined relationship between their expected return and standard deviation.

Portfolios which have returns that are perfectly positively correctively correlated with the market portfolio are referred to as efficient portfolios. In this context, adjustment of the Efficient Frontier has shown in Graph 4.

For efficient a portfolios, the relationship between risk and return is depicted by the straight line $R_f MZ$. The equation for this line, called the Capital Market Line (CML), is:

$$E(R_j) = R_f + \lambda\sigma_j \qquad ...(10)$$



Graph 4: Adjustment of the Efficient Frontier

Where $E(R_j)$, the Expected Return on portfolio *j*, R_f is the risk free rate, λ is the slope of the market line and σ_j is the standard deviation of portfolio *j*.

Given that the market portfolio has an expected return of $E(R_M)$ and standard deviation of σ_M, the slope of the CML can be obtained as follows:

$$\lambda = \frac{E(R_M) - R_f}{\sigma_M} \qquad \text{...(11)}$$

Where λ, the slope of the CML may be regarded as the "Price of risk" in the market.

If CAPM is valid, all securities will lie in a straight line called the Security Market Line (SML) in the $E(R)$, β_i frontier.

As per the Security Market Line,

$$E(R_i) = R_f + \left(\frac{E(R_M) - R_f}{\sigma_M^2}\right)\sigma_{iM} \qquad \text{...(12)}$$

Since $\sigma_{iM} = \rho_{iM}\sigma_i\sigma_M$, Eq (7) can be re-written as:

$$E(R_i) = R_f + \left(\frac{E(R_M) - R_f}{\sigma_M}\right)\rho_{iM}\sigma_i \qquad \text{...(13)}$$

If the returns on *i* and *M* are perfectly correlated (this is true for efficient portfolios), ρ_{iM} is 1 and Eq. (8) becomes:

$$E(R_i) = R_f + \left(\frac{E(R_M) - R_f}{\sigma_M}\right)\sigma_i \qquad \text{...(14)}$$

Equation (9) is the equation of CML line. Hence, CML line has derived from SML and CML is a special case of the SML.

Capital Asset Pricing Model: Empirical Evidence

The CAPM is often criticised as being unrealistic because of the assumptions of this model on which it is based. The assumptions are :

(a) investors will only require a return for the systematic risk of their portfolios, since unsystematic risk has been removed and can be ignored,

(b) A standardised holding period is assumed by the CAPM in order to make comparable the returns on different securities,

(c) Investors can borrow and lend at the risk-free rate of return,

(d) Perfect capital market is required to explain this model. This assumption means that all securities are valued correctly and that their returns will plot on to the SML.

The noteworthy point is that the CAPM says that the risk of a stock should be measured relative to a comprehensive "market portfolio" that in principle can include not just traded financial assets, but also consumer durables, real estate, and human capital. Though, it is difficult to predict from beta how individual stocks might react to particular movements, investors can probably safely deduce that a portfolio of high-beta stocks will move more than the market in either direction, or a portfolio of low-beta stocks will move less than the market (McClure, 2017).

The study has been analysed the Empirical Evidence on Capital Asset Pricing Model. According to the CAPM, the expected return on a security is:

$$E(R_i) = R_f + \beta_i[E(R_M) - R_f]$$

The ideal way to test the CAPM would be to observe investors' expectations of betas and expected returns on individual securities and the market portfolio and then compare the expected return on each security with its return as predicted by CAPM. Unfortunately, this procedure is not very practical since information on investor expectations in very practical since information on investor expectations is very sketchy.

The CAPM Model estimates the two important points; Estimate the security characteristic lines (SCLs) and Estimate the security market line (SML).

For Estimating the Security Characteristic Lines, (SCLs), the betas for each security in the sample have estimated. There are two ways in which security beta is estimated.

$$R_{it} = a_1 + b_i R_{Mt} + e_{it} \quad ...(15)$$

$$R_{it} - R_{ft} = a_i + \beta_i (R_{Mt} - R_{ft}) + e_{it} \quad ...(16)$$

In equation (15), the return on security *i* is regressed on the return on the market portfolio, whereas in Equation (16), the excess return on security *i* is regressed on the excess return on market portfolio and this equation is used more commonly. In this case, the beta for each security is simply the slope of its security characteristic line.

For estimating the Security Market Line (SML), beta values are required.

$$\overline{R_i} = \gamma_0 + \gamma_1 b_i + e_i \quad i = 1...n \quad ...(17)$$

Comparing Eqs (11) and (12), the inference that if the CAPM holds:

I. The relationship should be linear. This means that terms like b_i^2, if substituted for b_i, should not yield better explanatory power.

II. γ_0, the intercept, should not be significantly different from the risk –free rate, $\overline{R_f}$.

III. γ_1, the slope coefficient, should not be significantly different from $\overline{R_M - R_f}$.

IV. No other factors, such as company size or total variance, should affect $\overline{R_i}$.

V. The model should explain a significant portion of variation in returns among securities.

VI. If above points are hold good, the CAPM model is applicable.

Numerous empirical studies have been conducted to test the CAPM. The following general conclusions that emerge from different studies:

I. In general γ_0 is greater than the risk-free rate and γ_1 is less than $\overline{R_M - R_f}$. This means that the actual relationship between risk (as measured by beta) and return is flatter than than the CAPM.

II. In addition to beta, some other factors, such as standard deviation of returns and company size, too have a bearing on return.

III. Beta does not explain a very high percentage of the variance in return among securities.

While reviewing the empirical evidence, bear in mind two important problems. First, the studies use historical returns as proxies for expectations. This assumes that the expected returns will be the same as the realized returns. Second, the studies use a market index a as a proxy for the market portfolio. Richard Roll has argued persuasively that since the 'true' market portfolio (which in principle must include all assets – financial, real, as well as human – and not just equity stocks), cannot be measured, the CAPM cannot be tested (Prasanna (2012).

A Key challenge to the CAPM came from a set of studies that have suggested that it is possible to rely on certain firm or security characteristics and earn superior returns even after adjustment for risk as measured by beta. Notwithstanding the various problems associated with the model, the CAPM is the most widely used risk return model.

The model assumptions, prescriptions and calculations are embedded in countless computers nationwide. Instead of various controversies, the CAPM popularity may be attributed to the following factors.

I. Some objective estimate of risk premium is better than a completely subjective estimate or no estimate.

II. CAPM is a simple and intuitively appealing risk-return model. Its basic message that diversifiable risk does not matter is accepted by nearly every one.

III. While there are plausible alternative risk measures, no consensus has emerged on what course to plot if beta is abandoned. It appears that the CAPM remains popular not because there is no competition, but because there is excess of it.

Arbitrage Pricing Theory (APT): An Additional Evidence of CAPM

The situation of CAPM Model perhaps may change as additional evidence is gathered in favour of arbitrage pricing theory and operational guidelines for applying that theory are developed further. Since it is unlikely that markets are inefficient for extended periods of time, financial economists began looking for alternative risk-return models, beyond the CAPM. In the mid-1970s, Stephen Ross developed an alternative model called the Arbitrage Prancing Theory (APT) which is reasonably intuitive, requires only limited assumptions, and allows for multiple risk factors.

Arbitrage pricing theory is an asset pricing model based on the idea that an asset's returns can be predicted using the relationship between that asset and many common risk factors. The APT does not require the following assumptions (which undergird the CAPM): the utility functions of investors are quadratic; security returns are normally distributed; the market portfolio that contains all risky assets is mean variance efficient.

The equilibrium relationship according to the APT is as follows:

$$E(R_i) = \lambda_0 + b_{i1}\lambda_1 + b_{i2}\lambda_2 + \dots b_{ij}\lambda_j \qquad \dots(18)$$

Where $E(R_i)$, the expected return on asset is i, λ_0 is the expected return on an asset with zero systematic risk, b_{ij} is the sensitivity of asset i's return to the common risk factor j and λ_j is the risk premium related to the j^{th} risk factor. In this regard, Comparison of CAPM and APT are as follows (Table 3):

Table 3: Comparison of CAPM and APT

Model	*CAPM*	*APT*
Nature of relation	Linear	Linear
Number of risk factors	1	k
Factor risk premium	$[E(R_M) - R_f]$	λ_j
Factor risk sensitivity	β_i	b_{ij}
Zero-beta return	R_f	λ_0

Source: Chandra, Prasanna (2012), Investment Analysis and Portfolio Management, McGraw. Hill Publication, pp-8.12-8.14.

The APT was a revolutionary model because it allows the user to adapt the model to the security being analyzed. And as with other pricing models, it helps the user decide whether a security is undervalued or overvalued and so he or she can profit from this information. APT is also very useful for building portfolios because it allows managers to test whether their portfolios are exposed to certain factors.

CAPM: Different Applications

The model has several advantages over other methods of calculating required return,

(a) It considers only systematic risk, reflecting a reality in which most investors have diversified portfolios from which unsystematic risk has been essentially eliminated,

(b) It generates a theoretically-derived relationship between required return and systematic risk which has been subject to frequent empirical research and testing, (c) It is generally seen as a much better method of calculating the cost of equity than the dividend growth model (DGM) (d) It is clearly superior to the WACC in providing discount rates for use in investment appraisal. The different applications of this model are:

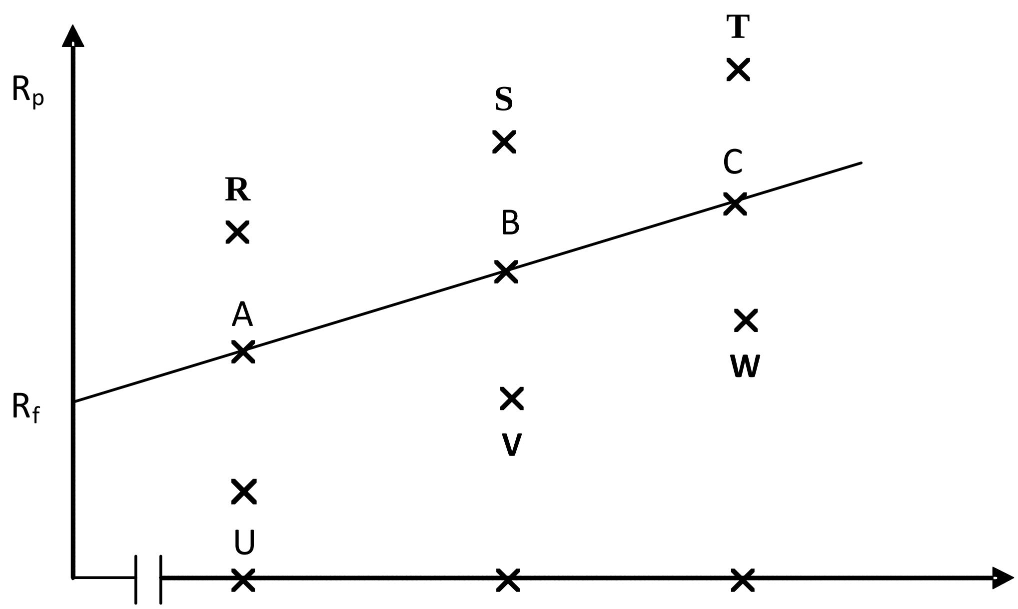
(a) Asset Pricing

The CAPM has asset pricing implications because it tells what required rate of return should be used to find the present value of an asset with any particular level of systematic risk (beta). In equilibrium, every asset's expected return and systematic risk coefficient should plot as one point on the CAPM. If the assets expected rate of return is different from its required rate of return, that asset is either under priced or overpriced. This implication is useful only if the beta coefficient is stable over time. However, in reality, the betas of assets do change with the passage of time as the assets earning power changes. The job of security analyst is, thus, to find the assets with disequilibrium prices, because it will be profitable to buy under priced assets and sell short the overpriced assets. In asset pricing, the expected return of the asset at time is:

$$E(R_t) = (E(P_{t+1}) - P_t)/P_t$$

(b) Evaluation of securities

Relative attractiveness of the security can be found out with help of security market line. Stocks with risk factor are expected to yield more return and verse. But the investor would be interested in knowing whether the security is offering return more or less Proportional to its risk. The Evaluation of Securities with SML has shown at Graph 5.



Graph 5: Evaluation of Securities with SML

The Graph 5, provides an explanation for the evaluation. There are nine points in the diagram *A*, *B* and *C* lie on the security market line, *R*, *S* and *T* above the SML line and *U*, *V* and W below the SML. *A*, *R* and *U* have the same level of Beta. Likewise, same beta values for *S*, *B* and *V* and again same beta value for *T*, *C* and *W*. The stocks above the SML yield higher returns for the same level of risk. They are underpriced compared to their beta value. With the simple rate of return formula, we can prove that there are undervalued.

$$R_i = \frac{P_i - P_o + Div}{P_o}$$

P_i is the present price, P_o- the purchase price and Div-Dividend. When the purchase price is low *i.e.* when the denominator value is low the expected could be high. Applying the same principle the stocks *U*, *V* and *W* can be classified as overvalued securities and expected to lower returns then sticks of comparable risk. The denominator value may be high i.e., the purchase price may be high. The prices of these scrips may fall and lower the denominator. Thereby, they may increase the return on securities.

From Graph 5, the securities *A*, *B* and *C* are on the line and therefore, it may be considered to be appropriately valued. They offer return in proportion to their risk. They have average stoke performance since are neither undervalued nor overvalued. Hence, by using Capital Asset Pricing Model, the values of the securities may be evaluated (Pandian, 2006).

(c) Expected Return for a portfolio offers

It is a useful tool in determining if an asset being considered for a portfolio offers a reasonable expected return for risk. Individual securities are plotted on the SML graph. If the security's expected return versus risk is plotted above the SML, it is undervalued since the investor can expect a greater return for the inherent risk. And a security plotted below the SML is overvalued since the investor would be accepting less return for the amount of risk assumed.

(d) Determination of Risk

Beta values are now calculated and published regularly for all stock exchange-listed companies. The problem here is that uncertainty arises in the value of the expected return because the value of beta is not constant, but changes over time. The yield on short-term Government debt, which is used as a substitute for the risk-free rate of return, is not fixed but changes on a daily basis according to economic circumstances. As a result, Beta value also changes. But, from the Beta value, the risk of a particular share can be determined.

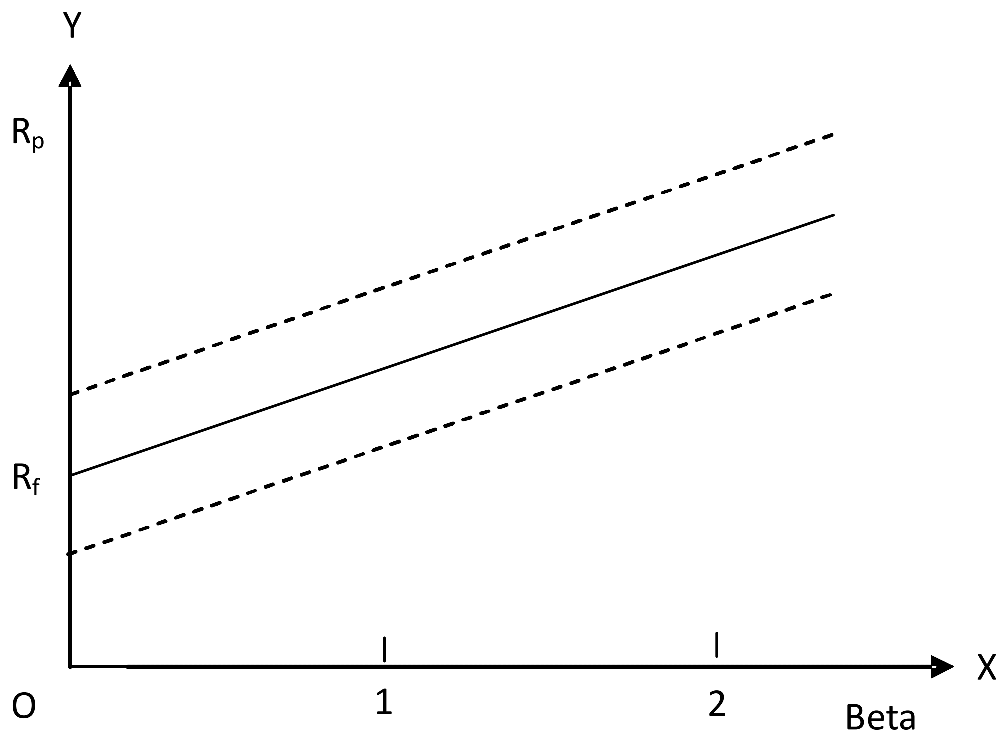
(e) Investment Appraisal

Once the expected/required rate of return is calculated using CAPM, we can compare this required rate of return to the asset's estimated rate of return over a specific investment horizon to determine whether it would be an appropriate investment. To make this comparison, you need an independent estimate of the return outlook for the security based on either fundamental or technical analysis techniques, including *P*/*E*, *M*/*B* etc.

(f) Market imperfection and SML

Information regarding the share price and market condition may not be immediately available to all investors. Imperfect information may affect the calculation of securities. In a market with perfect information, all securities should lie on SML. Market imperfections would lead to a band of SML rather than a single line. Market imperfections affect the width of the SML to a band. If imperfections are more, the width also would be larger(Pandian, 2006). SML in imperfect market is given in Graph 6,

Present validity of CAPM, the CAPM is greatly appealing at an intellectual Level, Logical and rational. Now-a-days, investment analysts have been more creative in adapting CAPM for their uses. The model focuses on the market risk, makes the investors to think about the riskiness of the assets in general. It has been useful in the selection of securities and portfolios. From this model, one can find out the expected returns for a firm's security; this expected return can be used as an estimate of the cost of retained earnings.



Graph 6: Market imperfection and SML

CAPM: Modified Form

Though the CAPM has been regarded as a useful tool for both analysts of financial securities and financial managers, it is not without critics. The CAPM has serious limitations in the real world, discussed as flows (Gupta and Joshi, 2007):

(i) The CAPM is used on expectations about the future, Expectations cannot be observed but we do have access to actual returns. Hence empirical tests and data for practical use tend to be based almost exclusively on historical returns.

(ii) Beta (systematic risk) coefficient is unstable, varying from period to period depending up on the method of compilation. They may not be reflective of true risk involved. Due to the unstable nature of beta it may not reflect the future volatility of returns although it is based on the post history. History evidence of the tests of Beta showed that they are unstable and they are not good estimates of future risk.

(iii) CAPM focuses attention only on systematic (market related) risk. However, total risk has been found to b e more relevant and both types of risk appear to be positively related to returns.

(iv) Investors do not seem to follow the postulation of CAPM and do not diversify in a planned manner.

(v) The analysis of SML is not applicable to the bonds are a part of the portfolio of the investors. The factors influencing bonds in respect of risk and return are different and the risk of bonds is rated and known to investors.

Thus, it can say that the applicability of CAPM is broken by the less practical nature of this model as well as complexity and difficulty of dealing with beta values. On the basis of the above limitations, the model has modified in different way. The remarkable modification has made by David Luenberger (1997).

The model can be modified to include size premium and specific risk. This is important for investors in privately held companies who often do not hold a well-diversified portfolio. The equation is similar to the traditional CAPM equation "with the market risk premium replaced by the product of beta times the market risk premium (Luenberger, David, 1997).

$$E(R_i) = R_f + \beta_i(RP_m) + RP_s + RP_u \qquad \text{...(19)}$$

$E(R_i)$ is required return on security i

R_f is risk-free rate

RP_m is general market risk premium

RP_s is risk premium for small size

RP_u is risk premium due to company-specific risk factor

Later on, the asset price (P_o) has been derived in better way by using Capital Asset Pricing Model. The equation of the asset price (P_o) is as follows:

$$P_o = \frac{1}{1+R_f} - \frac{CoV\left(P_T, R_M\right)\left(E\left(R_M\right) - R_f\right)}{Var(R_M)} \qquad \text{...(20)}$$

Where, P_T is the payoff of the asset or portfolio.

This is a linear relationship. This is known as certainty equivalent pricing formula.

CONCLUSION

In finance, the Capital Asset Pricing Model (CAPM) presents a very simple theory that delivers a simple result. The various findings of these studies are also mixed. The model explains the relationship between the return of any asset and the risk component involved with that return. The model can be expressed in different form. The Security Market Line (SML) and Capital Market Line (CML) both are important for understanding the risk of the shares. The significant point is that the CML can be derived from SML and vice-versa. The model has different applications like investment appraisal, asset pricing, risk assessment of shares, expected Return for a portfolio offers etc. Moreover, the model has also been modified in different way and Arbitrage Pricing Theory is an additional evidence of CAPM. Despite it failing numerous empirical tests, and the existence of more modern approaches to asset pricing and portfolio selection, the CAPM still remains popular due to its simplicity and utility in a variety of situations. Hence, it can be concluded that though some studies raise doubts about CAPM's validity, the model is still widely used in the investment community.

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