Testing Capital Asset Pricing Model (CAPM) on Dhaka Stock Exchange

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Research Article

Keywords: Dhaka Stock Exchange, Bangladesh, CAPM

Posted Date: June 7th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-573032/v2>

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Abstract

The study focuses on finding the validity of the capital asset pricing model (CAPM) on the Dhaka Stock Exchange (DSE) on both individual securities and portfolio levels. Using 102 securities data with the monthly stock prices for preceding five years, the outcome suggests that CAPM does not hold true for DSE, both on an individual company level and portfolio level. The securities market of Bangladesh (DSE in this case) proved inefficient as unsystematic risk premium become significant and beta cannot measure the risk component of securities investment.

Introduction

Capital Asset Pricing Model (CAPM) is a well-recognized model, especially in a developed market. The more and more uses and acceptability of the model made it such an important one that even in an emerging market like the one in Bangladesh, CAPM got considerable attention. Dhaka Stock Exchange though formed many years ago, yet to function in force. This is due to the absence of a strong economy. The Bangladeshi economy is gaining momentum yearly, and now it is considered one of the emerging economies.

Economic progression is somehow linear to stock market development. More and more companies are listed in DSE and the size of the market is growing. So as the market grew bigger, sophisticated models like CAPM get importance. CAPM can be used to see the strength and efficiency of the market. In pursuit of developing an appropriate model for the investor who undertook risk in DSE, testing of a well-recognized model like CAPM, APT is necessary.

Finding a good way of analyzing the investor's risk is so important to build the confidence of the market. To make investors more educated and make the market more educated, the validity test of modern financial theory is vital. So CAPM testing will be performed to determine an appropriate model to measure the risk and return trade-off.

Literature Review

Most of the studies on the validity of the Capital Asset Pricing Model (CAPM) rejected the validity of CAPM. On the spur of these result, Levy and Roll (2012) used a reverse engineering approach for testing the model and shows that with slight variations in the empirically estimated parameters, well within their estimation-error bounds, the CAPM perfectly holds. Ray, Savin, and Tiwari (2009) conducted CAPM testing using some sub-periods and they showed that evidence for rejecting the CAPM on statistical grounds is weaker than the consensus view suggests. They highlight the pitfalls of testing multiple hypotheses with the conventional heteroskedasticity and autocorrelation robust (HAR) test with asymptotic P-values.

Porras (1998), in a contrasting study of CAPM with the Fama- French 3 Factors model, found CAPM as the best one. However, in the case of high (low) returns on the low (high) portfolio, he found none of the

models appropriate. Frankel and Dickens (1983) offered a new technique for testing CAPM, and this technique requires the use of time series data on actual asset-holdings and non-linear maximum likelihood estimation. Frankel and Dickens (1983) offered a new technique for testing CAPM, and this technique requires the use of time series data on actual asset-holdings and non-linear maximum likelihood estimation.

Hodgson, Linton and Vorkink (2001) develop a semiparametric approach. Their estimated betas are lower than the Ordinary Least Square (OLS) estimates, and their parameter estimates are much less consistent with the CAPM restrictions than the corresponding OLS estimators. Hodgson, Linton and Vorkink (2001) develop a semiparametric approach. Their estimated betas are lower than the Ordinary Least Square (OLS) estimates and their parameter estimates are much less consistent with the CAPM restrictions than the corresponding OLS estimators.

Avramov and Chao (2003) conducted a study on the international equity market by testing and comparing the international CAPM and conditional ICAPM versions of Fama and French, they suggested that best performing model is ICAPM with the value premium constructed based on global earning to price ratio. Adriaens Donkers and Melenberg (2008) found CAPM quite useful and better than the traditional alternative multifactor model. This result is observed while working with the actual data. Schwinn (2010) found that in the original one-period CAPM, the linear relation between beta and the expected periodic return is obtained only by adjusting the expected continuously compounded return, and the linearity is well preserved as the length of the period is increased.

Beaulieu, Dufour, and Khalaf (2011) searched for robust estimation in New York Stock Exchange (NYSE) and found that NYSE returns showed exact confidence sets that are very different from the asymptotic ones and allowed for non-Gaussian distributions. In their study with many stocks, Pesaran and Yamagata (2012) found statistically significant evidence against Sharpe- Lintner CAPM is mainly due to the recent financial crisis. Further they found a strong negative correlation between twelve-month moving average p-values and the returns of long/short equity strategies relative to the return on S &P 500 over the period December 2006 to September 2011 suggested that abnormal profits are earned during episodes of market inefficiencies. Murugesan (2006) showed that when we extend the mathematical property of the Security Market Line (SML) to the market portfolio for equilibrium conditions, some conditions do not.

Some argued CAPM is a good estimate in the developed market, but in the case of the emerging market, it may not provide a good estimate, and very few studies have been conducted in emerging or developed markets. Zubairi and Farooq (2010), in their study with oil, gas and fertilizer companies listed in Karachi Stock Exchange (KSE) found a weak correlation between realized excess returns and expected return based on CAPM. But Tahir, Abbas, Sargana and Ayub (2011) found CAPM's linearity in Karachi Stock Exchange (KSE).

Another study (2012) in KSE was conducted on a comparative basis between CAPM and Shariah CAPM (SCAPM). No significant results were found in higher and lower capitalization portfolios under any of the

models, however, results were statistically significant for middle capitalization portfolios and the explanatory power of SCAPM was slightly better than CAPM. Similar results generated by Ahmed, (2021).

Fernando and Nimal (2009) tested CAPM in Colombo Stock Exchange (CSE) by developing an artificial market. They showed that CAPM performs poorly at the low standard deviation of market risk premium instead of common understanding and the chance of detecting CAPM by the tow pass OLS approach (power of the test) is less than 10%.

Ward and Muller (2011) conducted a study on Johannesburg Stock Exchange (JSE) because CAPM is not a valid model for JSE. But they found contrasting results; they found that portfolios constructed based on ranked beta exhibit a monotonic, inverse relation to what the CAPM prescribes for most of the time –series. The use of single beta CAPM is inappropriate in this regard. Godeiro (2012) in his study on the Brazilian Stock Exchange (BSE) found that conditional variance has good explanatory power on the excess return of assets.

Some studies are also done in the Bangladeshi market, though the number is not a lot. Ali, Islam, and Chowdhury (2010), using Fama and Macbeth approach for 160 Dhaka Stock Exchange (DSE) stock, found a relation between risk (beta) and return. Still, they conclude that this relation is not linear. They further concluded on the weak implication of CAPM on the emerging capital market. Incidents like Covid-19, Rohingyas crisis can also increase the market's volatility and increase the risk premium. (Ahamed, 2021 and Minar, 2019). Pramanik (2020) suggest using optimization technique to increase the market efficiency.

A study on CAPM on individual stocks and portfolio level in Dhaka Stock Exchange (DSE) Hasan, Kamil, Mustafa, and Baten (2011) refute the CAPM hypothesis. They provide evidence against CAPM though they found a linear relation between Beta and security return. They used 80 non-financial stocks in their study. The same group of researchers studied in the same market, working with portfolio this time (2013) found the same result again. Again, they refused the CAPM hypothesis in DSE.

Data And Methodology

The methodology used in the study is based on the paper written by Hasan et. Al. (2011). Basic difference with their study is the time frame of the study and the number of companies used in the study. Another notable difference is the number of independent variables used; in the present study number of independent variables are three, which is one less than their study.

Data Description & Companies Selection

All stocks of Dhaka Stock Exchange (DSE), except of financial sectors (Banks, Financial Institutions, Mutual Funds, Insurances) which have 5 years data are selected. In this way 102 listed companies from 14 difference sectors were used in this experiment. The study uses monthly data for the experiment. The DSE general Index (DGEX) is used as a proxy for the market portfolio. This index is a market value

weighted index which is comprised of all listed companies of the exchange and reflects general trends of the Bangladesh stock market. Furthermore, Bangladesh government 91-days Treasury-bill rate is used as the proxy for the risk-free asset.

Variables

To examine the risk-return trade off, in a sample of individual companies and portfolios, the average excess returns for each company are taken as the dependent variable and the company's beta, squared beta, and unique risk are taken as independent variables.

Return Calculation and Dividend, Split & Right Adjustment:

Returns are calculated using natural logarithm.

$$R_T = (\text{LN } P_{T+1}) / (\text{LN } P_T) \quad (1)$$

Here, R_T = Return for the period T,

P_{T+1} = Price of stock at time T+1

P_T = Price of stock at time T.

Cash Dividend Adjustment:

$$P_A = P_0 + C \quad (2)$$

Here, P_A = Adjusted Price

C = Cash dividend amount

P_0 = Unadjusted price or raw price

Bonus Share / Stock Dividend Adjustment:

$$P_A = P_0 * (1 + BP) \quad (3)$$

Here, BP = Bonus share percentage

Cash and stock dividend adjustment:

$$P_A = P_0 * (1 + BP) + C \quad (4)$$

Right Share Adjustment:

$$P_A = P_0 * (1 + RP) - RP * IP \quad (5)$$

Here, RP = Right share percentage (1R: 1 means 100% RP)

IP = Issue price

Split Adjustment:

$$P_A = P_0 * SM \quad (6)$$

Here, SM = Split multiple (if BDT 100 Face Value share becomes, BDT 10 Face Value share then split multiple is 100/10 = 10).

Portfolio Construction

To construct 17 portfolios (6 companies in each portfolio), at first beta are sorted according to ascending order. Then portfolio is constructed in the manner following table represents.

Table 1: Portfolio Formulation (Figures in BDT)

Portfolio	Beta Serial
Portfolio 1	1,34,35,68,69,102
Portfolio 2	2,33,36,67,70,101
Portfolio 3	3,32,37,66,71,100
Portfolio 4	4,31,38,65,72,99
Portfolio 5	5,30,39,64,73,98
Portfolio 6	6,29,40,63,74,97
Portfolio 7	7,28,41,62,75,96
Portfolio 8	8,27,42,61,76,95
Portfolio 9	9,26,43,60,77,94
Portfolio 10	10,25,44,59,78,93
Portfolio 11	11,24,45,58,79,92
Portfolio 12	12,23,46,57,80,91
Portfolio 13	13,22,47,56,81,90
Portfolio 14	14,21,48,55,82,89
Portfolio 15	15,20,49,54,83,88
Portfolio 16	16,19,50,53,84,87
Portfolio 17	17,18,51,52,85,86

Beta serial is made with the sorted beta. The company which has the lowest beta among 102 companies got serial number 1, and in the same way company with highest beta among all companies got serial number 102. Portfolio is formed in this manner so that diversification can be achieved.

Estimating the risk-return trade-off using the CAPM for individual companies:

According to the CAPM returns can be explained as:

$$R_{it} = R_{ft} + \beta_i (R_{mt} - R_{ft}) \quad (7)$$

where, R_{it} is the rate of return on company i at time t , R_{ft} is the rate of return on a risk free asset at time t , R_{mt} is the rate of return on the market index at time t and β_i is the beta of company i , to be

estimated. β_i can also be express by $\text{Cov}(R_i, R_m) / \text{Var}(R_m)$ where R_i is the rate of return on company i and R_m is the rate of return on the market index. In this study beta is calculated by using this formula. Beta can also be calculated by using following regression model:

$$R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + e_{it} \quad (8)$$

$$UR = \sigma_i^2 - \beta_i^2 \sigma^2 \quad (9)$$

where, e_{it} is the random disturbance term in the regression equation at time t and UR refers to the unique risk (the variance of the regression residuals, e_{it}), σ_i^2 refers to the variance of the returns for the company, σ^2 refers to the variance of the returns for index, the proxy for the market portfolio.

Equation (2) can be estimated using Ordinary Least Squares (OLS). For each company in the sample, R_{it} is regressed on R_{mt} to estimate beta, β_i . Equation 3 measures Unique Risk (UR) which is the difference between the total variance of the returns on the company and the company's market risk.

By taking $R_{it} - R_{ft} = r_{it}$ the excess return of company i and $R_{mt} - R_{ft} = r_{mt}$, the average risk premium, the Equation (2) can be rewritten as:

$$r_{it} = \alpha_i + \beta_i r_{mt} + e_{it} \quad (10)$$

Finally for testing CAPM following regression model is used:

$$r_i = \alpha_0 + \alpha_1 \beta_i + \alpha_2 \beta_i^2 + \alpha_3 UR + e_i \quad (11)$$

where, r_i refers to the average excess returns for company i over the whole sample, β_i is the estimate of the systematic risk contained in company i and is obtained from the first stage regression in equation (2), β_i^2 is the square of β_i , UR refers to unique risk estimate obtained from Equation (3), and e_i is the regression residual. ($\alpha_0, \alpha_1, \alpha_2, \alpha_3$) are the parameter estimates.

Estimating the risk-return trade-off using the CAPM for Portfolios

The next step is to construct portfolios. For this construction, the total number of companies are arranged in descending order of beta and grouped into 17 portfolios of 6 stocks each. This is done to achieve diversification and thus reduce any errors that might occur due to the presence of unique risk.

We define average portfolio excess returns of companies (r_{pt}) as:

$$r_{pt} = \frac{\sum r_{it}}{K} \quad (12)$$

Where, k is the number of companies included in each portfolio ($k = 1 \dots 6$), P is the number of portfolios ($p = 1 \dots 17$) and r_{it} is the excess return on companies. The following equation is the equation

of portfolio beta;

$$r_{pt} = \alpha_p + \beta_p r_{mt} + e_{pt} \quad (13)$$

Where, β_p is the beta of portfolio p, r_{mt} is the average risk and e_{pt} is the random disturbance term in the regression equation.

Now following cross sectional regression (11) is used for portfolio: premium and e_{pt} is the random disturbance term in the regression equation.

$$r_p = \gamma_0 + \gamma_1 \beta_p + \gamma_2 \beta_p^2 + \gamma_3 UR_p + e_p \quad (14)$$

where, r_p is the average excess return on portfolio p, β_p is an estimate of beta of portfolio p and is obtained from the regression in equation (7), β_p^2 is the square of β_p , UR_p refers to unique risk of portfolio returns that is $UR_p = \sigma^2(e_{pt})$, and e_p is the random disturbance term in the regression equation. $\gamma_0, \gamma_1, \gamma_2, \gamma_3$, are the parameter estimates.

Research hypotheses

The estimated parameters will allow testing a series of hypotheses regarding the CAPM. For CAPM to hold true, the following hypotheses should be satisfied.

- $\gamma_0 = 0$, that is γ_0 should not be significantly different from zero

This means intercept term of multiple regression equation should be proved statistically insignificant.

- $\gamma_1 > 0$, that is there should be a positive price of risk in the capital markets.

This means beta should postulate a significant relationship with excess market return. That is, beta should prove statistically significant.

- $\gamma_2 = 0$ or the Security Market Line (SML) should represent a linear relationship

According to this hypothesis statistical insignificance of squared beta is expected.

- $\gamma_3 = 0$ or the unique risk which can be diversified should not affect return

To hold CAPM true unsystematic risk, which is unique risk in the study, should have minimal effect, and any effect, whatsoever needs to be proved statistically in significant for the seek of this study.

Empirical Analysis

To examine CAPM validity or testing CAPM, using the prescribed model in this study, beta is the key element. To find out beta for 102 companies, and 17 portfolios (using those 102 companies), return adjustment is key. After adjusting cash dividend, stock dividend, split, right share, adjusted price is found. Then by using these adjusted prices monthly return for 102 stocks were found. In the return calculation, assumption of log normal distribution of return is used. Then these monthly returns are averaged (using simple average) to find averaged return.

From this averaged return average excess return is calculated. For this purpose, 91-day Treasury bill rate is used. Firstly, average of risk-free rate is calculated for the period of July 2008 to June 2013, and then from individual company's monthly return, excess return is calculated by subtracting averaged risk-free return from that.

This averaged excess return is the dependent variable for testing CAPM. Then independent variables like beta, squared beta (square of beta), and unique risk are calculated.

A list of 10 companies, with both dependent and independent variables are presented in the following page,

Table 2: List of dependent and independent variables

Serial	Company	Avg. Excess Return	Beta	Squared Beta	Unique Risk
1	Aramit	1.81%	1.30	1.68	2.22%
2	Confidence	3.06%	1.43	2.04	1.87%
3	Heidelberg	1.74%	0.80	0.64	0.47%
4	Lafarge Surma	-1.36%	0.98	0.97	1.56%
5	Meghna	1.35%	1.35	1.81	2.58%
6	Fu-Wang	0.47%	1.18	1.40	2.60%
7	Monno	0.32%	1.24	1.53	3.62%
8	Standard	0.84%	0.56	0.31	2.72%
9	Aftab Auto	3.13%	1.21	1.47	3.43%
10	Anwar Galvanizing	0.28%	0.99	0.99	3.14%

The explanatory power of the model is 16.35% which is quite low than likings, but the model is found statistically significant as, significance of F is less than 0.05 (level of significance)

Table 3: Empirical Results

Variables	Coefficients	Coefficients (Portfolio)
Intercept	0.011409332 (0.010218041)	-0.124442265 (0.105922628)
Beta	-0.024242818 (0.01946628)	0.192585745 (0.151987219)
Squared Beta	0.011831225 (0.009484885)	-0.064832551 (0.040440917)
Unique Risk	0.319384771*** (0.108895305)	0.648690355** (0.27196851)

**5% Significance

***1% Significance

Research hypothesis γ_0 is accepted as intercept of the model found statistically insignificant at both 5% and 10% level of significance. Unfortunately, beta is also found statistically insignificant at both 5% and 10% level of significance. Same is the case for squared beta, the only variable which is found statistically significant is unique risk variable.

For the validity of CAPM Intercept, Squared Beta and Unique Risk needed to be statistically insignificant and Beta needed to be statistically significant. But desired result is found in case of Intercept and Squared Beta, and in case of Beta and Unique Risk opposite result is found. So, validity of CAPM in DSE stocks at individual company level is unproved. Or in other word it can be stated that CAPM is found as an inappropriate model at individual stock level in DSE. The result is same in portfolio case, like the one in individual company case. Here also desired result is found in case of Intercept and Squared Beta, but in case of Beta and Unique Risk result is opposite. This means that CAPM is not valid in case of portfolio also. Beta is not the appropriate measure for risk taken, there is reward for unsystematic risk, which is quite significant.

Conclusion

The test found CAPM inappropriate, so is this study found. The study demonstrated the failure of CAPM in both Individual Company level and Portfolio. Beta has been proved inadequate measure for risk. This tells that DSE is not an efficient market till now and due to this in efficiency diversification cannot be achieved by using portfolio. This conclusion is drawn on the basis that unique risk component of the study is found statistically significant in both individual company and portfolio cases. As CAPM is failed in validity test, other model like arbitrage pricing theory, 3 Factors Model can be good alternative for Dhaka stock exchange. But to say that surely, arbitrage pricing theory, 3 Factors Model need to pass the validity test.

Declarations

Conflicts Of Interest Statement

The author states that there is no conflict of interest.

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