Paradigms: A Research Journal of Commerce, Economics and Social Sciences
ISSN 1996-2800, 2010, Vol. 4, No. 1, pp. 80-97.
DOI: 10.24312/paradigms040105

TEST OF CAPITAL ASSET PRICING MODEL ON STOCKS AT KARACHI STOCK EXCHANGE

ARBAB KHALID CHEEMA*
Faculty of Commerce, University of Central Punjab

ABSTRACT

This paper attempts to empirically test the single-factor CAPM developed by Sharpe (1964), Lintner (1965) and Jan Mossin (1966) and others, which proposes that the expected returns of capital assets are dependent on their risk relative to the entire market which is quantified by a correlation co-efficient between asset returns and market returns. The test of 20 stocks at Karachi Stock Exchange have shown that though, the beta co-efficients are significant, their strength is considerably weak. Therefore, other factors which are unaccounted for in this model are important in determining risk and return. In addition, betas are less relevant in a volatile emerging capital markets like the KSE. Thus, the multi-factor models are better than the classical CAPM at determining the risk-return relationship. However, the single-factor CAPM remains in practice beacause of its simplicity.

Keywords: CAPM; Expected Returns; Karachi Stock Exchange.

INTRODUCTION

Capital Asset Pricing Model (CAPM) has been the mainstay for determining a theoretically appropriate required rate of return of an asset that is to be added to an already well-diversified portfolio, given the non-diversifiable risk of the asset. 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.

* Arbab Khalid Cheema is a student of M.Phil at Faculty of Commerce, University of Central Punjab.

The CAPM works on the notion that all risk of a single asset cannot be eliminated through diversification. The systematic risk or market risk cannot be eliminated and thus, the investor has to accept a degree of risk for each of the assets selected for the portfolio. This component of risk is quantified by measuring a correlation co-efficient between the returns of the asset and those of the well diversified portfolio over a time period. This co-efficient reflects the risk of the asset relative to the market. Higher value implies that the asset is high risk relative to the market and vice versa. Investors would want a higher return for high risk assets and they would accept a lower return for low risk ones.

The question is to empirically test the strength of these correlations between the returns of the individual asset and those of the well-diversified portfolio and to ascertain whether these correlations are significant. Statistically significant beta values would prove that the CAPM is good measure for determining required returns for individual assets or portfolios.

This paper empirically tests the CAPM for stocks of 20 selected companies listed at the Karachi Stock Exchange for the period 2004 – 2007 to determine whether their returns are significantly correlated to market returns. The first section is about literature review. The second section explains the data and research methodology; the third section comprises the discussion and analysis of the results and the last section has the conclusion.

LITERATURE REVIEW

The modern portfolio theory, developed by Markowitz with contribution from the work of Tobin (1958), expressed risk of capital assets with the variability of returns measured by statistical measures like variance and standard deviation, assuming that expected returns are normally distributed over a period of time. An investor, for a given level of return, would choose an asset with less variability i.e. less risk. Similarly, a capital asset with higher expected return would be chosen for a given level of risk. The theory also implied that investors can combine different assets to minimize risk and maximize return to make an efficient portfolio. This is by virtue of correlations among the assets within the portfolio which would reduce the overall variance and hence, risk of the portfolio.

Markowitz constructed the mean-variance model, designed to construct the optimal portfolio based on idea that between risk and return there is a positive relation. The investor can attain any desired point along the capital market line by diversifying through various combinations of risky assets (Markowitz, 1952).

Even though the theory of Markowitz was spectacular and useful in this field, it had some inconveniences. For instance, it is done taking into account a very abstract concept in Economics, i.e. utility. The economical practice has shown that the models constructed based on the idea of utility are very difficult or even impossible to be applied. Also, the mathematics beyond of the Mean-Variance is very sophisticated, which makes the application to be very difficult when portfolio consist of a great number of shares. Specifically, to estimate the benefits of diversification would require that practitioners calculate the covariance of returns between every pair of assets, which is very difficult.

Capital Asset Pricing Model (CAPM) came out of the work of Sharpe (1964), Lintner (1965) and Jan Mossin (1966) on Markowitz's portfolio theory. The model was developed to explain the differences in risk premium across assets. The CAPM shows clearly that these differences are generated by the differences in the riskiness of assets, i.e. the higher the risk of an asset the higher the risk premium demanded by investors. Mathematically, CAPM is represented by the equation (Sharpe, 1964):

$$E(R_i) = R_f + \beta_i (R_m - R_f)$$

Where $E(R_i)$ is the expected return of stock i; β_i is the relative risk of share i; R_m is the expected return of the market portfolio; R_f is the risk-free rate of return; and $(R_m - R_f)$ represents the risk premium.

As the investor assumes risk of the asset, he/she would want a return more than that of a risk-free asset. This is represented mathematically by $(R_m - R_f)$. The premium would be higher for a riskier asset. Thus, the return and risk increase in linear fashion. The correlation co-efficient (β_i) between the returns of the asset and those of the market portfolio quantifies the relative risk. A positive value of β would imply that the returns of the asset moves with those of the market and a negative value means that the returns of the asset fall when the market moves upwards and vice versa. A value more than 1 would mean that if the

market moves 1 point, the particular asset moves more than that. A value less than 1 means the asset returns are less sensitive to changes in market returns.

The portfolio theory and CAPM work under a set of assumptions that have been set forth by the works of Markowitz (1952), Tobin (1958), Sharpe (1964), Lintner (1965) and others. These are summarized as follows:

1. Investors target the efficient frontier to maximize economic utility.
2. Investors are rational and risk-averse.
3. Investors diversify their savings across a range of investments.
4. Investors cannot influence prices; hence, they settle at the offered price.
5. Investors have access to limitless funds at the risk free rate for lending and borrowing.
6. There are no transaction or taxation costs.
7. Securities are infinitely divisible to permit optimal asset allocation.
8. All investors have identical prospects as regards distribution of expected returns.
9. Perfectly competitive markets exist.

A very important conjecture of this model is the division of risk into two components: diversifiable (non-systematic) risk and non-diversifiable (systematic) risk. When pricing, the only significant risk is the systematic one, since investors can mitigate the non-systematic risk through diversification (Sharpe, 1964).

As the modern portfolio theory described risk as variability of expected returns, it implies that a higher value of β means the asset is more risky as compared to asset with lower value of β. The risk premium would then be calculated by relative risk (β_i) times ($R_m - R_f$). A high risk investment would have a higher expected return and vice versa; but in conditions of equilibrium, all assets would fall on the SML depending on their risk.

The β (beta co-efficient) of portfolios have shown more stability over a time as compared to those of individual stocks. Black, Jensen, and Scholes (1972) found a positive linear relationship between monthly excess return and portfolio beta. The returns are assumed to have normal distribution but if they are positively skewed, investors would be

willing to pay more for an opportunity of higher returns. Kraus and Litzenberger (1976) tested CAPM and confirmed that investors pay more for positive Skewness.

The CAPM have come under quite a few criticisms over time. The size and P/E ratio also affect average returns in addition to beta. Basu (1977) found that stocks with low P/E ratios outperformed those with high P/E ratios. Banz (1981) showed that portfolios of stocks with low capitalizations had higher expected returns as compared to porfolios with stocks having large capitalization. They must be treated as additional risk factors alongside beta. Bhandari (1988) found that financial leverage can elucidate a spectrum of average returns after both beta and size have been taken into account.

Ross (1976) proposed the Arbitrage Pricing Theory (APT) where stock returns were presented as a function of multiple risk factors. These risk factors include GDP, interest rates, inflation and so on. In contrast, CAPM relies on only a single factor i.e. the relative risk.

Similarly, Fama and French (1992) evaluated the effects of beta, size, E/P ratio, financial leverage and Book-to-Market Equity ratio on the stock returns of various American stocks. They found that the conventional risk-return relationship, as proposed by CAPM, failed to hold for the period 1963 – 1990 even when univariate tests were performed. However, all other variables were found to be statistically significant and displayed expected results in univariate tests for each variable. This research lead to the Fama–French three-factor model by Fama and French (1993) which introduced 2 more variables in addition to beta; the size represented by market capitalization and book-to-market value ratio.

Sharpe defended his model in an interview appearing in “Dow Jones Asset Manager”. Sharpe (1998) answered in response to a question:

> The CAPM is not dead. Anyone who believes markets are so screwy that expected returns are not related to the risk of having a bad time, which is what beta represents, must have a very harsh view of reality.
>
> "Is beta dead?" is really focused on whether or not individual stocks have higher expected returns if they have higher betas relative to the market. It would be irresponsible to assume that is not true. That doesn't mean we can confirm the data.

> We don't see expected returns; we see realized returns. We don't see ex-ante measures of beta; we see realized beta. What makes investments interesting and exciting is that you have lots of noise in the data. So it's hard to definitively answer these questions.

However, there are many studies that support the CAPM. Kothari, Shanken and Sloan (1995) critisized the Fama-French study and suggested that the results of this study were periodic in nature and might be insignificant over a longer time period.

Pettengill, Sundaram and Mathur (1995) attempted to overcome the problem of negative market and portfolio risk premiums. Although these did not pose any problem in estimating beta co-efficients, the risk-return relationship was depreciated. If negative data points are plotted along with positive data points, the slope of the regression line will most likely be very close to zero implying that there is no meaningful relationship between betas and risk. On the other hand, when positive and negative data points are plotted on two different scatter diagrams, the two regression lines, with positive and negative slopes will both be consistent with the security market line.

Another aspect to be considered while examining the importance of relative risk is the assumption that world capital markets are completely integrated. Integration means that two assets identical in their risk profile have identical expected returns in different markets (Harvey, 1995). Factors such as tax regime, investment precincts, promptness of information, currency exchange regulations, the accessibility and precision of accounting information, the number of cross-listed securities on renowned exchanges, market liquidity, political risk, and the institutional arrangements that protect investors all contribute to the degree of integration. It is unlikely that emerging markets such as the Karachi Stock Exchange are integrated enough for this assumption to be true. In such conditions, relative risk as defined by beta cannot explain the expected returns.

Jagannathan and Wang (1996) tested the CAPM assuming that slopes do not remain constant over time i.e. they are non-stationary. Their research findings strongly supported CAPM when betas and expected returns were allowed to vary over time by assuming that the CAPM holds in each and every period.

DATA AND METHODOLOGY

The daily closing prices were taken for stocks of 20 companies which had relatively high volumes. The KSE 100 Index was taken as a proxy for the well-diversified market portfolio. The index values and closing prices were obtained for the period starting January 2004 up to December 2007. Since the purpose of the study was to test the strength and significance of beta as measure of risk, risk-free rates of return and calculation of risk premiums were not required.

Daily returns could be computed by two methods. One is to divide the difference between the closing price on day t and closing price on day t-1 with closing price on day t-1; and the other is to take a log difference for closing prices on day t and day t-1:

$$R_i = (P_t - P_{t-1}) / P_{t-1}$$

$$R_i = Ln\ (P_t) - Ln\ (P_{t-1})$$

Where R_i is the return of stock i; P_t is the closing price of a stock on day t; P_{t-1} is the closing price of a stock on day t – 1; while Ln (P_t) and Ln (P_{t-1}) are natural logs of closing prices on day t and t – 1. The natural log method was adopted due to its ability to make a time series data stationary which would make the regression more reliable.

Regression Model

CAPM calculates beta which is nothing but a correlation co-efficient of the regression between stock or portfolio returns with those of the market. Thus, the returns of individual stocks were regressed against those of the market represented by KSE 100 Index. The return of individual stocks is the dependent variable while the return of the KSE 100 index is the independent variable. The regression model is as follows:

$$R_{it} = \alpha + \beta_i\ KSE_t + \varepsilon_t$$

Where R_{it} represents return of stock i at time t; β_i is the correlation coefficient of stock i; KSE_t is the return of KSE 100 Index at time t while ε_t represents the error term of the regression.

As time series data is being used, Durbin-Watson (DW) test is needed to check for any positive serial correlation among adjacent residuals; a common occurring in business and economics. The DW statistic is a test for first-order serial correlation; it measures the linear association between adjacent residuals from the regression model.

If there is no serial correlation, the DW statistic will be around 2. The DW statistic will fall below 2 if there is positive serial correlation. If there is negative correlation, the statistic will lie somewhere between 2 and 4. Usually the limit for non-serial correlation is considered to lie between 1.8 and 2.2. The auto-regression for the residuals would be as follows:

$$\varepsilon_t = \rho\varepsilon_{t-1} + \alpha_t$$

Where ε_t is the error term in the model at time t while ε_{t-1} is its lagged value; ρ is the auto-correlation parameter; and α_t is the white noise (Gujarati, 2002).

Hypotheses

For the CAPM regression, the null hypothesis states that the returns of the individual stocks are not significantly correlated with market returns while the alternate hypothesis is that the returns of the individual stocks are positively and significantly correlated with market returns.

For serial correlation, the null hypothesis is $\rho = 0$ (No serial correlation among the residuals while for the alternate hypothesis, $\rho \neq 0$ (Positive/Negative serial correlation among the residuals).

DISCUSSION AND ANALYSIS OF RESULTS

The purpose of this study is to empirically test whether beta is relevant as a measure of relative risk. This is displayed by the significance level of the correlation co-efficient. The results show that most companies' stocks have betas that are statistically significant at a level of 1%. Only three companies, Sitara Chemicals, Azgard Nine and NIB Bank had insignificant betas. The null hypothesis is rejected for the remaining 17 companies. This

implies that the market has a relevant influence on stock's performance. According to this information, beta is a good measure of risk.

The values of the betas are very low for all stocks; the highest value calculated is 0.532 for Pakistan State Oil. The strength of the correlation is weak. Most companies have their betas in the range of 0.2 to 0.3. Thus, one may assume that these stocks are not very risky because they do not move too much with changes in market return. So, from a theoretical point of view, the Karachi Stock Exchange could be a good environment for investors with a low appetite for risk. An investment horizon of about 4 years would be quite safe.

However, as mentioned before, the single-factor CAPM has been criticized for the fact that relative risk alone does not account for all the risk. The question arises that, to what extent the market return as the sole independent variable, explains the variation in individual stock returns. This can be answered by looking at the values of adjusted R squared. The R squared depicts the proportion of variation in the dependent variable explained by the independent variable. In this particular study, the values of adjusted R squared are to be considered because number of observations for the each of the stock is large, being close to 1,000 observations. These values are very low for these stocks under observation; the highest being 0.282 for Pakistan State Oil which means that about 28% of the variation in stock returns of PSO can be explained by the market returns. 17 out of the total 20 stocks had adjusted R squared values less than 0.1 i.e. 10%.

Moreover, the constant terms are statistically insignificant for all of the 20 stocks. The values of t-statistic are extremely low; thus, leading to the conclusion that there is too much noise in data. There are too many observations that deviate from the regression line. This implies that there are other factors having a great influence on the stocks' returns. Beta alone cannot explain everything. The answer lies within the residuals, i.e. the error variable which comprises those factors that have unaccounted for in the single-factor CAPM. The low values of Adjusted R squared imply that the major portion of variation is not explained by beta.

The Durbin-Watson test generally presented non-correlated residuals. Only for 2 companies, Adamjee insurance and Attock Refinery, the test was inconclusive while for the remaining 18 companies, there was no evidence of positive correlation. The alternate hypothesis is rejected for all companies in favor of the null hypothesis.

The stock returns of each company were plotted against those of the KSE 100 index. Generally, the pattern was not well defined; the linear shape could not be observed and too many observations did not fall on the regression line. The regression lines were flat due to low beta values. However, in almost all cases, most of the observations were stacked together in an almost circular region.

CONCLUSION

The statistically significant but low beta values may lead investors to think that the risk is low, thus, they would be safe from market fluctuations due to low responsiveness of individual stock returns. This assumption is, however, flawed due to two reasons.

First, the low adjusted R squared highlights the importance of residuals. The beta only explains a small amount of the variation in stock returns. Thus, this single-factor model is insufficient and justifies the multi-factor models like the three-factor Fama-French Model and similar models. Other factors have to be taken into account to estimate returns and select stocks for formation of portfolios.

The low beta value, if hypothetically considered to be the only factor in operation, would mean less price gains for these stocks as their returns would only be minutely responsive to a bullish market. An investor would not be able to take advantage of a market moving upwards.

The Arbitrage Pricing Theory as proposed by Ross (1976) uses numerous factors for estimation of expected returns. Multi-factor models of risk and return, like the three factor Fama-French Model based on micro-economic factors and the macro-economic based model proposed by Chen, Roll and Ross (1986)are definitely better at explaining risk and return relationship. However, it is impossible to account for every possible risk factor in existence.

Shanken (1982) has raised questions regarding the possibility of empirical testing of the APT.

Despite all criticisms, a single-factor CAPM based on relative risk may still be the easiest and simplest way of defining the risk-return relationship that could be used on a routine basis by any ordinary investor regardless of the deficiencies.

REFERENCES

Banz, R. W. (1981). The relationship between return and market value of common stocks. *Journal of Financial Economics, 9* (1), 3-18.

Basu, S. (1977). Investment performance of common stocks in relation to their price-earnings ratios: A test of the efficient market hypothesis. *The Journal of Finance, 32* (3), 663-682.

Bhandari, L. C. (1988). Debt/Equity ratio and expected common stock returns: Empirical Evidence. *The Journal of Finance, 43* (2), 507-528.

Black, F., Jensen, M. C., & Scholes, M. S. (1972). The capital asset pricing model: Some empirical tests. In M. C. Jensen, *Studies in the theory of capital markets.* New York: Praeger Publishers.

Chen, N.-F., Roll, R., & Ross, S. A. (1986). Economic Forces and the stock market. *The Journal of Business, 59* (3), 383-403.

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics, 33* (1), 3-56.

Fama, E. F., & French, K. R. (1992). The cross-section of expected stock returns. *The Journal of Finance, 47* (2), 427-465.

Gujarati, D. (2002). *Basic Econometrics* (4th Edition ed.). Columbus, Ohio: Mcgraw-Hill.

Harvey, C. R. (1995). Predictable Risk and Returns in Emerging Markets. *The Review of Financial Studies, 8* (3), 773-816.

Jagannathan, R., & Wang, Z. (1996). The Conditional CAPM and the cross-section of expected returns. *The Journal of Finance, 51* (1), 3-53.

Kothari, S. P., Shanken, J., & Sloan, R. G. (1995). Another look at the cross-section of expected stock returns. *The Journal of Finance, 50* (1), 185-224.

Kraus, A., & Litzenberger, R. H. (1976). Skewness Preference and the valuation of risk assets. *The Journal of Finance, 31* (4), 1085-1100.

Lintner, J. (1965). The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. *The Review of Economics and Statistics, 47* (1), 13-37.

Markowitz, H. (1952). Porfolio Selection. *The Journal of Finance, 7* (1), 77-91.

Mossin, J. (1966). Equilibrium in a capital asset market. *Econometrica, 34* (4), 768-783.

Pettengill, G. N., Sundaram, S., & Mathur, I. (1995). The conditional relation between beta and returns. *The Journal of Financial and Quantitative Analysis, 30* (1), 101-116.

Ross, S. A. (1976). The arbitrage theory of capital asset pricing. *Journal of Economic Theory, 13* (2), 341-360.

Shanken, J. (1982). The arbitrage pricing theory: Is it testable? *The Journal of Finance, 37* (5), 1129-1140.

Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *The Journal of Finance, 19* (3), 425-442.

Sharpe, W. F. (1998, May/June). Revisiting the capital asset pricing model. (J. Burton, Interviewer) Dow Jones Asset Management.

Tobin, J. (1958). Liquidity preference as behavior towards risk. *The Review of Economic Studies, 25* (2), 65-86.

TABLES AND ILLUSTRATIONS

TABLE 1

Beta Co-efficient relative to KSE 100 Index returns and significance levels

	Company	Symbol	Co-efficient	Significance
1	Oil and Gas Development Corporation	OGDC	.237	.000
2	Pakistan State Oil	PSO	.532	.000
3	National Bank of Pakistan	NBP	.346	.000
4	Sitara Chemical Ltd.	SITC	-- .013	.721
5	Engro Chemicals Ltd.	ENGRO	.380	.000
6	DG Khan Cement Ltd.	DGKC	.243	.000
7	Attock Refinery Ltd.	ATRL	.276	.000
8	Pakistan Oilfields Ltd.	POL	.344	.000
9	Fauji Fertilizer Ltd.	FFC	.109	.001
10	Lucky Cement Ltd.	LUCK	.256	.000
11	Nishat Mills Ltd.	NML	.213	.000
12	HUB Power Company Ltd.	HUBCO	.085	.008
13	Bank of Punjab	BOP	.166	.000
14	Adamjee Insurance Company Ltd.	AICL	.237	.000
15	NIB bank	NIB	-- .034	.290
16	Fauji Fertilizer Bin Qasim Ltd.	FFBL	.249	.000
17	Azgard Nine Ltd.	ANL	.015	.650

	Company	Symbol	Co-efficient	Significance
18	Sui Southern Gas Company Ltd.	SSGC	.173	.000
19	Sui Northern Gas Pipelines Ltd.	SNGP	.245	.000
20	Muslim Commercial Bank	MCB	.241	.000

TABLE 2

Adjusted R Squared Values for all Regressions against KSE 100 Index Returns

	Company	Symbol	Adjusted R Squared
1	Oil and Gas Development Corporation	OGDC	.055
2	Pakistan State Oil	PSO	.282
3	National Bank of Pakistan	NBP	.119
4	Sitara Chemical Ltd.	SITC	- .001
5	Engro Chemicals Ltd.	ENGRO	.143
6	DG Khan Cement Ltd.	DGKC	.058
7	Attock Refinery Ltd.	ATRL	.075
8	Pakistan Oilfields Ltd.	POL	.117
9	Fauji Fertilizer Ltd.	FFC	.011
10	Lucky Cement Ltd.	LUCK	.065
11	Nishat Mills Ltd.	NML	.044
12	HUB Power Company Ltd.	HUBCO	.006
13	Bank of Punjab	BOP	.027
14	Adamjee Insurance Company Ltd.	AICL	.055
15	NIB bank	NIB	.000
16	Fauji Fertilizer Bin Qasim Ltd.	FFBL	.061
17	Azgard Nine Ltd.	ANL	.000
18	Sui Southern Gas Company Ltd.	SSGC	.029

	Company	Symbol	Adjusted R Squared
19	Sui Northern Gas Pipelines Ltd.	SNGP	.059
20	Muslim Commercial Bank	MCB	.057

TABLE 3

Durbin-Watson Test for all Regressions against KSE 100 Index Returns

	Company	Symbol	Durbin-Watson Test
1	Oil and Gas Development Corporation	OGDC	2.101
2	Pakistan State Oil	PSO	2.107
3	National Bank of Pakistan	NBP	1.997
4	Sitara Chemical Ltd.	SITC	2.013
5	Engro Chemicals Ltd.	ENGRO	2.107
6	DG Khan Cement Ltd.	DGKC	2.072
7	Attock Refinery Ltd.	ATRL	1.678
8	Pakistan Oilfields Ltd.	POL	1.918
9	Fauji Fertilizer Ltd.	FFC	2.115
10	Lucky Cement Ltd.	LUCK	1.916
11	Nishat Mills Ltd.	NML	1.886
12	HUB Power Company Ltd.	HUBCO	1.997
13	Bank of Punjab	BOP	2.089
14	Adamjee Insurance Company Ltd.	AICL	1.692
15	NIB bank	NIB	1.944
16	Fauji Fertilizer Bin Qasim Ltd.	FFBL	2.093
17	Azgard Nine Ltd.	ANL	1.775
18	Sui Southern Gas Company Ltd.	SSGC	1.965

	Company	Symbol	Durbin-Watson Test
19	Sui Northern Gas Pipelines Ltd.	SNGP	2.019
20	Muslim Commercial Bank	MCB	1.963