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An Empirical Analysis of Higher Moment Capital Asset Pricing Model for Karachi Stock Exchange (KSE)

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Abstract

The purpose behind this study is to explore the relationship between expected return and risk of portfolios. It is observed that standard CAPM is inappropriate, so we introduce higher moment in model. For this purpose, the study takes data of 60 listed companies of Karachi Stock Exchange 100 index. The data are inspected for the period of 1st January 2007 to 31st December 2013. From the empirical analysis, it is observed that the intercept term and higher moments coefficients (skewness and kurtosis) are highly significant and different from zero. When higher moment is introduced in the model, the adjusted R square is increased. The higher moment CAPM performs cooperatively perform well.

Keywords

Capital Assets Price Model, Higher Moment

1. Introduction

In financial economics literature, CAPM (Capital Assets Pricing Model) is one of the most vital advancements. CAPM was introduced by Sharpe [1], Lintner [2] and Mossin [3]. It was first development of mean-variance CAPM, which identified the expected return on portfolio is linearly related to market based or systematic risk.

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Researcher utilized different technique to analysis the CAPM for different equity markets in the different region of the world. The studies conducted by Black, Jensen and Scholes [4] and Fama and MacBeth [5] are shown their result according to Standard CAPM. Some studies like Roll and Ross [6] rejected the standard CAPM, when portfolio used to proxy for the market was inefficient. Jegadeesh [7] and Fama and French [8] argued that because of the bad proxies of the market portfolio CAPM is failure. After 1980s, CAPM was addressed in view of surprising anomalies which were accounted by Reiganum [9], Elton, Martin and Rentzler [10]. Roll and Ross [6] and Kandel, Shmuel and Stambaugh [11] show that insignificant relationship between expected return and risk. Lsakov [12] shows that market beta may not be suitable for capturing risk return relationship. So researcher started to search for an alternate model which explained efficiently the relationship between risk and return because large number of empirical studies against the standard CAPM. The key problem of standard CAPM is that, it assumed that return is distributed normally.

In real the returns are asymmetric or fat tail distribution, this information is motivated us to used higher moment (skewness and kurtosis) in finding the risk return relationship. Doan [13] and Levy [14] argued that higher moments cannot be ignored. The results provided better picture if they added little information the shape of distribution. Rubinstein [15], Kraus and Litzenberger [16], Hwang and Satchell [17] and Ranaldo and Favre [18] argued that when the equity and market returns were not normally distributed, the standard CAPM was not enough to capture market risk and return relationship. They recommended for the addition of higher moment. Current studies Ang, Chen and Xing [19], and Xing, Zhang and Zhao [20] also pointed out that asymmetry of the return distribution is play vital role to determine assets return.

There were few work related to higher moment CAPM. Fang and Lai [21] analyze that systematic variance, co-skewness and co-kurtosis added to risk premium of equity returns in United States stock market. Dittmar [22], Hwang and Satchell [22] and Harvey and Siddique [23] analysis co-skewness and co-kurtosis in emerging economy market and they highlighted that higher moment CAPM better explain return and risk relationship. Christie-David and Chaudhary [24] used the four-moment CAPM on the future market returns and showed that explanatory power is increased, when higher moment introduced. Chang, Johnson and Schill [25] compared the four moment CAPM with Fama French two factor model and found that SMB (difference between small size firm and large size firm portfolios) and HML (difference between high book to market value firm to low book to market value firm) become insignificant when higher moment is introduced in CAPM. Berenyi [26] used the higher moment CAPM to capture the return and shows that volatility alone is not enough to measuring the risk of portfolio. Messis, Iatridis and Blanas [27] analysis that Athens stock market is positively skewed and kurtosis risk is not compensated.

In this research, the effects of unconditional skewness and unconditional kurtosis will be examined in case of Karachi Stock Exchange 100 index firm. The degree of asymmetry of distribution is shown by skewness, where positive (negative) skewness represent distribution with asymmetric tail extending towards more positive (negative) values. If we ignore skewness risk in designing portfolio causes CAPM model devalue. Kurtosis depicts the relative peakness or flatness in return distribution. Kurtosis greater than 3 indicates that distribution is more flat compared to normal distribution. According to Hood, John, Nofsinger and Kenneth [28] the investors not like negative skewness and excess kurtosis because the negative skewness increase weight in the lower tail at expense of the upper tail and the excess kurtosis increases weight in both tail at the expense of the central area of the distribution.

After brief introduction and review literature of higher moment CAPM, next we discuss research methodology and data description in Section 2. Result and discussion in Section 3 and last but not the least conclusion of the research study.

2. Research Methodology and Data Description

2.1. Data Description

The data utilized in this study consist of 60 non financial firms for the period of 1st January 2007 to 31st December 2013 (daily data).

The rate of return of each stock or equity was calculated as follow

$$R_t = \ln\left(P_t / P_{t-1}\right) \tag{0}$$

where P_t is closing price at period t, P_{t-1} is closing price at period $t-1$, ln is natural log. In this study we use in-

dividual stock return rather than portfolios for taking analysis Kim [29]. For proxy of market portfolio KSE-100 index return used. The proxy of risk free return is 3 months T-Bills of government of Pakistan.

2.2. Normality Test of Returns

It has been observed that most of the economics and finance time series data has not normally distributed Brown and Matysiak [30]. In the same line most of the stock return are observed fat tails more peak than normal distribution Bekaret and Harvey [31]. The causes of non normal distribution of stock return is that due to illiquidity, lack of divisibility and low information of transparency Ranaldo and Favre [18].

To check the normality of a sample's distribution, the prominent test: Jarque-Bera test was considered in this research. The Jarque-Bera test for normality is now presented by considering the following null hypothesis

To analysis the normality in data of stock return, the study use Jarque-Bera test, which most prominent test of normality. The Jarque-Bera test for normality is set following hypothesis.

Ho = Return follows the normal distribution.

H1 = Return do not follows the normal distribution.

$$JB = \frac{n}{6}\left[S^2 + \frac{K^2}{4}\right] \tag{1}$$

where n is number of observation. S is the Skewness and K is the excess kurtosis. The test follow the chi square distribution with two degree of freedom.

2.3. Estimation of Mean Variance CAPM

According to CAPM, which developed by Sharpe and Linter [1] return can be elucidate as follows

$$R_{it} = R_{ft} + \beta_i\left(R_{mt} - R_{ft}\right) \tag{2}$$

where R_{it} is the rate of return of i^{th} firm at time t, R_{ft} is a risk free rate of return at time t. R_{mt} is the rate of return on the market index at time t and β_i is firm beta of company, which is co-variance of market return and individual firm return divided by variance of market return. First of all we regress following equation to determine systematic risk. It is also known as first pass equation.

$$R_{it} - R_{ft} = \alpha_i + \beta_i\left(R_{mt} - R_{ft}\right) + e_{it} \tag{3}$$

where e_{it} is the white noise error term in the above CAPM regression model at time t. Above equation is estimated by using OLS (ordinary least square) method. In second stage, we run second pass equation as follows.

$$\overline{r_i} = \gamma_0 + \gamma_1\beta_i + e_i \tag{4}$$

$\overline{r}$ refer to average excess returns of individual firm over the sample period. B is the estimate of the systematic risk or market risk of individual firm, which obtained from first pass equation. e_i is white noise error term, γ_0 and γ_1 are parameter of second pass equation.

2.4. Estimation of Higher Moment CAPM

The result of JB normality test shows that stock returns are distributed asymmetric and leptokurtic, so the mean variance CAPM is inappropriate because it cannot capture co-skewness (third moment) and co-kurtosis (fourth moment) factors. As suggested by Kraus and Litzenberger [16], Homaifar & Graddy [32] and Hussain [33] the following equation used to capture higher moment.

$$\overline{r_i} = \gamma_0 + \gamma_1\beta_i + \gamma_2\delta_i + \gamma_3\kappa_i + e_i \tag{5}$$

where the parameter β denotes the co-variance, δ_i shows co-skewness and κ_i is co-kurtosis of stock i which are time series regression coefficient of first pass equation.

$$R_{it} - R_{ft} = \alpha_i + \beta_i\left(R_{mt} - R_{ft}\right) + \delta_i\left(R_{mt} - R_{ft}\right)^2 + \kappa_i\left(R_{mt} - R_{ft}\right)^3 + e_{it} \tag{6}$$

The slope coefficient of above first pass equation (cubic CAPM) or time series equation is used in second pass equation.

3. Result and Discussion

Table 1 reported the first four moments of daily stock returns of 60 non financial firms. It is noted that average

Table 1. The first 4 moments of daily stock return of the studied companies, which listed in Karachi Stock Exchange.

Company	Mean (%)	Standard Deviation (%)	Skewness	Kurtosis	Jarque Bera (normality test)
Abbot Laboratory	−0.21	3.67	−1.05	207.18	47176.65
Al Abbas Suger Mills	1.11	3.01	−0.77	246.17	64811.01
Al Gazi Tractor	0.08	2.35	−1.71	176.15	26240.24
Atlas Battery	0.68	4.76	−1.31	140.71	25616.36
Atlas Honda	0.02	1.24	−1.01	150.1	21899.60
Attock Cement	0.02	2.99	−0.23	137.97	19385.41
Attock Petroleum	0.07	3.59	−20.32	762.13	615009.94
BATA	0.12	5.37	−6.60	363.55	138524.67
Buxly Paint	−0.04	3.37	−11.90	338.88	120653.54
D.G khan Cement	0.00	2.35	−2.42	41.46	1599.21
Dewan cement	−0.07	4.70	−0.21	79.03	6151.19
Dewan sugar	−0.06	5.25	0.15	44.37	1821.80
General Tyre	−0.02	3.29	−0.03	132.52	17850.98
Gillite Pakistan	0.01	3.47	−0.19	181.52	33916.07
Glaxo Smith	−0.02	2.12	−2.61	51.51	2533.42
Gul Ahmed	−0.03	3.15	−0.78	214.92	47792.32
Habib Sugar	0.04	4.12	−0.23	372.11	144983.03
Hino Pak Motor	0.02	4.65	−10.51	385.53	156187.66
Honda Atlas Car	−0.05	4.45	−1.83	149.75	22932.77
ICI Pakistan	0.03	2.24	−6.33	160.27	26490.82
Indus Motor Ltd.	0.02	2.18	−4.16	93.89	8864.82
Ittehad Chemical	0.01	2.85	−1.81	114.48	13239.69
Japan Power	−0.02	4.78	0.06	47.86	2141.34
Johanson & Philips	0.04	6.16	−4.37	262.29	71623.85
Kohinoor Textile	−0.04	5.85	0.38	149.35	22791.87
Lakson Tobbaco	0.03	4.36	0.19	272.96	77552.51
Mitchall Fruits	0.00	2.82	−14.37	483.39	246459.16
Milat Tractor	0.04	2.00	−0.36	4.27	2.25
Nishat Mills	0.05	3.22	−1.80	261.01	70855.75
Nestle Pakistan	0.05	1.78	0.01	3.98	1.03
OGDC	0.00	1.91	−0.19	5.50	6.81
Pak Suzuki	0.04	1.64	−0.47	10.11	54.69
Pak Petroleum Ltd	−0.08	4.85	0.30	119.08	14340.57
PIA	−0.02	1.90	−0.03	3.41	0.18
PTCL	0.00	1.74	−2.10	45.33	1925.53
Shall Pakistan	−0.01	3.77	−4.40	118.50	14278.85
Singer Pakistan	−0.06	3.99	0.32	51.61	2515.39
Southern Electric	0.02	9.40	−0.25	269.35	75495.33
Samin Textile	0.05	2.79	−1.77	72.25	5116.99
Siemens	−0.01	1.95	−0.04	3.78	0.66
SNGC	−0.02	1.99	0.08	5.27	5.50
SSGC	0.02	1.23	0.12	2.32	23.45

Significance level 5%.

daily returns are varied from −0.08% (Pakistan Petroleum) to 1.11% Adam Sugar mills. The skewness ranger from −20.3 (Attock Petroleum) to 0.32 (Singer Pakistan). Excess Kurtosis could be as high as 762 (attock Petroleum) ranging from 3.41 (PIA). In above table skewness shows that out 60 firms only 9 firms have positively skewed. The excess kurtosis column shows that the behavior of the firms is leptokurtic, which means that the curve was relatively more peaked than normal curve. These findings are consistent with the finding of Mandelbrot [34], Mandelbrot and Taylor [35], Campbell [36] and Md Zobear [37] as they identified that stock return exhibit fat tails distribution. The result of JB test shows that only 6 firms returns are normally distributed out of 60 firms. The main features of the KSE data are that returns were positive, volatile, asymmetric and fat tails.

According CAPM model the intercept term or constant term insignificant and should not be difference from zero and there is positive relation or trade of between risk and return. **Table 2** shows that constant term statistically significant, which indicated that important variables are missing. Also there are slightly positive relationship between market beta or market risk and return, our result are in line of Thomas [38] and Mecangni and Sourial [39] found positive relationship between risk and return. Hence based on the intercept criterion, the CAPM hypothesis is rejected in case of KSE.

To analysis the effects of higher moment of CAPM model, 3rd and 4th moment were incorporated in CAPM model. The results of higher CAPM model is reported in **Tables 2-5**.

The results show that the coefficient of variance, skewness and kurtosis are positive and significant. All investor are compensated in higher expected return for taking the systematic variance, skewness and kurtosis risk.

Table 2. OLS (Ordinary Least Square Method) estimates of CAPM.

Variable	Coefficients	Standard Error	t statistics	Adjusted R-Square
Constant	0.032	0.00384	8.33	0.021
Market Beta	0.064	0.0325	1.97	

Significance level 5%.

Table 3. OLS estimate of CAPM with skewness.

Variable	Coefficients	Standard Error	t statistics	Adjusted R-Square
Constant	0.021	0.00394	5.33	0.106
Market Beta	0.045	0.413	0.11	
Skewness	0.048	0.018	2.67	

Significance level 5%.

Table 4. OLS Estimate of CAPM with kurtosis.

Variable	Coefficients	Standard Error	t statistics	Adjusted R-Square
Constant	0.02	0.0016	12.47	0.09
Market Beta	0.037	0.1721	0.215	
Kurtosis	0.021	0.0057	3.67	

Significance level 5%.

Table 5. OLS Estimate of higher moment CAPM.

Variable	Coefficients	Standard Error	t statistics	Adjusted R-Square
Constant	−0.254	0.0181	7.89	0.167
Market Beta	0.014	0.1312	2.09	
Skewness	0.256	0.0670	3.21	
Kurtosis	0.012	0.0154	3.99	

Significance level 5%.

Table 3 and **Table 5**, it is indicated that skewness coefficient is significant. A significant value of skewness coefficient was compensated by the market and the excess returns of KSE market had a non-linear relationship with the market portfolio (Md Zobear *et al.* 2013). The finding of our research indicated that usual market model of CAPM is inappropriate and exhibit the validity of the quadratic CAPM model as extension.

The coefficient of kurtosis is a positive investment incentive. A positive kurtosis coefficient means that the asset is adding kurtosis to the market portfolio or vice versa. The result of **Table 4** and **Table 5** shows that the risk premium for kurtosis was significant and shows expected sign as portfolio return are positive correlated with kurtosis. The finding of our research indicated that higher kurtosis is compensated by higher portfolio's returns.

The introducing of higher moment (skewness and kurtosis) as additional explanatory component in the regression of portfolio's returns. The finding suggest that CAPM model is not linear its non-linear. After introducing skewness and kurtosis, the adjusted R square was increase 0.021 to 0.167. The model with skewness was better than the model with kurtosis because it exhibited better performed.

4. Conclusion

The paper analyzes the importance of higher moment (skewness and kurtosis) of returns distribution in capturing the variation of average stock returns for companies listed in the KSE. The finding of the study shows that standard CAPM is unable to capture assets return efficiently. The JB test of normality shows that stock returns of KSE not normally distributed. The investor concerns about the higher moment of returns. Our study supports strongly the inclusion of terms represents skewness and kurtosis. The study also showed that after inclusion of higher moments in the model, the adjusted R square increased, which also supported higher moment in KSE. Therefore, we concluded that higher moment CAPM was more superior to Sharpe and Linter standard CAPM model. It is important for future research to design theoretical model which in-corporate higher moment in CAPM model.

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