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Capital Asset Pricing Model for the Stock Market in Pakistan

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Abstract: *The Capital Asset Pricing Model (CAPM), within modern financial theory, offers a theoretical framework for pricing assets with uncertain returns. CAPM assesses systematic risk and proposes a linear relationship between risk and expected returns for any asset. It serves as a potent tool for pricing risky assets. In this present study, the trade-off between risk-return was investigated within the framework of CAPM and its validity was tested on the daily returns of companies listed in the chemical, textile and food sectors of the Pakistan stock market during the period July 2004- Feb 2014. The results of empirical testing by regression analysis supported the CAPM's validity for these sectors in Pakistan and found CAPM β as a single factor which was priced by the market. The KSE-100 index was used as a market, and the year treasury-bills return rate was taken as a risk-free rate.*

Key Words: Pakistan Stock Market, Capital Asset Pricing Model, Excess Returns, Risk-free Rate, β

Introduction

The Capital Asset Pricing Model (CAPM), developed by Sharpe (1964) and John Lintner (1965), stands as a powerful tool in asset pricing theory and the estimation of risky assets. CAPM elucidates the balance between asset risks and returns and predicts the linear relationship between risk and return for any asset. It measures risk and asset returns as compared to the overall market (Aliyev & Soltanli, 2018; Rossi, 2016; Hasan *et al.*, 2011). Two types of risks are associated with every asset. A risk which is non-diversifiable and arises from the market is called systematic risk, and its standardized measure is β_k (risk of asset k). A risk which is diversifiable is a non-systematic risk (Rossi, 2016; Rachev et al., 2007). CAPM represents a significant milestone in financial economics (Atkins & Ng, 2014). It establishes the connection between asset risks and their anticipated returns. Estimating the expected return on assets holds paramount importance in financial contexts. As highlighted by Reilly & Brown (2005), a pivotal element in capital asset pricing theory is the risk-free asset, characterized by its rate of return known as the Risk-Free Rate (RFR). RFR adds up to CAPM to specify expected return rates for risky assets (Reilly & Brown 2005). Saastamoinen (2008) applied the CAPM to perform rational asset pricing analysis using data from 32 major capital companies listed on the Helsinki Stock Exchange (OMXH) during the period from 2002 to 2007. Ordinary least square (OLS) regression was used as a traditional method in testing asset pricing theory. OLS estimated the extended CAPM coefficients for the daily basis dataset of prices for thirty Dow Jones Industrial Average Stocks for the period 2002- 2009 (Allen et al., 2009) and analyzed the weekly data of the NYSE, NASDAQ and AMEX stocks (from the website of Yahoo Finance) and estimates of β were calculated for the period 1999-2013 (Atkins & Ng 2014).

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Empirical tests were used to determine the validity of a model, and empirically testing the CAPM's validity was a very interesting subject for financial scholars from earlier times to modern research. The empirical research conducted by Black et al. (1972) and Fama-MacBeth (1973) provided support for the original form of CAPM. To delve into the essential characteristics and practical application of CAPM, we compiled monthly data spanning from July 1926 to September 2009 from Kenneth R. French, encompassing 100 portfolios. The weighted average return of NASDAQ, AMEX, and NYSE index returns was employed as the market return rate, with the one-month T-bill rate serving as the risk-free rate (RFR). Empirical evidence from Ordinary Least Squares (OLS) regression affirmed a positive relationship between returns and systematic risk, validating CAPM. Additionally, OLS Estimates of CAPM β were computed (Chang et al., 2011). Barnes and Hughes (2002) discovered the significance of CAPM beta (β) at both ends of the return distribution based on data from 1028 consecutive trading days involving 1093 firms sourced from the Center for Research in Security Prices.

Literature showed that the validity of CAPM was also tested for the daily, weekly & monthly returns of stocks from the London Stock Exchanges (LSE) during 2012 to 2020 (Pham, 2021), monthly returns of 12 banking stocks from Borsa Istanbul for the period 2001 to 2010 and used to describe the pricing of financial assets on the basis of their risk (Aliyev & Soltanli, 2018), monthly returns of 9 countries from the Central & South-East European emerging markets during 2006-2010 (Džaja & Aljinović, 2013), monthly stock returns of 80 non-financial firms from Dhaka Stock Exchange (DSE) during 2005-2009 (Hasan *et al*., 2011), monthly returns of stocks in ISE-50 from the Istanbul Stock Exchange (ISE) during 2006-2010 (Bilgin & Basti, 2011), for the 64 companies of ISE-100 during 2002-2006, (Köseoğlu & Mercangöz, 2013), for weekly data of 60 firms listed Kuala Lumpur Stock Exchange during 2010-2014 (Lee, Cheng, & Chong, 2016), for the cement and power generation & distribution sectors of ISE for 2012-2013 (Demircioglu, 2015), for 29 stocks of Nepal stock exchange during 2011-2019 (Sah, 2020), for the 50 stocks of 10 portfolios from Indian Stock Market from 2003 to 2008 (Basu & Chawla, 2010), and for the returns of all companies listed in Tokyo Stock Exchange on the 1st section during the period of 1964 to 1969 (Lau, Quay, & Ramsey, 1974).

Motivation

Pakistan's stock market is a developing market, and Western theories may have different applicability in Pakistan. To check it, testing the CAPM's validity in the Pakistan Stock Exchange (PSX), previously known as the Karachi Stock Exchange (KSE), is very important. A lot of studies on CAPM have been conducted in many countries, while a few studies are associated with CAPM in Pakistan. The CAPM validity on the Pakistan stock market was tested for the monthly data of 306 companies during the period 2001-2014 (Wu et al., 2017), annual data of 22 companies (1 company from every 22 sectors) during the period 2008-2012 (Shamim, Abid, & Shaikh, 2014), for the ten different companies of KSE during 2006-2010 (Khan et al., 2012), for the monthly, quarterly & semi-annual data of 387 companies from KSE (Raza et al., 2011), for the quarterly data of 17 companies from the Oil and Gas & fertilizer sector of KSE during the time period 2004-2009 (Zubairi & Farooq, 2011), for the weekly & monthly data of Tobacco sector of KSE during period 2004 to 2007 (Hanif 2010), and for the monthly returns of 49 companies of KSE during period 1993-2004 (Javid & Ahmed, 2008).

The previous studies of testing the CAPM's validity in Pakistan have been conducted for different stock markets, sectors, time periods, & on a quarterly, weekly & monthly basis. The significance of this study was to review the applicability of CAPM in the Pakistan stock market and to test its validity on the daily returns of companies listed in the chemical, textile & food sectors of PSX. For the present study, data on the closing prices of 15 companies in three major sectors (5 from each sector) during the period of 10 years from July 2004 to February 2014 was used on a daily basis. So, this study, with a larger set of data and important sectors, will play a significant role in the literature. This study aims to calculate the excess returns of daily data of the chemical, textile & food sectors of PSX, test the validity of the Capital asset pricing model on these sectors of the Pakistan stock market and estimate CAPM β without intercepting and testing its significance to investigate the tradeoff between risk-return. The rest of the paper is organized as follows.

The capital asset pricing model is explained in section 2. The methodology and data of the companies listed in the chemical, textile & food sectors of PSX are explained in section 3. In section 4, the results of descriptive, empirical testing of CAPM's validity & OLS estimate are described. Discussion & comparison with previous studies is made in section 5. Section 6 is comprised of the conclusions and future direction of the study.

Capital Asset Pricing Model (CAPM)

CAPM describes the tradeoff between the risks and expected returns of the assets and predicts the linear risk-return relation of any asset, i.e. higher risk leads to higher return, and low risk leads to lower return. The CAPM is employed to calculate the expected rates of return estimates for individual assets. Mathematically, CAPM is defined as

$$E(R_k) = R_f + \beta_k * \left(E(R_m) - R_f\right)$$

$E(R_k)$ & $E(R_m)$ Are the expected returns of k^{th} risky asset and market, respectively, R_f is RFR, and β_k Is a systematic/ non-diversifiable risk measure for any k^{th} asset. The best linear predictor of k^{th} asset returns on the basis of returns of the market by the regression analysis on CAPM is

$$\hat{R}_k = \alpha_i + \hat{\beta}_k * R_m$$

The estimate of β_k (slope of a linear predictor of k^{th} assets returns taking returns of the market as predictor) is $\hat{\beta}_k$ and significance of β_k It is based on linear regression. The relevant measure of risk for an individual risky asset is its covariance with the market portfolio, denoted as '$cov(k, m)$'. The beta (β) coefficient relates this covariance to the market variance, thus serving as a standardized measure of risk expressed as '$\beta_k = \frac{cov(k,m)}{\sigma_m^2}$'. As the β for any market portfolio is one if the β of k^{th} asset > one, then its systematic risk is more than the market and if the β of k^{th} asset <1, then its systematic risk is lower than the market. Higher risk leads to higher return, and low risk leads to lower return.

The β of the k^{th} asset is estimated by the linear regression.

$$R_{kt} - R_{ft} = \alpha_k + \beta_k * \left[R_{mt} - R_{ft}\right] + \varepsilon_{kt}$$

R_{kt}, R_{mt} & R_{ft} Are the respective returns of k^{th} asset, market & risk-free rate at 't' time, α_k Is the constant term, and β_k Is the CAPM risk measure of k^{th} asset. ε_{kt} is the error term (at 't' time), and $\varepsilon_{kt} \sim N(0, \sigma_k^2)$. In a time series regression on CAPM, the single dependent variable is the excess returns of the k^{th} asset $(R_{kt} - R_{ft})$ & the single independent variable is the excess returns of the market $(R_{mt} - R_{ft})$ At 't' time, the regression is simple linear regression.

Methodology and Data

To fit the CAPM, the values of daily returns for individual stocks and markets are calculated by the daily closing prices of individual stocks and markets, respectively. The risk-free rate exists in the CAPM theory for lending or borrowing massive investments. Excess returns are calculated by subtracting the risk-free rate from the returns of individual assets (Ruppert, 2004). A stock exchange (SE) plays a crucial role in a country's capital market. It serves as a structured marketplace for buying and selling financial and industrial securities. Globally, a lot of researches are on the stock markets, for example for the Taiwan stock market (Lin & Liang, 2011), Vietnam stock market (My & Tmong, 2016), Indian stock market (Gunasekaran & Ramaswami, 2011), Bangladesh stock market (Hasan *et al.*, 2011), Istanbul stock exchange (Senol & Ozturan, 2009), and Spanish stock market, (Ferruz et al., 2007). The capital market of Pakistan is considered a developing capital market, and PSX is the biggest SE of Pakistan, which was previously known as KSE, and it is the oldest in South Asia. It was announced as the "best-performing stock market". For the economic growth of any country, the chemical, textile and food sectors are very important. In this study, the three sectors, chemical, textile and food, were chosen from PSX, and a total of 15 companies from these sectors were taken. The list of selected companies from each sector is given in Table 1.

Table 1
List of selected companies from chemical, textile & food sectors during July 2004 - Feb 2014

S. No	Chemical	Textile	Food
1	DAWH (Dawood Hercules)	NCL (Nishat Chunian Limited)	DWSM (Dewan Sugar Mills)
2	DSFL (Dewan Salman Fiber Limited)	IDRT (Idrees Textile)	MZSM (Mirza Sugar Mills)
3	FFBL (Fauji Fertilizer Bin Qasim Limited)	KOIL (Kohinoor Industries Limited)	QUICE food
4	ISI Pakistan	KTML (Kohinoor Textile Mills Limited)	SGML (Shakarganj Mills Limited)/ SML (Shakarganj Limited)
5	NICL (Nimir Industrial Chemical Limited)	REWM (Reliance Weaving Mills)	SHSML (Shahmurad SugarXD Mills Limited)

Most of the companies listed in KSE were in 2004 and later, so daily closing prices for the years period from 2004 to 2014 for the above-mentioned companies of PSX were taken from the official online websites of Open Doors & KSE. Data of missing observations (due to instability in politics & internal crises of Pakistan) were excluded. In the capital market of Pakistan, the KSE-100 index is performing amongst the best markets, so it was taken as the market, and 12-month TB rates were used as RFR to fit the CAPM. State Bank of Pakistan provided these TB rates. These data files were in Excel files. For a comprehensive analysis, we utilized R software. R has gained significant traction in both industry and academia, becoming the most popular and essential language and tool over the past decade. Testing the CAPM's validity was a very interesting subject for financial scholars from earlier to modern research, and different empirical testing techniques were reused. The CAPM's validity in PSX is empirically tested by regression analysis.

1. The intercept term (α) should not be significantly different from zero, i.e.
$H_o: \hat{\alpha} = 0$ should be accepted against the hypothesis $H_1: \hat{\alpha} \neq 0$
2. A significant relationship exists between independent & dependent variables within the framework of CAPM, i.e.
$H_o: \hat{\beta} = 0$ must be strongly rejected against $H_1: \hat{\beta} \neq 0$
3. The relationship between β and return should be significantly linear, i.e.
$H_o: \hat{\beta}_2 = 0$ must be accepted against $H_1: \hat{\beta}_2 \neq 0$
4. Risk measure (β) should be the only factor that is priced by the market
See (Pham, 2021; Sah, 2020; Nyangara et al., 2016; Hassan et al., 2011; Basu & Chawla, 2010; Rachev et al., 2007; Xu & Yang, 2007; Michailidis, 2006).

Results

Return formula was used to calculate the daily returns of all the companies of chemical, textile and food sectors of PSX & market (KSE-100) from daily closing prices during 2004-2014, and excess returns of companies and market were obtained by differencing the RFR from the returns of companies and market respectively in the excel files. We imported Excel files containing daily excess returns data into the R language for subsequent analysis. Descriptive statistics for daily excess returns of 15 companies in the chemical, textile and food sectors of KSE are shown in Table 2.

Table 2
Descriptive statistics for daily excess returns of chemical, textile & food sectors

Companies	Minimum	Maximum	Skewness	Kurtosis	Observations
Chemical Sector					
DAWH	-0.8688	0.0487	-3.1926	66.63	2143
DSFL	-0.3189	0.2869	0.8076	4.480	2286
FFBL	-0.2494	0.0496	0.5186	1.219	2300
ICI	-0.3723	0.0483	0.2743	1.909	2292
NICL	-0.5771	0.9504	3.1793	50.146	2317

Textile Sector					
NCL	-0.2401	0.0483	0.2170	0.671	2317
IDRT	-0.3801	0.3175	0.1906	2.30	1699
KOIL	-0.6603	0.8245	1.5894	17.38	2039
KTML	-0.3560	0.2049	0.0442	2.320	2282
REWM	-0.4394	0.1864	-0.2087	4.336	1549
Food Sector					
DWSM	-0.5176	0.4177	0.3106	6.855	1678
MZSM	-0.4811	2.4431	10.010	250.28	1816
QUICE	-0.6076	1.3704	3.1577	39.13	1613
SGML	-0.3839	1.1997	5.4045	109.25	1707
SHSML	-0.3088	1.1863	5.5633	109.44	1586

The minimum values of the excess returns of all the companies are negative, but the maximum values are positive. The excess returns of most companies are positively skewed with high peaks. As in a time series regression on CAPM, excess returns of companies of k^{th} asset $(R_{kt} - R_{ft})$ & excess returns of the market $(R_{mt} - R_{ft})$ Are single dependent & independent variables, respectively, so simple regression is applied to all companies independently, and CAPM's validity is tested empirically. All the results of empirical testing of CAPM's validity are presented in Table 3.

Table 3

CAPM's validity for the returns of companies listed in PSX

Companies	p-value ($\hat{\beta}$)	p-value ($\hat{\alpha}$)	p-value ($\hat{\beta}_2$)	R^2
Chemical Sector				
DAWH	0.000**	0.355	0.032*	93.56 %
DSFL	0.000**	0.273	0.070	87.05 %
FFBL	0.000**	0.624	0.117	97.64%
ICI	0.000**	0.538	0.529	96.95%
NICL	0.000**	0.140	0.067	81.42 %
Textile Sector				
NCL	0.000**	0.691	0.293	93.53 %
IDRT	0.000**	0.555	0.512	74.79 %
KOIL	0.000**	0.608	0.356	66.44 %
KTML	0.000**	0.241	0.772	87.89 %
REWM	0.000**	0.120	0.725	84.51 %
Food Sector				
DWSM	0.000**	0.444	0.150	67.24 %
MZSM	0.000**	0.990	0.491	55.1 %
QUICE	0.000**	0.981	0.892	55.42 %
SGML	0.000**	0.476	0.808	77.57 %
SHSML	0.000**	0.081	0.505	77.44 %

** indicates the significance at a 5% significance level

* indicates the significance at a 10% significance level

Null hypotheses of $\hat{\alpha} = 0$ are accepted & $\hat{\beta} = 0$ are strongly rejected for all the companies at a 5% level of significance, which is in favour of CAPM. Acceptance of null hypotheses of $\hat{\beta}_2$ =0 in the polynomial fitting on all the selected companies evaluated the linear risk-return relation. High values of R-square confirmed that β is a single factor priced by the market. For some companies in the food sector, the values of R-square (R^2) are not very high, but overall results support the CAPM. All the results of empirical testing of CAPM's validity are in favour of CAPM for the companies of chemical, textile & food sectors of PSX, which indicates that CAPM holds in the chemical, textile & food sectors of Pakistan stock market during the period of 2004 to 2014.

OLS estimates of CAPM β without the intercept term are calculated for all the selected companies. The values of $\hat{\beta}_{companies}$ Greater than one indicates higher risk & the values $\hat{\beta}_{companies}$ Less than 1 indicates a lower risk for all companies as compared to the market. Higher risk leads to higher return, and low risk leads to lower return. The significance of the estimates of CAPM β is also tested. Estimates of CAPM β and their significance are presented in Table 4.

Table 4

OLS regression estimates of chemical, textile & food sectors

Companies	$\hat{\beta}$	Standard error	t- value	p-value
Chemical Sector				
DAWH	1.0045	0.0057	176.5	0.000*
DSFL	1.0091	0.0081	124	0.000*
FFBL	1.0034	0.0032	308.1	0.000*
ICI	1.000	0.0037	269.6	0.000*
NICL	0.9947	0.0099	100.7	0.000*
Textile Sector				
NCL	1.0060	0.0055	183	0.000*
IDRT	0.9901	0.0140	70.98	0.000*
KOIL	0.9875	0.0155	63.52	0.000*
KTML	1.0007	0.0078	128.7	0.000*
REWM	0.9921	0.0108	91.89	0.000*
Food Sector				
DWSM	0.9920	0.0169	58.67	0.000*
MZSM	0.9761	0.0207	47.2	0.000*
QUICE	0.9656	0.0216	44.7	0.000*
SGML	0.9974	0.0130	76.82	0.000*
SHSML	0.9833	0.0133	73.77	0.000*

** indicates the significance at a 1% significance level

Estimates of β for the companies of the chemical sector indicate higher risk & higher return as compared to the market. The β estimates for the food sectors show the lower risk & return as compared to the market. The p-values of β estimates for all the companies are less than 0.01, showing the estimates of all CAPM β are significant at a 1% level of significance and linear risk-return tradeoff exists in the Pakistan stock market. Expected returns of companies can be estimated by incorporating the values of $\hat{\beta}_{companies}$ in the equation

$$\hat{R}_{companies} = \hat{\beta}_{companies} * R_m$$

Discussion & Comparison

This study was conducted to test the CAPM's validity on the chemical, textile & food sectors of the Pakistan stock market during the period of 10 years (July 2004- Feb 2014). The KSE-100 index was used as a market, and the 12-month treasury-bills return rate was taken as a risk-free rate. Daily returns & excess returns were calculated from the daily prices of all selected companies of these sectors. CAPM's validity was tested empirically by regression analysis, and estimates of CAPM βs were also found.

Past researchers reported the CAPM a powerful tool in the theory of asset pricing and estimating the risk-return relation (Aliyev & Soltanli, 2018; Rossi, 2016; Hasan *et al.*, 2011) and the role of risk-free assets and estimating the expected return of assets are very important in risky securities (Reilly & Brown 2005). β is a standardized measure of systematic risk (Rossi, 2016; Rachev et al., 2007). OLS regression was used as a traditional method in testing asset pricing theory and estimating the CAPM coefficients (Allen et al., 2009; Atkins & Ng, 2014; Ullah et al., 2021).

Empirical analysis of CAPM concluded its validity for the12 banking stocks from Borsa Istanbul for the period 2001 to 2010 and used to predict the overall outcome of these banking portfolios (Aliyev& Soltanli,

2018) for weekly data of 60 firms listed in the Kuala Lumpur Stock Exchange during 2010-2014 (Lee, Cheng, & Chong, 2016), for the 64 companies of ISE-100 during 2002-2006, (Köseoğlu & Mercangöz, 2013), and for the Japanese market during 1964-69 (Lau, Quay, & Ramsey, 1974). While CAPM was not found valid for the daily, weekly & monthly returns of stocks from the London Stock Exchanges (LSE) from 2012 to 2020 (Pham, 2021), monthly returns of 9 countries from the Central & Southeast European emerging markets from 2006-2010 (Džaja & Aljinović, 2013), monthly stock returns of 80 non-financial firms from Dhaka Stock Exchange (DSE) during 2005-2009 but found a positive relation between return & β and linearity in the market line of securities (Hasan *et al.*, 2011), for the monthly returns of stocks in ISE-50 from the Istanbul Stock Exchange (ISE) during 2006-2010 (Bilgin & Basti, 2011), and for the 50 stocks of 10 portfolios from Indian Stock Market from 2003 to 2008 (Basu & Chawla, 2010).

To test the CAPM's validity in the Pakistan stock market, different studies showed variations in results on the different stock markets, sectors, time periods, & on the data on a daily, weekly & monthly basis. Evidence of CAPM was available in the earliest studies of Ahmad & Zaman (1999) and Qasim (2004) for KSE Pakistan (Wu et al., 2017). Javid & Ahmed (2008) & Khan et al. (2012) involving the KSE resulted in favour of CAPM with limited applicability, while the results of studies of Hanif (2010), Zubairi and Farooq (2011), Shamim, Abid, & Shaikh, (2014), & Wu et al., (2017) were not supporting the CAPM. Empirical testing of CAPM gave different results for a shorter period. It rejected CAPM in any year and supported it in some other year (Sah, 2020). Results of CAPM were found to be more accurate for monthly basis data of KSE as compared to quarterly and semi-annually in KSE (Raza et al., 2011).

Conclusion

In the present study, the results of simple and polynomial regression are in favour of CAPM and supported its validity for the chemical, textile & food sectors of PSX on the daily return during the period 2004-2014. It was found that previously, companies were not mispriced, and a linear relation existed between the risk & return. Results of R-squares conclude that β is found as a single factor priced by the market. OLS estimates of CAPM β without intercept term are calculated and are found significant. Estimates of β for the companies of the chemical sector indicate higher risk & higher return as compared to the market. The β estimates for the food sectors show the lower risk & return as compared to the market. This study further may be extended to other sectors of Pakistan's stock market, and the period of data may be extended. A comparison may then be made between this and previous studies.

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