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THE EFFECT OF TIME-VARYING BETA ON THE VALIDITY OF THE CAPM IN NAIROBI SECURITIES EXCHANGE

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Purpose-The Capital Asset Pricing Model (CAPM) is widely used to price assets in the Nairobi Securities Exchange (NSE). This paper examines whether it is more adequate for capital asset pricing in the NSE if the beta estimate is assumed to be a random variable rather than a point estimate.

Methodology-The study follows a descriptive approach and it is based on secondary data. Precisely, it is based on the monthly returns of the 20 companies that formed the NSE 20-share index from 1st January 2013 to 31st December 2016. First, the CAPM is tested on this data using the Classical Linear Regression Model (CLRM), where the beta estimate is assumed to be a constant. Then, a multivariate General Autoregressive Conditional Heteroscedastic (GARCH) model of the Diagonal BEKK (Baba, Engle, Kraft and Kroner) type is fitted on the data to compute time-varying betas and the test of the CAPM is repeated using these betas. Analysis is done using the E-views software, 9th edition.

Findings- From the regression analysis in the first test, beta is statistically significant. Ranking the securities from the one with the highest beta to the one with the lowest beta shows that the security with the highest beta is not the one with the highest expected return. Neither does the security with the lowest beta have the lowest return. ICDC has the highest beta (1.649329) estimate but it actually has negative expected returns (-2.18494). From these results, it is clear that the CAPM does not hold in the NSE. When time-varying betas are calculated, it is possible to construct various combinations of returns and beta where the stocks with the highest returns have the highest betas and those with the lowest returns have the lowest betas. This clearly shows that using time-varying betas improve the validity of the CAPM on the NSE.

Implications- Beta, which is a measure of the systematic risk, is the most important parameter of the CAPM model. Assumptions about it should therefore be made carefully. Precisely, it should not always be assumed to be constant. Other assumptions of the CAPM should also be put to test before it is applied in pricing assets in the NSE.

Value- The CAPM is used to compare securities such as stocks, investment funds, equities, and bonds. It is also used to price portfolios and to choose the mean variance portfolio. Investors also use this model to compare the intrinsic value of an asset to its book value. In project appraisals, the CAPM gives a better view of the feasibility of a project than the Net Present Value (NPV). When using the CAPM in all these ways, investors, financial officers and managers will find using time-varying betas more useful than using constant ones. Indeed, using time-varying betas will give a more realistic picture of the economic reality underlying the trading of securities.
Key words: CAPM, Dynamic CAPM, beta, time-varying beta

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Introduction

The modern day CAPM is the brainchild of Harry Markowitz. He formulated the portfolio theory in 1952. This theory explains how investors choose efficient portfolios from a set of securities. It states that rational investors consider the mean and variance of returns on securities when choosing the securities to invest in. It is however, difficult to determine the efficient frontier using this theory given the amount of data required and the complexity of the computations.

Sharpe (1965) and Lintner (1965) brought a breakthrough in the research on capital markets when they extended Markowitz Portfolio Theory into the CAPM. The CAPM establishes a positive linear relationship between the expected returns of a security and the risks taken. Precisely, it states that there is a positive relationship between the return of a risky asset and the sensitivity of this return to the return of the entire market. The sensitivity of the return of a risky asset to the return of the entire market is measured by beta. It is a measure of the systematic risk and it is therefore the most important parameter of the model.

One of the challenges encountered when applying the linear CAPM in capital markets is the instability of beta. Beta changes with the changes in the operating, investing and financing activities of a firm as these are the activities that constitute the changes in the risk profile of the firm. These changes in beta to reflect economic reality bring about the concept of time-varying beta in the testing of the CAPM.

Empirical tests of the CAPM on the NSE and other stock markets have yielded conflicting results. In particular, Were, A (2012) tested the CAPM on weekly returns data of the NSE's 20-Share Index and found out that CAPM was valid at the NSE. Just a year after this study, another test showed that the CAPM is not valid at the NSE (Otieno A., 2013). They both used the same data set but different time lines. Were used weekly stock returns data from January 2005 to June 2012 while Otieno used a smaller data set- from 1st January 2009 to 31st December 2012. The tests on the CAPM in both cases were based on a regression model. Another study had earlier invalidated the CAPM at the NSE (Otieno V. 2011).

Recently, Kamau (2014) studied the validity of the CAPM and the Fama-French three-factor model on the NSE, and the results were just similar to those of the previous tests. She used monthly returns data of all the firms listed on the NSE in the period 1st January 2008 to 31st December 2013. Her results concur with those of Otieno A. (2013). She also found no substantial evidence on the applicability of the Fama-French three-factor model.

Empirical tests of the CAPM has also been performed on different securities markets in various parts of the world. For instance, Coffie and Chukwulobelu (2015) studied the Application of CAPM to individual securities rather than portfolios on the Ghana Stock Exchange. They used 19 individual companies listed on the exchange from January 2000 to December 2009. The results rejected the application of the strictest form of CAPM but upholds the validity of Jensen (1968) and Jensen, Black, and Scholes (1972) versions of the CAPM. Testing of the CAPM had been done on the same stock exchange earlier by Acheampong and Agalega, (2013). The two had tested the standard CAPM with constant beta and found it to be invalid in the Ghana Stock Exchange. The test was based on a regression model. After performing several statistical tests based on the standard CAPM formula, they could not reject the null hypothesis that the difference between the expected and actual returns was statistically insignificant. This led to the conclusion that the CAPM was not valid for the GSE. They also used the Fama and MacBeth (1973) technique and got the same results.

Elsewhere, Alqisie, A, (2016) tested the CAPM on the Amman Stock Exchange using monthly returns data of companies listed on the Amman Stock Exchange. He used the techniques applied by Black, Jensen and Scholes (1972) and concluded that the CAPM was invalid for the ASE. The results of the Fama and MacBeth (1973) on the same data set yielded the same results. CAPM tests on the Karachi Stock Exchange however gave different results. Raza et al (2011) studied the validity of CAPM in this stock exchange using Data of 387 companies. The result showed that CAPM is valid for short-term investments only. However, Shaikh A.S (2013) performed the same test and invalidated the CAPM model on the same stock exchange. In Zimbabwe, Nyangara. M et al (2016) tested the CAPM on 31 firms listed on the Zimbabwe Stock

Eexchange and concluded that the CAPM is invalid in the ZSE mainly due to skewness and liquidity anomalies of the model. Further tests revealed that the CAPM is fairly applicable for 3-6 month data.

In a bid to improve the applicability of the CAPM on the NSE, various modifications and variations have been put forward and yielded better reports. For instance, Maina (2013) challenged the normality assumption of distribution of returns in the CAPM on the NSE. He estimated Beta using the Generalized Hyperbolic Distribution which captures skewness, heavy tails and peakedness of financial data, unlike the normal distribution. He used the NSE20 share index, Mumias Sugar Company and Safaricom as a representative sample of the entire market. His results were that with more precise beta estimates, the CAPM is applicable on the NSE. Furthermore, Ekisai (2015) performed a time series analysis of the D-CAPM to determine whether it explains the movement of returns in the NSE. He used 5-year data for 47 firms, from January 2010 to Dec 2014. Actual returns were compared to returns calculated using the D-CAPM. The results showed that D-CAPM largely explains the behavior of returns in the NSE. This paper makes one more modification on the CAPM: the use of time-varying beta instead of a constant one.

Constant betas versus time-varying betas

The CAPM is a linear model. Indeed, its linearity in the NSE is verifiable (Otieno V.O, 2011). That is why previous studies on the CAPM are based on the CLRM. These studies are based on several assumptions. For instance, the CLRM assumes that errors are normally distributed with a mean 0 and finite and constant variance δ^2 i.e. $Var\,(\lambda_t) = \delta^2 > \infty$, where λ_t are the errors. In other words, the CLRM assumes that the errors are homoscedastic. The errors are also assumed to be linearly independent and also independent of the corresponding x variates. This explains why the beta estimate, which is the point estimate of the covariance between the market return and the return of a particular asset is assumed to be a constant. This assumption has its own implications. Precisely, if heteroscedasticity is present but it is ignored, the estimates obtained during data analysis will be wrong and the adopted distributions of data will be inappropriate.

Heteroscedasticity tests on stock returns data from various studies show that the errors are heteroscedastic. Indeed, with most financial time series data, the variance of the errors varies with time. This is the motivation behind ARCH models, which estimate conditional volatility (variance). Beta is a measure of volatility in the market and since volatility varies, it also varies with time and the homoscedastic assumption should be challenged.

It has also been proven that Linear models in finance cannot explain several stylized facts of financial time series data such as leptokurtosis, volatility clustering and leverage effects (Brooks, 2008). Stock returns, like many other financial relationships are non-linear according to Campbell, Lo and MacKinlay (1997). The way investors trade-off risk and return is also a non-linear function. This means that for the CAPM to be tested more accurately, non-linear models such as GARCH models should be used to estimate its parameters, especially beta. Indeed, tests have shown that GARCH models and Arbitrage Pricing Theory (APT) models are more accurate in predicting expected stock returns than the linear CAPM (Groenewold & Fraser (1997) and Scheicher (2000). Fraser and Hamelink (2004) also found that the GARCH models are more powerful than the CAPM in predicting stock returns. Several studies have also proven that the GARCH models are very useful in estimating and forecasting volatility in the NSE. For example, Noah M, (2013) fitted both symmetric and asymmetric GARCH models on the NSE 20 share index. Mekoya, (2013) also used the same models to forecast volatility in the NSE.

In the dynamic CAPM, variances and covariances vary with time. Consequently, expected returns also vary with time. In this case, beta is a random variable. Many researchers have found the dynamic CAPM to be more realistic than the static one. For example, Bollerslev, Engle and Wooldridge (1988) estimated a trivariate CAPM using the VECH model on US Treasury bills, bonds and stocks. Conditional covariances were found to be variable and significant. This meant that betas also varied over time and could be forecasted over a period of time. On the other hand, Ricardo A.T. (2002) studied the application of ARCH models in portfolio selection. He obtained beta estimates using the traditional OLS method and compared them using betas calculated with the presence of GARCH effects. He found a significance difference between the two sets of beta. The portfolios formed using the different sets of betas were also significantly different. Godeiro L.L. (2013) also got the same results on the test of the conditional CAPM on the Brazilian Stock Exchange Market. He used stock returns data from 1st January 1995 to 20th March 2012 of 28 firms of the Ibovespa portfolio. Dynamic betas were estimated using the Kalman Filter and multivariate GARCH Dynamic Conditional Covariance methods. He noted that dynamic betas were more realistic, noting that there was particularly a large increase in betas during the 2008 world economic crisis.

The use of time-varying beta to form the dynamic CAPM is thus more realistic than using the constant beta. The constant beta is based on historical data, and investors are more concerned with the future than the past. Using a multivariate GARCH model, it is possible to forecast future time-varying betas and use the same information to predict future returns. This information is useful in making sound investment decisions in the NSE.

Methodology

This study follows a quantitative and qualitative research approach. Numerical data obtained from the NSE is used to make inferences about less tangible aspects such as the validity of the CAPM at the NSE. The research is also both descriptive and analytical. Quantitative techniques were used to identify and classify various elements of the historical prices of the NSE 20 share index, which is taken to be a suitable representative of the market portfolio. This is a non-probabilistic sample which is both a convenience and purposive sample because it contains the most actively traded stocks. It mainly consists of blue chip companies and therefore it is a reflection of the entire market and we can generalize the results to the entire NSE from the results of this sample. Monthly returns of the firms that make up the NSE 20 share index were obtained from the NSE. Trading continued consistently throughout the period of study for 17 out of 20 firms. KCB and KQNA didn't trade in 2013 while EQTY didn't trade for the better part of 2014 and 2013. However, this inconsistency does not affect the overall outcome of the data analysis. The annualized average rate of return on the 91-day treasury bills issued within the period of study is used as a proxy for the risk free rate. The data for the rates of return is got from the Central Bank of Kenya. On the other hand, the market return is taken to be the returns on the Nairobi All Share Index.

Analytical model

Continuously compounded stock returns are calculated using the formula:

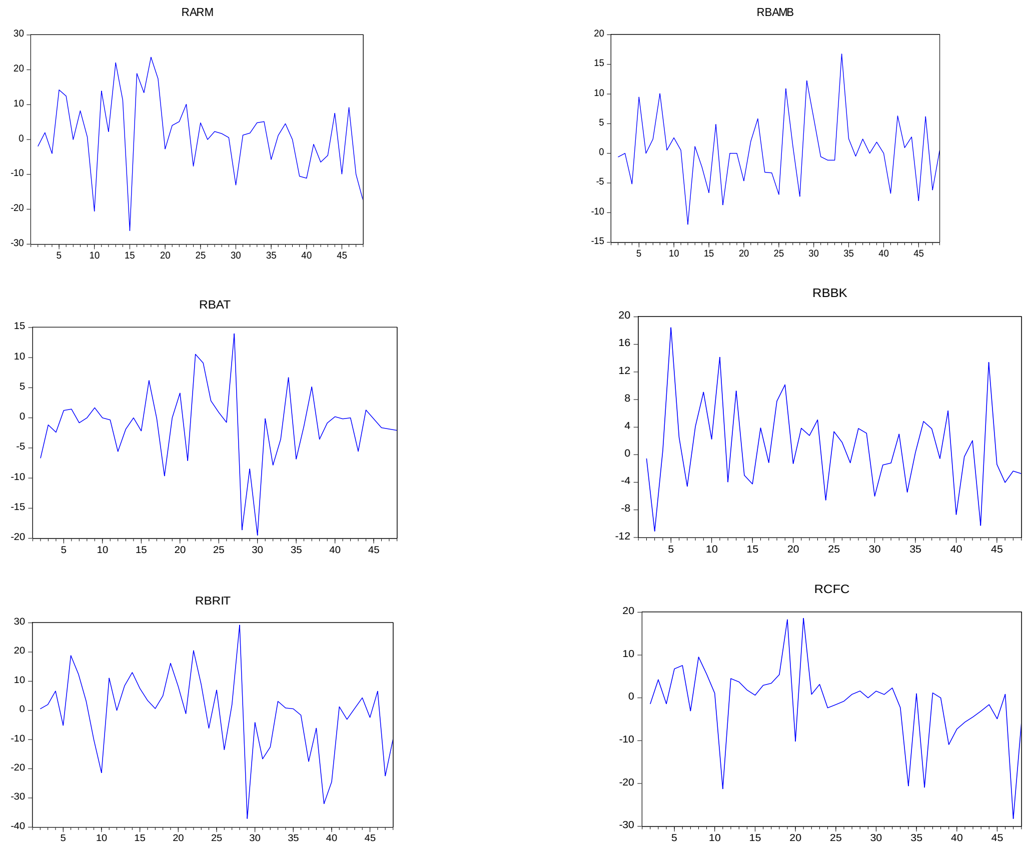
$$R_t = 100 * \log\left(\frac{pt}{pt-1}\right)$$

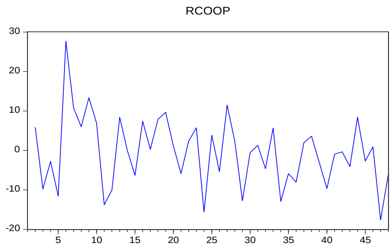
Where Pt is the price of a stock at time t.

Diagnostic Tests on the Data

Several diagnostic tests had to be performed on the data to make it suitable for the study. To begin with, QQ plots of the monthly returns data show volatility clustering where large changes in stock prices are followed by large changes and small changes are followed by small changes.

Plots of various stock returns over time

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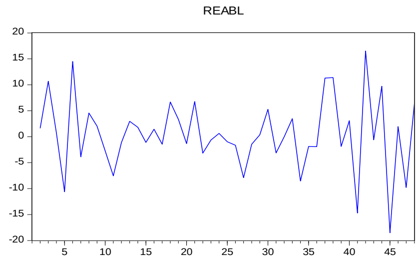
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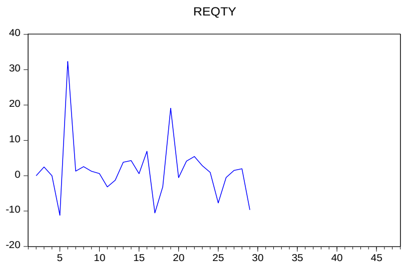
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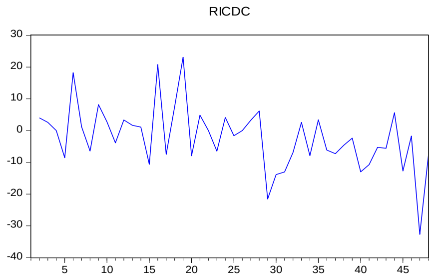
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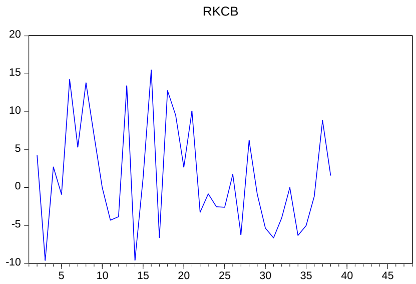
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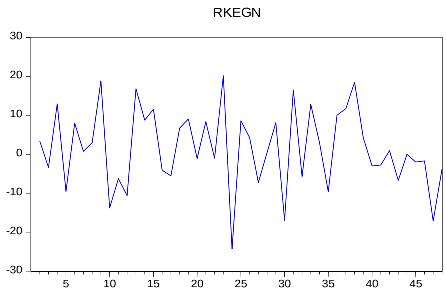
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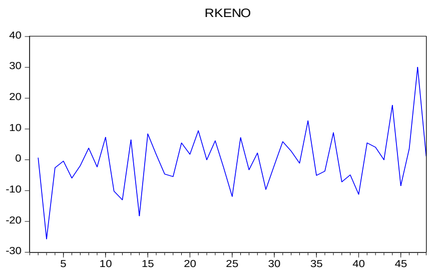
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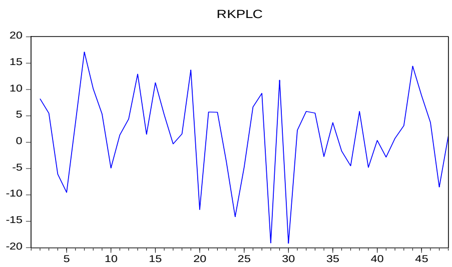
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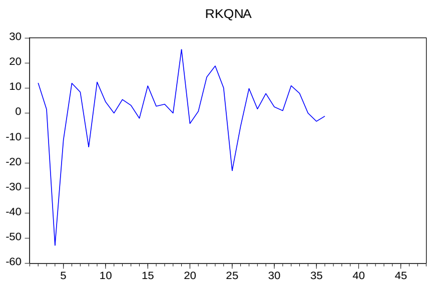
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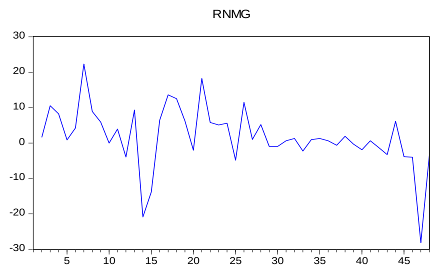
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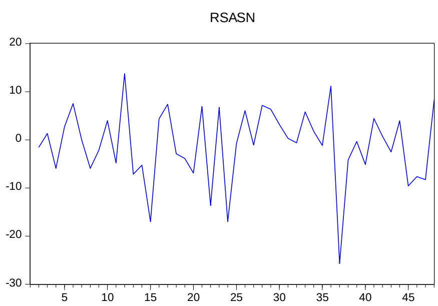
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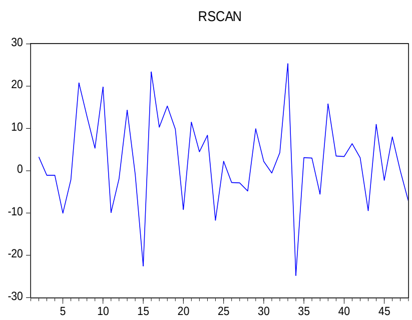
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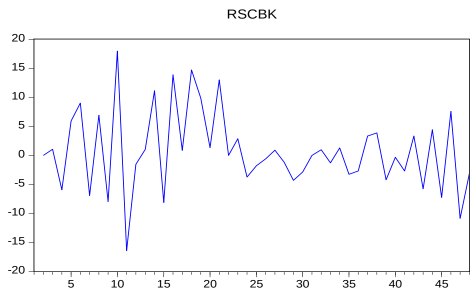
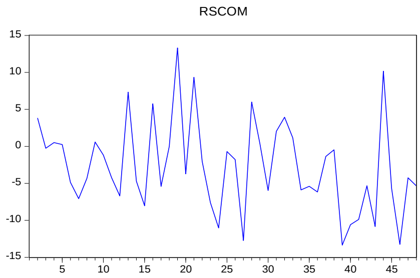
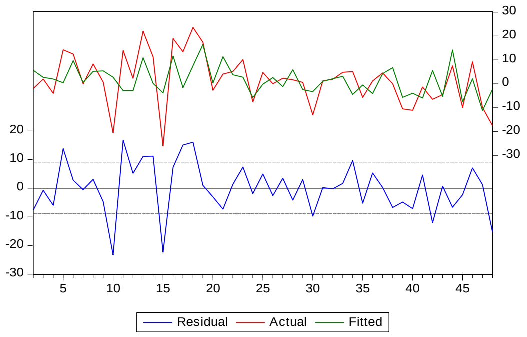




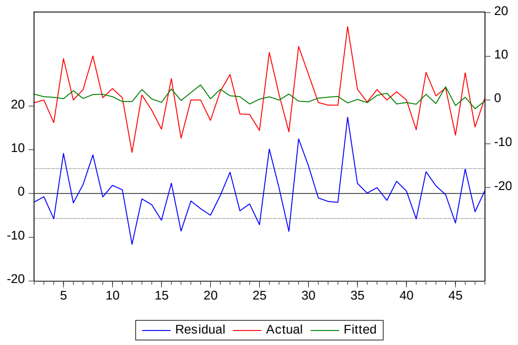
Residual plots of each of the stock returns series were also plotted to test for heteroscedasticity. These plots show systematic variability over the chosen sample, except a few outliers. This is a clear sign of heteroscedasticity. Since the study focuses on a small data set, the residual plots are sufficient to detect heteroscedasticity. The more robust ARCH test also shows the presence of ARCH effects on the various stock returns.

Residual Plots

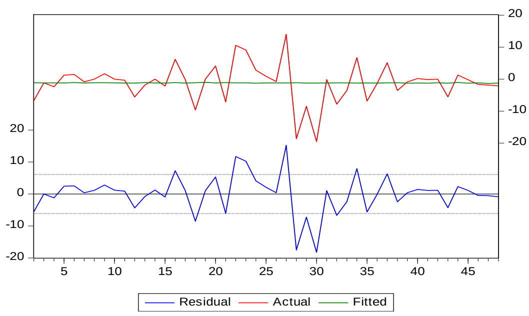
RARM



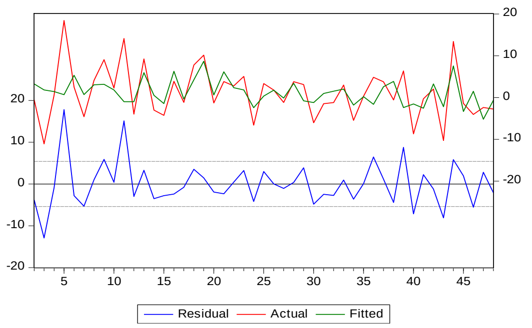
RBAMB



RBAT

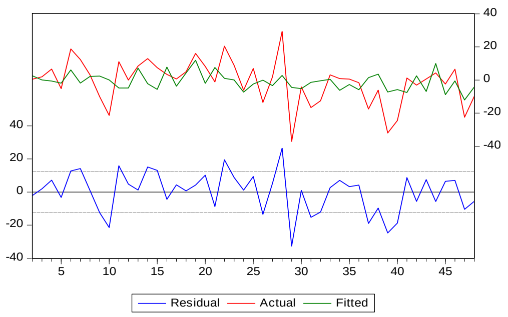


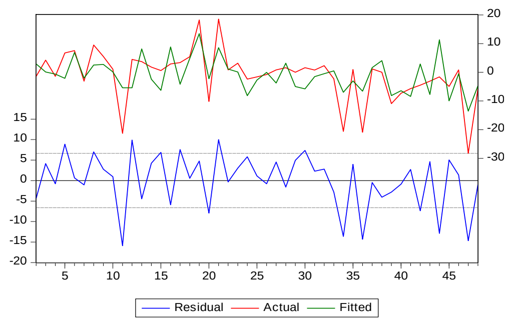
RBBK



RBRIT

RCFC





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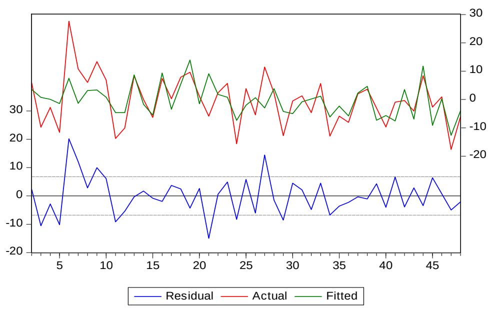

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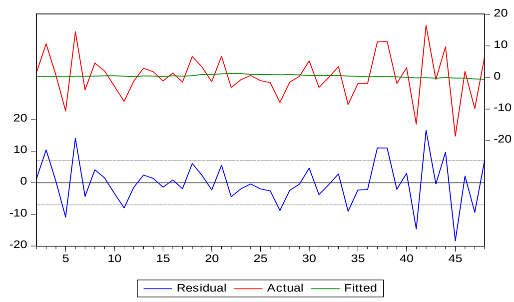

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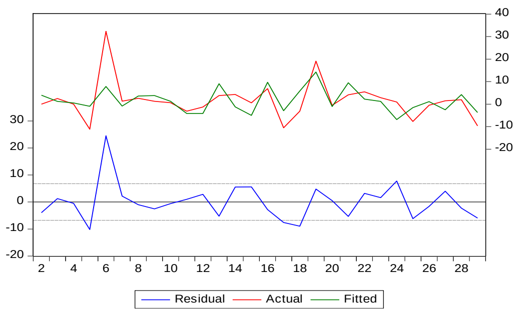

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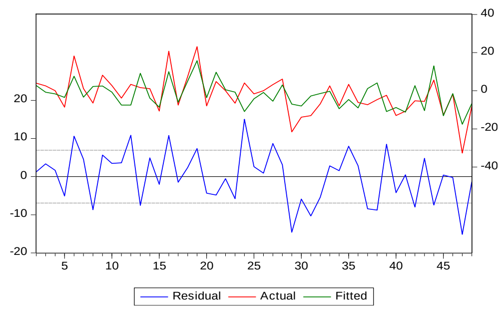

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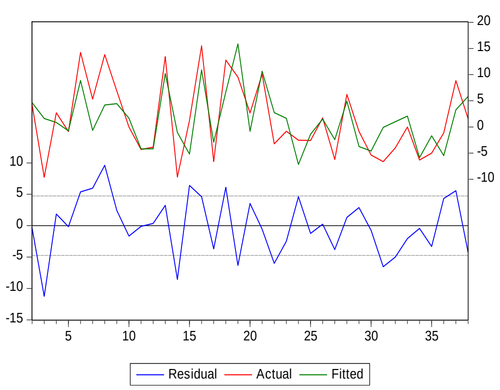

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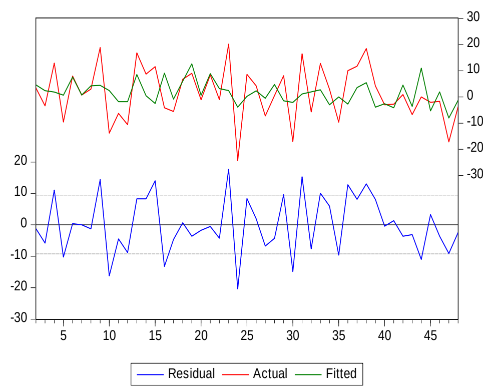

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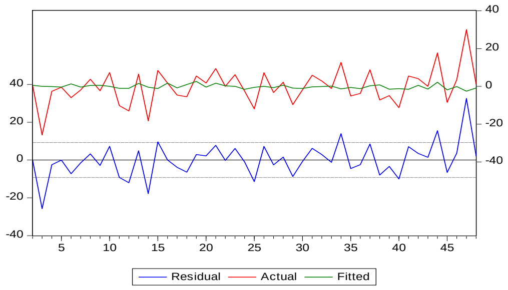

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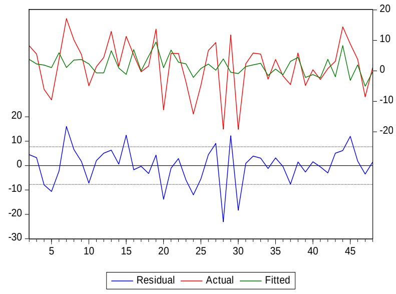

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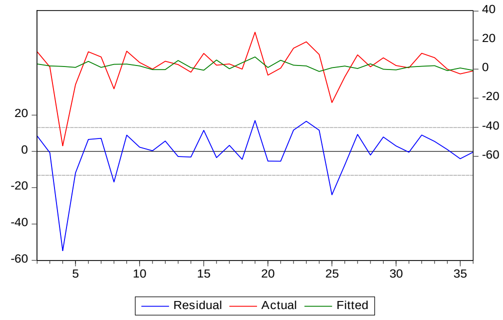

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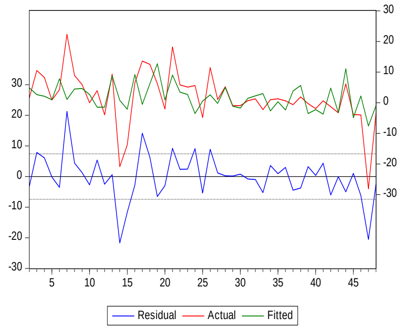

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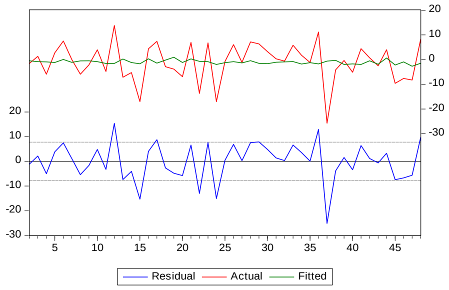
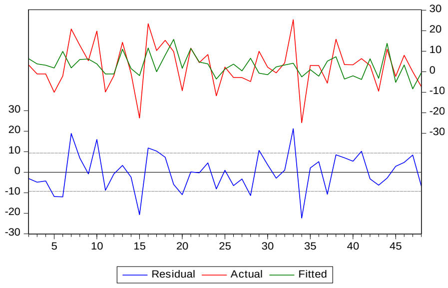


RSCAN



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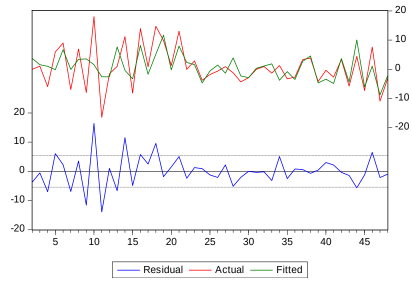

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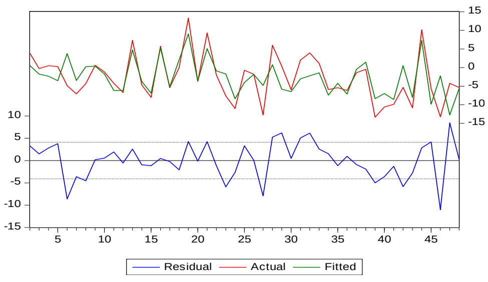
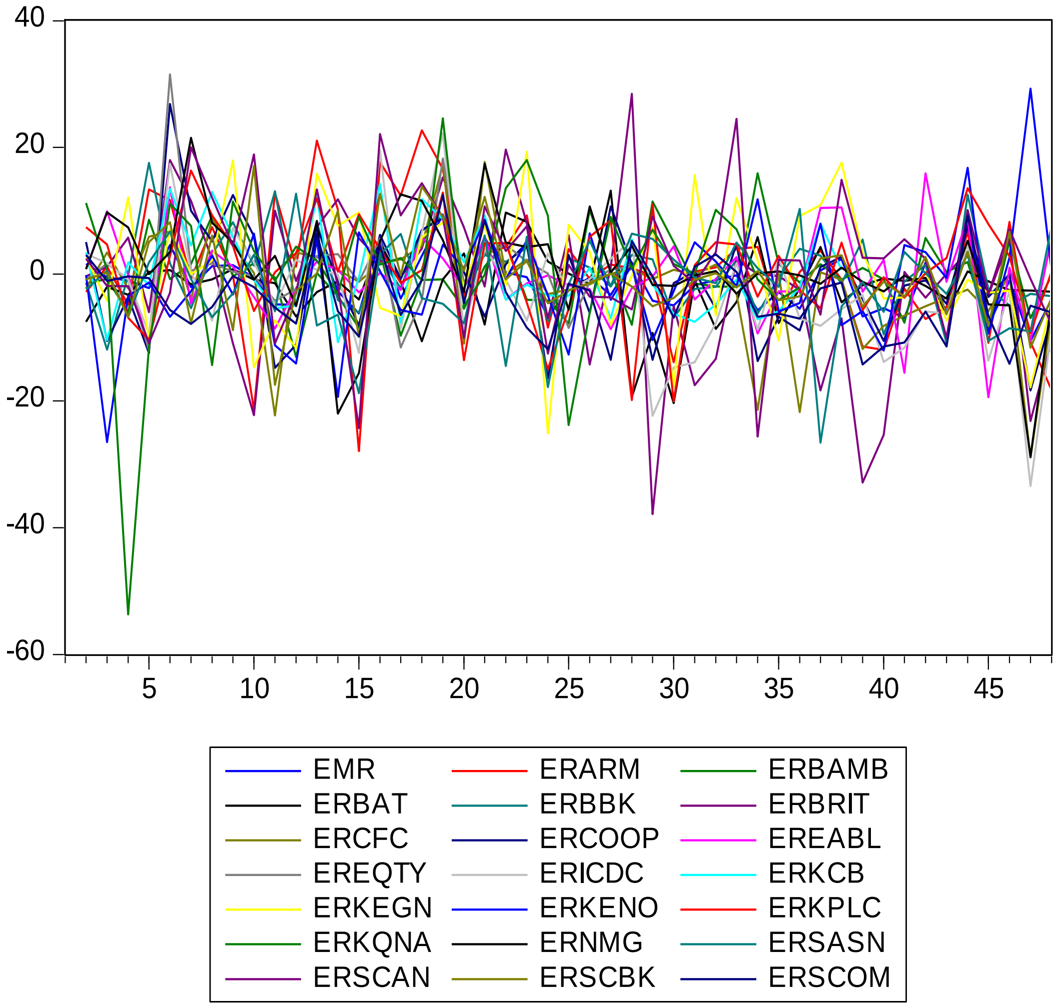


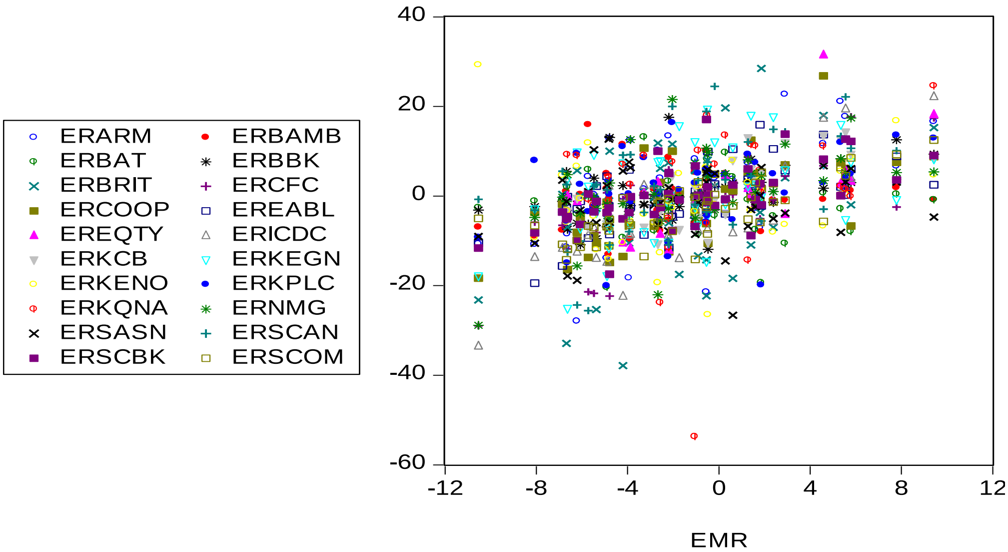
Excess returns series over the market and over each of the stock returns are generated by deducting the monthly risk-free rate from the continuously compounded returns. A plot of the excess returns over the risk free rate are show that the series appear to move together



Graph 1: A Plot of Excess returns over time

Source: Author's computation

A scatter plot of the excess returns will give a better view, as shown below



Graph 2: Scatter Plot

Source: Author's Computation

Overview of the CAPM

The CAPM formula can then expressed as

$E(R_{asset}) = R_f + \beta\,(R_{mkt} - R_f)$

Where

- $E(R_{asset})$ is the expected return of an asset
- R_f is the risk free rate
- β is the Beta
- R_{mkt} is the return on the market

If we subtract R_f from both sides of the CAPM equation described above to get excess returns, we have:

$E(R_{asset} - R_f) = R_f - R_f + \beta\,(R_{mkt} - R_f)$ -- (1)

This equation can be re-written as

$E(R_{asset} - R_f) = \beta\,(R_{mkt} - R_f)$ (Sharpe-Lintner CAPM)

Denoting the market risk premium $(R_{mkt} - R_f)$ by **Ω**, we have

$E(R_{asset} - R_f) = \beta\Omega$, -- (2)

Which can be rewritten as

$E(R_{asset}) = R_f + \beta\Omega$, since R_f is not a random variable. This equation is called the Security Market Iine.

Beta is a measure of risk which is calculated as follows

$\beta = \frac{Co\ (R_{asset}\ R_{mkt}\ )}{Var\ \ (R_{mkt}\ )}$

From equation (2), we can estimate a simple financial time series equation that is consistent with the CAPM

Let us denote the excess returns of a certain risky security to be:

R^{e}_{asset} , Then

$R^{e}_{asset} = \alpha + \beta\Omega + \omega_t$-- (3)

Where α is a parameter to be estimated while ω_t is a white noise process with mean 0

Taking the Expectation, we get

$E(R^{e}_{asset}) = E(\alpha) + \beta E(\Omega) + E(\omega_t)$, which becomes

$E(R^{e}_{asset}) = \alpha + \beta E(\Omega)$ -- (4)

Testing The CAPM using constant Betas

To test the CAPM using constant betas, excess stock returns are regressed against excess market returns .The regression equation is of the form:

$R^{e}_{asset\ ,t} = \alpha + \beta\left(R^{e}_{mkt\ ,t}\right) + \omega_t$

Where $R^{e}_{asset\ ,t}$ is the excess return of a stock over the risk free rate at time t and $R^{e}_{mkt\ ,t}$ is the excess return of the market over the risk free rate. Descriptive statistics of the returns data is summarized in this table.

Stock	Mean	Std. Dev.	Kurtosis	Jarque-Bera	Probability	Beta	Rank	t-statistic (for Beta)	Probability	Significance
ICDC	-2.1849	9.873912	4.633716	5.246224	0.07258	1.649	1	6.915721	0.00	Significant
KCB	1.38531	7.096818	2.20186	2.439242	0.29534	1.419	2	6.721415	0.00	Significant
ARM	1.5161	10.55483	3.174536	0.484179	0.78499	1.379	3	4.536975	0.00	Significant
CFC	-1.0643	8.736871	5.126762	15.21701	0.0005	1.337	4	5.858545	0.00	Significant
COOP	-0.3686	8.797582	3.689594	2.132523	0.34429	1.327	5	5.686127	0.00	Significant
EQTY	1.58435	8.408958	8.159648	46.15792	0	1.304	6	3.929607	0.00	Significant
SCAN	2.76283	10.57059	3.336722	0.503752	0.77734	1.213	7	3.785361	0.00	Significant
SCOM	-2.6738	6.176323	2.948586	1.695321	0.42842	1.087	8	7.70507	0.00	Significant
NMG	1.79126	8.525021	6.05004	24.10184	6E-06	1.028	9	4.042581	0.00	Significant
KEGN	1.52015	10.13266	2.708794	0.509794	0.775	1.02	10	3.220993	0.00	Significant
BRIT	-0.9830	13.18334	3.620461	3.320237	0.19012	1.017	11	2.780745	0.00	Significant
SCBK	0.69489	6.893071	3.339981	1.264171	0.53148	1.017	12	5.488987	0.00	Significant
EABL	0.44669	6.924604	3.690494	1.135581	0.56678	0.981	13	5.105719	0.00	Significant
KPLC	1.64408	8.243882	3.240963	3.166547	0.2053	0.708	14	2.671758	0.00	Significant
BBK	1.22052	6.111191	3.472911	2.230046	0.32791	0.69	15	3.71686	0.01	Significant

KQNA	2.04083	13.17901	10.0484	98.51844	0	0.607	16	1.027632	0.31	Insignificant
BAMB	0.52731	5.770823	3.444509	1.713471	0.42455	0.289	17	1.464781	0.15	Insignificant
KENO	-0.1864	9.193925	5.017668	8.447617	0.01464	0.265	18	0.835315	0.41	Insignificant
SASN	-1.0088	7.723208	4.092411	7.637114	0.02196	0.201	19	0.748621	0.46	Insignificant
BAT	-1.1924	6.041398	5.188365	12.03298	0.00244	0.017	20	0.078746	0.94	Insignificant

Table 1: Descriptive statistics of the returns data

Source: Author's computation

From the regression analysis, beta is statistically significant. Ranking the securities from the one with the highest beta to the one with the lowest beta shows that the security with the highest beta is not the one with the highest expected return. Neither does the security with the lowest beta have the lowest return. ICDC has the highest beta (1.649329) estimate but it actually has negative expected returns (-2.18494). From these results, the CAPM is clearly invalid in the NSE.s

The BEKK (1,1) Model

The BEKK (1,1) model (Baba, Engle, Kraft and Kroner (1995)) is a multivariate GARCH model which takes the form

$$H_t = C'C + A' \in_{t-1} \in'_{t-1} A + G' H_{t-1} G$$

From this equation, the terms $C'C + A' \in_{t-1} \in'_{t-1}$ form the ARCH part of the model while the terms $G' H_{t-1} G$ from the GARCH part of the model. Here,

- H_t is a 2 x 1 vector of the volatilities of the market return and of a certain stock
- $C'C$ is the intercept, which is a 2 x1 vector of ambient volatility, which is the value of the volatility when the other terms of the equation are 0.
- A is a 2 x 2 matrix of parameters which represent the degree to which the volatility at a certain time determines the volatility of the next period.
- $\in_{t-1}$ are the time lags
- G is the variance-covariance matrix. It is a 2 x 2 matrix which represents the sensitivity of the volatility at time t to the volatility at time t-1.

In the matrix notation, the model can be expressed as

$$\begin{bmatrix} \delta^2_{mkt} \\ \delta^2_{ai} \end{bmatrix} = \begin{bmatrix} C_m \\ C_{ai} \end{bmatrix} + \begin{bmatrix} a11 & a12 \\ a21 & a22 \end{bmatrix} \begin{bmatrix} \in_{t-1} \\ \in_{t-1} \end{bmatrix} + \begin{bmatrix} b11 & b12 \\ b21 & b22 \end{bmatrix} \begin{bmatrix} \delta^2_{mkt,t-1} \\ \delta^2_{ai,t-1} \end{bmatrix}$$

From this model, our interest is the variance covariance matrix which is then used to calculate time-varying betas.

Estimation of Time-Varying Betas

The parameters of the BEKK model are estimated by the method of Maximum Likelihood Estimation. The likelihood function:

$L(\emptyset) = -\frac{TN}{2} log 2\pi - \frac{1}{2}\sum_{t=1}^{T} \log(\,|H_t| + \in'_T\ {H_t}^{-1} \in_t\,)$ is maximized with respect to each parameter. $\emptyset$ is the set of parameters to be estimated

Alternatively, the parameters can be estimated by running the BEKK model in E-views. After estimating the parameters, the variance covariance matrix is obtained from where estimation of betas can done in the usual way for each month.

$$\beta_{i,t} = \frac{\sigma_{im},t}{\sigma^2_m,t}$$

Where

$\beta_{i,t}$ is the time-varying Beta estimate of a stock i

σ_{im},t is the covariance between the returns of asset i and the market portfolio

σ^2_m,t is the variance of the returns of the market portfolio

Each security has 47 different betas as shown in the table below.

Time-Varying beta schedule

SCOM	SCBK	SCAN	SASN	NMG	KQNA	KPLC	KENO	KEGN	KCB	ICDC	EQTY	EABL	COOP	CFC	BRIT	BBK	BAT	BAMB	ARM
1.946	0.810	0.800	0.330	0.301	1.842	1.327	0.191	2.641	1.944	2.385	2.658	1.615	2.542	0.822	2.714	-0.214	-0.106	-0.053	0.837
1.621	0.710	0.963	0.309	0.288	1.546	1.083	0.494	2.247	2.025	2.279	2.479	1.324	2.292	0.932	1.638	0.067	0.395	-0.035	1.026
1.437	0.716	1.105	0.292	0.291	1.243	1.286	0.842	1.972	2.254	2.196	2.580	1.309	2.518	1.016	1.867	0.276	0.461	0.001	1.178
1.370	0.695	1.220	0.278	0.302	1.188	1.456	1.001	1.811	2.409	2.130	2.620	1.197	2.719	1.081	1.840	0.434	0.509	0.037	1.263
1.322	0.595	1.412	0.266	0.318	1.136	1.335	1.089	1.737	2.441	2.074	2.463	1.301	2.797	1.132	1.980	0.554	0.565	-0.081	1.256
1.098	1.125	0.714	0.256	0.336	1.263	0.998	1.125	1.686	1.703	2.026	1.731	1.751	1.684	1.174	2.542	0.645	0.296	-0.031	1.468
1.213	1.057	0.747	0.248	0.357	1.066	1.368	1.144	1.439	1.863	1.985	1.793	1.592	1.986	1.209	0.598	0.715	0.355	-0.024	1.442
1.182	1.099	1.067	0.240	0.379	0.762	1.133	1.092	1.384	1.880	1.949	1.899	1.467	2.103	1.238	1.663	0.768	0.351	0.179	1.460
1.219	0.636	1.110	0.233	0.402	0.870	1.098	1.151	1.469	1.914	1.916	1.969	1.291	2.156	1.262	0.811	0.808	0.289	0.151	1.412
1.232	0.786	1.275	0.227	0.427	0.809	1.295	1.188	1.227	2.058	1.887	2.142	1.158	2.433	1.282	1.452	0.838	0.328	0.153	1.344
1.227	1.387	1.453	0.222	0.452	0.706	1.256	0.780	1.301	1.842	1.860	1.611	1.259	2.178	1.300	0.703	0.859	0.382	0.107	1.185

1.235	1.155	1.329	0.217	0.478	0.499	1.354	0.433	1.302	1.698	1.836	1.345	1.070	2.039	1.315	1.417	0.874	0.230	0.408	1.168
1.211	0.822	1.246	0.212	0.504	0.507	0.387	0.223	1.419	1.266	1.813	1.038	0.839	1.421	1.328	1.355	0.884	0.294	0.223	1.478
1.138	0.609	1.235	0.208	0.531	0.529	0.632	0.196	1.039	1.374	1.793	1.140	0.776	1.708	1.339	0.621	0.890	0.334	0.228	1.380
1.193	0.891	1.668	0.204	0.558	0.201	1.163	0.503	0.915	1.334	1.774	0.988	0.702	1.648	1.348	0.721	0.892	0.300	0.328	1.587
1.133	1.440	1.652	0.201	0.585	0.271	0.756	0.420	0.894	1.008	1.756	0.821	0.547	1.222	1.357	0.960	0.891	-0.139	0.293	1.730
1.099	1.161	1.329	0.197	0.613	0.235	0.819	0.427	1.039	1.079	1.739	0.891	0.557	1.434	1.364	0.765	0.888	-0.006	0.369	1.526
1.098	1.456	1.382	0.194	0.641	0.237	0.888	0.592	1.026	1.084	1.723	0.942	0.691	1.479	1.371	1.140	0.884	0.360	0.276	1.631
1.168	1.412	0.848	0.191	0.668	1.259	-0.137	0.241	1.109	0.681	1.709	0.604	0.526	0.798	1.376	1.385	0.878	0.204	0.095	1.768
0.971	1.178	0.910	0.188	0.696	1.298	-0.002	0.328	0.899	0.817	1.695	0.705	0.523	1.034	1.381	0.184	0.871	0.258	0.117	1.638
1.104	1.425	0.907	0.185	0.724	1.095	0.036	0.146	0.993	0.743	1.682	0.663	0.629	0.982	1.385	0.616	0.863	0.495	0.114	1.521
1.031	1.187	0.929	0.183	0.752	1.157	0.233	0.242	0.860	0.889	1.669	0.791	0.579	1.238	1.389	1.006	0.855	0.343	0.138	1.439
1.101	1.028	0.992	0.181	0.780	1.139	0.485	0.333	0.895	1.037	1.658	0.934	0.566	1.536	1.392	0.948	0.846	0.286	0.129	1.373
1.206	0.965	1.196	0.178	0.808	0.615	-0.118	0.298	1.211	0.963	1.647	0.766	0.458	1.346	1.395	1.221	0.837	0.407	0.177	1.378
1.133	0.867	1.164	0.176	0.836	0.865	0.106	0.296	0.818	1.078	1.636	0.876	0.473	1.624	1.397	0.750	0.827	0.403	0.228	1.299
1.187	0.771	1.154	0.174	0.864	0.823	0.377	0.397	0.860	1.227	1.626	1.029	0.478	1.946	1.399	1.229	0.817	0.384	0.238	1.248
1.278	0.681	1.215	0.172	0.891	0.595	0.791	0.440	0.904	1.287	1.617	1.075	0.621	2.139	1.401	1.252	0.807	0.582	0.185	1.198
1.267	0.570	0.950	0.170	0.919	0.576	1.549	0.501	0.846	1.362	1.608	1.193	0.544	2.200	1.402	2.695	0.797	0.887	0.003	1.166
1.169	0.684	0.775	0.168	0.947	0.358	1.795	0.378	0.794	1.378	1.600		0.511	2.149	1.403	2.800	0.787	0.600	-0.253	1.137
1.213	0.724	0.811	0.167	0.974	0.287	0.761	0.404	1.017	1.318	1.592		0.315	2.035	1.404	1.000	0.777	0.067	-0.285	1.214
1.204	0.679	0.969	0.165	1.002	0.301	0.949	0.547	0.815	1.445	1.584		0.382	2.337	1.405	1.591	0.768	0.129	-0.216	1.179
1.242	0.651	1.089	0.163	1.029	0.299	1.100	0.659	0.846	1.591	1.577		0.427	2.628	1.405	1.412	0.758	0.192	-0.157	1.153
1.259	0.610	1.364	0.162	1.057	0.338	1.186	0.768	0.871	1.732	1.570		0.498	2.848	1.406	1.709	0.749	0.247	-0.112	1.138
1.230	0.488	1.963	0.160	1.084	0.320	0.887	1.066	0.820	1.475	1.563		0.821	2.170	1.406	1.139	0.739	0.518	-0.577	1.065
1.222	0.571	1.678	0.159	1.111	0.378	1.077	1.010	0.889	1.546	1.557		0.810	2.359	1.406	1.333	0.730	0.413	-0.464	1.081
1.213	0.656	1.228	0.158	1.138		0.900	0.799	0.738	1.422	1.551		0.749	2.014	1.406	1.235	0.721	0.377	-0.229	1.058
1.190	0.681	1.081	0.156	1.166		1.165	0.788	0.879	1.532	1.545		0.901	2.243	1.406	0.734	0.712	0.280	-0.147	1.064
1.178	0.744	1.327	0.155	1.193		1.016	0.952	0.974		1.540		1.146	2.157	1.406	0.999	0.704	0.356	-0.093	1.044
1.274	0.836	0.923	0.154	1.219		0.599	0.643	0.779		1.535		0.922	1.704	1.406	3.098	0.695	0.343	-0.079	1.148
1.205	0.721	0.826	0.153	1.246		0.670	0.382	0.861		1.530		0.667	1.642	1.405	1.550	0.687	0.369	-0.034	1.213
1.176	0.728	0.586	0.152	1.273		0.487	0.532	0.860		1.525		1.116	1.424	1.405	0.577	0.679	0.375	0.164	1.179
1.073	0.727	0.697	0.151	1.300		0.698	0.555	0.805		1.521		1.309	1.633	1.404	0.896	0.671	0.338	0.221	1.105
1.199	0.873	0.986	0.150	1.326		0.817	0.531	0.899		1.517		1.029	1.481	1.404	0.829	0.664	0.169	0.137	1.126
1.142	0.814	0.837	0.149	1.353		-0.091	-0.071	0.748		1.512		1.047	0.973	1.403	0.775	0.656	0.044	0.127	1.161
0.957	0.955	0.771	0.148	1.379		0.456	-0.154	0.814		1.509		1.378	0.917	1.402	0.574	0.649	0.124	0.244	1.233
1.005	0.848	0.823	0.147	1.405		0.608	-0.036	0.769		1.505		1.266	1.179	1.402	0.690	0.642	0.158	0.237	1.188
0.905	1.183	0.581	0.146	1.432		-0.038	0.832	1.124		1.501		1.168	0.775	1.401	1.757	0.636	0.123	0.262	1.275

Table 2: time-varying beta schedule

With these time-varying betas, a regression model of the form of $R^{e}_{asset} = \alpha + \beta\Omega + \omega_t$ is run to test the validity of the CAPM in the NSE as done with the constant betas.

Hypothesis tests show that these time-varying betas have an effect on the excess returns.

From these betas, we can form various return and beta combinations that validate the CAPM as shown in the table below.

	Mean	Beta	Beta combinations which validate the CAPM				
SCOM	-2.6738	0.904673					0.90467
ICDC	-2.18494						1.501
BAT	-1.19243		0.295662	0.169	0.328		
CFC	-1.06435	0.932067				0.932	
SASN	-1.00889		0.330242	0.183	0.33		
BRIT	-0.98305	1.006049	0.775418	0.184		0.999	1.55
COOP	-0.36866	1.03443	0.79776			1.034	1.638
KENO	-0.18643	1.151067	0.832205	0.378	0.378	1.092	
EABL	0.446685	1.168294	0.83918	0.382	0.382	1.116	1.751
BAMB	0.527311			0.408	0.408		
SCBK	0.694888	1.183113	0.8912	0.8912	0.8912	1.183113	
BBK	1.220523		0.891728	0.891728	0.891728	1.220523	
KCB	1.385306	1.286696	1.286696	1.286696	1.286696	1.286696	1.863
ARM	1.516096	1.299156	1.299156	1.299156	1.299156	1.299156	
KEGN	1.520149	1.300745	1.300745	1.300745	1.300745	1.300745	
EQTY	1.584346	1.34536	1.34536	1.34536	1.34536	1.34536	1.899
KPLC	1.644081	1.368021	1.368021	1.368021	1.368021	1.368021	
NMG	1.791259	1.431674	1.431674	1.431674	1.431674	1.431674	
KQNA	2.040827	1.545531	1.545531	1.545531	1.545531	1.545531	
SCAN	2.762833	1.668359	1.668359	1.668359	1.668359	1.668359	1.963

Table 3: Beta and return combinations which show validity of the CAPM

Source: Author's computation.

Conclusions

Testing the CAPM on the individual stocks of the NSE show that the CAPM is invalid, since high betas are not associated with high returns and low betas are not associated with low returns. Using beta as a point estimate limits the researcher to only one outcome. However, when betas are modelled as random variables which vary over time, they give a more realistic picture of the economic reality underlying the trading of stocks in the market. For a specific stock, beta takes a wide range of values depending on the movement of the market index. In fact, beta is negative for some firms at certain times. This is because is possible for a stock to move in the reverse direction to the movement of the market, though such incidences are rare.

From the combinations of beta which validate the CAPM in the NSE above, it is very that if the aspect of time-variation of the beta estimate is considered, then the CAPM is more verifiable in the NSE. This variation should not be ignored. Time varying betas therefore make CAPM more valid in the NSE.

Recommendations

From the findings of this study, it is clear that the. Overall, it is important to put to test the various assumptions of the CAPM. This study tested the assumption that the estimates of the variance and covariance are the same for all investors over the test period. There is significant evidence that the use of time varying variances and covariances instead of a constant ones can improve the validity of the CAPM in the NSE. Other assumptions of this model should be tested to make it more useful in pricing securities at the NSE.

In this study, monthly returns have shown that time-varying beta improves the validity of the CAPM to a certain extend. Daily or weekly data can be used to get daily/weekly betas to further improve on the Beta estimate. Also, in this study, variation of beta was studied while holding returns constant. The aspect of time varying returns can also be modelled together with time-varying betas to further improve on the validity of the CAPM. More firms should also be included to make the test more robust.

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