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

BY

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DECLARATION

Declaration by the candidate

I hereby declare that this study is my original work, which has never been produced for a degree at The University of Nairobi or any other university.

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Declaration by the Supervisor

This dissertation has been submitted for examination with my approval as University Supervisor.

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DEDICATION

Special dedication to my late father, Mr. Joseph Mumo Ndutu who always believed in my abilities. May his soul rest in eternal peace.

ABSTRACT

There has been a lot of research on the validity of the CAPM in the NSE. Majorly, the findings are mixed- some researchers report that the CAPM is valid while others report that it is not. Most of the previous tests of the CAPM were based on the CLRM, which assumes that variances are homoscedastic, among other assumptions. This paper examines this assumption and its effect on the quality of the beta estimate of the CAPM.

In the CLRM, beta is a point estimate of the covariance between the market return and the return of a particular asset. It is therefore a constant. When heteroscedasticity is factored in, variances vary with time, hence beta varies with time as well. Several econometric models have been proposed to model time-varying betas. The most common model is the GARCH model, which forms the basis of this study.

The data is first tested for 'ARCH effects' to determine whether the GARCH model can be used to estimate it. The test shows that models of the ARCH type can be fitted on the data. A multi-variate GARCH model of the Diagonal BEKK type is then fitted on the monthly returns of the 20 companies that form the NSE 20-share index from 1St January 2013 to 31st December 2016. Time-varying betas are then calculated and CAPM re-tested using these betas. The results are that time-varying betas improves the validity of the CAPM on the NSE.

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LIST OF ABBREVIATIONS

APT	-	Asset Pricing Models
BEKK	-	Baba, Engle, Kraft and Kroner
NSE	-	Nairobi Stock Exchange
CAPM	-	Capital Asset Pricing Model
CLRM	-	Classical Linear Regression Model
GARCH	-	Generalized Autoregressive Conditional Heteroscedasticity
NASI	-	Nairobi All Share Index
VECH	-	Vector Error-Correction Heteroscedastic
WACC	-	Weighted Average Cost of Capital
DCC	-	Dynamic Conditional Correlation

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Capital markets are crucial in the economic development of any country. Considering the risk and uncertainties of investments, investors are in dilemma when choosing investments. There are several ways of choosing the assets to invest in, such as the Dividend Growth Model and the CAPM. The CAPM suggests a more predictable way of determining the overvalued and undervalued securities in the market and making an appropriate investment decision. That is why extensive research on its validity has been going on for a long time.

The portfolio theory (Markowitz, 1952) explained how investors can choose efficient portfolios from a set of securities. According to this theory, 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 computations.

Sharpe (1965) and Lintner (1965) brought a breakthrough in the research on capital markets when they extended Markowitz Portfolio Theory into the CAPM. Ross (1976) took over from where Sharpe and Lintner had left and formed the Arbitrage Pricing Model. There have been several extensions of the CAPM as research on its applicability continues. Indeed, since the CAPM was introduced, it has been tested and re-tested by scholars all over the world. The results are mixed- some support it while others reject it- but the application of the model in finance continues. For this reason, it is important to continue testing it through different methods.

Valid or not, the CAPM is widely used in the NSE in pricing and valuation of assets. It is still used to measure the cost of equity, to determine the best mix of debt and equity and to value value. There is therefore the need to continue subjecting it to different tests so that investors, financial analysts and managers can know the risks they take whenever they employ it as a measure of value. In this paper, I will examine the effect of time-varying betas on the validity of the CAPM on the NSE.

1.1.1. An Overview of the CAPM

The CAPM is one of the many models of asset returns. According to Sharpe (1964) and Lintner (1965) the CAPM takes the form:

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

Where $E(R_{asset})$ is the expected return of a risky security, R_f is the risk free rate and $R_{mkt}$is the return on the market. According to this model, the return on of a risky security in a financial market depends on the risk-free rate and the risk premium.

The CAPM quantifies the risk of a certain security and uses this risk to estimate the expected return. Being a single factor model, it relates this return to only one factor- the sensitivity of the return of a certain security to the return of the entire market. This sensitivity is measured by beta. It is based on a number of assumptions and it therefore has several limitations. For it to be applicable, several conditions must also hold to avoid anomalies in the pricing of stocks.

The CAPM itself is also based on various assumptions. Some of these assumptions include: Investors have identical one-period horizon, the market is perfect, the estimates of expected returns, variance and covariance are the same for all investors, borrowing and lending is done at the risk-free rate and the same currency is used for measurement. Clearly, most of these assumptions are unrealistic. Further tests on the CAPM should avoid most of these assumptions.

1.1.2. Beta and the CAPM

The single factor CAPM relates the return of a risky security to Beta. Beta measures systematic risk and it is therefore the most important parameter in the CAPM. According to the Harvard Business Review (HBR, 1982), empirical studies show that beta is linearly related to the past returns of risky securities. This supports the CAPM linear structure. However, one of the problems encountered when applying the CAPM in real life situation is the instability of beta. Beta changes with the changes in the operating, investing and financing activities of a firm which constitute changes in the risk profile of the firm.

1.1.3. Time-varying Beta

In the linear CAPM, beta is a constant. It is the slope of the regression equation. While the estimation of beta using the CLRM can be improved by forming portfolios, the fact that beta may vary randomly over time is ignored in this model. It is possible for beta to remain constant. However, with everyday changes in the activities of the business, you expect it to change with time to reflect economic reality. In fact, there could be a different beta value for every day. As Beta varies, the expected return of a stock according to the CAPM equation varies. This makes it important to consider the aspect of time-varying betas when determining the validity of the CAPM in the NSE.

1.1.4. The Nairobi Securities Exchange

According to the Capital Market Authority's Quarterly Statistical Bulletin for the quarter ended June 2017, there were 68 listed companies in the Nairobi Stock Exchange as at 30th June 2017. However, these companies have reduced to 64 after the delisting of Hutchings Biemer, Marshalls East Africa and A. Baumann.

Founded in 1954, the Nairobi Securities Exchange is a member of the African Securities Exchange Association. Trading in stocks and bonds are the main trading activities. Other investment options offered by the NSE include the NSE clear limited and Central depository and Settlement Corporation Limited. Its main indices of performance are the NASI, NSE 20 share index, FTSE NSE indices and Chuley. The NSE is itself listed on the exchange. It is a corporate body with a board of directors consisting of 11 members.

1.2. Research Problem

Most investors use the CAPM to make investment decisions. This has led to the interest in testing of the model on the NSE to determine its validity. Consequently, the CAPM has been tested on the NSE by many researchers, giving contradictory results. These results have triggered more research on the verifiability of the model on the NSE. For example, 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 test on the CAPM in both cases were based on a regression model. Another study had earlier invalidated the CAPM at the NSE (Otieno 2009).

It is arguable that in the tests for the CAPM in the NSE and other markets in the world, the problem lies in the estimation of the parameters of the model. For instance, it is not easy to calculate the return on the market. The proxies used for the market return, like the NASI used in this paper, are inadequate (Richard Roll (1977)). If all the parameters are estimated correctly, the verifiability of the CAPM on a certain stock market would be easier to estimate. Tests of the CAPM using more accurate estimates are therefore important since its use is still widespread. The current study improves the beta estimate by modelling it as a random variable rather than a constant.

From the equation above, it is clear that the CAPM is a linear model. Indeed, its linearity in the NSE is verifiable (Otieno V.O, 2009). That is why previous studies on the CAPM are based on the CLRM. These studies are based on several assumptions. Precisely, the CLRM assumes that errors are normally distributed with a mean 0 and finite and constant variance δ^2. The errors are also assumed to be linearly independent and also independent of the corresponding x variates. Each of these assumptions has its own implications. Previous studies on the CAPM on the NSE have ignored these possible implications. This paper focuses on the assumption that the errors have a constant and finite variance, i.e. $(Var\,(\lambda_t) = \delta^2 > \infty)$, where λ_t are the errors. The study proceeds without making this assumption to determine whether such a move can improve the validity of the CAPM on the NSE. In support of the move, studies have shown that with most financial time series data, the variance of the errors vary with time. This is the motivation behind ARCH models, which estimate conditional volatility (variance).

When the errors have finite variance, they are said to be homoscedastic. However, when the variance varies with time, they are said to be heteroscedastic. 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 heteroscedasticity exists in stock returns.

The assumption that the variance of the errors is finite therefore does not hold. On top of the homoscedasticity assumption, the adoption of the CAPM as a linear regression is unsuitable in modelling various relationships in finance in the first place. Linear models in finance cannot explain several stylized facts of financial time series data such as leptokurtosis, volatility clustering and leverage effects (Brooks, 2008). They are therefore not reliable.

To begin with, 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 modelled more accurately, non-linear models should be used to estimate its parameters, especially beta.

A non-linear model can be non-linear in mean, variance or both. Since beta is a function of covariance and variance, a model that is non-linear in variance is suitable in estimating it. The GARCH model is an example of such a model. In this study, the data is tested for the presence of ARCH effects to determine whether the GARCH models are suitable for estimation of various relationships of the data. The same concept is extended to allow for fitting of multivariate GARCH models which are used to estimate time-varying betas.

In addition, in the linear regression CAPM, estimation of beta is based on historical data. Investors are usually interested in the future, not the present. That is why this study suggests that the multivariate GARCH model of the BEKK can be used to estimate time-varying betas so that an investor can forecast the betas in the coming periods and make sound investment decisions today. The BEKK model is used to predict the covariances between a particular asset and the market and the variance of the market. These forecasted values are used to estimate a beta that varies with time.

In all the previous tests of the CAPM on the NSE, the issue of time-varying beta is not studied. Overall, the applicability of time-varying betas in the CAPM has not been studied extensively in finance. In the NSE situation for instance, GARCH models are fitted on data to estimate volatility, not beta, (Mekoya, 2013 and Noah M, 2013). Though volatility is a measure of risk just like Beta, it is measured by the variance or standard deviation of time series data. Unlike Beta, it does not consider the movement of the whole market. This study therefore comes at a time when research on the effect time-varying beta is needed to determine where things stand as far as the validity of the CAPM on the NSE is concerned.

1.3. Objectives of the Study

To determine whether the use of time varying beta instead of a constant beta can improve the validity of the CAPM in the NSE

1.4. Value of the Study

This study is useful to various classes of people in the finance and investments world. Investors will use it to make sound investment decisions. The CAPM is widely used as a measure of performance. For this reason, investors use it to determine the securities to invest in, hold or sell. This research helps these investors make informed decisions. Systematic risk, which is measured by Beta is an investor's major concern. Its estimation is therefore very important to investors.

The CAPM states that the expected return on a financial instrument is a function of the risk free rate and the risk premium. According to the Investopedia, where the CAPM holds, a stock should be able to earn the return that is equivalent to its cost of equity, otherwise its price will fall. If a company cannot earn this return, it is only fair that it lets its shareholders invest elsewhere and earn it. Investors can use the CAPM to make a decision on whether to hold their investments in a certain security or invest elsewhere.

Financial analysts also use the CAPM to determine the value of companies during acquisitions and mergers, and will find this study very useful. For each firm in a merging or acquisition agreement, the cost of equity and the WACC is calculated. These values are then compared to the cost of equity and WACC of the merged firm to determine the effect of conducting business jointly. If the merger/ acquisition adds value to the firms, then the agreement can be executed.

This study will also be useful to general managers and risk managers of various firms. They also use the CAPM to determine the appropriate level of acceptable risk in the firm depending on their risk appetite. The beta of the firm is a good measure of the overall risk of the firm. It is a measure of the volatility of the firm compared to the volatility of the market.

Researchers and academicians will also find this study useful as a basis for further research. More complex GARCH models can be used to model the volatility of stock returns and therefore improve the beta estimate more in a bid to validate the CAPM in various stock markets.

CHAPTER TWO

LITERATURE REVIEW

2.1.Introduction

Since the development of the portfolio theory by Markowitz in 1952, there has been several studies on the validity of the CAPM on various stock markets. This chapter summarizes the results of some of the past studies on the validity of the CAPM.

2.2.The Theoretical Review

As explained earlier, the CAPM was introduced after the portfolio theory. This section explains three theories that form the basis of this study. These theories include the Mean Variance Portfolio Theory, the volatility of asset returns and conditional betas.

2.2.1. The Mean-Variance Portfolio Theory (MPT)

According to the MPT theory (Markowitz, 1952), rational investors only consider risk and return or mean and variance when making investment decisions. They expect higher returns where they have taken higher risks and vice versa. Consequently, MPT theory specifies how to construct efficient portfolios- those that provide the highest return for a specific risk or the lowest risk for a specific return. The set of efficient portfolios form the efficient frontier. The MPT is not easy to implement because of computational difficulties and that is why the CAPM was introduced Sharpe and Lintner in 1964 and 1965 respectively. The basic principles underlying the CAPM are that investors should be rewarded for taking risks- mainly the systematic risk and the time value of their investments. Generally, investor’s reasonable expectations are that the return on their portfolios will be higher than the risk free rate.

The extension of the MPT to the CAPM meant that more assumptions had to be made.

Precisely, investors are assumed to have homogeneous expectations. They therefore have the same efficient frontier. Since the risk-free rate of return is assumed to be the same, the efficient frontier is a straight line, known as the capital market line.

2.2.2. Volatility of Asset Returns

Asset returns are volatile. Measured by the standard deviation or variance of a stock returns, volatility, just like beta is a good measure of risk. It occurs in clusters, and it evolves over time. It also varies within a given range. It reacts differently to good and bad news.

There are several models of the ARCH type that have been used to estimate the volatility of stock returns. The ARCH models are the simplest of such models. Simple ARCH models have several limitations, and that is why the GARCH models were introduced. These models have been proven to be very effective in modeling volatility and predicting stock returns. Indeed, tests have shown that GARCH models and APT models are more accurate in predicting expected stock returns than the CAPM (Groenewold and 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. These studies pave way for more studies on the use of the GARCH models in predicting the volatility of stock returns. In particular, this study uses the Multivariate GARCH model of the BEKK type to improve the beta estimate of the CAPM.

2.2.3. Dynamic Betas

The equilibrium CAPM gives the expected return of an asset at a given period of time. Under this constant CAPM, the beta parameter is constant. However, the returns of securities are known to be very volatile, changing every other. This means that the risk premium, which is the independent variable in the CAPM is also volatile. It may also mean that the beta is volatile.

Beta is a measure of volatility in the market. This volatility varies, and so does the beta estimate. As these values change, the level of risk also changes with time. Under the dynamic CAPM, variances and covariances vary with time. Consequently, expected returns also varies 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. The results were that there is 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 DCC 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. These results gave me more reasons to apply the concept of time-varying betas on the test of the CAPM on the NSE.

2.3.Empirical Review

The CAPM has been tested severally on both sable and emerging markets. In the NSE for instance, it has been tested by several scholars. To begin with, Otieno, (2009) tested CAPM on 48 listed firms at the NSE. He used monthly adjusted stock returns of the 48 companies from 1998 to 2010. His findings were that while the linear structure of CAPM is supported at the NSE, higher beta didn't give higher returns, as CAPM asserts. The study thus negates the CAPM. He adopted the Black et al (1972) testing methodology of the CAPM. Later, Were (2012) tested the CAPM on weekly returns at the NSE and negated Otieno's findings. She used weekly NSE data for 20 companies which formed the NSE 20 share index then from January 2005 to June 2012. The companies were grouped into 4 portfolios, each having 5 stocks. The CAPM was tested on each of these portfolios and the findings were that the portfolio with the lowest beta had the lowest return and vice-versa. The study thus supported the validity of CAPM, amid the presence of the size, value and momentum anomalies of beta estimates. In this paper, I will shed more light on the momentum anomaly which can be described by volatility clustering.

Otieno (2013) further studied CAPM's validity in the Nairobi Securities Exchange in 2013. Through simple regression, he tested the model on 30 firms listed on the NSE using a 4-year data set from 1st January 2009 to 31st Dec 2012. His results are that CAPM is not valid in the NSE. Stocks with higher (lower) betas did not have higher (lower) returns, even after portfolios were formed to enhance the accuracy of the beta estimate. He recommended that more firms can be included in the study and GARCH models be used to characterize the risk-return relationship implied by the CAPM, which I do in this paper. 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 (2013). She also found no substantial evidence on the applicability of the Fama-French three-factor model.

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.

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, P, Agalega, E, (2013). Acheampong and Agalega's 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, Acheampong and Agalega 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 is not valid for the GSE. They also used the Fama and MacBeth (1973) technique and got the same results.

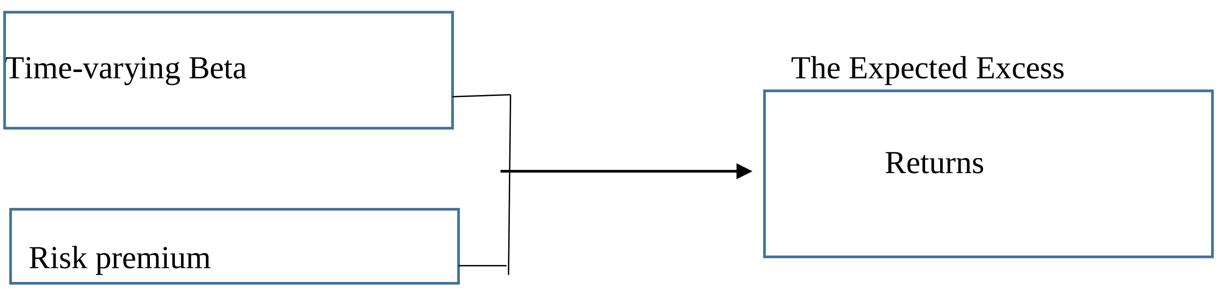
Elsewhere, Alqisie, A, (2016) tested the CAPM on the Amman Stock Exchange using monthly returns data of companies listed on the Amman Stock Exchange. He used the techniques applied by Black, Jensen and Scholes (1972) and concluded that the CAPM was invalid for the ASE. The results of the Fama and MacBeth (1973) on the same data set yielded the same results. CAPM tests on the Karachi Stock Exchange however give 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 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.

With these contradictory results, the testing of the CAPM on the NSE merits more research. This study provides the basis for further research in the testing of the CAPM on the NSE by avoiding the unrealistic assumption that the errors of returns have constant variance.

2.4. Conceptual Framework

This study is concerned with the effect of time-varying beta on the validity of the CAPM in NSE. Time varying betas and the risk premium are thus the independent variables or the input. The excess returns is the dependent variable or output. The relationship between time-varying beta and expected returns is studied.



2.5. Conclusion of the Literature Review

The various tests of the CAPM that proof its invalidity in various stocks point out to the limitations of the CAPM, which include the fact that it assumes that firms are only subjected to market risk. There are other risks such as credit risk and operational risk which also affect the level of expected return. Most previous tests on the CAPM were also based on constant betas. Since heteroscedasticity has been proven to exist in majors stock markets, it is important to test the CAPM with heteroscedasticity in mind.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1.Introduction

In this chapter, I will explain how I got the data, the approach I will adopt throughout the study and how I intent to analyze the data.

3.2.Research Design

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 perception that the CAPM is invalid 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. It gives reasons why the CAPM test may be negative at the NSE.

3.3.The Population

The population in this study is the entire market portfolio. According to Investopedia, the market portfolio consists of all the assets/investments of all forms in the financial market in the world. In the current study, the market portfolio is taken to be the total number of firms listed on the NSE, which is 68.

3.4.Sample Design

A suitable representative of the market portfolio is chosen to be the NSE 20 share index. 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.

3.5.Data Collection

Historical data for the NSE 20 share index will be obtained from the NSE. The Nairobi Securities Exchange record historical price data accurately and stores this data in a retrievable format for future reference.

3.6.Data Analysis

This study uses monthly returns data of the firms that make up the NSE 20 share index from January 2013 to December 2016.

Continuously compounded stock returns will be calculated using the formula:

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

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

The CAPM formula is expressed as

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

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:

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

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)

In this paper, the annualized average rates of return on the 91-day treasury bills issued within the period of study 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.

3.6.1. Estimation of Time-Varying Betas

Time-varying beta will be estimated using the variance covariance matrix of the BEKK model fitted on the returns on the market series and the returns on a specific stock series. The BEKK model will be run in E-views. From the model, the variance covariance matrices can be obtained, from where estimation of the Beta can done in the usual way for each month.

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

Where

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

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

σ_{m}^{2}, t is the variance of the returns of the market portfolio

3.6.2. 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.

These parameters will be estimated by maximizing the likelihood function below with respect to each parameter:

$$L(\emptyset) = -\frac{TN}{2} log2\pi - \frac{1}{2}\sum_{t=1}^{T} \log(|H_t| + \in'_T \ {H_t}^{-1} \in_t)$$

Where $\emptyset$ is the set of parameters to be estimated

Alternatively, the parameters can be estimated using Eviews which has a packaged program for estimating these parameters.

In the matrix notation, the model can be expressed as

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

From this model, I will only be interested in the variance covariance matrix which I will use to calculate time-varying betas. After time-varying betas are obtained, a regression model of the form of $R_{asset}^e = \alpha + \beta\Omega + \omega_t$ (as in equation 3 above) will then be run. Hypothesis testing will then be done to determine whether time-varying betas have an effect on the excess returns.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSION

4.0. Introduction

This study focuses on the estimation of time-varying betas and determining their effect on the validity of the CAPM in the NSE. The Eviews software 9^{th} edition is used in data analysis in this study. The monthly stock price data used for this study is found in Appendix II. 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.

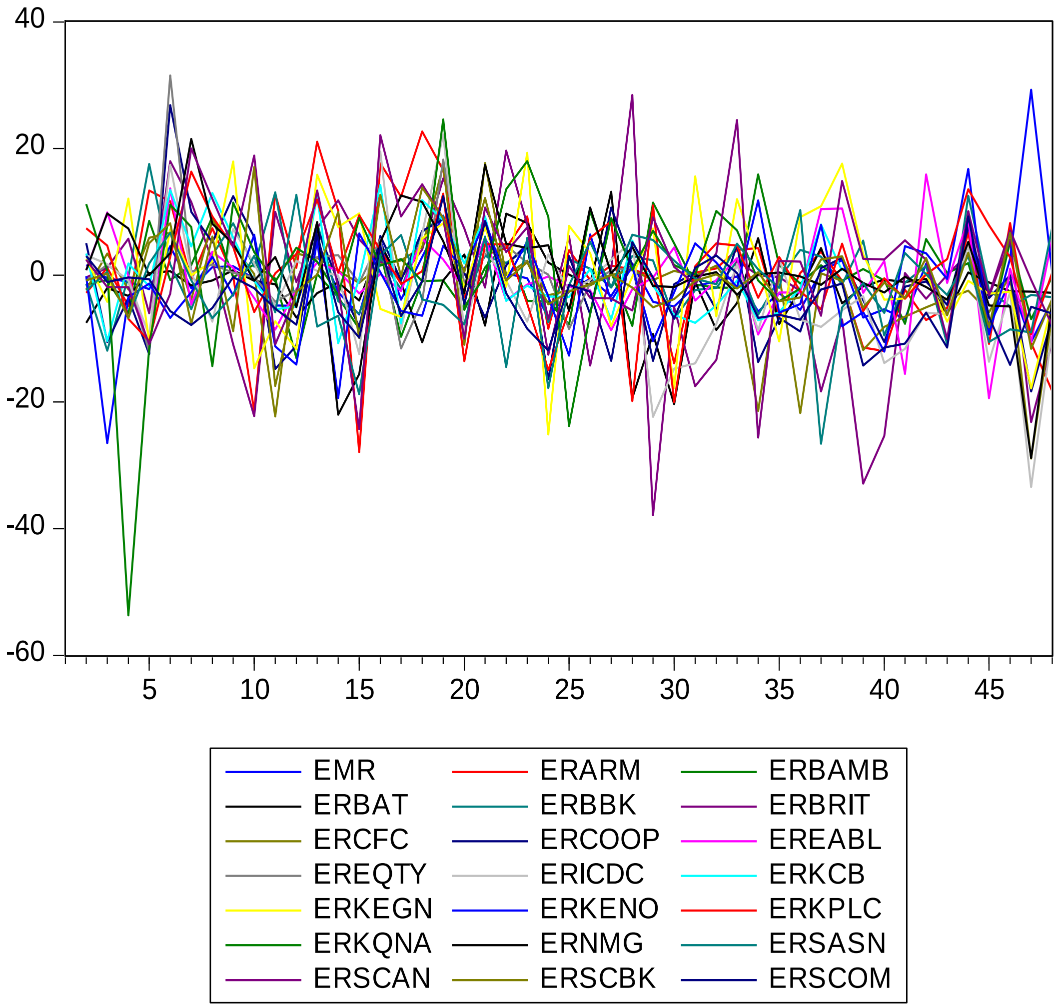
4.1. Diagnostic Tests on the Data

Various statistical tests are done on the data to check for the presence of the stylized facts of financial data. Precisely, QQ plots (Appendix I) are drawn to show volatility clustering where large changes in stock prices are followed by large changes and small changes are followed by small changes. As shown in Table 1, the data is also leptokurtic, with a kurtosis of more than 3 in most cases.

Residual plots of each of the stock returns series are also drawn to tests for heteroscedasticity. As seen from the Appendix I, 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.

4.2. Analysis of the data and presentation of results

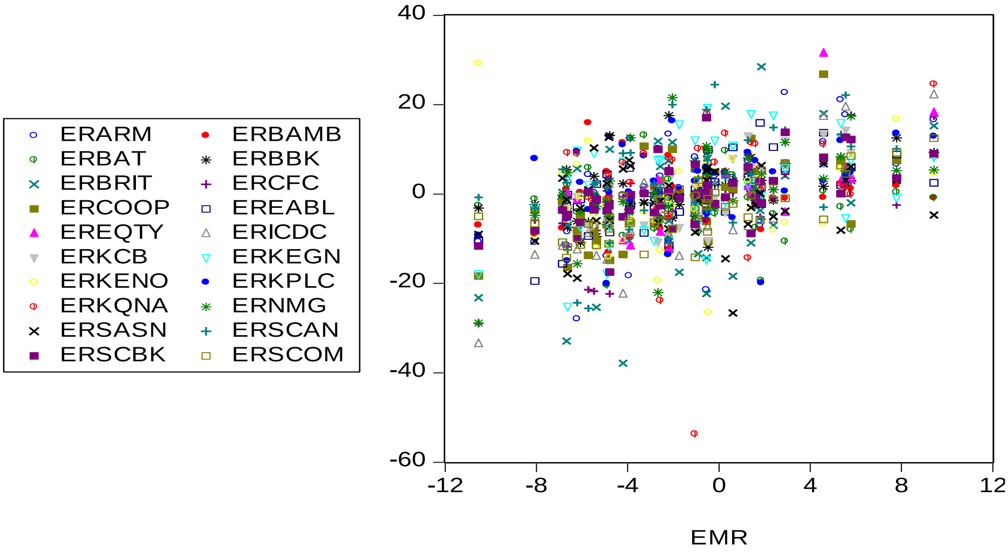
Excess returns series over the market and over each of the stocks are generated as by deducting the monthly risk-free rate from the continuously compounded returns. A plot of the excess returns over the risk free rate are show that the series appear to move together.



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

4.2.1. 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.

4.2.2. Testing The CAPM using time varying Betas

To get time-varying covariances and variances, the Diagonal BEKK model is fitted to the excess returns of each security. From the variance covatiance matrices, time-varying betas are computed as shown in appendix III. Each stock has 47 different betas as shown in the appendix.

Holding the expected returns constant, we can 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. Here are a few combinations. In each of the combinations, the stocks whose betas are not in line with the rest can be considered to be outliers. However, when the betas of ICDC are included, only 8 stocks appear to validate the CAPM.

	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 2: Beta and return combinations which show validity of the CAPM

Source: Author's computation

4.3. Findings and Conclusion

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. It 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 clear that if the aspect of time-variation of the beta estimate is considered, CAPM is more verifiable. Ignoring this variation is a big mistake. Time varying betas therefore make CAPM more valid in the NSE.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

This chapter summarizes the entire study by giving a report of the findings. It also points out the areas that could have been improved in the study and suggestions for further research in the same area.

5.2. Summary of the Findings

From the findings of this study, it is clear that the homoscedasticity assumption of the CLRM does not always hold. 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 should be tested to improve on the validity of the CAPM.

5.3. Limitations of the Study

In this study, beta was modelled as a random variable taking various values. The returns are assumed to be constant. If beta changes with time, then the expected returns also change with time. However, since it is difficult to study the effect of the change of two variables at once, this study focused on the change of beta with the assumption that the expected returns are constant. Additionally, though the test results show clearly that it is possible to have combinations of beta that are consistent with the assertions of the CAPM model, these combinations of beta occur at different times.

5.4. Recommendations for Further Research

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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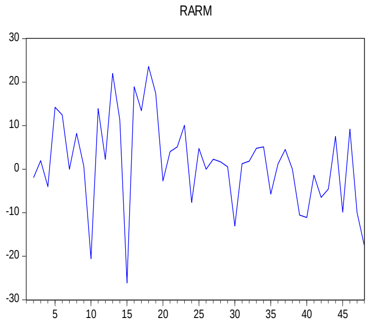
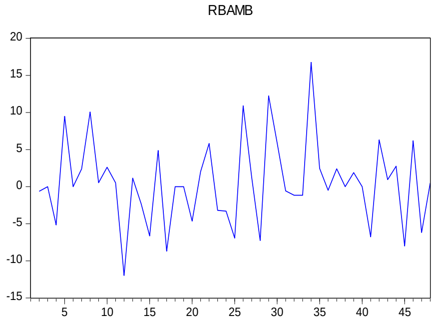
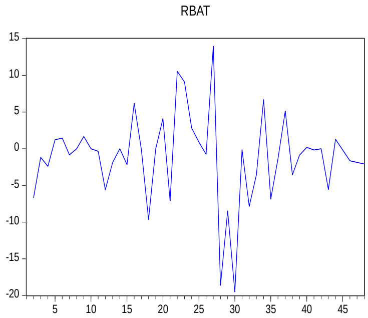
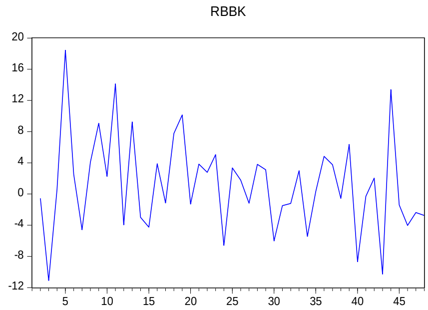
Appendix I: Graphs

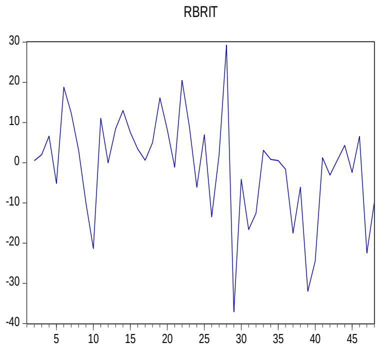
Plots of various stock returns over time

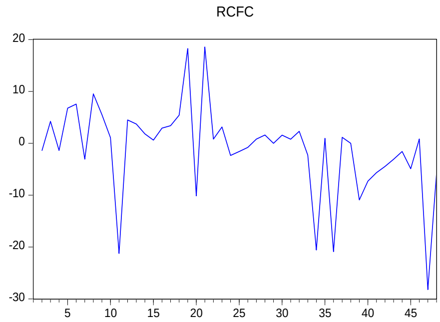


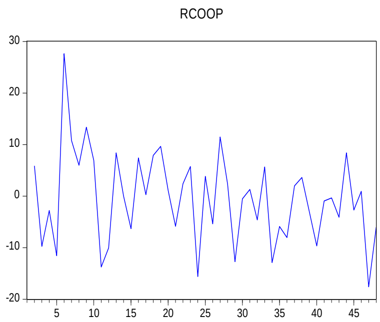


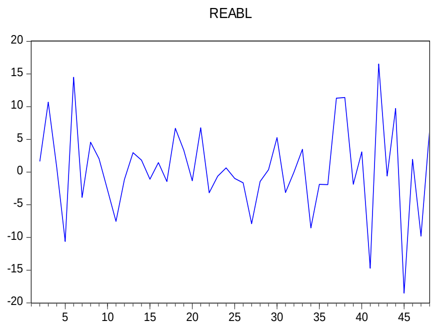


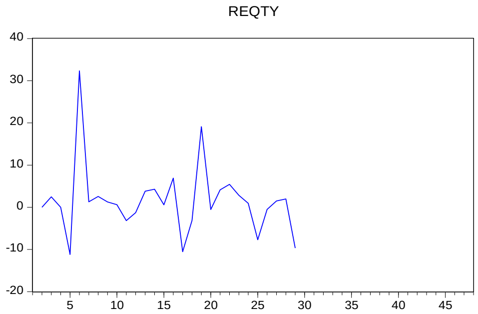








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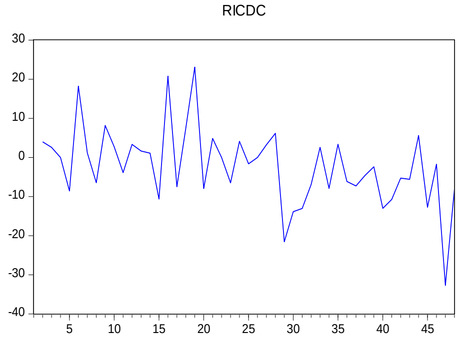
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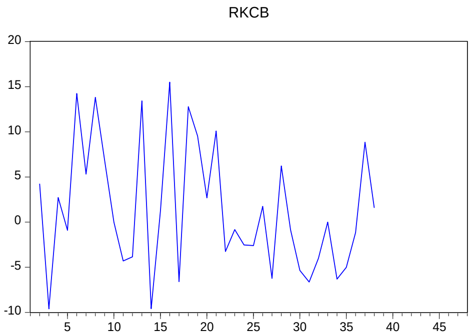
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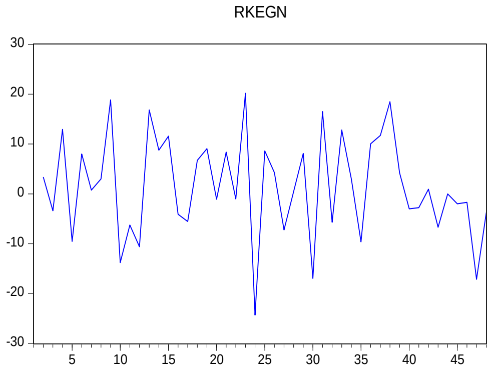
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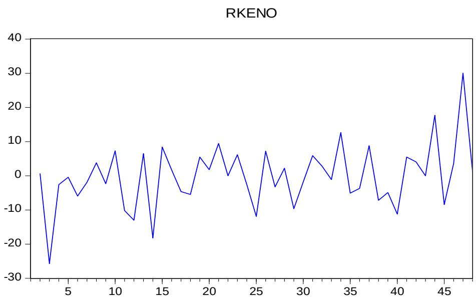
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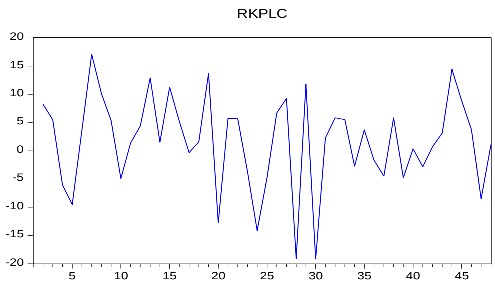
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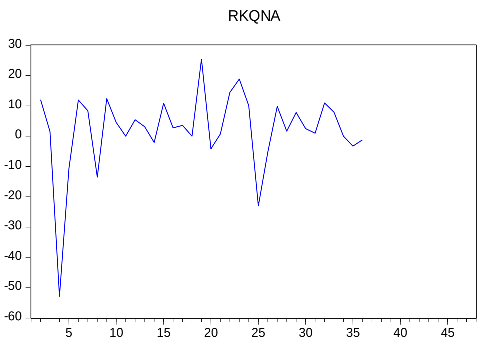
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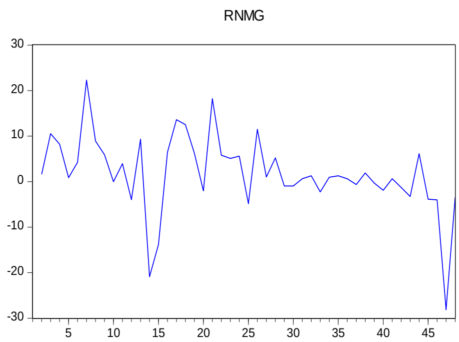
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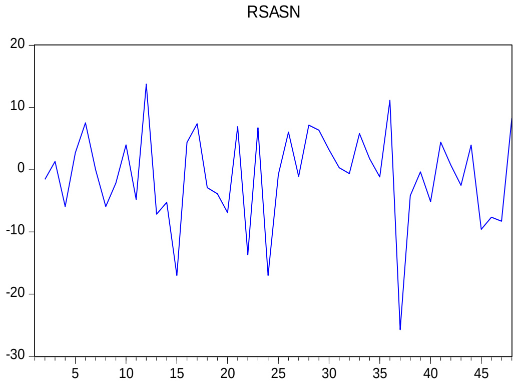
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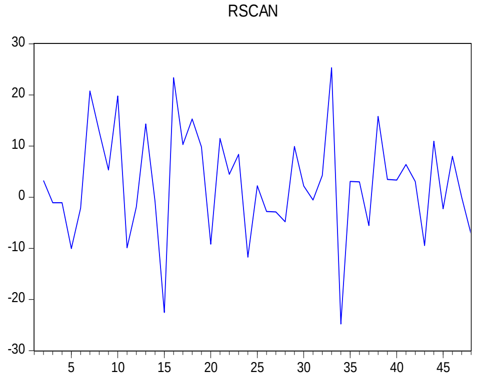
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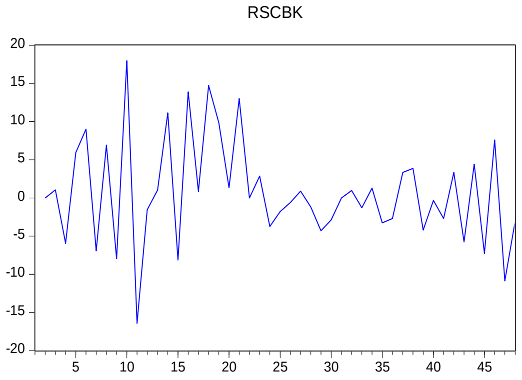
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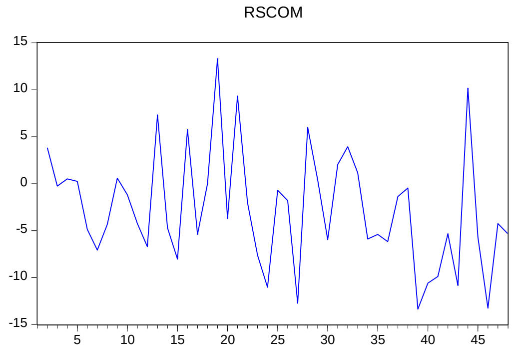
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Residual Plots

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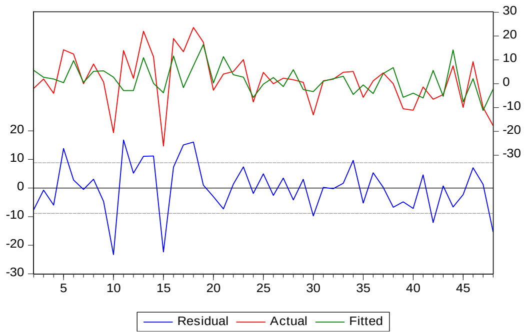

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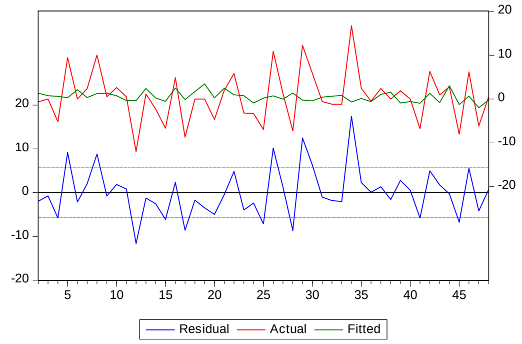

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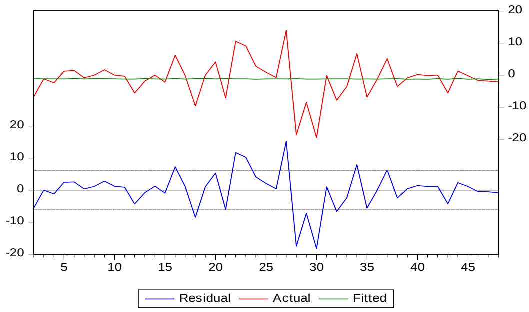

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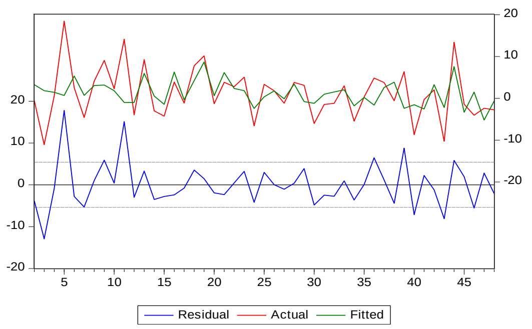

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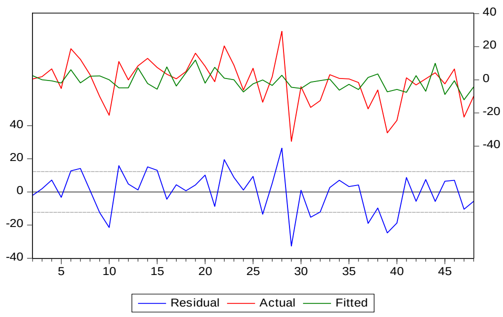

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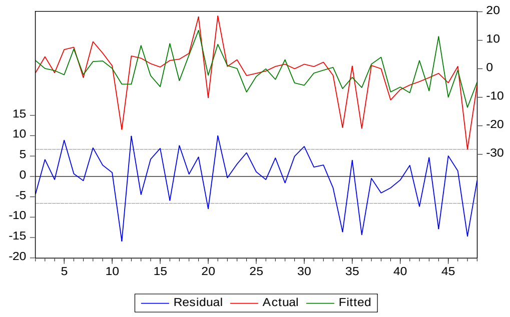

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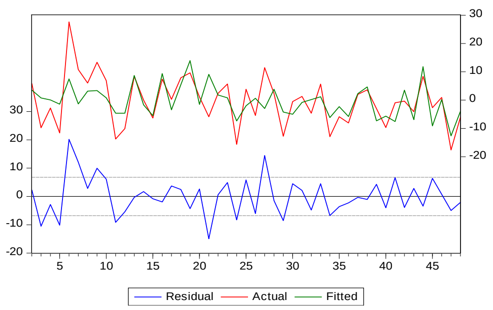
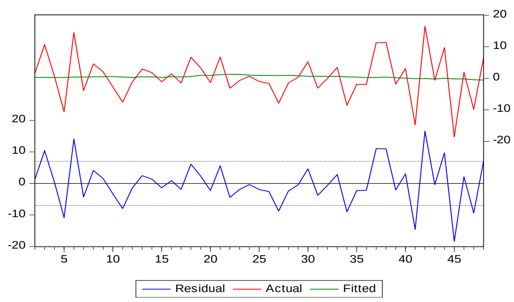


REABL



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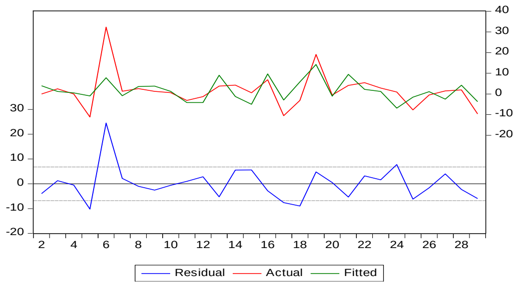
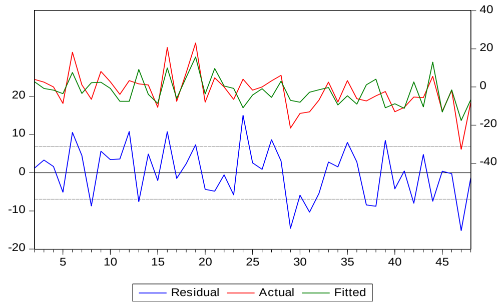
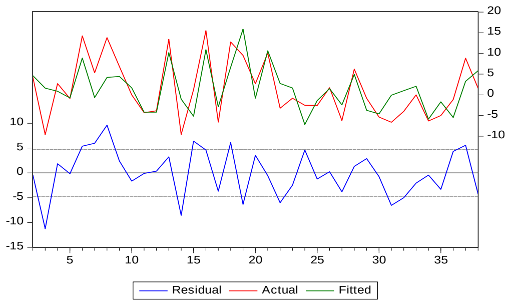


RICDC



RKCB



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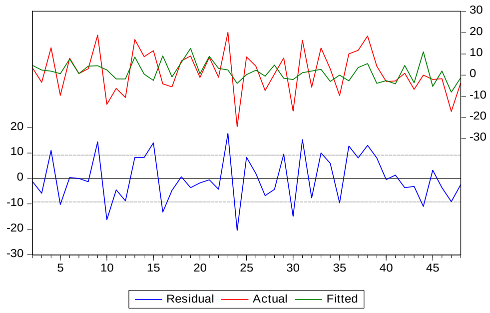

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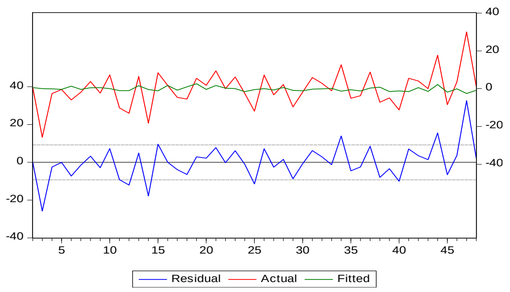

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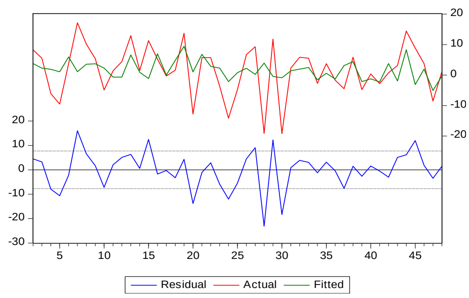

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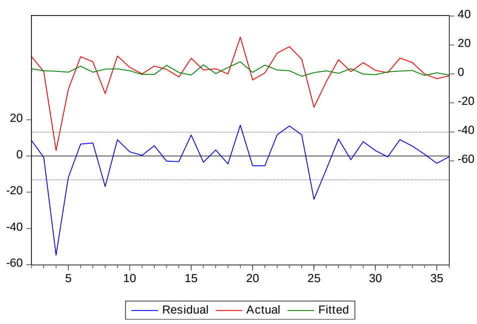

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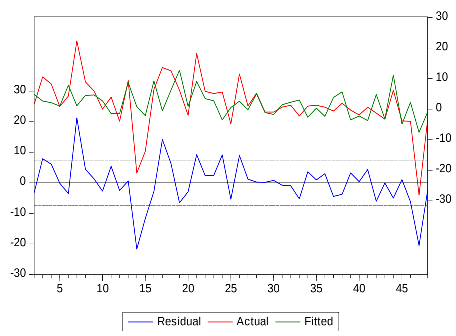

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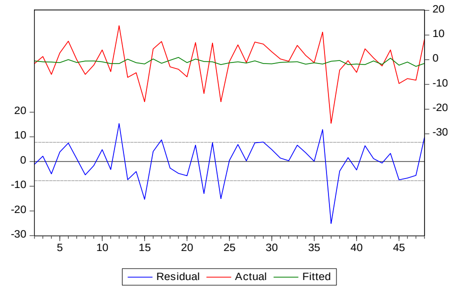

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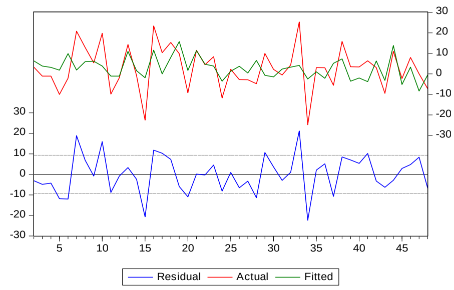

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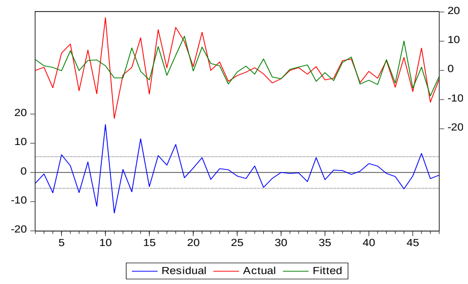

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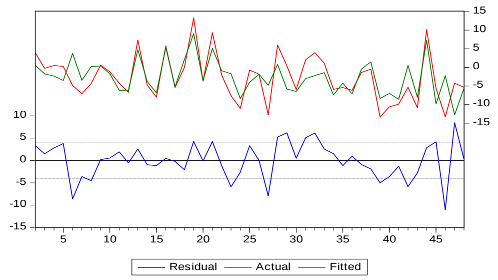

Appendix II :Monthly price data for NSE 20

	NASI	KENO	SCOM	KEGN	BBK	BRIT	COOP	KPLC	ARM	BAMB	BAT	ICDC	CFC	EABL	NMG	SASN	SCBK	SCAN	EQTY	KCB	KQNA
Date	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price
Dec-16	133.3	14.9	19.15	5.8	9.1	10	13.2	8.15	25.5	160	909	37	70.5	244	93	19.2	189	18.15	30	28.75	5.85
Nov-16	136.6	15	19.9	6	9.05	10.05	14	8.85	25	159	850	38.5	69.5	248	94.5	18.9	189	18.75	30	30	6.6
Oct-16	137	11.6	19.85	5.8	8.1	10.25	12.7	9.35	25.5	159	840	39.5	72.5	276	105	19.15	191	18.55	30.75	27.25	6.7
Sep-16	136.8	11.3	19.95	6.6	8.15	10.95	12.35	8.8	24.5	151	820	39.5	71.5	278	114	18.05	180	18.35	30.75	28	3.95
Aug-16	134.9	11.25	20	6	9.8	10.4	11	8	28.25	166	830	36.25	76.5	250	115	18.55	191	16.6	27.5	27.75	3.55
Jul-16	142.4	10.6	19.05	6.5	10.05	12.55	14.5	8.3	32	166	842	43.5	82.5	289	120	20	209	16.25	38	32	4
Jun-16	140.6	10.4	17.75	6.55	9.6	14.2	16.15	9.85	32	170	835	44	80	278	150	20	195	20	38.5	33.75	4.35
May-16	143.6	10.8	17	6.75	10	14.65	17.15	10.9	34.75	188	835	41.25	88	291	164	18.85	209	22.75	39.5	38.75	3.8
Apr-16	146.9	10.55	17.1	8.15	10.95	13.25	19.6	11.5	35	189	849	44.75	93	297	174	18.45	193	24	40	41.5	4.3
Mar-16	147.4	11.35	16.9	7.1	11.2	10.7	21	10.95	28.5	194	849	46	94	289	174	19.2	231	29.25	40.25	41.5	4.5
Feb-16	142	10.25	16.2	6.67	12.9	11.95	18.3	11.1	32.75	195	846	44.25	76	268	181	18.3	196	26.5	39	39.75	4.5
Jan-16	136.8	9	15.15	6	12.4	11.95	16.55	11.6	33.5	173	800	45.75	79.5	265	174	21	193	26	38.5	38.25	4.75
Dec-15	145.7	9.6	16.3	7.1	13.6	13	18	13.2	41.75	175	785	46.5	82.5	273	191	19.55	195	30	40	43.75	4.9
Nov-15	143.5	8	15.55	7.75	13.2	14.8	18	13.4	46.75	171	785	47	84	278	155	18.55	218	29.75	41.75	39.75	4.8
Oct-15	137.3	8.7	14.35	8.7	12.65	15.95	16.9	15	36	160	768	42.25	84.5	275	135	15.65	201	23.75	42	40.25	5.35
Sep-15	146.9	8.85	15.2	8.35	13.15	16.5	18.2	15.8	43.5	168	817	52	87	279	144	16.35	231	30	45	47	5.5
Aug-15	142.8	8.45	14.4	7.9	13	16.6	18.25	15.75	49.75	154	816	48.25	90	275	165	17.6	233	33.25	40.5	44	5.7
Jul-15	148.4	8	14.4	8.45	14.05	17.45	19.75	16	63	154	741	52	95	294	187	17.1	270	38.75	39.25	50	5.7
Jun-15	164.4	8.45	16.45	9.25	15.55	20.5	21.75	18.35	75	154	741	65.5	114	304	199	16.45	298	42.75	47.5	55	7.35
May-15	162.1	8.6	15.85	9.15	15.35	22.25	22	16.15	73	147	772	60.5	103	300	195	15.35	302	39	47.25	56.5	7.05
Apr-15	173.2	9.45	17.4	9.95	15.95	22	20.75	17.1	76	150	719	63.5	124	321	234	16.45	344	43.75	49.25	62.5	7.1
Mar-15	175.1	9.45	17.05	9.85	16.4	27	21.25	18.1	80	159	799	63.5	125	311	248	14.35	344	45.75	52	60.5	8.2

Feb-15	175.7	10.05	15.8	12.05	17.25	29.5	22.5	17.45	88.5	154	875	59.5	129	309	261	15.35	354	49.75	53.5	60	9.9
Jan-15	165.8	9.8	14.15	9.45	16.15	27.75	19.25	15.15	82	149	900	62	126	311	276	12.95	341	44.25	54	58.5	10.95
Dec-14	162.9	8.7	14.05	10.3	16.7	29.75	20	14.45	86	139	908	61	124	308	263	12.85	335	45.25	50	57	8.7
Nov-14	163.3	9.35	13.8	10.75	17	26	18.95	15.45	86	155	901	61	123	303	295	13.65	333	44	49.75	58	8.25
Oct-14	159.2	9.05	12.15	10	16.8	26.5	21.25	16.95	88	157	1,036.00	63	124	280	298	13.5	336	42.75	50.5	54.5	9.1
Sep-14	163.5	9.25	12.9	10.05	17.45	35.5	21.75	14	89.5	146	860	67	126	276	314	14.5	332	40.75	51.5	58	9.25
Aug-14	157.9	8.4	12.95	10.9	18	24.5	19.15	15.75	90	165	790	54	126	277	311	15.45	318	45	46.75	57.5	10
Jul-14	151.7	8.25	12.2	9.2	16.95	23.5	19.05	13	79	175	650	47	128	292	308	15.95	309	46		54.5	10.25
Jun-14	150.4	8.75	12.45	10.85	16.7	19.9	19.3	13.3	80	174	649	41.25	129	283	310	16	309	45.75		51	10.35
May-14	150.2	9	12.95	10.25	16.5	17.55	18.43	14.1	81.5	172	600	38.5	132	283	314	15.9	312	47.75		49	11.55
Apr-14	151.1	8.9	13.1	11.65	17	18.1	19.5	14.9	85.5	170	579	39.5	129	293	307	16.85	308	61.5		49	12.5
Mar-14	143.9	10.1	12.35	12	16.1	18.25	17.14	14.5	90	201	619	36.5	105	269	310	17.15	312	48		46	12.5
Feb-14	141.1	9.6	11.7	10.9	16.15	18.35	16.16	15.05	85	206	578	37.75	106	264	314	16.95	302	49.5		43.75	12.1
Jan-14	134.7	9.25	11	12.05	16.95	18.05	14.91	14.8	86	205	570	35.5	86	259	316	18.95	294	51		43.25	11.95
Dec-13	136.7	10.1	10.85	13.55	17.6	15.15	15.21	14.15	90	210	600	33	87	290	314	14.65	304	48.25		47.25	
Nov-13	141.2	9.4	10.8	16.3	17.5	14.25	15.77	15	90	210	579	31.5	87	325	320	14.05	316	56.5		48	
Oct-13	133.2	8.95	9.45	17	18.65	10.35	15.3	14.3	81	214	574	30.75	78	319	319	14	303	58.5			
Sep-13	127.4	8	8.5	16.5	17.1	8.1	13.89	14.35	72.5	214	575	27	72.5	329	313	13.3	302	60.5			
Aug-13	120	8.45	7.7	16.05	17.05	8.2	13.76	13.95	71.5	200	574	24.25	68.5	284	315	13.9	294	64.5			
Jul-13	122.9	8.8	7.3	16.2	17.4	7.95	13.71	14.05	67	213	574	23	65.5	335	311	14	304	66.5			
Jun-13	116.3	8.8	6.55	15.15	15.7	8	13.16	14.5	64	215	543	21.75	63.5	333	301	13.65	287	60.5			
May-13	126.8	10.5	7.25	15.15	17.95	8.35	14.31	16.75	69	221	550	23	62.5	367	320	14.2	300	67.5			
Apr-13	118.1	9.65	6.85	14.85	17.7	8.15	13.93	18.3	62.5	204	549	20.25	59.5	305	307.9	12.9	279	66			
Mar-13	117.9	10	6	14.6	17	8.7	14.06	19	68.5	217	540	19.9	60	311	295.8	11.95	301	71.5			
Feb-13	106.9	13.5	5.75	12.3	16.6	6.95	11.79	17.45	62	204	530	14.35	45.25	282	223.3	11	270	71.5			
Jan-13	103.5	13.65	5.45	11.85	16.15	6.3	11.1	17.65	52	205	519	13.25	42.75	301	215.8	11.95	262	66.5			

Appendix III: Schedule for time varying betas

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