University of Piraeus
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Testing the efficiency of FTSE 100 in the mean-standard deviation space: A new approach

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“An investment in knowledge pays the best interest”
-Benjamin Franklin

To my mother Helen and
my grandmother Dimitra

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Abstract

The purpose of this thesis is to prove the inefficiency of the FTSE 100 Index, so that the 3d model of Dr. George Diacogiannis and Dr. David Feldman holds. If there is a chance that the market index is inefficient then the appropriate model for asset pricing should be one model that confronts the index as inefficient. Reviewing the bibliography there is not any model apart from the 3d model we mentioned. The daily data concerning FTSE 100 Index prices and stock prices listed on FTSE 100 from June 2006 to June 2016 were received from Bloomberg terminal database. Splitting data to periods and sub periods with daily, weekly and monthly prices and returns, we followed Roll's methodology (1977) in order to create the efficient frontier portfolios. Moreover, for daily, weekly and monthly data of one period consisting of 10 years we will perform Fama and MacBeth (1973) linear regression to prove that CAPM does not hold. The final part was to find if the index return and standard deviation was in the efficient frontier by the following three ways: schematically, by calculating weights and statistically.

Keywords: *efficient frontier, inefficiency, FTSE 100 Index, 3d model, CAPM, asset pricing, Roll, mean-standard deviation space, Fama, MacBeth*

Περίληψη

Ο σκοπός της συγκεκριμένης διπλωματικής εργασίας είναι να ελέγξουμε την αποδοτικότητα του δείκτη FTSE 100, έτσι ώστε να ισχύει το 3d μοντέλο του Δρ. Γεώργιου Διακογιάννη και του Δρ. David Feldman. Εάν ο δείκτης δεν είναι αποδοτικός, τότε πρέπει να χρησιμοποιείται ένα μοντέλο που συμπεριφέρεται στον δείκτη ως μη αποδοτικός και δεδομένης της βιβλιογραφίας δεν υπάρχει άλλο τέτοιο μοντέλο εκτός του 3d. Οι ημερήσιες τιμές του δείκτη FTSE 100 και των μετοχών του αποκτήθηκαν από την βάση δεδομένων της Bloomberg. Με βάση όλα τα δεδομένα, χωρίστηκαν περίοδοι και υποπερίοδοι και μέσω της μεθοδολογίας του Roll (1977) κατασκευάστηκαν τα αντίστοιχα αποδοτικά σύνορα. Επιπλέον, με ημερήσια, εβδομαδιαία και μηνιαία δεδομένα τρέξαμε την γραμμική παλινδρόμηση των Fama και MacBeth (1973) για να αποδείξουμε πως το CAPM δεν ισχύει. Τέλος, με τρείς διαφορετικούς τρόπους (σχηματικά, υπολογισμός σταθμών και στατιστικά) βρίσκουμε αν ο δείκτης ανήκει στο αποδοτικό σύνορο.

Λέξεις κλειδιά: *αποδοτικό σύνορο, FTSE 100 δείκτης, 3d μοντέλο, Υπόδειγμα Αποτίμησης Κεφαλαιακών Στοιχείων, Roll, χώρος αναμενόμενης απόδοσης τυπικής απόκλισης, Fama, MacBeth*

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January 2017, Piraeus *Dimitra Iliaki*

Contents

Chapter 1: Introduction

The term “forecasting” is widely used in our lives, from weather forecasting to astrology forecasting or astronomical phenomena forecasting. Economically speaking, investors need to forecast accurate prices on gross domestic product (GDP), consumer price index (CPI), index and shares prices and returns or/and other macroeconomical factors that affect their portfolio. The holy grail of investment is to be able to forecast prices and returns on a short or a long term. In order to be accurate one should use a specific economic model for this procedure.

In 1964, the capital asset pricing model (CAPM) was invented by Treynor, Sharpe, Lintner and Mossin and has received a massive critique by other economists, such as Roll (1977), for the fact that most CAPM assumptions did not reflect the economic reality at all. Roll proved that if the market index is efficient then CAPM holds and vice versa. Other pricing models were invented each year since then and did reflect the returns in a much specious way. For instance in 1973 Merton invented the intertemporal CAPM, in 1976 Ross invented the arbitrage pricing theory model (APT), in 1992 Fama and French invented the three factor model (which they upgraded in a five factor one in 2015). The previous models had something in common with CAPM and that was the assumption that the market index is efficient. In 2013 Dr. George Diacogiannis and Dr. David Feldman invented the 3d model, in order to calculate asset returns. The specificity of this model is that it holds only when the market index (index) is inefficient and until today, this model is the only one that confronts the index as inefficient.

The purpose of this thesis is to prove the inefficiency of the FTSE 100 index, so that the 3d model of Dr. George Diacogiannis and Dr. David Feldman holds. If there is a chance that the market index is inefficient then the appropriate model for asset pricing should be one model that confronts the index as inefficient. Reviewing the bibliography there is not any model apart from the 3d model we mentioned. The daily data concerning FTSE 100 Index prices and stock prices listed on FTSE 100 from June 2006 to June 2016 were received from Bloomberg terminal database. From these data, we calculated daily returns, weekly prices and returns and monthly prices and returns. Splitting data to periods and sub periods with daily, weekly and monthly prices and returns, we followed Roll’s methodology (1977) in order to create the efficient frontier portfolios. The final part was to find if the index return and standard deviation was in the efficient frontier by the following three ways: schematically, by calculating weights and statistically. Moreover, for daily, weekly and monthly data of one period consisting of 10 years we will perform Fama and MacBeth (1973, see Subsection 3.2) linear regression to prove that CAPM does not hold. The restrictions of this thesis are the following: we use Roll’s methodology (1977) only for FTSE 100 Index and years 2006-2016.

This master thesis is consisted of six chapters. Chapter 1 is an introduction of this thesis objective and purpose. Chapter 2 focuses on the basics of portfolio theory terms, modeling theory and performance measures. On chapter 3 we review the literature concerning asset pricing models. Chapter 4 provides the methodology and data used in this thesis. On chapter 5 we provide the results analysis and then on chapter 6 we sum up summarizing the results of this study.

Chapter 2: Portfolio Theory

In this chapter, a timeless overview of portfolio theory will be presented. Different concepts will be clarified in order to proceed to the main subject.

2.1. Main Definitions

Securities are financial instruments (such as bonds, shares, derivatives) issued by a government, a company or other organization and represent debt or a right to distributed profits. A portfolio is a grouping of financial assets that contains all the holdings and cash available to an individual or entity. A share is one of the equal parts into which a company's capital is divided. A common stock is a security that represents ownership in a corporation. Holders of common stock exercise control by electing a board of directors and voting on corporate policy. Common stockholders are on the bottom of the priority ladder for ownership structure. In the event of liquidation, common shareholders have rights to a company's assets only after bondholders, preferred shareholders and other debt holders have been paid in full. A preferred stock is a class of ownership in a corporation that has a higher claim on its assets and earnings than common stock. Preferred shares generally have a dividend that must be paid out before dividends to common shareholders, and the shares usually do not carry voting rights. Preferred stock combines features of debt, in that it pays fixed dividends, and equity, in that it has the potential to appreciate in price. The details of each preferred stock depend on the issue.

A primary market, also known as “new issue market” (NIM) is a market that issues new securities on an exchange. Companies, governments and other groups obtain financing through debt or equity based securities. Primary markets are facilitated by underwriting groups, which consist of investment banks that will set a beginning price range for a given security and then oversee its sale directly to investors. On the other hand, a secondary market is a market where investors purchase securities or assets from other investors, rather than from issuing companies themselves. The national exchanges, such as the New York Stock Exchange (NYSE) and the NASDAQ are secondary markets. A market that determines stock prices based on supply and demand tends to be effective. In other words, we cannot use internal information or historical prices to forecast stock movements.

An index is a statistical measure of change in an economy or a securities market. In the case of financial markets, an index is an imaginary portfolio of securities representing a particular market or a portion of it. Each index has its own calculation methodology (Ground Rules formed by FTSE Russell mainly) and is usually expressed in terms of a change from a base value. Therefore, the percentage change is more important than the actual numeric value. Stock and bond market indices are used to construct index mutual funds and exchange-traded funds (ETFs) whose portfolios mirror the components of the index. When evaluating the performance of any investment, it is important to compare it against an appropriate benchmark. There are dozens of indexes that analysts use to gauge the performance of any given investment including the S&P 500, the Dow Jones Industrial Average, the Russell 2000 Index and even competitor funds.

2.2. Financial Indicators, Securities Return and Risk

One criterion to classify investments is by their risk. For instance, Treasury bills and deposits provide relative insurance. Government bonds, real estate and mutual funds are considered as a low risk investment. Stocks are seen as a medium risk investment, whereas derivatives contribute to a high risk portfolio. An investor depends on the expected return on an asset and on its risk to take an investment decision. Return and risk measures will be analyzed in this subsection.

One should bear in mind two criteria to evaluate a firm's stock. First of all, evaluate the quality of the firm by taking into account factors such as the management, the reputation, the dividend's history or profit's reinvestment. Secondly, we calculate financial indicators. The main financial indicators are the market value of the firm, price to earnings per share (P/E), price to earnings per share to growth ratio (PEG), dividend yield, price to book value (P/BV), price to sales per share (P/S) and trading volume. Table 2.1 provides mathematical formulas to each one of the indicators mentioned.

Table 2.1.: How to calculate financial indicators

Financial Indicator	**Mathematical Formula**
Market value	$= Number\ of\ common\ shares * Stock\ price\ \mathbf{(2.01)}$
Price to earnings per share (P/E)	1. *Calculate earnings per share (EPS)=* $\frac{Earnings}{Number\ of\ common\ shares}\ \mathbf{(2.02)}$ 2. *Divide stock price to EPS*
Price to earnings per share to growth ratio (PEG)	1. *Calculate annual growth g=* $\frac{EPS_t - EPS_{t-1}}{EPS_{t-1}} * 100\ \ \mathbf{(2.03)}$ 2. *Divide P/E to g*
Dividend yield	1. *Calculate dividends per share =* $\frac{Dividends}{Number\ of\ common\ shares}\ \mathbf{(2.04)}$ 2. *Divide dividends per share to stock price*
Price to book value (P/BV)	1. *Calculate book value BV =* $\frac{Equity}{Number\ of\ common\ shares}\ \mathbf{(2.05)}$ 2. *Divide stock price to BV*
Price to sales per share (P/S)	1. *Calculate sales per share S =* $\frac{Sales}{Number\ of\ common\ shares}\ \mathbf{(2.06)}$ 2. *Divide stock price to S*

Trading volume	*Divide the number of shares that changed hands during a trading day to the number of common shares*

The return on an asset is disciplined in three categories:

1. The expected return, which is the predicted return of a security, calculated by probabilistic measures or historical data.
2. The required return that represents the minimum return investors are willing to receive to purchase the asset.
3. The realized return, which is the real one after a defined time frame.

The realized return of a security is given by the following equation:

$$R_{it} = \frac{P_{it} - P_{it-1} + D_{it}}{P_{it}} \quad (\mathbf{2.07})$$

where R_{it} represents the return of the asset i at time t, P_{it} is the price of the asset i at time t, P_{it-1} is the price of the asset i at time t-1, D_{it} is the dividend in time t. Dividends are added to the equation at the ex-dividend day and only. For instance, we have closing prices data for a firm X for 29 January 2016 the closing price was 36$, for 29 February 2016 the closing price was 42$ and a dividend payment of 2$ and for 31 March 2016 the closing price was 47$. The realized return of an X stock is $\frac{42-36+2}{36} = 22.2\%$ for February 2016 and $\frac{47-42}{42} = 11.9\%$ for March 2016. In this method, we use historical data to calculate the return. However, P_{it} and D_{it} are random variables, so that R_{it} itself is a random variable and we assume that it follows a normal distribution.

Another way to measure the realized return is by taking logarithms:

$$\ln(1 + R_{it}) = \ln\left(\frac{P_{it} + D_{it}}{P_{it-1}}\right) \quad (\mathbf{2.08})$$

This method has two major advantages. The return of the asset is seen as a continuous rather than a discrete one and it approaches the normal distribution, which is used as a general assumption. In fact, many empirical studies proved that returns on stocks follow leptokurtic distributions (a distribution with positive excess kurtosis) and skewness.

In order to characterize a normal distribution, we need the expected return on an asset and its variance. If there is a mathematical way to value these variables then we calculate the probabilities for different R_i. The expected return of the security $E(R_i)$, under the normal distribution hypothesis is calculated as the mean of its returns and is the profit an investor expects to realize in a future period, based also on historical data.

$$E(R_i) = \frac{1}{T}\sum_{i=1}^{T} R_{it} \quad (\mathbf{2.09})$$

For example, we have the following monthly returns of a particular security: Month 1-Return: 0.03, Month 2-Return: 0.04, Month 3-Return: 0.08, Month 4-Return: -0.10, Month 5-Return: 0.01. The expected return of that security must be $\frac{0.03+0.04+0.08-0.10+0.01}{5} = 1.2\%$.

Variance is the expectation of the squared deviation of a random variable from its mean, and it informally measures how far a set of (random) numbers are spread out from their mean. The variance of the asset Var(R_{it}) measures the risk of the security. A large value of the variance stands for a bigger risk.

$$Var(R_i) = \frac{\sum_{t=1}^{T}(R_i - E(R_i)^2}{T-1} \quad (\mathbf{2.10})$$

Using the previous data, the variance of that security must be $\frac{(0.03-0.012)^2+(0.04-0.012)^2+(0.08-0.012)^2+(-0.10+0.012)^2+(0.01+0.012)^2}{5-1} = 0.021016$.

Expected return is a percentage, so variance is measured as a percentage squared and that does not make any sense. A solution to this problem is calculating the standard deviation σ which is the square root of the variance.

$$\sigma(R_i) = \sqrt{Var(R_i)} \quad (\mathbf{2.11})$$

Again, with the same data the standard deviation for this security must be $\sqrt{0.021016} = 0.144968$. In this point, we have to mention that many empirical studies have proved that the denominator should be T-2, so that σ would be unbiased, but T-1 is widely used. Consider two assets with the same expected return, one rational investor would choose the one with the minimum standard deviation. Between two assets with the same risk, again a rational investor would choose the one with the maximum expected return.

Coefficient of variation CV, also known as relative standard deviation (RSD), is a standardized measure of dispersion of a probability distribution or frequency distribution and combines the expected return and the standard deviation.

$$CV(R_i) = \frac{\sigma(_{R_i})}{E(R_i)} \quad (\mathbf{2.12})$$

It indicates the risk per unit of expected return of the security. Between two securities with different CV, a rational investor should choose the one with the minimum CV. For example, a particular security A has a CV of 0.39528 and another security B has a CV of 0.60663. A rational investor would choose to invest in security A rather than B. The CV has two major disadvantages. It uses the normal distribution hypothesis and it does not indicate the way that one asset affect the other. In order to identify the direction two asset follow we use another measure called covariance (Cov). Covariance is a measure of how much two random variables change together.

$$Cov(R_i, R_j) = \frac{\sum_{t=1}^{t}[(R_{it} - E(R_{it})][(R_{jt} - E(R_{jt})]}{T-1} \quad (\mathbf{2.13})$$

For instance, suppose we have the following monthly returns for security A and B: Month 1-A: 0.03, Month 2-A: 0.04, Month 3-A: 0.05, Month 4-A: 0.08, Month 5-A:

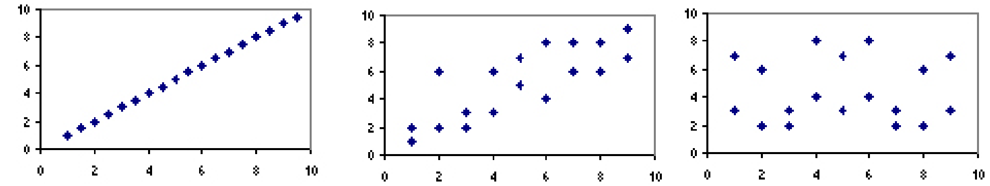
0.06, Month 6-A: 0.10, Expected Return of A: 0.04 Month 1-B: 0.04, Month 2-B: 0.07, Month 3-B: 0.08, Month 4-B: 0.09, Month 5-B: 0.07, Month 6-B: 0.13, Expected Return of B: 0.08. The covariance of securities A-B is $\frac{(0.03-0.04)(0.04-0.08)+\cdots+(0.10-0.04)(0.13-0.08)}{5} = 0.01152$. A positive covariance means that the same directional behavior, whereas a negative covariance indicates an opposite one. A zero covariance proves a nonlinear relationship between the assets. In the same stock exchange, it is common to find a positive covariance, since assets are affected by the same factors. On the other hand, we can calculate negative covariance between stocks traded on different stock exchanges.

The measure that is widely used as an indicator of the strength of the relationship between two assets is correlation (Corr). Correlation is the extent to which two variables have a linear relationship with each other.

$$Corr\left(R_i, R_j\right) = \frac{Cov(R_i, R_j)}{\sigma_\iota \sigma_j} \quad (\mathbf{2.14})$$

Suppose that we have calculated the following statistics $Cov(R_i, R_j)$ is equal to 0.00048, σ_ι is equal to 0.03162 and σ_j is equal to 0.03033. The correlation of these two assets is equal to $\frac{0.00048}{0.03162*0.03033} = 0.50043$. A strong positive correlation is 1, a positive correlation is between 0 and 1, while a negative correlation is between -1 and 0 and a strong negative correlation is -1. Zero correlation stands for nonlinear relationships. In Figure 2.1. X axis refers to R_i and Y axis refers to R_j.

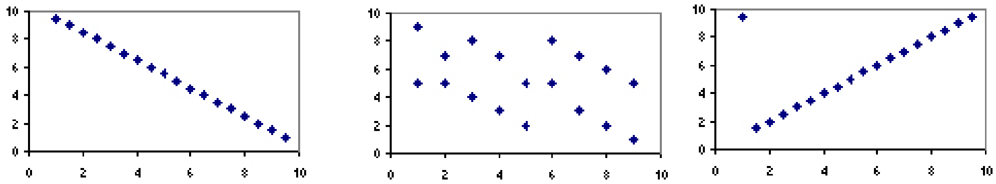
Figure 2.1.: Scatter plots of correlation coefficients



Maximum positive correlation (r = 1.0)

Strong positive correlation (r = 0.80)

Zero correlation (r = 0)



Maximum negative correlation (r = -1.0)

Moderate negative correlation (r = -0.43)

Strong correlation & outlier (r = 0.71)

Source: http://stattrek.com/statistics/correlation.aspx?Tutorial=AP

2.3. Portfolio Characteristics

As we have already seen, the purpose of portfolio is that it gives the opportunity to deal with different assets, thus different returns and risk. The simple asset characteristics that we discussed in subsection 2.2 can be expanded for the portfolio.

Portfolio’s return is the weighted average of its assets’ returns. The sum of the weights is equal to one.

$$Weight\ of\ an\ asset\ i(w_i) = \frac{Capital\ used\ to\ purchase\ the\ asset}{Total\ invested\ capital\ of\ portfolio} \quad \mathbf{(2.15)}$$

$$Capital\ used\ to\ purchase\ the\ asset = Number\ of\ assets * Asset\ price \quad \mathbf{(2.16)}$$

$$R_{pt} = \frac{P_{pt} - P_{pt-1} + D_{pt}}{P_{pt-1}} \approx \ln\left(\frac{P_{pt} + D_{pt}}{P_{pt-1}}\right) \quad \mathbf{(2.17)}$$

Where R_{pt} is the return of portfolio p at time t, P_{pt} is the value of the portfolio p at time t, P_{pt-1} is the value of portfolio p at time t-1 and D_p represents the dividends. The last equation can be rewritten as:

$$R_{pt} = \sum_{i=1}^{N} w_i R_i \quad \mathbf{(2.18)}$$

The expected return of the portfolio is calculated by the following equation.

$$E(R_p) = \sum_{i=1}^{N} w_i E(R_i) \quad \mathbf{(2.19)}$$

Where E(R_p) is the expected return of portfolio, N is the number of securities and E(R_i) is the expected return of asset i.

The standard deviation of the portfolio is expressed as follows:

$$\sigma(R_p) = \sqrt{\sum_{i=1}^{N} w_i^2 \, \sigma(_{R_i})^2 + \sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j Cov(R_{i,}R_j)} \quad \mathbf{(2.20)}$$

For i ≠ k, or in terms of variance:

$$Var(R_p) = \sum_{i=1}^{N} w_i^2 \sigma(R_i)^2 + \sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j Cov(R_i, R_j) \quad \mathbf{(2.21)}$$

Variance is further analyzed in two factors. The left part of the equation describes the nonsystematic risk that is a firm or industry specific hazard inherited in each investment. We will later prove that on a well-diversified portfolio this risk will be eliminated. The right part of the equation describes the systematic risk which is attributed to the market and influences all the trading securities. This risk can be reduced but not entirely eliminated by selecting assets with low or negative correlation. As we will later see, the systematic risk is measured by the beta coefficient.

The coefficient of variance CV of a portfolio p is measured the same way as if it was a single asset:

$$CV(R_p) = \frac{\sigma(R_p)}{E(R_p)} \quad \mathbf{(2.22)}$$

where σ(R_p) stands for the portfolio risk and E(R_p) is the expected return of the portfolio. In order to examine internal portfolio relationships, one can produce matrixes of variance-covariance coefficient and correlation coefficient which is an easy thing to do in excel. An example on 4 assets is presented in Tables 2.2 and 2.3.

Table 2.2.: Matrix of variance-covariance coefficient of 4 assets

	1	2	3	4
1	Var(1,1)			
2	Cov(2,1)	Var(2,2)		
3	Cov(3,1)	Cov(3,2)	Var(3,3)	
4	Cov(4,1)	Cov(4,2)	Cov(4,3)	Var(4,4)

Table 2.3.: Correlation coefficient matrix of 4 assets

	1	2	3	4
1	Cor(1,1)=1			
2	Cor(2,1)	Cor(2,2)=1		
3	Cor(3,1)	Cor(3,2)	Cor(3,3)=1	
4	Cor(4,1)	Cor(4,2)	Cor(4,3)	Cor(4,4)=1

Consider a portfolio p with two assets 1 and 2. We use the equation 2.21 to calculate the contribution of the assets in risk as follows:

$$\sigma(R_p)^2 = w_1\sigma_1^2 + w_2\sigma_2^2 + 2w_1w_2\sigma_{12} = w_1(w_1\sigma_1^2 + w_2\sigma_{12}) + w_2(w_2\sigma_2^2 + w_1\sigma_{12})$$

Where σ_{12}=Cov(R_1,R_2). The first part of the equation $w_1(w_1\sigma_1^2 + w_2\sigma_{12})$ is the contribution of asset 1 in risk, while the second part of the equation $w_2(w_2\sigma_2^2 + w_1\sigma_{12})$ is the contribution of asset 2 in risk. If we divide each part to $\sigma(R_p)^2$ we achieve the equation of beta coefficient of the asset in terms of portfolio p total risk.

$$Beta\ coefficient\ of\ asset\ 1\ in\ terms\ of\ portfolio\ p = \frac{(w_1\sigma_1^2 + w_2\sigma_{12})}{\sigma(R_p)^2} \quad (\mathbf{2.23})$$

$$Beta\ coefficient\ of\ asset\ 2\ in\ terms\ of\ portfolio\ p = \frac{(w_2\sigma_2^2 + w_1\sigma_{12})}{\sigma(R_p)^2} \quad (\mathbf{2.24})$$

In other words, beta shows the risk of asset i in the portfolio p relatively to the risk of the whole portfolio and is given by the following equation:

$$beta_i = \frac{Cov(R_i, R_p)}{\sigma(R_p)^2} \quad (\mathbf{2.25})$$

Beta is a relative measure of the volatility, or systematic risk, of a security or a portfolio in comparison to the market as a whole. Beta is used in the capital asset pricing model (CAPM), that we will later discuss, a model that calculates the expected return of an asset based on its beta and expected market returns. A beta equal to 1 means the asset follows the portfolio’s volatility. For a beta>1 we can assume that the asset is aggressive and more volatile than the portfolio. Namely, when portfolio over performs the asset will over perform in a higher rate. For example, if a stock's beta is 1.2, it is theoretically 20% more volatile than the market. On the other hand, for a beta<1 we can assume that the asset is defensive meaning fewer asset losses in case of portfolio devaluation.

A portfolio’s beta coefficient can be calculated as the weighted beta coefficients of all the assets in the portfolio.

$$beta_p = \sum_{i=1}^{N} w_i b_i \quad (\mathbf{2.26})$$

It can be proved that market portfolio (M), or benchmark portfolio, or index has beta equal to one. Beta can be also calculated by regression analysis.

An example of all the previous equation will be provided. Suppose that we have the following data for two securities.

Table 2.4.: An example of portfolio characteristics calculations

Months	Stock 1	Stock 2
1	0.10	0.08
2	0.03	0.03
3	0.09	0.01
4	0.08	0.08
5	0.06	0.03
6	0.12	0.07
$E(R_i)$	0.08	0.05
$Var(R_i)$	0.001	0.00092
Standard deviation(R_i)	0.031	0.030
CV	0.3875	0.6
$Cov(R_1,R_2)$	0.00048	
$Corr(R_1,R_2)$	0.51	
Portfolio weights	Stock 1	Stock 2
Portfolio 1	0.2	0.8
Portfolio 2	0.4	0.6
Portfolio 3	0.6	0.4

For portfolio 1, the expected return is $0.2 \ast 0.08 + 0.05 \ast 0.8 = 0.056$, the variance is $0.2^2 \ast 0.001 + 0.8^2 \ast 0.00092 + 2 \ast 0.2 \ast 0.8 \ast 0.00048 = 0.0007824$, the standard deviation is $\sqrt{0.0007824} = 0.02797$ and the CV is $\frac{0.02797}{0.056} = 0.49949$. Following the same steps, for portfolio 2 the expected return is 0.062, the variance is 0.00072, the standard deviation is 0.02686 and the CV is 0.43327. For portfolio 3, the expected return is 0.068, the variance is 0.00074, the standard deviation is 0.02716 and the CV is 0.39939. We choose to invest in portfolio 3 that has the minimum CV.

Another example, suppose we have chosen portfolio 3 to calculate the contribution of asset 1 and 2 in risk and their beta coefficient in terms of portfolio. The contribution of asset 1 in risk is $0.06(0.6 \ast 0.031^2 + 0.4 \ast 0.00048) = 0.048\%$. The contribution of asset 2 in risk is $0.4(0.4 \ast 0.030^2 + 0.6 \ast 0.00048) = 0.026\%$. The total contribution is 0.048%+0.026%=0.00074. The beta coefficient of asset 1 in terms of portfolio is $\frac{0.6 \ast 0.031^2 + 0.4 \ast 0.00048}{0.00074} = 1.073$. Following the same procedure, the beta coefficient of asset 2 in terms of portfolio is 0.88937.

2.4. Portfolio Diversification Proof

Diversification is the process of allocating capital in a way that reduces the exposure to any one particular asset or risk. A common path towards diversification is to reduce risk or volatility by investing in a variety of assets. An investor with a well-diversified portfolio can reduce the unsystematic risk. In this subsection we provide a proof to that sentence.

Consider a portfolio with N assets and equal weights. As mentioned, portfolio's total risk, or variance, is the sum of unsystematic and systematic risk.

$$\sigma_p^2 = \frac{\sigma_1^2 + \sigma_2^2 \ldots + \sigma_N^2}{N^2} + 2\frac{\sigma_{12} + \sigma_{13} \ldots + \sigma_{NN-1}}{N^2} \quad \mathbf{(2.27)}$$

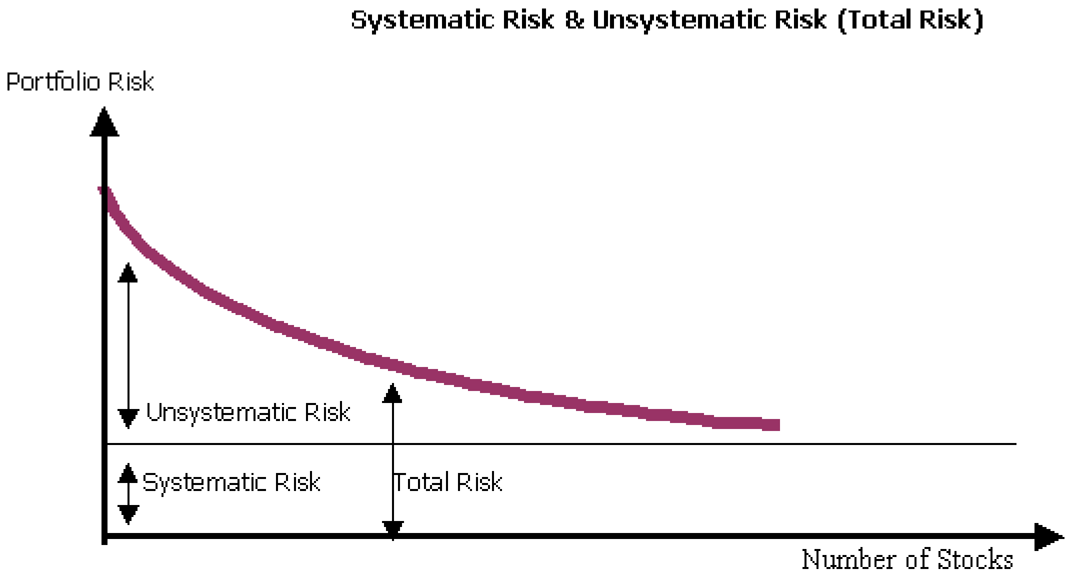
The left fraction stands for the unsystematic risk, whereas the right fraction stands for the systematic risk. With easy simplifications we reach the following equation:

$$\sigma_p^2 = \frac{1}{N}\overline{\sigma^2} + \frac{N-1}{N}\overline{\sigma_{\iota\jmath}} \quad \mathbf{(2.28)}$$

where $\overline{\sigma^2}$ is the mean variance. Still the left fraction defines the unsystematic risk and the right fraction defines the systematic risk.

If N→∞ the left fraction equals zero and the right equals $\overline{\sigma_{\iota\jmath}}$, so that $\sigma_p^2 = \overline{\sigma_{\iota\jmath}}$. The unsystematic risk is eliminated, whereas the systematic risk not. A reasonable question that occurs is how it is possible for an investor to purchase a portfolio of N assets. Most recent empirical studies proved that a portfolio of 15 to 20 different assets is well diversified also. In Figure 2.2 there is a graphical explanation of diversification proof.

Figure 2.2.: Diversification diagram-Systematic and Unsystematic Risk



Source: https://www.bionicturtle.com/forum/threads/non-systematic-variance.9294/

2.5. Modern Portfolio Theory (MPT) and the Efficient Frontier

Modern portfolio theory (MPT) or mean variance analysis was introduced by Harry Markowitz with his paper “Portfolio Selection” in 1952, for which he was later shared a Nobel Prize with Merton Miller and William Sharpe. MPT is a mathematical framework for assembling a portfolio of assets such that the expected return is maximized for a given level of risk, defined as variance. Its key insight is that an asset's risk and return should not be assessed by itself, but by how it contributes to a portfolio's overall risk and return.

In a Markowitz world four assumptions are made:

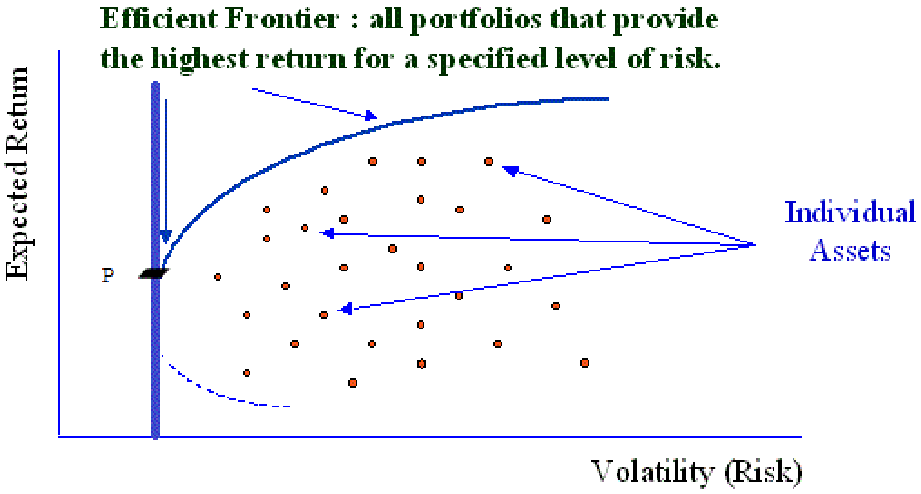
1. Between two assets with the same expected return, the one with the minimum standard deviation is preferred
2. Between two assets with the same standard deviation, the one with the maximum expected return is preferred.
3. All investors are risk averse.
4. Investors prefer to minimize the risk and maximize the expected return.

Also, there are four steps in order to invest in a portfolio:

1. Analyze the assets in terms of return and risk (2 dimensions).
2. Analyze the possible assets combinations and create portfolios.
3. Construct the efficient frontier.
4. Combine the efficient frontier with the investor's utility curve and choose the best portfolio.

An efficient portfolio is the one with the least risk and maximum return. Every spot on the blue curve of Figure 2.3. represents a portfolio with a minimum standard deviation (risk). We create a vertical line on the curve spot p and every each one of the portfolios above have both minimum variance and maximum expected return, thus they are efficient. The curve that extends from point p is called the efficient frontier. Portfolio p is called global minimum variance (GMV) portfolio as it has the minimum variance of all the portfolios of the efficient frontier.

Figure 2.3.: The efficient frontier



Source: https://jpw.ca/taking-the-mystery-out-of-asset-allocation.html

In order to create the efficient frontier, the idea is to minimize the variance of portfolio $\sigma_p^2 = \sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{j=1}^{N} w_i w_j \sigma_{ij}$ (see equation 2.21), where w_i stands for the weight of the asset i,σ_i is the standard deviation of asset I and σ_{ij} is the covariance between asset i and j. We minimize the portfolio variance under the following conditions:

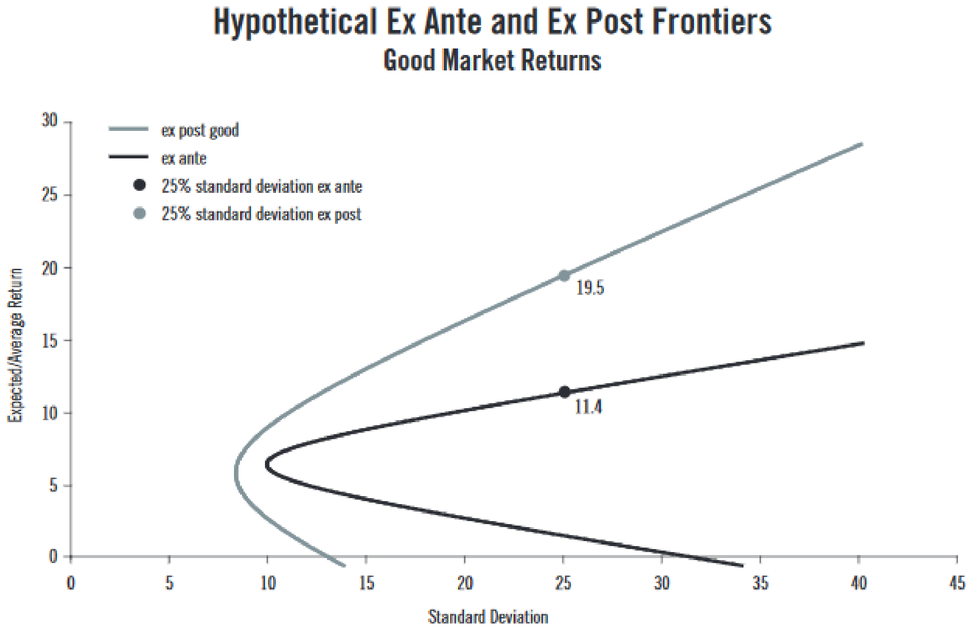
1. The expected return of the portfolio is given, i.e. $\sum_{i=1}^{N} w_i E(R_i) = k\%$
2. The sum of the weights is equal to one, i.e. $\sum_{i=1}^{N} w_i = 1$
3. The weights cannot be a negative number, i.e. $w_i \geq 0$

The solution is the weights that minimize the risk. For weights equal to zero do not invest in the asset.

When Markowitz introduced the efficient frontier in Journal of Finance, it was groundbreaking in many respects. One of its largest contributions was its clear demonstration of the power of diversification. However, a major problem is occurred. Markowitz world comes with the assumption that a portfolio of assets can be sufficiently described by the expected return and the variance of the portfolio and it does not take into account the correlation of the assets. Moreover, the weights, the variance, the covariance and the expected return of the assets are not constant over time. Still calculating variance, covariance and expected return based on historical data is a problem itself. On October 2008, James L. Davis wrote a paper on Dimensional Fund Advisors with a title "Efficient frontiers constructed with historical data can be misleading" explaining all the problems mentioned above. He claimed that an ex ante theoretical concept turned into an ex post tool for data analysis is wrong. He supposed that only 6 assets were available for investment. Then, Davis calculated the ex-ante efficient frontier and build ex post efficient frontiers using good, normal and bad market returns. A rational investor could think that normal market returns would lie closer to efficient frontier but this is not always the case. Davis proved that bad market returns did. In that year, Levy and Roll (1977) provided the answer why this happened on the paper "The market portfolio could be mean-variance after all", which we will discuss on chapter 3. Summarily, they said efficient frontier is the result of an optimization problem. It shows the set of portfolios that provide the best return-variability tradeoff, given the expected returns and covariances of the asset classes. An historical average return includes both the expected return and an average error, the part of the historical return that could not have been anticipated beforehand, while the ex-ante efficient frontier optimizes with respect to expected returns, the ex post frontier optimizes with respect to both expected returns and errors. In other words, the ex post frontier treats the average errors as if they were expected. Compared to the ex-ante frontier, portfolios on the ex post frontier tend to over-weight assets with positive errors and under-weight assets with negative errors.

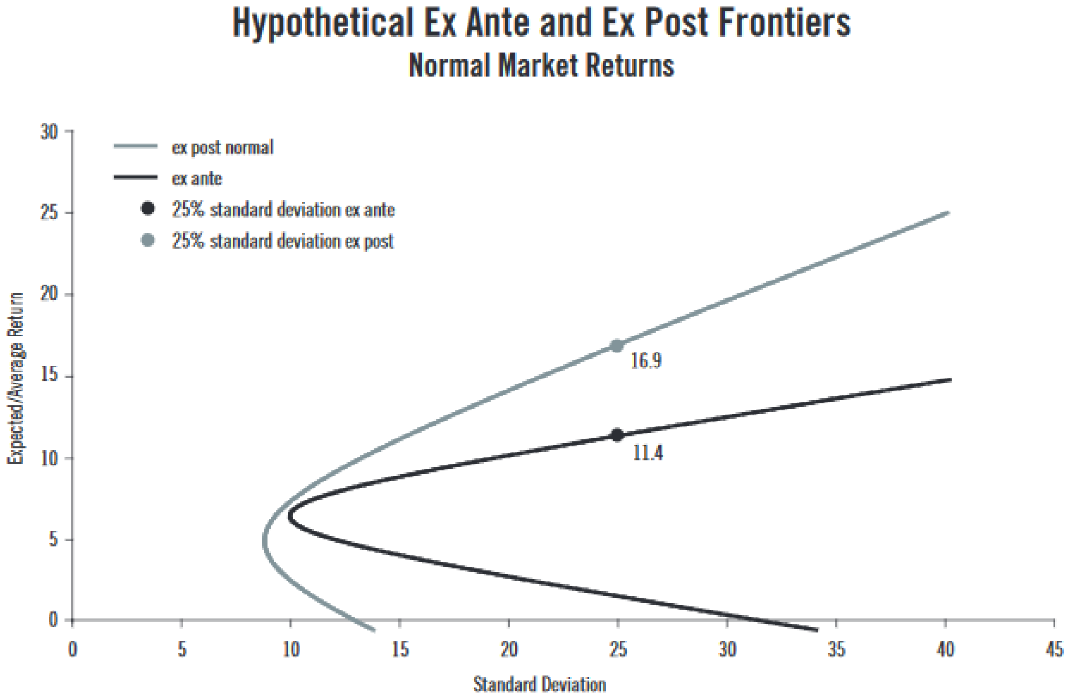
Figures 2.4, 2.5 and 2.6 were provided to strengthen Davis' findings.

Figure 2.4.: Hypothetical Ex Ante and Ex post Frontiers using Good Market Returns



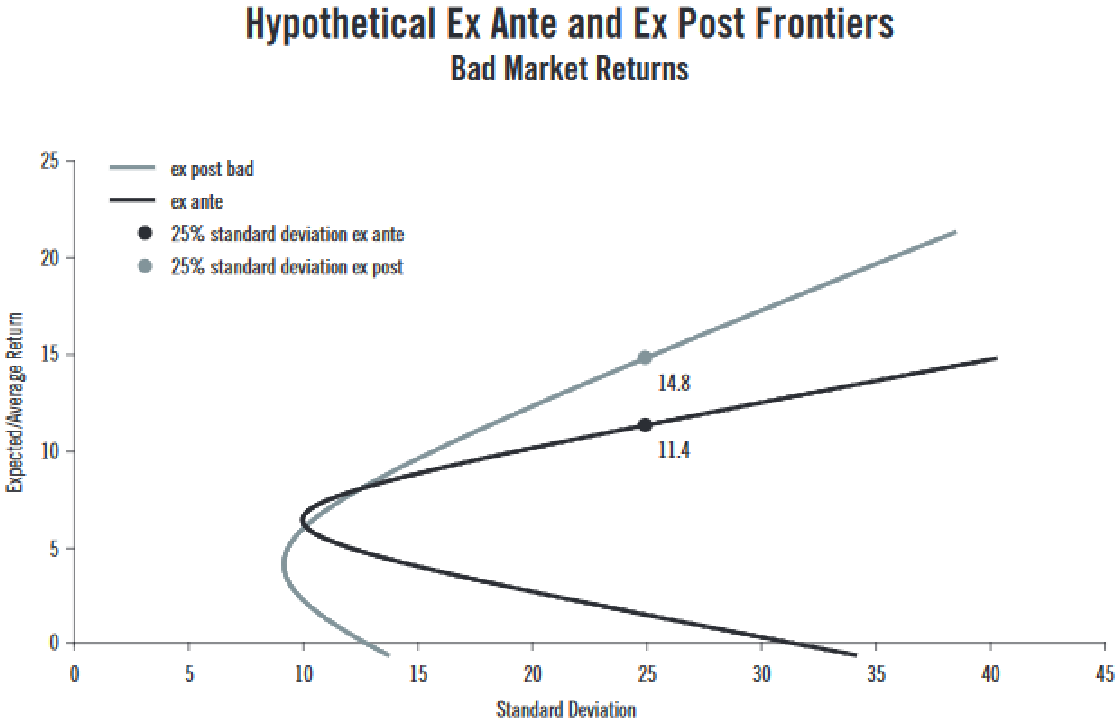
Source: https://us.dimensional.com/pdf/efficient_frontiers_misleading.pdf

Figure 2.5.: Hypothetical Ex Ante and Ex post Frontiers using Normal Market Returns



Source: https://us.dimensional.com/pdf/efficient_frontiers_misleading.pdf

Figure 2.6.: Hypothetical Ex Ante and Ex post Frontiers using Bad Market Returns



Source: https://us.dimensional.com/pdf/efficient_frontiers_misleading.pdf

2.6. Portfolio Modeling Theory

In this subchapter we will discuss basic models used to calculate expected returns of an asset or portfolio. Extended analysis will be provided on chapter 3, in which we will further review the literature.

2.6.1. Single Index Model (SIM)

The single index model is a return production model, the simplest of its kind. The idea behind the SIM is that many factors that affect asset returns could be summarized in one major factor, the market index. Mathematically, SIM is expressed as:

$$R_i = a_i + b_i * R_m + e_i \quad (\mathbf{2.29})$$

Where R_i is the return of asset i, a_i is the alpha or abnormal return of asset i and is constant (e.g. An alpha of 1% means the investment's return on investment over a selected period of time was 1% better than the market during that same period), b_i is the beta coefficient of asset i or the market's influence on asset i, R_m stands for the market index return and e_i is the error term-residual (the influence on R_i from unterritoried factors). We suppose that residuals are independent, normally distributed with mean zero and standard deviation σ_i. Thus, the expected return of residuals $E(e_i)$ is equal to zero:

$$E(e_i) = 0 \quad (\mathbf{2.30})$$

Asset return is split in two parts. First, the systematic return: b_i*R_m which depends on the market (macroeconomic factors) and second, the unsystematic return: a_i+u_i which depends on the firm (microeconomic factors).

The expected return of the asset is given by the following equation:

$$E(R_i) = a_i + b_i * E(R_m) \quad (\mathbf{2.31})$$

Where $E(R_i)$ is the expected return of asset i and $E(R_m)$ is the expected return of the market portfolio. The equation 2.31 can also be split in two parts: the unsystematic return a_i and the systematic return b_i*R_m.

From the equation 2.23 we can derive the variance of the asset return $Var(R_i)$ which we assume constant over time:

$$Var(R_i) = b_i^2 * Var(R_m) + Var(e_i) \quad (\mathbf{2.32})$$

Where $Var(R_m)$ is the variance of the market portfolio and $Var(e_i)$ is the variance of the residuals. Again the equation 2.32 can be split in $b_i^2 * Var(R_m)$ which is the systematic risk of the asset i and $Var(e_i)$ which is the non systematic risk of the asset i.

Alpha and beta can be derived mathematically or statistically. From equation 2.29 we calculate the $Cov(R_i,R_m)$ which is the risk of asset i on M.

$$Cov(R_i, R_m) = Cov(b_i R_m, R_m) = b_i Cov(R_m, R_m) = b_i Var(R_m) \leftrightarrow$$
$$b_i = \frac{Cov(R_i, R_m)}{Var(R_m)} \quad (\mathbf{2.33})$$

and therefore,

$$a_i = E(R_i) - b_i E(R_m) \quad (\mathbf{2.34})$$

Statistically, with the assumptions we made: $E(e_{it})=0$, $Cov(R_m,e_{it})=0$, $Var(e_{it})$ constant (homoscedasticity hypothesis: This assumption means that the variance around the regression line is the same for all values of the predictor variable (X)), $Cov(e_{it},e_{it-1})=0$ (zero autocorrelation hypothesis- Autocorrelation, also known as serial correlation, is the correlation of a signal with itself at different points in time.) and a,b constant, the least squares method will give us the exact same results as equations 2.33 and 2.34. Adding time t to SIM gives us a regression model. In practice, we have to compute R-squared (coefficient of determination). R-squared is a statistical measure of how close the data are to the fitted regression line and it ranges from zero to one. If R-squared equals to zero there is no linear relation between R_i and R_m. An R-squared of one is providing the best linear relation.

$$R^2 = \left[\frac{Cov(R_i, R_m)}{\sigma_i \sigma_m}\right]^2 \quad (\mathbf{2.35})$$

After computing R-squared, one have to examine the statistical significance of R-squared. In other words, we have to test the hypothesis H_0: $R^2=0$ and H_1: $R^2 \neq 0$ using the f-test. An F-test is any statistical test in which the test statistic has an F-distribution under the null hypothesis. We can do the same thing with t-test to examine the statistical significance of a_i and b_i. A t-test is any statistical hypothesis test in which the test statistic follows a Student's t-distribution under the null hypothesis. For a null hypothesis (H_0) to be rejected as false, the result has to be identified as being statistically significant.

Beta coefficient is a relative risk measure, whereas variance is an absolute risk measure. If $b_i<0$ then the asset returns move opposite with the market portfolio returns. If $0<b_i<1$ then the asset returns move defensively but with the market portfolio. If $b_i=1$ then the asset returns move exactly as the market portfolio's. If $b_i>1$ the asset returns move aggressively but with the market portfolio. Therefore, when an investor anticipates an upward movement in the market return, he invest in securities with beta>1 and when he anticipates a downward movement in the market return, he invest in securities with beta<1.

An example of SIM is provided.

Table 2.5.: An example of Single Index Model

Months	Stock 1	Stock 2	Index M
1	0.10	0.08	0.092
2	0.03	0.03	0.030
3	0.09	0.01	0.058
4	0.08	0.08	0.080
5	0.06	0.03	0.048
6	0.12	0.07	0.100
$E(R_i)$	0.08	0.05	0.068
Var(M)	-	-	0.00074
$Cov(R_1,R_M)$	0.00079	-	-

The $Cov(R_2,R_M)$ is equal to $\frac{(0.08-0.05)(0.092-0.068)+\cdots+(0.07-0.05)(0.100-0.068)}{5} = 0.00066$. The beta of stock 1 is equal to $\frac{0.00079}{0.00074} = 1.067$. The beta of stock 2 is equal to $\frac{0.00066}{0.00074} = 0.89$. The alpha of stock 1 is equal to $0.08 - 1.067 * 0.068 = 0.007444$ and the alpha of stock 2 is equal to $0.05 - 0.89 * 0.068 = -0.01052$.

We can extend the SIM analysis on a portfolio. The return of portfolio p (R_p) is given by equation 2.36:

$$R_{pt} = a_p + b_p R_{mt} + e_{pt} \quad \mathbf{(2.36)}$$

$$a_p = \sum_{i=1}^{N} x_i a_i \ \mathbf{(2.37)}$$

$$b_p = \sum_{i=1}^{N} x_i b_i = \frac{Cov(R_{pt}, R_{mt})}{Var(R_m)} \mathbf{(2.38)}$$

where R_{pt} is the return of portfolio p at time t, a_p is the weighted average of assets' alpha, b_p is the weighted average of assets' beta, R_{mt} is the return of market portfolio at time t, $Cov(R_{pt},R_m)$ is the risk of portfolio p on M and e_{pt} the residuals. The assumptions remain the same. That means $E(e_{pt})=0$, $Cov(R_{mt},e_{pt})=0$, $Var(e_{pt})$ is constant and $Cov(e_{pt},e_{pt-1})=0$. The variance of a portfolio p is given by the following equation:

$$Var(R_{pt}) = b_p^2 Var(R_{mt}) + Var(e_{pt}) \ \mathbf{(2.39)}$$

Where $Var(R_{pt})$ is the variance of the portfolio p, $Var(R_{mt})$ is the variance of the market portfolio and $Var(e_{pt})$ is the variance of the residuals. The equation 2.33 may be rewritten as follows:

$$1 = \frac{b_p^2 Var(R_{mt})}{Var(R_{pt})} + \frac{Var(e_{pt})}{Var(R_{pt})} \ \mathbf{(2.40)}$$

The left fraction stands for the contribution of systematic risk to the whole portfolio's risk and the right fraction stands for the contribution of non-systematic risk to the whole portfolio's risk. The smaller the contribution of non-systematic risk to the whole portfolio's risk is the better for the regression model. In case of a well-diversified portfolio, the right fraction approaches to zero.

If efficient frontier is calculated through SIM, all we have to do is use equations 2.41 and 2.42.

$$Cov(R_i, R_j) = b_i b_j Var(R_{mt}) \ \mathbf{(2.41)}$$

$$Var(R_{it}) = b_i^2 Var(R_m) + Var(e_{it}) \ \mathbf{(2.42)}$$

We may use SIM to calculate betas and because we calculate fewer parameters.

Many empirical studies have shown that SIM's assumptions are violated in practice. Therefore, tests for statistical significance may be wrong. This problem is solved with the use of basic econometrics. In fact, we find more accurate results using multifactor models.

2.6.2. Capital Market Theory

Capital market theory provides us answers to three questions. First, which is the relation between expected return and risk for efficient portfolios? Secondly, which is the relation between expected return and risk for an asset or a portfolio irrespective of their efficiency? Thirdly, which is the suitable risk measure for an asset or a portfolio?

Capital market theory is based on Markowitz theoretical approach with a key difference. Markowitz assumes that there are no risk free assets, whereas capital market theory hypothesizes a risk free asset, such as treasury bills. This theory comes with two models, the capital market line model and the capital asset pricing model, both based on the same following assumptions.

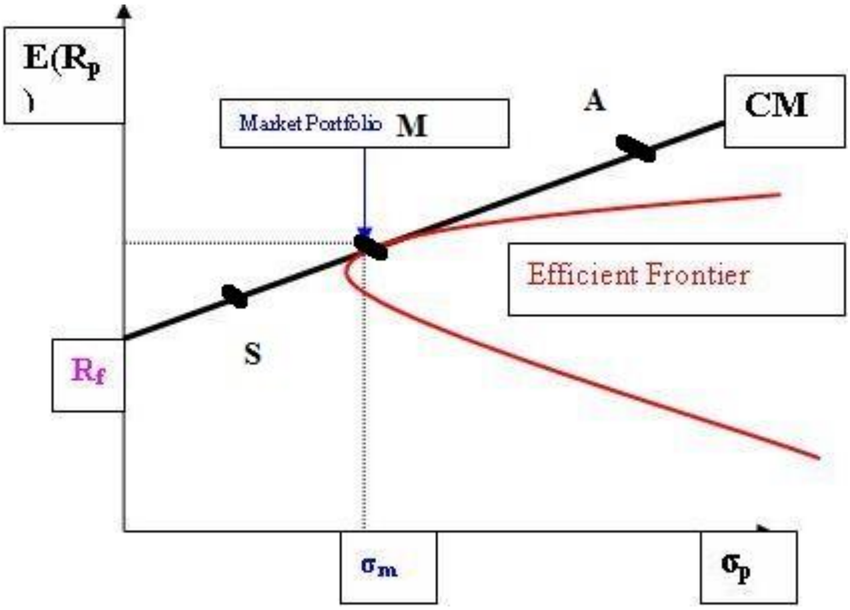
Capital market theory assumes that all investors follow Markowitz theory and purchase portfolios from the efficient frontier. Moreover, there is a risk-free asset that all investors can borrow and lend on its rate of return. Furthermore, there is a unique and common investment horizon. The market is perfect, thus no taxes, no transaction costs and no inflation exist, investors cannot individually affect the market prices, the assets are perfectly divided and an investor can invest in any quantity immediately and information is the same and available to everyone. The above mentioned market is always at equilibrium.

2.6.2.1. Capital Market Line (CML) Model

We did assume that investors follow the Markowitz theory, therefore they are able to create portfolios with minimum risk and maximum returns. Also, there is a unique and common investment horizon and this combined with the fact that information costs nothing, is a proof that that for this horizon there is one efficient frontier.

Since capital market theory is valid there is one risk-free asset with expected return equal to r_f. This can be depicted by a line touching the efficient frontier in a specific point. The portfolio that represents that point is the tangent market portfolio and is considered the most acceptable for an investor.

Figure 2.7.: Capital Market Line Model



Source: http://www.bankpedia.org/index.php/en/89-english/c/23151-capital-market-line-cml-encyclopedia

As we may understand from Figure 2.7 the capital market line which is the tangent line drawn from the point of the risk-free asset to the feasible region for risky assets, transforms in a way the Markowitz efficient frontier to a straight line. If an investor chooses a portfolio on the CML on the left of market portfolio, S for instance, it means that he is lending money on r_f, whereas if he chooses a portfolio on the CML on the right of market portfolio (such as A) it means that he is borrowing money on r_f. All portfolios below CML are inefficient and all portfolios above CML do not follow Markowitz rules. The optimal is the tangent portfolio or market portfolio M. We may assume that CML is a more realistic approach of any seen at the moment.

$$\text{Slope of the capital market line on S} = \frac{\mathrm{E}(\mathrm{R_s}) - r_f}{\sigma_{\mathrm{s}}} \quad (\mathbf{2.43})$$

$$\text{Slope of the capital market line on M} = \frac{\mathrm{E}(\mathrm{R_m}) - \mathrm{r_f}}{\sigma_{\mathrm{m}}} \quad (\mathbf{2.44})$$

Where $E(R_s)$ is the expected return of portfolio s, $E(R_m)$ stands for the expected return of portfolio m, r_f is the return of the risk-free asset, σ_s stands for the standard deviation of portfolio s and σ_m is the standard deviation of portfolio m. As points S and M are on the same line their slopes are equal. Equation 2.45 is the capital market line model or the new efficient frontier.

$$E(R_s) = r_f + \frac{E(R_m) - r_f}{\sigma_m}\sigma_s \quad (\mathbf{2.45})$$

Another way to calculate the equation 2.45 is considering the return on S (R_s) as a weighted average of the returns on F (r_f) and M (R_m) with weights equal to their investment percentages x_f and x_m respectively, such that:

$$R_S = x_f r_f + x_m R_m \quad \mathbf{(2.46)}$$

The next step is to calculate the expected return on S and its standard deviation:

$$E(R_s) = E\left(x_f r_f + x_m R_m\right) = x_f r_f + x_m E(R_m) \quad \mathbf{(2.47)}$$

Where $x_f + x_m = 1 \quad \mathbf{(2.48)}$

$$Var(R_s) = Var\left(x_f r_f + x_m R_m\right) = Var(x_m R_m) = x_m^2 Var(R_m)$$
$$\rightarrow \sigma(R_s) = x_m \sigma(R_s) \quad \mathbf{(2.49)}$$

Combining equations 2.47 and 2.49 we get equation 2.45.

The capital market line model is valid for efficient portfolios and only. This is because equation 2.45 is a result of the efficiency of market portfolio M. If M was outside of the Markowitz efficient frontier the equation 2.45 could not stand. Thus, CML requires an efficient S and M and answers the first question of capital market theory: which is the relation between expected return and risk for efficient portfolios? This relation is fully described in the above equation where investors require an extra return of their investment (above r_f) to hedge their risk. In other words, investors demand the return of the risk-free asset, as well as, a risk premium return. Therefore:

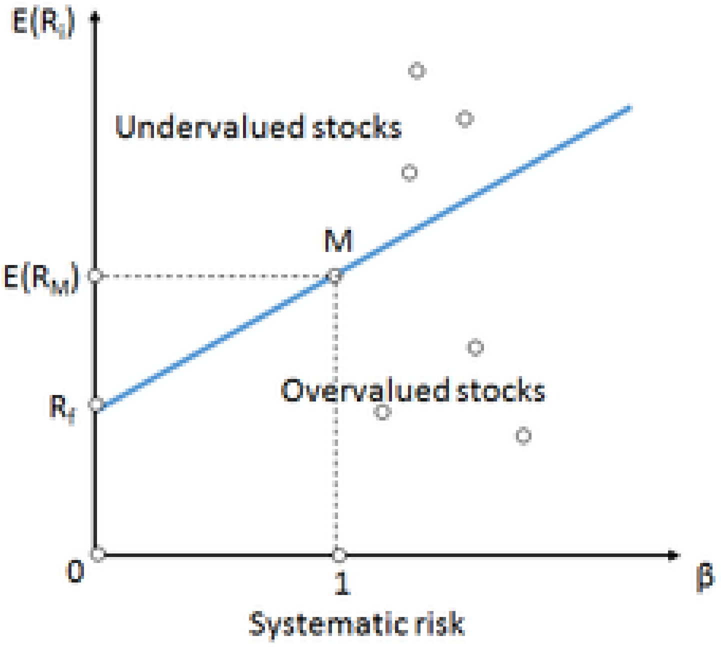
$$Risk\ premium\left(r_p\right) = \frac{E(R_m) - r_f}{\sigma_m} \sigma_s \quad \mathbf{(2.50)}$$

2.6.2.2. Capital Asset Pricing Model (CAPM)

Security market line (SML) is the representation of the capital asset pricing model. It displays the expected rate of return of an individual security as a function of systematic, non-diversifiable risk. In other words, the security market line is the depiction of the relation between expected return and risk expressed as beta, whereas of standard deviation as we have seen so far. Individual assets and portfolios are plotted on the security market line. If a security is plotted above the security market line, it is undervalued because an investor can expect a greater return for its risk. On the other hand, if a security is plotted below the security market line, it is overvalued because an investor can expect a lower return for the risk inherited. The market risk premium is determined by security' market line slope. A risk premium, as we discussed, is the minimum amount of money by which the expected return on a risky asset must exceed the known return on a risk-free asset in order to induce an individual to hold the risky asset rather than the risk-free asset.

The capital asset pricing model (CAPM) was developed by Jack Treynor (1962), William Sharpe (1964), John Lintner (1965) and Jan Mossin (1966).

Figure 2.8.: Security Market Line-CAPM



Source: https://en.wikipedia.org/wiki/Security_market_line

As we see in the Figure 2.8, the CAPM derives from the efficiency of M. It provides a positive and linear relation between expected return and betas. M is a well-diversified portfolio, thus its beta equals to one.

The equation expressing the security market line or CAPM is the following:

$$E(R_i) = r_f + [E(R_m) - r_f]b_i \quad (\mathbf{2.51})$$

Where $E(R_i)$ is the expected return of an asset or a portfolio i, r_f is the risk free rate, $E(R_m)$ is the expected return of market portfolio and b_i is the beta of an asset or a portfolio i. In that case, CAPM is valid for either an asset or a portfolio, despite their efficiency. That is the answer to the second question of capital market theory: which is the relation between expected return and risk for an asset or a portfolio irrespective of their efficiency? The risk premium on CAPM is given by:

$$Risk\ premium = \left[E(R_m) - r_f\right] b_i \quad \mathbf{(2.52)}$$

CML and CAPM are both positive linear relationships of expected returns and risk but they share many differences. The differences between the capital market line and the CAPM are the following:

- CAPM measures relative risk with beta coefficient (systematic risk), whereas CML measures risk with the standard deviation of returns (whole risk)
- The risk premium for CAPM is given by equation 2.52, while the risk premium for CML is given by equation 2.50
- CAPM is pricing efficient or inefficient assets or portfolios, while CML is pricing efficient portfolios

The last difference is giving us an idea to discuss. Suppose that we have an efficient portfolio S and M is also efficient. If S is on the CML, what is its beta? In that case, both CML and CAPM are valid, such that equations 2.45 and 2.51 are equal:

$$r_f + \frac{E(R_m) - r_f}{\sigma_m} \sigma_s = r_f + \left[E(R_m) - r_f\right] b_s$$

$$\rightarrow b_s = \frac{\sigma_s}{\sigma_m} \quad \mathbf{(2.53)}$$

Where σ_s represents the standard deviation of returns of portfolio S and σ_m represents the standard deviation of returns of market portfolio M. If S and M are inefficient the basic equation of beta described on the single index model is used (see equation 2.33). Thus, if we calculate beta with equation 2.53 and 2.33 and they give us the same result, S and M are efficient.

Though there is a way to calculate beta on CAPM through single index model, the models have some differences. CAPM is an equilibrium relation expressed as expected return. On the other hand, the single index mode is not an equilibrium relation and is expressed as percentage returns. Moreover, CAPM uses beta coefficient and single index model is a way to compute the beta coefficient.

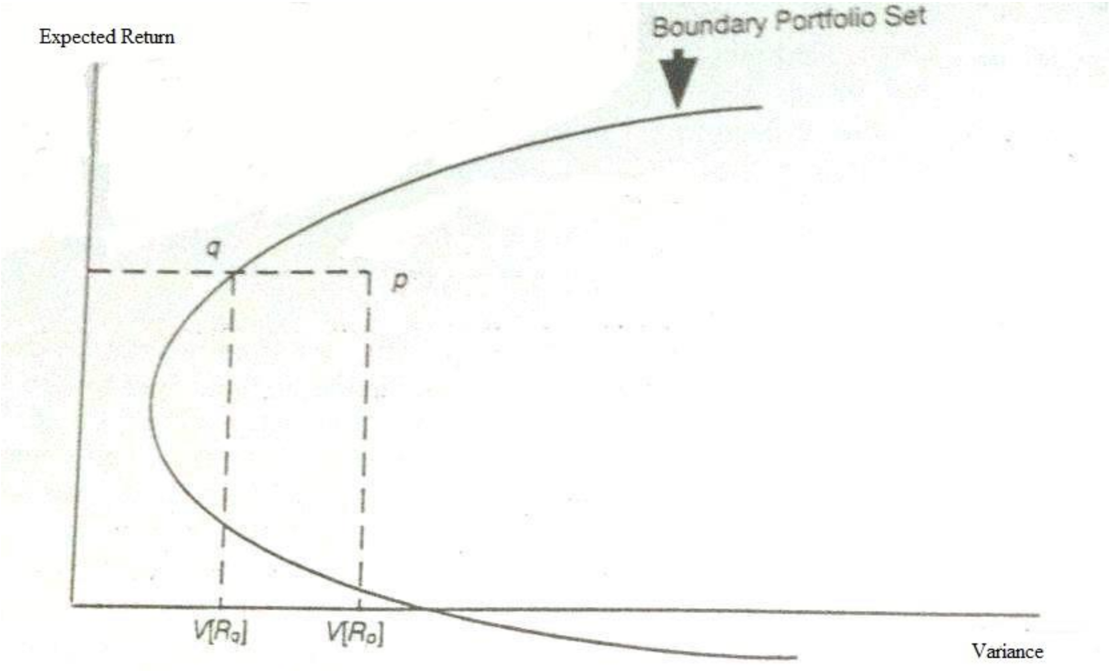
There is much critique on CAPM since its assumptions are invalid and many different models were proposed on the process to cover the blanks most of them are multifactor models, still CAPM remains the base. The most known critique is done by Roll (1977) (1977) who proved that if the market portfolio M is efficient then CAPM is valid and vice versa. As CAPM is the main subject of this thesis more on the proposed models will be discussed on chapter 3. To fulfill any curiosity at this point we will state the basic headlines. Jagannathan and Wang (1966) proposed the "conditional CAPM" which includes the conditionality of the moments. Furthermore, to overcome the problem of unlimited borrowing and lending at r_f, Black (1972) introduced the "zero beta CAPM or Black CAPM". One year later, Merton (1973) includes the preferences of investors and named the model "intemporal CAPM or ICAPM". Stephen Ross (1976) introduced his arbitrage pricing theory model or APT. Afterwards, Douglas Breeden and Robert Lucas (1979) presented the consumption based CAPM known as CCAPM. Adler and Dumas (1983) proposed the international CAPM. Ten years later, Fama and French (1993) proposed their three-factor model, though on 2015 they changed it into a five-factor model and the list is never-ending.

2.7. Non Efficient Portfolios and the Three Dimensional (3D) Model

CAPM is invalid means the benchmark M is inefficient. What happens in this case? Diacogiannis in 1999 on the paper "A three-dimensional risk-return relationship based upon the inefficiency of a portfolio: Derivation and implications" and afterwards on the paper "Linear beta pricing with inefficient benchmarks" with Feldman in 2013 proposed the three dimensional model (3D). This 3D model is based upon the inefficiency of portfolios and benchmark. It is proved that the inefficiency of a portfolio that has an expected return greater than the expected return of the global minimum variance portfolio, is a necessary and sufficient condition for expressing the expected return on any security under consideration as an exact linear function of its relative risk in that portfolio and an additional risk associated with moving inside the boundary portfolio set. Though many proposed models will be discussed on chapter 3, in this subchapter we will provide a proof of the 3D model in which we will base this thesis.

We consider a portfolio p, which lies inside the boundary portfolio set and a boundary portfolio q, such that their expected returns are equal (see Figure 2.9).

Figure 2.9.: Portfolios p and q-3D model



Source: Diacogiannis, G. (1999) "A three-dimensional risk-return relationship based upon the inefficiency of a portfolio: Derivation and implications", The European Journal of Finance, Vol. 5, pp. 225-235

The return of portfolio p is equal to the rate of return of the boundary portfolio q plus a residual term:

$$R_p = R_q + U_p \quad (\mathbf{2.54})$$

The residual term has expected return of zero and it is also uncorrelated with the rate of return of the boundary portfolio q. In other words, we created q and p in such way that:

$$E\left(R_p\right) = E\left(R_q\right) \quad (\mathbf{2.55})$$

Thus, $E\left(U_p\right) = 0$. Moreover, considering covariances on equation 2.54 reveals the equation 2.56:

$$Cov\left(R_i, R_p\right) = Cov\left(R_i, R_q\right) + Cov\left(R_i, U_p\right) \quad (\mathbf{2.56})$$

The portfolio q is efficient and therefore for portfolio q we may use the CAPM:

$$E(R_i) = r_f + \left[E\left(R_q\right) - r_f\right]b_{iq} \quad (\mathbf{2.57})$$

But as we know from equation 2.33:

$$b_{iq} = \frac{Cov(R_i, R_q)}{Var(R_q)} \quad (\mathbf{2.58})$$

Substituting equation 2.58 to 2.57 we get:

$$E(R_i) = r_f + \left[E\left(R_q\right) - r_f\right] \frac{Cov(R_i, R_q)}{Var(R_q)} \quad (\mathbf{2.59})$$

Substituting equation 2.56 to 2.59 we reveal the following relationship:

$$E(R_i) = r_f + \left[E\left(R_q\right) - r_f\right] \frac{Cov(R_i, R_p)}{Var(R_q)} - \left[E\left(R_q\right) - r_f\right] \frac{Cov(R_i, U_p)}{Var(R_q)} \quad (\mathbf{2.60})$$

Then, we substitute equation 2.55 to 2.60:

$$E(R_i) = r_f + \left[E\left(R_p\right) - r_f\right] \frac{Cov(R_i, R_p)}{Var(R_q)} - \left[E\left(R_p\right) - r_f\right] \frac{Cov(R_i, U_p)}{Var(R_q)} \quad (\mathbf{2.61})$$

$$\begin{aligned} \rightarrow E(R_i) = r_f + \left[E\left(R_p\right) - r_f\right] \frac{Cov(R_i, R_p)}{Var(R_q)} \frac{Var(R_p)}{Var(R_p)} \\ - \left[E\left(R_p\right) - r_f\right] \frac{Cov(R_i, U_p)}{Var(R_q)} \frac{Var(U_p)}{Var(U_p)} \end{aligned}$$

Thus:

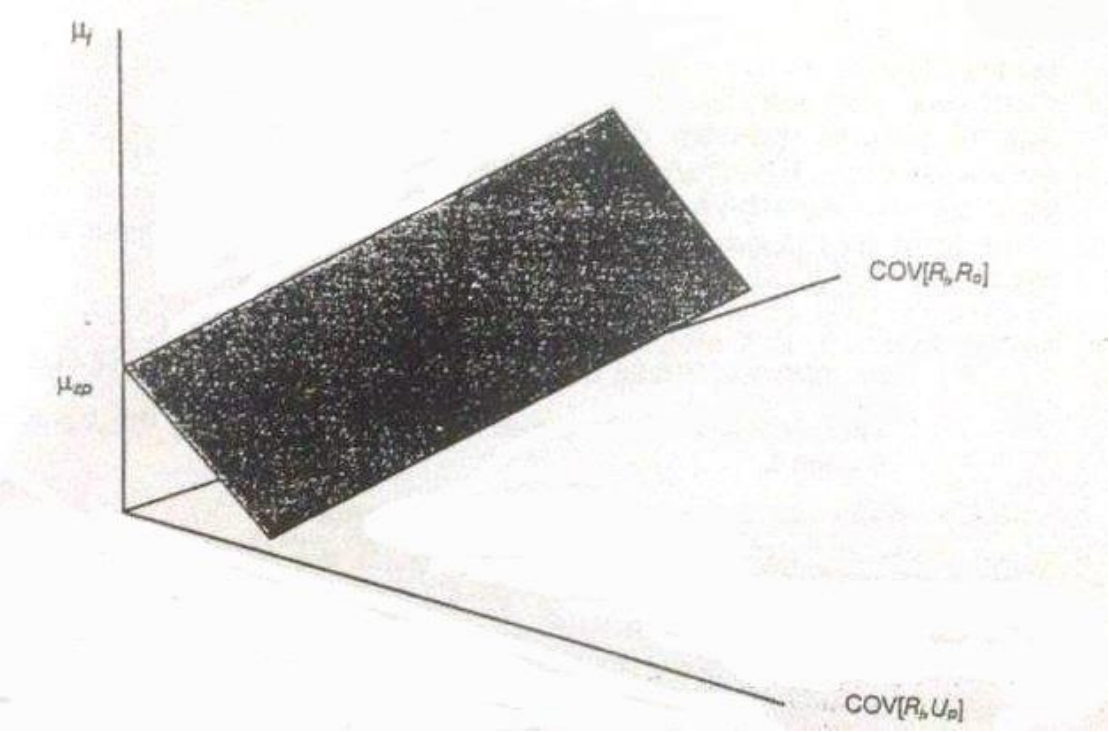
$$E(R_i) = r_f + \left[E\left(R_p\right) - r_f\right] \frac{Var(R_p)}{Var(R_q)} b_{ip} + \left[E\left(R_p\right) - r_f\right] \frac{Var(U_p)}{Var(R_q)} b_{iup} \quad (\mathbf{2.62})$$

Where $b_{ip} = \frac{Cov(R_i, R_p)}{Var(R_p)}$ $(\mathbf{2.63})$ and $b_{iup} = \frac{Cov(R_i, U_p)}{Var(U_p)}$ $(\mathbf{2.64})$

The equation 2.62 is the three dimensional risk-return relationship of inefficient portfolios.

Graphically equation 2.62 is a linear plane. On the vertical axis we have the expected returns and on the two horizontal axes we have Cov(R_i,R_p) and Cov(R_i,U_p) respectively.

Figure 2.10.: Security market plane-3D model



Source: Diacogiannis, G. (1999) "A three-dimensional risk-return relationship based upon the inefficiency of a portfolio: Derivation and implications", The European Journal of Finance, Vol. 5, pp. 225-235

It is obvious that CAPM is not valid in that case. In terms of CAPM the relationship of risk and return would be: $E(R_i) = r_f + \left[E\left(R_q\right) - r_f\right]b_{iq}$ as we saw in equation 2.57. As a result, using CAPM over the 3D model calculates misleading returns. This is because when the portfolio p is inefficient, there are two systematic risks that affect its return. CAPM does not include the term $\left[E\left(R_p\right) - r_f\right]\frac{Var(U_p)}{Var(R_q)}b_{iup}$ of equation 2.62 and therefore is invalid. Besides the missing term on CAPM, on 3D model betas are weighted with variance ratios, whereas on CAPM betas are not weighted.

The result of the 3D model has the following implications. First, a firm's cost of capital is underestimated or overestimated when one utilizes an exact linear relationship between expected return and beta calculated against a portfolio that lies inside the boundary portfolio set. Second, as we will later see in chapter 3, in most empirical tests of the CAPM, the estimates of the cross-sectional single linear regression have a higher intercept and a lower slope than exact linearity among sample average returns and sample betas would suggest. These findings are due to misspecification of the cross-sectional model employed in the tests.

2.8. Performance-Effectiveness Measures

As mentioned, in a Markowitz world an investor wants to find the profitable investment among investments with the same risk level and the safest among the ones with the same level of return. Measuring risk and return can be vital for an investor in order to hedge the risk and performance measures can help in that process. Someone can measure performance by net price changes, which is an absolute return measure, but it omits the risk parameter. There are numerous performance measures because each one fits to a different class of assets or to a different distribution of returns. Combining risk and return we get a range of measures analyzed below in historical published order at most.

2.8.1. Treynor Ratio

The Treynor ratio (also known as reward-to-volatility ratio) was introduced by Jack L. Treynor in 1965. This ratio is based on CAPM and incorporates all the assumptions made for this model. The equation of the Treynor ratio is the following:

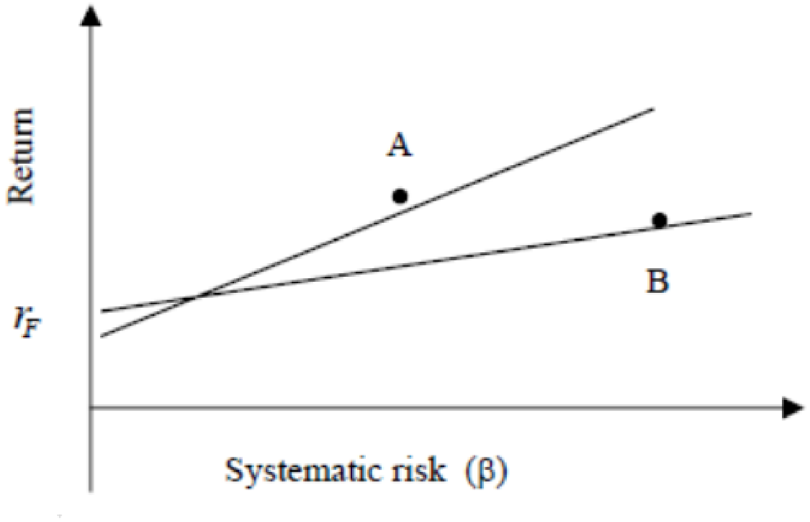
$$Treynor\ Ratio = \frac{R_p - r_f}{b_p} \quad \mathbf{(2.65)}$$

Where R_p stands for the return of the portfolio p, r_f stands for the risk-free rate and b_p is the beta coefficient of the portfolio p.

Treynor ratio expresses the excess return of the portfolio p over the risk-free rate per unit of portfolio’s systematic risk (beta). The ratio is similar to Sharpe ratio, as we will later discuss, with the only difference that instead of standard deviation of returns of portfolio it uses the relative risk of portfolio as its denominator. Due to this, Treynor ratio received quite bad critics, which is understandable in a way because in case of unsystematic risk existence the ratio is invalid.

Let aside the critique, it is used to rank portfolios with the same level of market risk and compare them with the market return. When the value of the Treynor ratio is high, it is an indication that an investor has generated high returns on each of the market risks he has taken. Another way to use Treynor ratio is to compare our portfolio with the market portfolio and calculate if our portfolio did better or worse in terms of return than the market. However, the Treynor ratio does not include any added value gained from active portfolio management.

Figure 2.11.: Treynor ratio for two portfolios



Source: https://de.wikipedia.org/wiki/Treynor-Ratio

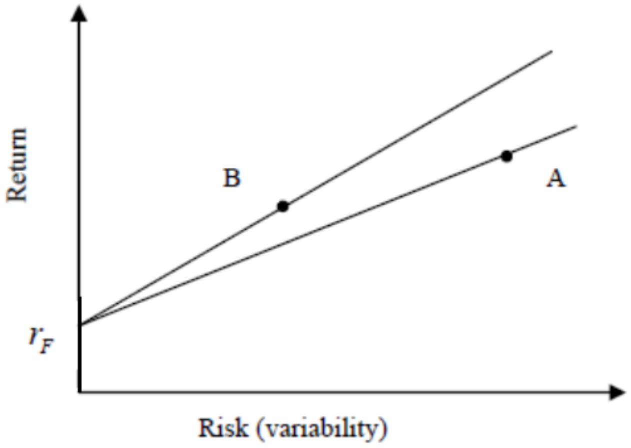
2.8.2. Sharpe Ratio

Sharpe ratio introduced by William F. Sharpe in 1966 is a measure for ranking portfolios and this ratio has become the industry standard for such ranking. Sharpe ratio (or reward-to-variability ratio) is expressed as the excess return of the portfolio p over the risk-free rate per unit of standard deviation of returns and it is based on the capital market line model. In fact, Sharpe ratio is the slope of the capital market line. The formula is the following one:

$$Sharpe\ Ratio = \frac{R_p - r_f}{\sigma_p} \quad (\mathbf{2.66})$$

Where R_p stands for the return of the portfolio p, r_f stands for the risk-free rate and σ_p is the standard deviation of returns of portfolio p.

Figure 2.12.: Sharpe ratio for two portfolios



Source: http://www.statpro.com/blog/how-sharp-is-the-sharpe-ratio/

Generally, the greater the value of the Sharpe ratio is, the best is the portfolio. Basic assumption of the capital market theory is that the return distribution is normal, but when returns are not normally distributed Sharpe ratio gives misleading results. This fact drove the need to incorporate skewness and kurtosis of return distribution to modern performance measures. One example is the adjusted Sharpe ratio that we will later discuss.

2.8.3. Jensen's Alpha

Jensen's alpha was introduced by Michael Jensen in 1968 and it is based on CAPM. Jensen's alpha is the first benchmark based measure to be used. Jensen assumes that CAPM and single index model both hold. The Jensen's alpha is measured by the following equation:

$$a_p = [E(R_p) - r_f] + [E(R_m) - r_f]b_p \quad \mathbf{(2.67)}$$

Where a_p is the Jensen's alpha, $E(R_p)$ is the expected return of portfolio p, r_f is the return of the risk free asset, $E(R_m)$ is the expected return of market portfolio and b_p is the beta coefficient of portfolio p.

If Jensen's alpha is positive the portfolio p over performs the benchmark, whereas if Jensen's alpha is negative the portfolio p underperforms the benchmark. The benchmark's alpha is equal to zero. Jensen's alpha can be used not only for portfolios but also for individual assets. Jensen's alpha is important to investors because they need to look not only at the total return of a security or portfolio, but also at the amount of risk involved in achieving that return.

2.8.4. Appraisal and Information Ratio

The appraisal ratio was introduced in 1973 by Jack L. Treynor and Fischer Black. It is given by the following equation:

$$Appraisal\ ratio = \frac{a_p}{\sigma_p} \quad (\mathbf{2.68})$$

Where a_p stands for Jensen’s alpha of portfolio p and σ_p stands for the standard deviation of returns of portfolio p. This ratio is used to measure the quality of a fund's investment picking ability. It compares the fund's alpha to the portfolio's unsystematic risk or residual standard deviation. The higher the ratio is, the better the performance of the manager in question.

Another way to express the appraisal ratio is the information ratio introduced in 1989 by Grinhold.

$$Information\ ratio = \frac{E(R_p - R_m)}{\sigma(R_p - R_m)} \quad (\mathbf{2.69})$$

Where R_p is the return of the portfolio p and R_m is the return of the benchmark. The information ratio is similar to the Sharpe ratio but, whereas the Sharpe ratio is the excess return of an asset over the return of a risk free asset divided by the variability or standard deviation of returns, the information ratio is the active return to the most relevant benchmark index divided by the standard deviation of the active return or tracking error. Information ratio cannot be used to compare portfolios of different risk level because it does not take into account the systematic risk. A positive information ratio indicates an over-performance towards the benchmark, while a negative information ratio indicates an underperformance towards the benchmark.

2.8.5. Drawdown measures

A drawdown is the peak-to-trough decline during a specific recorded period of an investment, fund or commodity. A drawdown is usually quoted as the percentage between the peak and the subsequent trough. Those tracking the entity measure from the time a retrenchment begin to when it reaches a new high. The maximum drawdown is the maximum potential loss over a specific time period. The average drawdown is the average continuous negative return over an investment period.

$$Average\ drawdown = \sum_{i=1}^{d} \frac{D_i}{d} \quad (\mathbf{2.70})$$

Where D_i is the drawdown over the overall period and d is the number of individual drawdowns over the overall period.

Drawdown can be used as a measure of performance and numerous ratios have been derived from it. Calmar (California Managed Account Reports) ratio developed by Terry W. Young in 1991 is a Sharpe type ratio. Calmar ratio's formula is that of the equation 2.71:

$$Calmar\ ratio = \frac{R_i - r_f}{D_{max}} \quad \mathbf{(2.71)}$$

Where R_i is the return of asset I, r_f is the return of the risk free rate and, D_{max} is the maximum drawdown. Burke ratio was introduced by Gibbon Burke in 1994 and again it is a Sharpe type ratio stated in the following equation.

$$Burke\ ratio = \frac{R_i - r_f}{\sqrt{\sum_{i=1}^{k} D_i^2}} \quad \mathbf{(2.72)}$$

Sterling ratio developed by L.N. Kestner in 1996, it is also a Sharpe type ratio. Just like the Calmar ratio, a higher Sterling ratio is generally better because it means that the investment is receiving a higher return relative to risk.

$$Sterling\ ratio = \frac{R_i - r_f}{D_{aver}} \quad \mathbf{(2.73)}$$

Where D_{aver} is the average drawdown.

2.8.6. Modigliani-Modigliani Risk-Adjusted Performance Measure (M^2 RAP)

This risk-adjusted performance measure was suggested by Leah and Franco Modigliani in 1997. It measures the returns of the portfolio, adjusted for the risk of the portfolio relative to that of the benchmark and is also derived from the Sharpe ratio.

$$M^2 = \left(R_p - r_f\right)\frac{\sigma_m}{\sigma_p} + r_f \quad \mathbf{(2.74)}$$

Where R_p is the return of portfolio p, r_f is the return of the risk free asset, σ_m is the standard deviation of the returns of market portfolio and σ_p is the standard deviation of the returns of portfolio p.

It shows that there is some kind of return punishment for a portfolio with risk level higher than the market risk level and a return reward for a portfolio with lower risk level than the market one. The general idea is that a portfolio can have a higher/lower risk level by borrowing at/lending to the risk free rate, therefore by increasing/reducing leverage. Again, the bigger the measure is, the higher the performance.

2.8.7. Upside-Downside Risk-Adjusted Measures

Downside risk is an estimation of a security's potential to suffer a decline in value if the market conditions change, or the amount of loss that could be sustained as a result of the decline. Downside risk explains a "worst case" scenario for an investment, or how much the investor stands to lose. Semivariance (downside potential) is a measure of the dispersion of all observations that fall below the mean or target value of a data set and is a downside risk measure.

$$Semivariance = \frac{1}{n} \sum_{r_t < average}^{n} (Average\ return - r_t)^2 \quad \mathbf{(2.75)}$$

$$Downside\ Potential = \sum_{i=1}^{T} \frac{\min(R_i - R_T, 0)}{T} \quad \mathbf{(2.76)}$$

$$Downside\ Risk = \sqrt{\sum_{i=1}^{T} \frac{[\min(R_i - R_T, 0)]^2}{T}} \quad \mathbf{(2.77)}$$

Where R_i is the return of the asset or the portfolio i, R_T is the minimum accepted return and T is the number of periods

On the other hand, upside risk is the uncertain possibility of gain and is calculated using data only from days when the benchmark has gone up.

$$Upside\ Potential = \sum_{i=1}^{T} \frac{\max(R_i - R_T, 0)}{T} \quad \mathbf{(2.78)}$$

$$Upside\ Risk = \sqrt{\sum_{i=1}^{T} \frac{[\max(R_i - R_T, 0)]^2}{T}} \quad \mathbf{(2.79)}$$

Where R_i is the return of the asset or the portfolio i, R_T is the minimum accepted return and T is the number of periods. The upside and the downside potentials are providing us a list of measures. We will discuss a few of them.

The Sortino ratio developed by F.A. Sortino and R. van der Meer in 1991 is given by the following equation.

$$Sortino\ ratio = \frac{R_p - R_T}{\sigma_D} \quad \mathbf{(2.80)}$$

It is like the Sharpe ratio, but instead of r_f it uses R_T. The upside potential ratio was introduced by F.A. Sortino, R. Van der Meer and A. Platinga in 1999.

$$Upside\ Potential\ ratio = \frac{upside\ potential}{downside\ risk} = \frac{\sum_{i=1}^{T} \frac{\max(R_i - R_T, 0)}{T}}{\sqrt{\sum_{i=1}^{T} \frac{[\min(R_i - R_T, 0)]^2}{T}}} \quad (\mathbf{2.81})$$

The Bernardo-Ledoit gain-loss ratio developed by A. Bernardo and O. Ledoit in 2000 is the upside potential to downside potential for R_T equals to zero.

$$Bernardo - Ledoit\ gain - loss\ ratio = \frac{\sum_{i=1}^{T} \frac{\max(R_i, 0)}{T}}{\sum_{i=1}^{T} \frac{\min(R_i, 0)}{T}} \quad (\mathbf{2.82})$$

The Omega ratio was introduced in 2002 by W.F. Shadwick and C. Keating and it implicitly adjust for both skewness and kurtosis.

$$Omega\ Ratio = \frac{upside\ potential}{downside\ potential} = \frac{\sum_{i=1}^{T} \frac{\max(R_i - R_T, 0)}{T}}{\sum_{i=1}^{T} \frac{\min(R_i - R_T, 0)}{T}} \quad (\mathbf{2.83})$$

The Omega-Sharpe ratio is derived from the Omega ratio above.

$$Omega - Sharpe\ Ratio = Omega\ Ratio - 1 \quad (\mathbf{2.84})$$

2.8.8. Value at Risk (VaR) and Conditional Value at Risk (CVaR) Measures

Value at Risk (VaR) is an attempt to provide a single number summarizing the total risk in a portfolio of financial assets. It is the maximum potential losses of a portfolio during a specific period, under a specific confidence level of the return distribution. VaR asks the question “how bad can things get?”

There are three methods of calculating VAR: the historical method, the variance-covariance method and the Monte Carlo simulation. The historical method simply re-organizes actual historical returns, putting them in order from worst to best. It then assumes that history will repeat itself, from a risk perspective. The variance-covariance method assumes that stock returns are normally distributed. In other words, it requires that we estimate only two factors: an expected return and a standard deviation, which allow us to plot a normal distribution curve. The idea behind the variance-covariance is similar to the ideas behind the historical method - except that we use the familiar curve instead of actual data. The advantage of the normal curve is that we automatically know where the worst 5% and 1% lie on the curve. The third method involves developing a model for future stock price returns and running multiple hypothetical trials through the model. Obviously, an investor should choose portfolios or individual assets with minimum VaR.

Conditional Value at Risk (CVaR, expected shortfall or tail VaR) was created to be an extension of VaR. The VaR model does allow managers to limit the likelihood of incurring losses caused by certain types of risk. The problem with relying solely on the VaR model is that the scope of risk assessed is limited, since the tail end of the distribution of loss is not typically assessed. Therefore, if losses are incurred, the amount of the losses will be substantial in value. Mathematically speaking, CVaR is derived by taking a weighted average between the value at risk and losses exceeding the value at risk.

2.8.9. Adjusted (or Modified) Sharpe Ratio (ASR)

ASR was introduced in 2006 and explicitly adjusts for skewness and kurtosis by incorporating a penalty factor for negative skewness and excess. It is given by the following equation:

$$ASR = SR\left[1 + \frac{S}{6}SR - \frac{K-3}{24}SR^2\right] \quad (\mathbf{2.85})$$

Where SR is the Sharpe ratio (see equation 2.66), S is the skewness of a distribution, K is the kurtosis of a distribution. Skewness and kurtosis are given by the following equations:

$$S = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{R_i - E(R_i)}{\sigma_{Ri}}\right]^3 \quad (\mathbf{2.86})$$

$$K = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{R_i - E(R_i)}{\sigma_{Ri}}\right]^4 \quad (\mathbf{2.87})$$

Where R_i is the return of asset or portfolio i, $E(R_i)$ is the expected return of asset or portfolio I, σ_{Ri} is the standard deviation of returns of asset or portfolio I and N is the number of observation of the returns.

The mean is the first moment of a distribution, the variance is the second moment, the skewness is the third and the kurtosis is the fourth. Skewness is a measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. Skewness of a normal distribution is equal to zero. Kurtosis is a measure of the "tailedness" of the probability distribution of a real-valued random variable. Kurtosis of a normal distribution is equal to three.

Investor should prefer high average returns, lower variance (or standard deviation), positive skewness and lower kurtosis.

Chapter 3: Literature Review

This chapter is an expansion of the portfolio theory discussed on chapter 2. An overview of the literature focusing on asset pricing models will be provided in historical order. The capital asset pricing model (CAPM) was developed by Jack Treynor (1962), William Sharpe (1964), John Lintner (1965) and Jan Mossin (1966), as we have seen in subsection 2.6.2.2. We divide the period from the introduction of CAPM until today to two sub periods. This is because Richard Roll in 1977 on his paper “A critique of the asset pricing theory’s tests. Part 1: On past and potential testability of the theory” made the most important critique on CAPM, thus the two sub periods are before Roll’s critique (before 1977- subchapters 3.1 to 3.7) and after Roll’s critique (after 1977- subchapters 3.8 to 3.26).

3.1. The Capital Asset Pricing Model: Some Empirical Tests (1972- Black Fischer, Jensen Michael and Scholes Myron)

In previous works of Jensen (1968, 1969) the relationship between the expected return and systematic risk of a large sample of mutual funds suggest that CAPM might provide an adequate description of relation between risk and return for securities. On the other hand, evidence by Douglas (1969), Lintner (1965) and Miller and Scholes (1972) seemed to indicate that CAPM does not provide a complete description of the structure of security returns. More specifically, Miller and Scholes suggested that the alpha on individual asset depend in a systematic way on their beta, that high beta assets tend to have negative alpha and the low beta assets tend to have positive alpha. Some statistical misspecifications in above studies leaded Black, Jensen and Scholes to write the paper we examine with their main purpose to present some additional tests on CAPM and provide additional insights into the nature of the structure of security items.

The simpler test Black, Jensen and Scholes propose is to test if the alpha of a security over some time period is significantly different from zero since alpha on CAPM model is zero. We remind that CAPM equation is the following one:

$$E(R_i) = r_f + \left[E(R_m) - r_f\right]b_i \quad \mathbf{(3.1)}$$

Where $E(R_i)$ is the expected return of an asset or a portfolio i, r_f is the risk free rate, $E(R_m)$ is the expected return of market portfolio and b_i is the beta of an asset or a portfolio i. However, the test just proposed is inefficient since it makes use of information on only a single security whereas data is available on a large number of securities. One procedure is to run tests on grouped data such that we obtain the maximum possible dispersion of the risk coefficients, b_k.

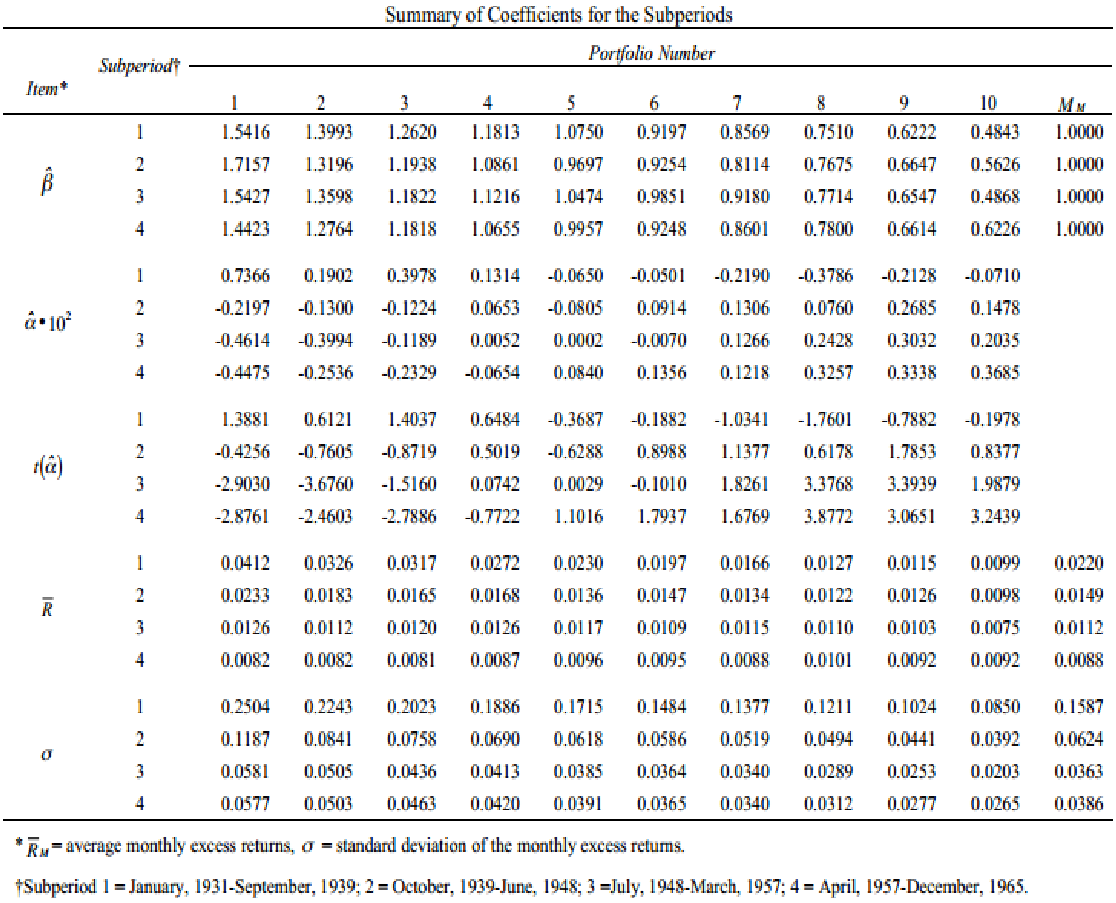
The data Black, Jensen and Scholes used were taken from the University of Chicago Center for Research in Security Prices Monthly Price Relative File and contained monthly price, dividend, and adjusted price and dividend information for all securities listed on the New York Stock Exchange in the period January 1926 to March 1966. The monthly returns on the market portfolio, R_{mt} were defined as the returns that would have been earned on a portfolio consisting of an equal investment in every security listed on the NYSE at the beginning of each month. The risk-free rate was defined as the 30-day rate on U.S. Treasury Bills for the period 1948-66. For the period 1926-47 the dealer commercial paper rate was used because Treasury bill rates were not available.

First Black, Jensen and Scholes did a time series analysis, based on the following regression:

$$\widetilde{R_{k\imath t}} = a_k + b_k\widetilde{R_{mt}} + \widetilde{e_{kt}} \quad (\mathbf{3.2})$$

Where $\widetilde{R_{k\imath t}}$ is the average return of all securities in the kth portfolio, $\widetilde{R_{mt}}$ stands for the average return of the market portfolio, and $\widetilde{e_{kt}}$ is the residual variance from regression. They assign the individual assets to groups in terms of their betas from the highest to the lowest. Ten portfolios were created, the 10% with the largest $\widehat{b_{\jmath 0}}$ to the first portfolio and so on. Then Black, Jensen and Scholes calculated the returns. As a result of the time series analysis Black, Jensen and Scholes found that the intercepts $\hat{a}$ were consistently negative for the high risk portfolios $(\hat{b} > 1)$ and consistently positive for the low risk portfolios $(\hat{b} < 1)$, contrary to the predictions of the traditional form of the model. Therefore, the high risk securities earned less on average over these 35 years than the amount predicted by the traditional form of the CAPM. At the same time, the low risk securities earned more than the amount predicted by the model. The effect became stronger though time, being strongest in the 1947-1965 period. A summary of the time-series regression statistics is provided in Figure 3.1.

Figure 3.1.: Summary of the regression statistics BJS 1972 (time-series)



Summary of Coefficients for the Subperiods

*Item**	*Subperiod†*	*Portfolio Number*										
		1	2	3	4	5	6	7	8	9	10	M_M
$\hat{\beta}$	1	1.5416	1.3993	1.2620	1.1813	1.0750	0.9197	0.8569	0.7510	0.6222	0.4843	1.0000
	2	1.7157	1.3196	1.1938	1.0861	0.9697	0.9254	0.8114	0.7675	0.6647	0.5626	1.0000
	3	1.5427	1.3598	1.1822	1.1216	1.0474	0.9851	0.9180	0.7714	0.6547	0.4868	1.0000
	4	1.4423	1.2764	1.1818	1.0655	0.9957	0.9248	0.8601	0.7800	0.6614	0.6226	1.0000
$\hat{\alpha} \cdot 10^2$	1	0.7366	0.1902	0.3978	0.1314	-0.0650	-0.0501	-0.2190	-0.3786	-0.2128	-0.0710	
	2	-0.2197	-0.1300	-0.1224	0.0653	-0.0805	0.0914	0.1306	0.0760	0.2685	0.1478	
	3	-0.4614	-0.3994	-0.1189	0.0052	0.0002	-0.0070	0.1266	0.2428	0.3032	0.2035	
	4	-0.4475	-0.2536	-0.2329	-0.0654	0.0840	0.1356	0.1218	0.3257	0.3338	0.3685	
$t(\hat{\alpha})$	1	1.3881	0.6121	1.4037	0.6484	-0.3687	-0.1882	-1.0341	-1.7601	-0.7882	-0.1978	
	2	-0.4256	-0.7605	-0.8719	0.5019	-0.6288	0.8988	1.1377	0.6178	1.7853	0.8377	
	3	-2.9030	-3.6760	-1.5160	0.0742	0.0029	-0.1010	1.8261	3.3768	3.3939	1.9879	
	4	-2.8761	-2.4603	-2.7886	-0.7722	1.1016	1.7937	1.6769	3.8772	3.0651	3.2439	
$\bar{R}$	1	0.0412	0.0326	0.0317	0.0272	0.0230	0.0197	0.0166	0.0127	0.0115	0.0099	0.0220
	2	0.0233	0.0183	0.0165	0.0168	0.0136	0.0147	0.0134	0.0122	0.0126	0.0098	0.0149
	3	0.0126	0.0112	0.0120	0.0126	0.0117	0.0109	0.0115	0.0110	0.0103	0.0075	0.0112
	4	0.0082	0.0082	0.0081	0.0087	0.0096	0.0095	0.0088	0.0101	0.0092	0.0092	0.0088
σ	1	0.2504	0.2243	0.2023	0.1886	0.1715	0.1484	0.1377	0.1211	0.1024	0.0850	0.1587
	2	0.1187	0.0841	0.0758	0.0690	0.0618	0.0586	0.0519	0.0494	0.0441	0.0392	0.0624
	3	0.0581	0.0505	0.0436	0.0413	0.0385	0.0364	0.0340	0.0289	0.0253	0.0203	0.0363
	4	0.0577	0.0503	0.0463	0.0420	0.0391	0.0365	0.0340	0.0312	0.0277	0.0265	0.0386

* $\bar{R}_M$ = average monthly excess returns, σ = standard deviation of the monthly excess returns.

†Subperiod 1 = January, 1931-September, 1939; 2 = October, 1939-June, 1948; 3 =July, 1948-March, 1957; 4 = April, 1957-December, 1965.

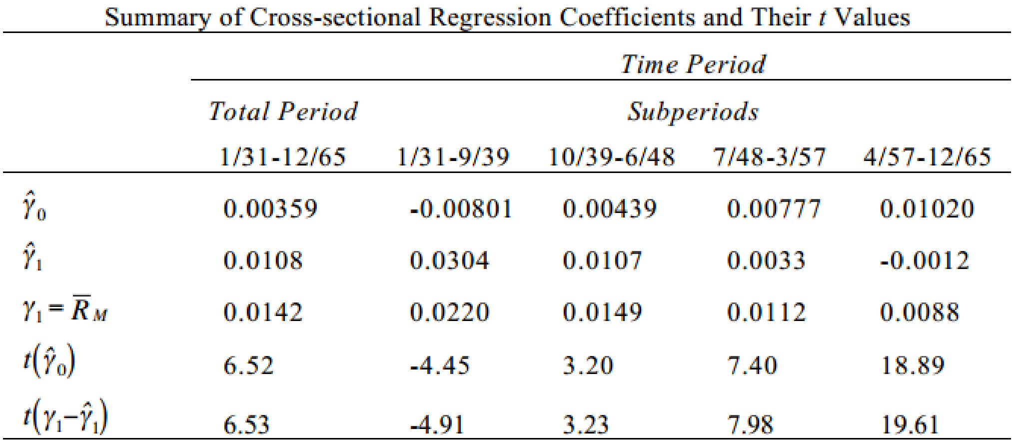
Source: Black, F. Jensen, M. and Scholes, M. (1972) "The capital asset pricing model: Some empirical tests", M. Jensen ed., Studies in the theory of capital markets, pp. 79-121

Moreover, aside from the time series analysis, Black, Jensen and Scholes ran a cross-sectional regression model given on equation 3.3 still on the same grouping of assets.

$$\bar{R}_j = \gamma_0 + \gamma_1 \hat{b}_j + \tilde{u}_j \quad \mathbf{(3.3)}$$

They discovered that the relation between mean excess return and beta was linear. However, the intercept and the slope of the cross sectional relation varied in different sub periods and were not consistent with the traditional form of the CAPM. The traditional form of the CAPM implies that $\gamma_0=0$ and $\gamma_1=E(\widetilde{R_m})$. A summary of the cross-sectional regression statistics is provided in Figure 3.2.

Figure 3.2.: Summary of the regression statistics BJS 1972 (cross-sectional)



Summary of Cross-sectional Regression Coefficients and Their *t* Values

	Time Period				
	Total Period	*Subperiods*			
	1/31-12/65	1/31-9/39	10/39-6/48	7/48-3/57	4/57-12/65
$\hat{\gamma}_0$	0.00359	-0.00801	0.00439	0.00777	0.01020
$\hat{\gamma}_1$	0.0108	0.0304	0.0107	0.0033	-0.0012
$\gamma_1 = \overline{R}_M$	0.0142	0.0220	0.0149	0.0112	0.0088
$t(\hat{\gamma}_0)$	6.52	-4.45	3.20	7.40	18.89
$t(\gamma_1 - \hat{\gamma}_1)$	6.53	-4.91	3.23	7.98	19.61

Source: Black, F. Jensen, M. and Scholes, M. (1972) "The capital asset pricing model: Some empirical tests", M. Jensen ed., Studies in the theory of capital markets, pp. 79-121

The data indicate that the expected return on a security can be represented by a two-factor model such as:

$$E(\hat{r}_j) = E(\tilde{r}_z)(1 - b_j) + E(\widetilde{r_m})b_j \quad (\mathbf{3.4})$$

Where r indicates total returns, $E(\tilde{r}_z)$ is the expected return on a second factor named beta factor, $\tilde{r}_z$ stands for a return on a portfolio that has a zero covariance and $\widetilde{r_m}$ stands for a return on the market portfolio. That two-factor model implies that $\gamma_0 = E(\tilde{r}_z)$, which is not necessarily zero and $\gamma_1 = E(\widetilde{r_m}) - E(\tilde{r}_z)$. The beta factor on the two-factor model had a non-zero mean and that mean was non-stationary over time.

From evidence of both time series and cross sectional runs Black, Jensen and Scholes were led to reject the hypothesis that $\gamma_0=0$, but γ_1 was mainly statistical significant and positive.

3.2. A New Look At the Capital Asset Pricing Model (1973- Blume Marshal E. and Friend Irwin)

The purpose of this paper was to examine both theoretically and empirically in greater depth the reasons why the market line theory did not adequately explain differential return on financial assets. For that reason, Blume and Friend worked with data from all securities listed on the New York Stock Exchange in the period January 1950 to June 1968.

Their first thought was that the most sever restriction in the development of CAPM appeared to be the assumption that the short sales mechanism works perfectly in that the total proceeds from a short sale can (with no transaction costs) be used to purchase additional assets and that there is no limit to the quantity of short sales allowed.

Because CAPM stated on equation 3.1 is an ex ante model in terms of expectations, to test it, one must make the transition to an ex post model by specifying some return generating process. The ex post CAPM is given by equation 3.5:

$$R_{it} = R_{0t} + b_i(R_{mt} - R_{0t}) + \varepsilon_{it} \quad \mathbf{(3.5)}$$

Where R_{it} is the return of portfolio/asset i, R_{0t} is the return of the risk free asset, b_i is the beta coefficient of portfolio/asset i, R_{mt} represents the return of the market portfolio and ε_{it} stands for the residuals. Apart from equation 3.5 and based on the previous discussed article of Black, Jensen and Scholes, Blume and Friend run a regression on a modified model given by equation 3.6.

$$\widetilde{R_\iota} = E\left(\widetilde{R_\iota}\right) + \widetilde{\delta_1} + b_i\left(\widetilde{\delta_2} - \widetilde{\delta_1}\right) - \widetilde{\varepsilon_\iota} \quad \mathbf{(3.6)}$$

Where $\widetilde{\delta_2}, \widetilde{\delta_1}$ are two factors common to all securities and assumed to be independently distributed with zero expectation and finite variance, $\widetilde{\varepsilon_\iota}$ is also an independent random variable with expected value of zero and finite variance and b_i is a constant appropriate to asset i.

Beta coefficients were estimated for each common stock listed on NYSE during January 1950 to December 1954 by regressing monthly investment relatives properly adjusted for capital changes and cash dividends. Twelve portfolios of eighty securities apiece were formed with equal weights. The first portfolio had the lowest estimates of beta and so on. Monthly returns for each portfolio from January 1955 to December 1959 were calculated and all of these steps were repeated to yield similar regressions for January 1960-December 1964 and January 1965-June 1968.

The empirical results cast serious doubt on the validity on the validity of the market line theory in either its original form or as recently modified. On the other hand, these results do confirm the linearity of the relationship for NYSE stocks. That suggests that the CAPM and its associated short sales assumptions may be useful in explaining returns on well-seasoned common stocks. This can be viewed as linear combinations of the market portfolio and some zero beta portfolios which would only include such stocks and no other financial instruments. Moreover, cross section regression tests reject prediction C3 of the CAPM. C1 refers to linearity, C2 refers to no systematic effects of non-beta risk and C3 refers to positive expected return-risk tradeoff. In fact, the average value of R_{0t} in estimates is greater than the average risk free rate and the average value of R_{it} is less than the observed average market return in excess of the bill rate. Blume and Friend concluded that the market for NYSE stocks is segmented from the bond market unless the return generating process is different from any heretofore tested.

3.3. Risk, Return and Equilibrium: Empirical Tests (1973- Fama Eugene F. and MacBeth James D.)

As we discussed previously, CAPM in equation 3.1 has the following three testable implications. C1 states that the relationship between the expected return on a security and its risk in any efficient portfolio m is linear. C2 refers to the point that b_i is a complete measure of the risk of security i in an efficient portfolio m. C3 states that in a market of risk averse investors higher risk would be associated with higher expected return, that means $E(\widetilde{R_m}) - E(\widetilde{R_0}) > 0$.

In that paper, Fama and MacBeth test those implications. To do so, they used the following regression model.

$$\widetilde{R_{it}} = \widetilde{\gamma_{0t}} + \widetilde{\gamma_{1t}} b_i + \widetilde{\gamma_{2t}} b_i^2 + \widetilde{\gamma_{3t}} s_i + \widetilde{\eta_{it}} \quad (\mathbf{3.7})$$

C1 implies that E($\widetilde{\gamma_{2t}}$) equals zero. The term b_i^2 is included to test linearity. C2 implies that E($\widetilde{\gamma_{3t}}$) equals zero. C3 implies that E($\widetilde{\gamma_{1t}}$)=E($\widetilde{R_{mt}}$)-E($\widetilde{R_{0t}}$)>0.

To examine these cases, they obtained monthly percentage returns from January 1926 to June 1968 for all common stocks traded on NYSE and created 20 portfolios of equal weights. To do so, Fama and MacBeth used the first 7 years of data to form portfolios, the next 5 years were used to compute initial values of the independent variables, then the risk-return regression were fit month to month for the following five 4-year periods.

The results lead the authors to manifest that they cannot reject the hypothesis of these models that the pricing of common stocks reflects the attempts of risk-averse investors to hold portfolios that are "efficient" in terms of expected value and dispersion of return. Moreover, the observed "fair game" properties of the coefficients and residuals of the risk-return regressions are consistent with an "efficient capital market”, that is a market where prices of securities fully reflect available information. More specifically, they ended up with a little value of E($\widetilde{\gamma_{2t}}$) and it was no statistically significant so that b_i^2 is not a factor that affects notably on returns. Furthermore, E($\widetilde{\gamma_{1t}}$) is statistically significant, greater than zero and less than (R_m-R_0). This means that the relation of returns and betas is positive and linear. Also, E($\widetilde{\gamma_{0t}}$) is statistically greater than R_0 and this fact supports zero beta CAPM that does not assume the existence of a riskless asset rather than the original form of CAPM. The zero beta CAPM or Black CAPM was introduced by Black in 1972 to overcome the problem of unlimited lending and borrowing at r_f and is given by the following equation.

$$E(R_i) - E(R_G) = b_i(E(R_m) - E(R_G)) \quad (\mathbf{3.8})$$

Where $E(R_i)$ is the expected return of asset i, $E(R_G)$ is the expected return of asset G (G is a portfolio where its returns are uncorrelated with the market portfolio returns and is called the zero beta portfolio), b_i is the beta coefficient of asset i and $E(R_m)$ is the expected return of the market portfolio.

3.4. An Intertemporal Capital Asset Pricing Model (1973- Merton Robert C.)

The CAPM was criticized for the Markowitz mean-variance criterion and for the additional assumptions required, especially homogeneous expectations and the single-period nature of the model, although it is generally treated as if it holds intertemporally. The Intertemporal Capital Asset Pricing Model, or ICAPM, was an alternative to the CAPM provided by Robert Merton in 1973 and includes the investors' preferences due to consumption and wealth needs.

The ICAPM is a linear model that has the simplicity of CAPM, it is consistent with expected utility maximization and provides a specification of the relationship among yields that is more consistent with empirical evidence. The ICAPM is based on the following assumptions:

1. All assets have limited liability
2. No transaction costs, no taxes, assets are divisible
3. There are a sufficient number of investors with comparable wealth levels so that each investor believes that he can buy and sell as much of an asset as he wants at the market price
4. The capital market is always in equilibrium
5. There exists an exchange market for borrowing and lending at the same rate of interest
6. Short sales of all assets with full use of the proceeds is allowed
7. Trading is continuous
8. The vector set of stochastic processes describing the opportunity set and its changes is a time homogeneous Markov process
9. Only local changes in the state variables of the process are allowed
10. For each asset in the opportunity set at each point in time t the expected rate of return per unit time, defined by:

$$a = \frac{E_t\left[\frac{P_{t+h} - P_t}{P_t}\right]}{h} \quad (\mathbf{3.9})$$

And the variance of the return per unit time defined by:

$$Var = \frac{E_t[\left(\frac{[P_{t+h} - P_t]}{P_t} - ah\right)^2}{h} > 0 \quad (\mathbf{3.10})$$

And are continuous functions of h.

Skipping the mathematical proof of the ICAPM, the intertemporal capital asset pricing model equation is the following one:

$$a_i - r = \frac{\sigma_i[\rho_{im} - \rho_{in}\rho_{n,m}]}{[\sigma_m(1-\rho_{nm}^2)]}(a_m - r) + \frac{\sigma_i[\rho_{in} - \rho_{im}\rho_{n,m}]}{[\sigma_n(1-\rho_{mn}^2)]}(a_n - r) \quad (\mathbf{3.11})$$

Where a_i, a_m, a_n are the returns of asset i, market m and asset n respectively, r is the risk free asset return, σ_i, σ_m, σ_n are the standard deviations of asset i, market m and asset n respectively and ρ_{nm} is the correlation coefficient between n, m.

The consumer-investor knows at each point in time the investment opportunity set and the stochastic processed of the changes in the investment opportunity set. The main difference between ICAPM and standard CAPM is the additional state variables that acknowledge the fact that investors hedge against shortfalls in consumption or against changes in the future investment opportunity set. The ICAPM uses mean-variance analysis to create normal distribution of consumption risk over time. Because ICAPM covers multiple time periods, multiple beta coefficients are used to determine how many security concerns covary with a basket of risky securities. A criticism of ICAPM is that it assumes that consumer expectations are homogenous, meaning that it cannot take into account individual risk preferences.

3.5. The Demand for Risky Assets (1975- Friend Irwin and Blume Marshall E.)

Economists had generally at that point been convinced that the market utility function had risk-aversion properties somewhere between a negative exponential utility function with constant absolute risk aversion and increasing relative risk aversion and a constant elasticity utility function with decreasing absolute risk aversion but with constant proportional risk aversion. The widely held assumption of increasing (or at most constant) relative risk aversion was open to question. The purpose of Friend and Blume‘s paper was to systematically exploit cross sectional data on household asset holding to assess the nature of household’s utility functions.

The data used in this paper where provided by Federal Reserve Board (FRB) Surveys of the Financial Characteristics of Consumers and Changes in Family Finances and are concerning more than 2100 households detailed information on the value of assets, liabilities and income at the end of 1962 and 1963. Friend and Blume constructed three different types of balance sheets for both years. The first type included all assets and associated liabilities with the exception of human wealth and homes. The second type included only human wealth and the third type contained not only homes but also an estimate of human wealth. Those balance sheets were expressed as ratios. Friend and Blume used the proportion of wealth allocated to risky assets, a, as a measure of the reaction to risk by the decision maker. They used a quadratic approximation to the utility function for wealth. Using this approximation, they found that a is the product of two terms. The first term was the market price of risk in a mean-variance context and the second term was the inverse of the relative risk aversion measure for wealth evaluated at the initial wealth level. A tax term also enters the expression for a. Using the data above, they determined a value for a for each household. Then, the 2100 households were formed in 5 groups determined by the level of household wealth and an average a and four different measures of wealth was calculated for each group.

Friend and Blume found that for some wealth measures, relative risk aversion for the representative decision maker increases slightly, while for others, it decreases slightly. No clear pattern for increasing or decreasing relative risk aversion for after tax wealth for a representative decision maker was obtained. More specifically, when wealth is defined as net worth exclusive of homes and automobiles, households exhibit relative risk aversion. When wealth includes homes and automobiles, increasing or constant relative risk aversion is obtained, depending on whether homes are treated as risky assets at market value or owner’s equity value. If housing is treated as a risk free asset, the tendency towards decreasing relative risk aversion is reinforced, whether housing is measured by its equity or market value. When human capital is incorporated into net worth, moderate increasing risk aversion is found.

3.6. The Arbitrage Theory of Capital Asset Pricing (1976- Ross Stephen A.)

As we have seen to this point, multi factor models were introduced to fill the gaps of the one factor models and to provide further help in the empirical process. In 1976, Stephen Ross introduced the Arbitrage Pricing Theory Model (APT). Arbitrage is basically buying in one market and simultaneously selling in another, profiting from a temporary difference. This is considered riskless profit for the investor as we will further discuss. The APT is an asset pricing model based on the idea that an asset's returns can be predicted using the relationship between that same asset and many common risk factors. More specifically, this theory predicts a relationship between the returns of a portfolio and the returns of a single asset through a linear combination of many independent macroeconomic variables. The model’s equations are the following.

$$R_j = a_j + b_{j1}F_1 + b_{j2}F_2 + \cdots + b_{jk}F_k + \varepsilon_k \quad (\mathbf{3.12})$$

Where R_j is the return of asset j, a_j stands for a constant for asset j, b_{jk} is the sensitivity of asset j to the kth macroeconomic factor, F_k is a systematic factor and εk is the risky asset's idiosyncratic random shock with mean zero.

$$E(R_j) = r_f + b_{j1}RP_1 + b_{j2}RP_2 + \cdots + b_{jk}RP_k \quad (\mathbf{3.13})$$

Where $E(R_j)$ is the expected return of asset j, r_f is the risk free rate, b_{jk} is the sensitivity of asset j to the kth macroeconomic factor, RP_k is the risk premium of the kth macroeconomic factor.

The APT can be applied to both assets and portfolios and has more flexible assumption requirements than CAPM. APT assumes that investors are risk averse, no transaction costs or taxes or restrictions on short sales for any asset exist, all investors have homogeneous expectations, the total demand for every asset is positive and in equilibrium there are no arbitrage opportunities.

Whereas the CAPM requires the market's expected return, APT uses the risky asset's expected return and the risk premium of a number of macroeconomic factors. Another difference between those two models is that CAPM is concerned to find equilibrium of the market by holding optimal portfolios, while APT finds this equilibrium by ruling out arbitrage opportunities. The mechanism is simple as an idea. The asset price today should equal the sum of all future cash flows discounted at the APT rate. If the theoretical price does not equals the market price, the arbitrageur get long position on the undervalued asset and get short position on the overvalued asset.

The APT was a revolutionary multifactor model because it allows the user to adapt the model to the security being analyzed. APT is also very useful for building portfolios because it allows managers to test whether their portfolios are exposed to certain factors.

APT may be more customizable than CAPM, but it is also more difficult to apply because determining which factors influence a stock or portfolio takes a considerable amount of research. It can be virtually impossible to detect every influential factor much less determine how sensitive the security is to a particular factor. To get this mechanism to work, we have to determine the macroeconomic factors on the APT model and this is not a fact that Ross clarify on this paper. However, ten years later in 1986, Nai-Fu Chen, Richard Roll and Stephen Ross in a paper named “Economic Forces and the Stock Market” identified the following macroeconomic factors as significant in explaining security returns: surprises in inflation, surprises in GNP as indicated by an industrial production index, surprises in investor confidence due to changes in default premium in corporate bonds and surprise shifts in the yield curve.

Most empirical studies have shown that three to five factors are sufficient to describe the observed returns. Moreover, the number of factors cannot exceed the number of assets. APT is a one-period model and studies have shown that APT can explain the observed returns quite good for medium and long time periods. For time horizons below one year, the factors might not be able to explain data adequately.

3.7. A Critique of the Asset Pricing Theory's Tests (1977- Roll Richard)

In 1977, Richard Roll made a serious critique on CAPM. However, we must not interpret it as a critique on the model itself, due to references and criticism to published papers at that point, such as the Fama and MacBeth paper (1973) that we discussed earlier in this thesis. The most important thing one should bear in mind from that paper is the statement that if the market portfolio M is efficient, then CAPM is valid and vice versa. Roll suggested that it is impossible to create or observe a truly diversified market portfolio because a market portfolio would include every investment in the market including commodities, collectibles and virtually anything with markeTable value. A proxy for the overall market is a market index. Without observing all investment opportunities it is not possible to test the mean-variance efficiency of a portfolio and therefore, to test CAPM. The criticism to other papers published until that moment was not only the question what to use as market portfolio, but also the fact that mean-variance efficiency of the market portfolio is equivalent to the CAPM equation holding and that is a mathematical fact (tautological). That would be one reason why the previous papers that we discussed were supporting CAPM at some point.

The mean-variance tautology argument applies to the arbitrage pricing theory and all asset-pricing models of the equation form 3.12, where F_k are unspecified factors. If the factors are returns on a mean-variance portfolio, the equation holds exactly. It is always possible to identify in-sample mean-variance efficient portfolios within a dataset of returns. Consequently, it is also always possible to construct in-sample asset pricing models that exactly satisfy the pricing equation of APT.

To be more precise on the points that Roll made on this paper, he provided a situation where M is not efficient. In that case, the mean returns are not exact linear functions of betas, but this does not imply that mean returns are necessarily related to non-linear functions of beta. For instance, the equation:

$$R = a + g * b \quad (\mathbf{3.14})$$

Is a possibility if M is inefficient, where a is a vector whose elements are non-constant but are unrelated to the elements of portfolio p, and g is a scalar constant.

Moreover, for the Fama and MacBeth paper (1973), Roll stated that given that the risk has replaced the parameter beta, we have already seen that Fama and MacBeth's C1-C3 are simply implications of the fact that M is assumed ex-ante efficient. If M is known to be efficient, these relations are not independently testable, they are tautological. However, there are testable hypotheses in the Fama-MacBeth paper. Roll mentioned that the hypotheses really were the following. The first hypothesis stated as H1: Investors regard as optimal those particular investment portfolios that are mean-variance efficient. Assuming identical probability assessments by all investors, this hypothesis leads to H2 that the market portfolio is ex-ante efficient.

As for Black, Jensen and Scholes' paper (1972), Roll mentioned that their paper tested a joint hypothesis: the Sharpe-Lintner theory and the hypothesis that the portfolio they used as the market proxy was the true market portfolio. This joint hypothesis was indeed tested and it was rejected. Therefore, we can conclude that either the Sharpe-Lintner theory is false, or the portfolio used by Black, Jensen, and Scholes was not the true market portfolio, or both. The portfolio used by Black, Jensen, and Sholes was certainly not the true market portfolio, but whether it was statistically close to the true market portfolio, thus leading to conclusion that the Sharpe-Lintner theory is false, or whether it was closer than the Sharpe-Lintner assumptions are to reality is beyond our capacity to know. In summarizing all these empirical exercises about the CAPM, Roll concluded that not a single paper contains a valid test of the theory.

In response to Roll's point Stambaugh (1982) constructed broader market indices, which included, for instance, bonds and real estate and found that such test did not seem to be very sensitive to the choice of market proxy.

3.8. An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities (1979- Breeden Douglas T.)

Breeden (1979) and Lucas (1978) provided the foundation of consumption CAPM or CCAPM. While CAPM relies on market portfolio's returns to calculate expected returns of financial assets, CCAPM relies on the aggregate consumption. In CCAPM risky assets create uncertainty in consumption. To be more precise, what an investor will spend depends on his wealth and this wealth is a result of his decision to invest on risky assets. The CCAPM equation is the following:

$$E(R_i) = r_f + b_c\left[E(R_m) - r_f\right] \quad (\mathbf{3.15})$$

Where E(Ri) is the expected return of asset i, rf is the return of the risk free asset, bc stands for the consumption beta coefficient and E(Rm) is the expected return of the market portfolio. The consumption beta is defined as:

$$b_c = \frac{Cov(R_i, Consumption\ growth)}{Cov(R_m, Consumption\ growth)} \quad (\mathbf{3.16})$$

In the CCAPM, an asset is more risky if it pays less when consumption is low (that means that savings are high). The consumption beta is equal to one, if the risky asset is moving perfectly with the consumption growth. The central prediction of the CCAPM is that the premiums that assets offer are proportional to their consumption betas. In the CCAPM, the economy is assumed to be populated by a large number of households that are identical in all respects, including preferences and endowments. This assumption allows decision making to be analyzed by examining the behavior of a single, representative household.

The CCAPM has been criticized because it relies on only one parameter, as CAPM does. Furthermore, CCAPM performs poorly on empirical grounds due to a proportion of consumers that do not participate actively in the stock market, and therefore the basic link of consumption and stock returns assumed in CCAPM is not valid.

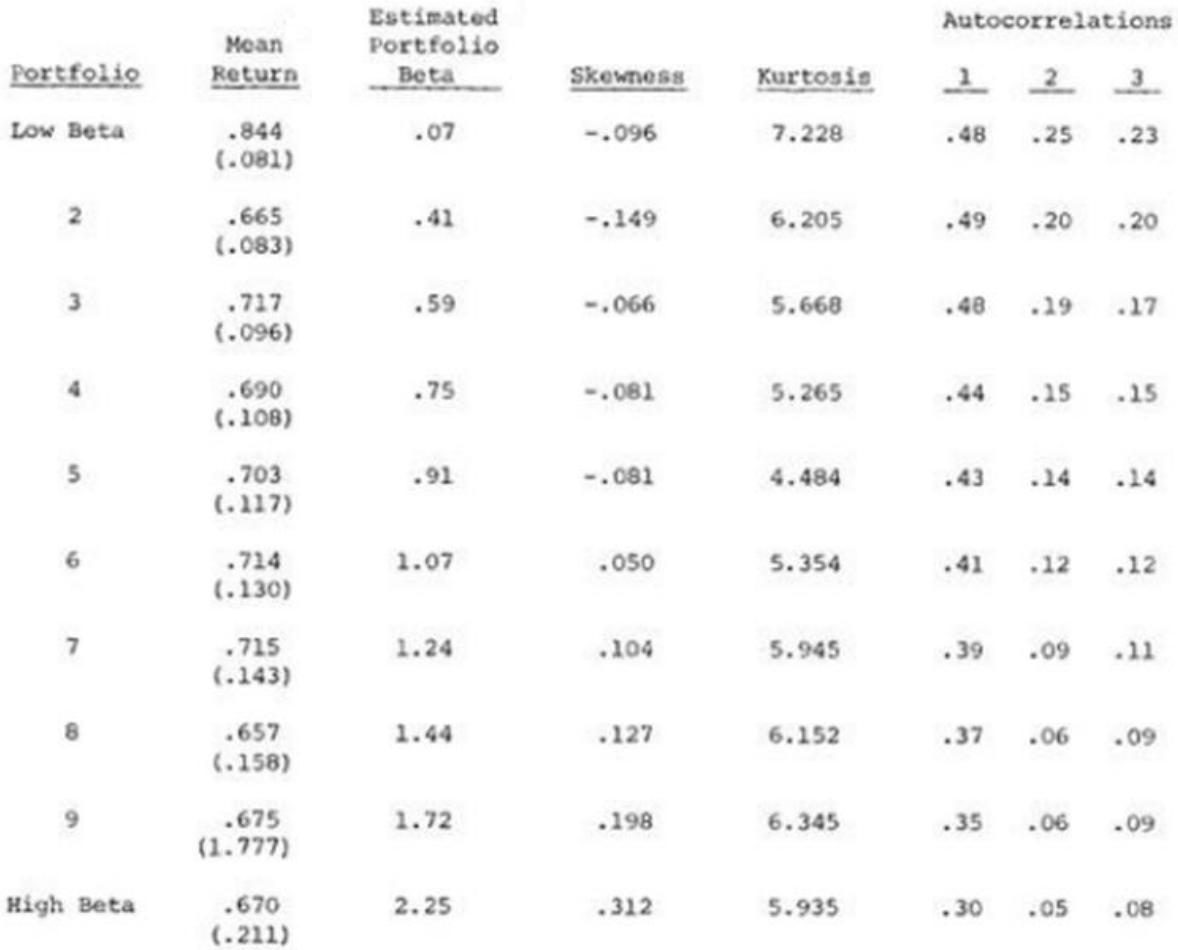
3.9. A New Empirical Perspective on the CAPM (1981- Reinganum Marc R.)

The purpose of Reinganum’s paper is to test whether securities with different estimated betas systematically experience different average rates of return. Reinganum states that the equation of CAPM (3.1) shares an important implication, the beta hypothesis. The beta hypothesis is that assets with different estimated betas have different average rates of return. Confirmation of the beta hypothesis would provide evidence that supports the fact that betas matter in equilibrium pricing. On the other hand, evidence rejecting the beta hypothesis would seem to indicate that risk premiums associated with betas are economically insignificant. While, Roll as we previously discussed questioned the testability of the theoretical CAPM, Reinganum question the empirical representation of the model.

Again, in this paper there is a two period testing where in period A individual security betas are estimated and securities are placed into one of ten portfolios (with equal weights) based upon the relative rank of their estimated beta and afterwards, in period B the returns of the ten beta portfolios are calculated. Then, with time series analysis Reinganum tests whether or not the ten portfolios experience significantly different average returns. Reinganum run different regressions for daily and monthly returns, all data from NYSE and AMEX listed companies from period 1963-1979 for the daily returns and NYSE listed companies from period 1930-1979 for monthly returns. For daily returns, the beta portfolios were revised annually, while for the monthly returns, the beta portfolios were revised every five years.

The test done with daily returns reveal that the hypothesis of identical mean returns would be rejected, but this rejection should not be interpreted as evidence supporting CAPM because the average daily return of the low beta portfolio actually exceeded the average daily return of the high beta portfolio by 0.03%. Also, the portfolio returns seemed to be both skewed and leptokurtic. Figure 3.3 provides the daily returns statistics for the 10 beta portfolios.

Figure 3.3.: Daily returns statistics (Reinganum 1981)

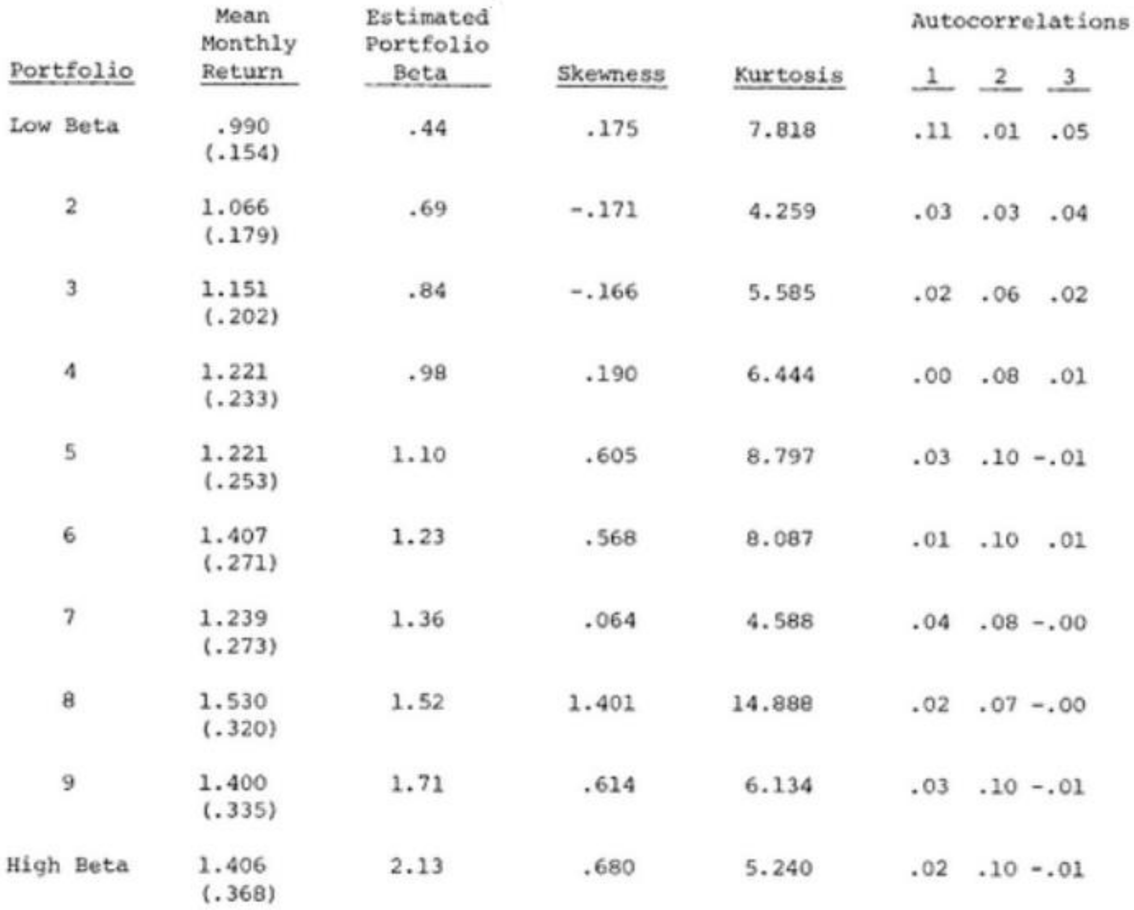


Portfolio	Mean Return	Estimated Portfolio Beta	Skewness	Kurtosis	Autocorrelations 1	2	3
Low Beta	.844 (.081)	.07	-.096	7.228	.48	.25	.23
2	.665 (.083)	.41	-.149	6.205	.49	.20	.20
3	.717 (.096)	.59	-.066	5.668	.48	.19	.17
4	.690 (.108)	.75	-.081	5.265	.44	.15	.15
5	.703 (.117)	.91	-.081	4.484	.43	.14	.14
6	.714 (.130)	1.07	.050	5.354	.41	.12	.12
7	.715 (.143)	1.24	.104	5.945	.39	.09	.11
8	.657 (.158)	1.44	.127	6.152	.37	.06	.09
9	.675 (1.777)	1.72	.198	6.345	.35	.06	.09
High Beta	.670 (.211)	2.25	.312	5.935	.30	.05	.08

Source: Reinganum, M.R. (1981) "A new empirical perspective of CAPM", Journal of Financial and Quantitative Analysis, Vol. 16, pp. 439-462

As for the monthly returns, the result was that one cannot reject the null hypothesis of identical mean returns because there was variability in the time-series of portfolio returns, the month by month rankings of portfolio returns could not be distinguished from random rankings (see Figure 3.4).

Figure 3.4.: Monthly returns statistics (Reinganum 1981)



Portfolio	Mean Monthly Return	Estimated Portfolio Beta	Skewness	Kurtosis	Autocorrelations		
					1	2	3
Low Beta	.990 (.154)	.44	.175	7.818	.11	.01	.05
2	1.066 (.179)	.69	-.171	4.259	.03	.03	.04
3	1.151 (.202)	.84	-.166	5.585	.02	.06	.02
4	1.221 (.233)	.98	.190	6.444	.00	.08	.01
5	1.221 (.253)	1.10	.605	8.797	.03	.10	-.01
6	1.407 (.271)	1.23	.568	8.087	.01	.10	.01
7	1.239 (.273)	1.36	.064	4.588	.04	.08	-.00
8	1.530 (.320)	1.52	1.401	14.888	.02	.07	-.00
9	1.400 (.335)	1.71	.614	6.134	.03	.10	-.01
High Beta	1.406 (.368)	2.13	.680	5.240	.02	.10	-.01

Source: Reinganum, M.R. (1981) "A new empirical perspective of CAPM", Journal of Financial and Quantitative Analysis, Vol. 16, pp. 439-462

Concluding, Reinganum reported that during the period 1964-1979 the NYSE-AMEX stock portfolios with widely different estimated betas possess statistically indistinguishable average returns. In that period, portfolios of small firms experienced average returns nearly 20% higher than portfolios of large firms. Furthermore, the cross sectional differences in portfolio betas estimated with common market indices are not reliably related to differences in average portfolio returns, the returns of high beta portfolios are not significantly different from the returns of low beta portfolios. Thus, the risk premiums associated with these betas do not seem to be of economic and empirical importance.

3.10. International Portfolio Choice and Corporation Finance: A synthesis (1983-Adler Michael and Dumas Bernard)

Adler and Dumas extended the CAPM to international investments. CAPM is used to define the expected return for a given risk level, whereas when looking at investments in an international setting, the international CAPM is used to incorporate the forex risk with an addition of foreign currency risk premium. The international CAPM is expressed as follows:

$$E(R_i) = r_{fd} + b_i\left(E\left(R_{mj}\right) - r_{fd}\right) + c_j FCRP_j \quad (\mathbf{3.17})$$

Where $E(R_i)$ stands for the expected return of asset i, r_{fd} is the domestic currency risk free return, b_i is the beta coefficient of asset i in comparison with the world market portfolio, $E(R_{mf})$ represents the world market portfolio expected return, c_j is the sensitivity of the domestic currency returns to changes in foreign currencies and $FCRP_j$ stands for the difference between the expected future spot exchange rate and the forward rate, divided by today's spot rate.

International CAPM uses the same inputs as the CAPM but also takes into account other variables that influence the returns on assets on a global basis. As a result, the international CAPM is more useful than CAPM. However, while the international CAPM improves upon the unrealistic assumptions of CAPM, several assumptions are still required for the theoretical model to be valid. The most important assumption is that international capital markets are integrated. An integrated market means that a stock of NYSE has the same price purchased at the stock of London stock exchange (if tradable). If this assumption fails and international markets are segmented, then there will be pricing discrepancies among assets with similar risk profiles in different currencies. As a result, segmented markets will cause investors to make higher allocations to specific assets in specific countries, resulting in inefficient asset pricing. International CAPM also assumes unlimited lending and borrowing at the risk-free rate, as CAPM does. Moreover, the international CAPM assumes purchasing power parity (PPP) to be valid. PPP equation is the following one:

$$S = \frac{P_k}{P_j} \quad (\mathbf{3.18})$$

Where S stands for the exchange rate of currency k to currency j, P_k represents the cost of good l in currency k and P_j represents the cost of good l in currency j.

3.11. A Test of the Efficiency of a Given Portfolio (1989- Gibbons Michael R., Ross Stephen A. and Shanken Jay)

Gibbons, Ross and Shanken were influenced by Roll's critique that emphasized the regression tests of CAPM were probably of quite low power and the grouping of assets might lower the power further. Insofar as proxies were used for the market portfolio, the Sharpe-Lintner theory is not being tested. If the proxy is not a valid surrogate, then as tests of the CAPM the existing empirical investigations are somewhat beside the point. On the other hand, if the proxy is valid, then the small sample distribution and power of the tests are unknown. The problem Gibbons, Ross and Shanken consider is the central one addressed in tests of the CAPM. Since the theory is equivalent to the assertion that the market portfolio is mean-variance efficient, they wish to test whether any particular portfolio is ex ante mean-variance efficient.

Gibbons, Ross and Shanken consider the following multivariate linear regression:

$$\widetilde{r_{\iota t}} = a_{ip} + b_{ip}\widetilde{r_{pt}} + \widetilde{\varepsilon_{\iota t}} \quad (\mathbf{3.19})$$

A regression that is similar to what we have already seen. Also, they state the null hypothesis that a_{ip} is equal to zero. Given the normality assumption, they test the null hypothesis with Hotteling's T^2 test and afterwards with other statistical tests. Generally, the normality assumption has been viewed as providing a good working approximation to the distribution of monthly stock return. There is some evidence, however, that the true distributions are slightly leptokurtic relative to the normal distribution. Furthermore, Gibbons, Ross and Shanken used data from the Center for Research in Security Prices (CRSP) from 1928 to 1982, specifically monthly returns of NYSE stocks and created 10 beta sorted portfolios, as Black, Jensen and Scholes (BJS) did in 1972. The empirical illustration failed to reject the ex-ante efficiency of the equal weighted Index of CRSP when using 10 beta sorted portfolios as in BJS. Such a result may occur because the null hypothesis is in fact true, or it may be due to the use of a test which is not powerful enough to detect economically important deviations from efficiency of the Index.

Then, Gibbons, Ross and Shanken tested the test itself. The multivariate test considered here requires that the number of assets under study always be less than the number of time series observations. This restriction is imposed so that the sample variance-covariance matrix remains nonsingular. It appears that N (number of assets) should be roughly a third to one half of T (time series observations) and when five years of monthly data are used, 20 to 30 assets may be appropriate.

Furthermore, they consider a set of 12 industry portfolios. An industry grouping seems reasonable on economic grounds and also captures some of the important correlations among stocks. To measure the return from a "buy-and-hold" investment strategy, the relative market values of the securities are used to weight the returns. Almost every monthly return on the CRSP data from1926 through 1982 is included. The multivariate test rejects the null hypothesis at the 1% level even though all 12 univariate t-statistics fail to reject at even the 5% level.

This paper provides significant information and evidence about the January effect. If the data are sorted by January returns versus non-January returns, the multivariate approach confirms the importance of the size effect. For the month of January, one's investment should be a long position on smaller firms and a short position on larger firms.

3.12. The Cross-Section of Expected Stock Returns (1992- Fama Eugene F. and French Kenneth R.)

In 1992, Eugene Fama and Kenneth French published a three-factor model to describe stock returns. Fama and French started with the observation that two classes of stocks have tended to do better than the market as a whole, the small caps and stocks with a low P/B ratio. The three factors affecting the asset return are the company size (or market value), the price to book value ratio and the returns of market portfolio (market risk). The equation of the three factor model is:

$$R_{jt}-r_f=a_j+b_j\left(R_{mt}-r_f\right)+b_{SMB}SMB_t+b_{HML}HML_t+\varepsilon_{jt}\quad(\mathbf{3.20})$$

Where R_{jt}-r_f denotes the excess return of asset j from r_f which is the risk free rate return, a_j is a constant for asset j indicating management performance, b_j is the sensitivity coefficient of asset j towards the R_{mt}-r_f parameter which is the excess market portfolio return from r_f, b_{SMB} is the sensitivity coefficient towards the SMB factor, SMB_t is the small (market capitalization)-minus-big size factor, b_{HML} is the sensitivity coefficient towards the HML factor, HML_t is the high (book to market ratio)-minus-low factor and ε_{jt} is the error term of the regression.

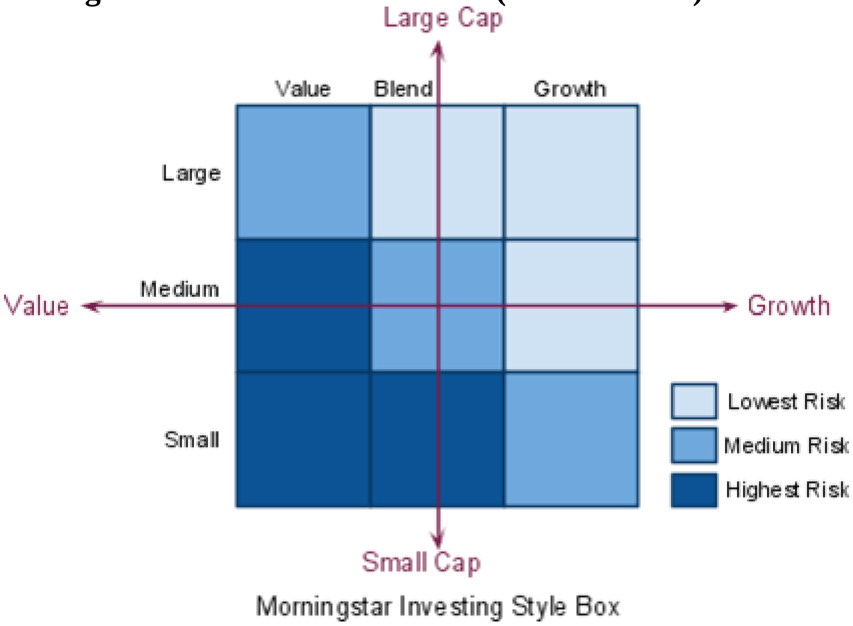
SMB represents the factor that is constructed by sorting portfolios, in terms of containing assets with small market capitalization minus portfolios containing big market capitalization (the size proxy). HML represents the factor that is constructed by sorting portfolios in terms of containing assets with high book-to-market value minus portfolios containing low book-to market value (the BE/ME proxy). The sensitivity factors of SMB and HML are evaluated by linear regressions.

Fama and French, to test their three-factor model, used data from all nonfinancial firms of NYSE, AMEX and NASDAQ from period 1962 to 1989. They excluded financial firms because the high leverage that is normal for these firms probably does not have the same meaning as for nonfinancial firms, where high leverage more likely indicates distress. The result was that their model explains over 90% of the diversified portfolios returns, compared with the average 70% given by the CAPM. They find positive returns from small size as well as value factors, high book-to-market ratio and related ratios (see Figures 3.1 and 3.2). Examining beta and size, they find that higher returns, small size, and higher beta are all correlated. They then test returns for beta, controlling for size, and find no relationship. Assuming stocks are first partitioned by size the predictive power of beta then disappears. They discuss whether beta can be saved and the Sharpe-Lintner-Black model resuscitated by mistakes in their analysis, and find it unlikely.

Figure 3.5.: Three-factor model (Fama-French) Part 1

Source: https://portfoliosolutions.com/latest-learnings/fama-french-three-factor-model

Figure 3.6.: Three-factor model (Fama-French) Part 2



Source: https://www.bogleheads.org/wiki/Fama_and_French_three-factor_model

Fama and French three-factor model suffers from multicollinearity. An implicit assumption when using the OLS estimation method is that the explanatory variables are not correlated with one another. Multicollinearity is a phenomenon in which two or more predictor variables in a multiple regression model are highly correlated, meaning that one can be linearly predicted from the others with a substantial degree of accuracy. In this situation the coefficient estimates of the multiple regressions may change erratically in response to small changes in the model or the data. Multicollinearity does not reduce the predictive power or reliability of the model as a whole, at least within the sample data set; it only affects calculations regarding individual predictors. That is, a multiple regression model with correlated predictors can indicate how well the entire bundle of predictors predicts the outcome variable, but it may not give valid results about any individual predictor, or about which predictors are redundant with respect to others. A standard approach to deal with multicollinearity is to drop one of the collinear variables. The collinear variables in this model are the size and the book to market equity. The average of the monthly correlations between the cross-sections of ln(ME) and ln(BE/ME) for individual stocks is -0.26. Fama and French mention that we should not exaggerate the links between size and book to market equity, as a correlation of -0.26 is not extreme and those variables are both needed to explain the cross-section of average returns.

An interesting concept of the three-factor model is that it transforms the macroeconomic APT factors to microeconomic ones. In 2015, Fama and French extended the model, adding another two factors (profitability and investment) in a paper that we will further discuss.

3.13. The CAPM is alive and well (1993- Jagannathan Ravi and Wang Zhenyu)

Jagannathan and Wang claim that the lack of support of the empirical studies over CAPM may be due to the inappropriateness of some assumptions. For instance, most of the empirical studies that we discussed suppose that the return of a specific index, such as the NYSE index, could be used as a market portfolio proxy. However, these indices do not take into account many economic factors, as the human capital.

In their work, Jagannathan and Wang, run the same regression as Fama and French did in 1992 using the same data (see subchapter 3.12). Like Fama and French, they found zero risk premium for beta and a strong size effect. With that information, Fama and French concluded that CAPM did not provide a useful framework for explaining the cross section of expected returns and they formed their three-factor model. On the other hand, Jagannathan and Wang mentioned that other explanations are still possible. They wonder that 28 years of data may be too few significant observations to measure expected returns accurately using realized average returns. Additionally, they pointed out that the use of a value-weighted portfolio of all stocks listed in NYSE and AMEX may be one of the reasons for the unsatisfactory performance of CAPM. One other reason could be the unrealistic assumption that portfolio betas remain constant over time. Jagannathan and Wang relaxed these two reasons and examined whether the results would change significantly.

For that purpose, they included the human capital factor in the model and let the betas vary over the business cycles by including a premium over betas. Labor income from salaries and wages was taken from the monthly seasonally adjusted personal income numbers by Federal Reserve Bulletin. The authors stated the following equation:

$$E(R_i) = c_0 + c_1 b_i^{vw} + c_2 b_i^{labor} + c_3 b_i^{prem} \quad (\mathbf{3.21})$$

Where c_0, c_1, c_2, c_3 are constants, b_i^{vw} is the beta of the value weighted portfolio of all stocks traded on NYSE and AMEX, b_i^{labor} is the labor beta and b_i^{prem} is the premium over betas.

Jagannathan and Wang found out that when human capital is also included in measuring wealth, the CAPM is able to explain 28% of the cross section of average returns. Moreover, when betas are allowed to vary over the business cycles, the CAPM is able to explain 57%. Nevertheless, they concluded that their results may not provide a strong support of CAPM as they seem at first sight and that is because of the fact that 28 years of data could be few.

3.14. The Conditional Relation between Beta and Returns (1995-Pettengill Glenn N., Sundaram Sridhar and Mathur Ike)

While the previous studies focused on an unconditional positive relation between portfolio betas and realized portfolio returns, Pettengill, Sundaram and Mathur prove that these studies were biased due to the conditional relation between beta and realized returns. The authors approach was that a positive relation is always predicted between beta and expected returns, but this relation is conditional on the market excess returns when realized returns are used for tests.

Data used for this study were monthly returns for all NYSE securities from January 1926 to December 1990, CRSP equally weighted index as a proxy for the market index and three-month T-bill rates as a proxy for the risk free rate. Portfolios were formed using the Fama and MacBeth (1973) approach. Then, Pettengill, Sundaram and Mathur state that if the realized market return is above the risk-free rate return, portfolio betas and returns should be positively related, but if the realized market return is below the risk-free return, portfolio betas and returns should be inversely related. Therefore, they introduce a multi-factor conditional relationship between betas and realized return which separates positive market returns from negative market returns as an alternative approach to unconditional models.

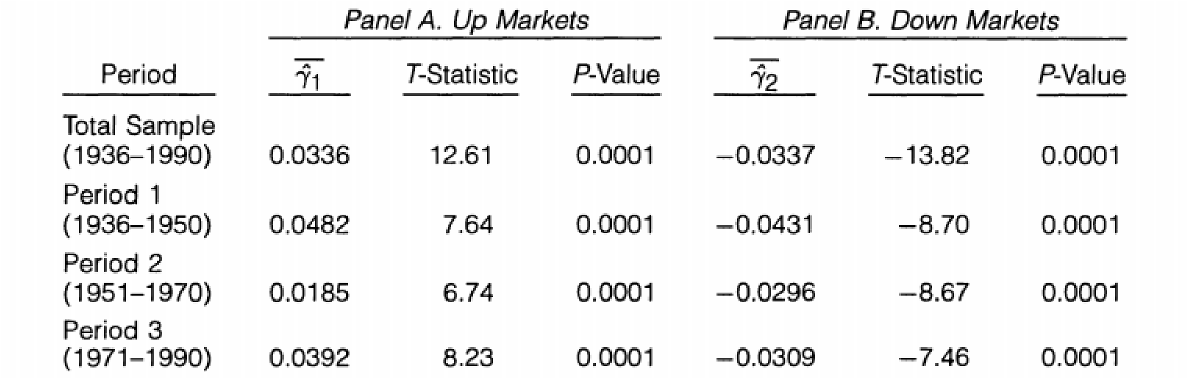
$$R_{it} = \widehat{\gamma_{0t}} + \widehat{\gamma_{1t}} * \delta * b_i + \widehat{\gamma_{2t}} * (1 - \delta) * b_i + \varepsilon_t \quad (\mathbf{3.22})$$

Where δ=1 if market excess returns are positive ($R_{mt} - R_{ft} > 0$) and δ=0 if market excess returns are negative ($R_{mt} - R_{ft} < 0$).

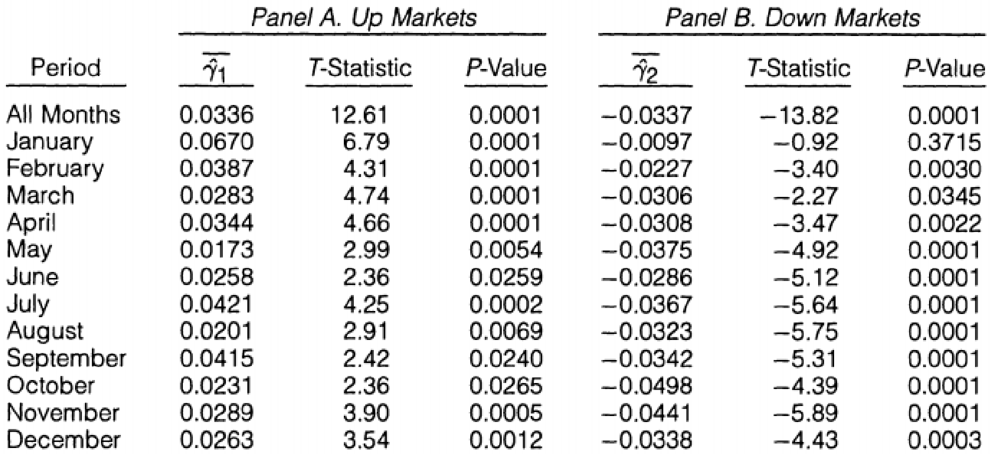
First, they run a test for a systematic relation between beta and returns. Their second concern is to determine if a systematic relationship between beta and return translates into a positive reward for holding risk which means holding securities with higher betas.

The results lead to an existing systematic relation between beta and returns for the total sample period which is consistent across sub periods and across months in a year. Moreover, there is a positive trade-off between average portfolio returns and beta. In other words, there is a reward for holding beta risk if market excess returns are positive on average and the risk-return relationship is symmetrical between periods of positive and negative excess market returns. Figure 3.7 provides the t-statistics and p-values.

Figure 3.7.: T-statistics and p-values (PSM 1995)



	Panel A. Up Markets			*Panel B. Down Markets*		
Period	$\overline{\hat{\gamma}_1}$	*T*-Statistic	*P*-Value	$\overline{\hat{\gamma}_2}$	*T*-Statistic	*P*-Value
Total Sample (1936–1990)	0.0336	12.61	0.0001	−0.0337	−13.82	0.0001
Period 1 (1936–1950)	0.0482	7.64	0.0001	−0.0431	−8.70	0.0001
Period 2 (1951–1970)	0.0185	6.74	0.0001	−0.0296	−8.67	0.0001
Period 3 (1971–1990)	0.0392	8.23	0.0001	−0.0309	−7.46	0.0001



	Panel A. Up Markets			*Panel B. Down Markets*		
Period	$\overline{\hat{\gamma}_1}$	*T*-Statistic	*P*-Value	$\overline{\hat{\gamma}_2}$	*T*-Statistic	*P*-Value
All Months	0.0336	12.61	0.0001	−0.0337	−13.82	0.0001
January	0.0670	6.79	0.0001	−0.0097	−0.92	0.3715
February	0.0387	4.31	0.0001	−0.0227	−3.40	0.0030
March	0.0283	4.74	0.0001	−0.0306	−2.27	0.0345
April	0.0344	4.66	0.0001	−0.0308	−3.47	0.0022
May	0.0173	2.99	0.0054	−0.0375	−4.92	0.0001
June	0.0258	2.36	0.0259	−0.0286	−5.12	0.0001
July	0.0421	4.25	0.0002	−0.0367	−5.64	0.0001
August	0.0201	2.91	0.0069	−0.0323	−5.75	0.0001
September	0.0415	2.42	0.0240	−0.0342	−5.31	0.0001
October	0.0231	2.36	0.0265	−0.0498	−4.39	0.0001
November	0.0289	3.90	0.0005	−0.0441	−5.89	0.0001
December	0.0263	3.54	0.0012	−0.0338	−4.43	0.0003

Source: Pettengill, G.N., Sundaram, S. and Mathur, I. (1995) "The conditional relation between beta and returns", Journal of Financial and Quantitative Analysis, Vol. 30, pp. 101-116

3.15. The Conditional CAPM and the Cross-Section of Expected Returns (1996- Jagannathan Ravi and Wang Zhenyu)

Extending the previous article discussion, we see the need of expressing the conditional CAPM in terms of expected return and risk was vital. Thus, to overcome the conditionality of moments used in CAPM for returns and risks, Jagannathan and Wang proposed the conditional CAPM.

$$E(R_{it}|I_{t-1}) = \gamma_{0t-1} + \gamma_{1t-1} b_{it-1} \quad \mathbf{(3.23)}$$

Where $E(R_{it}|I_{t-1})$ express the expected return of asset i at time t given the public information I available at time t-1, γ_{0t-1} is the conditional expected return on a zero beta portfolio, γ_{1t-1} is the conditional market risk premium and b_{it-1} is the conditional beta of asset i defined as:

$$b_{it-1} = \frac{Cov(R_{it}, R_{mt}|I_{t-1})}{Var(R_{mt}|I_{t-1})} \quad \mathbf{(3.24)}$$

Jagannathan and Wang decompose this conditional model in an unconditional one and they get the following equations:

$$E(R_{it}) = \gamma_0 + \gamma_1 \overline{b_\iota} + Var(\gamma_{1t-1})\theta_i \quad \mathbf{(3.25)}$$

Where θ_i is the beta-prem sensitivity, $\overline{b_\iota}$ is the expected beta, η_{it-1} is the residual beta and they are defined as follows:

$$\theta_i = \frac{Cov(b_{it-1}, \gamma_{1t-1})}{Var(\gamma_{1t-1})} \quad \mathbf{(3.26)}$$

$$b_{it-1} = \overline{b_\iota} + \theta_i(\gamma_{1t-1} - \gamma_1) + \eta_{it-1} \quad \mathbf{(3.27)}$$

It can be seen from equation 3.25 that the residual betas do not affect the unconditional expected return. Therefore, when considering unconditional returns, we may ignore the residual betas and concentrate on the first two parts of each conditional beta. Since the beta-prem sensitivity and the expected beta cannot be estimated, we may as well look directly at how the stock returns react to the market return on average and how they respond to the changes of the market risk premium. This led the authors to define the following two types of unconditional betas:

$$b_i = \frac{Cov(R_{it}, R_m)}{Var(R_m)} \quad \mathbf{(3.28)}$$

$$b_i^{\gamma} = \frac{Cov(R_{it}, \gamma_{1t-1})}{Var(\gamma_{1t-1})} \quad \mathbf{(3.29)}$$

Where the b_i is the market beta that measures the average market risk as we already knew and the b_i^{γ} is the premium beta that measures the beta instability risk. The equation formed with these betas is the following:

$$E(R_{it}) = a_0 + a_1 b_i + a_2 b_i^{\gamma} \quad \mathbf{(3.30)}$$

The theorem used to form the equation 3.30 is stated as follows: “If b_i^{γ} is not a linear function of b_i, then there are some constants a_0, a_1 and a_2 , such that the equation 3.30 holds for every asset i.”

At this point of the literature reviewing, the article leads us to see the need of expressing a capital asset pricing model with two betas instead of one is growing further after the general equilibrium multi-beta model of Merton in 1973 and the two-beta version of the linear factor model of Ross in 1976 and this might had set the base of the model of Diacogiannis we proved in subchapter 2.7.

3.16. On Persistence in Mutual Funds Performance (1997- Carhart Mark M.)

In 1997, multifactor models such as the three factor model of Fama and French (1992) was already a trend in economic forums. Carhart extended this model into a four factor one.

$$(R_{it} - r_f) = a_i + b_i(R_{mt} - r_f) + b_{SMB}SMB_t + b_{HML}HML_t + b_{MOM}MOM + e_{it} \quad \mathbf{(3.31)}$$

Where $(R_{jt} - r_f)$ denotes the excess return of asset i from r_f, a_i is a constant for asset i indicating management performance, b_i indicates the sensitivity coefficient of asset i towards the parameter $(R_{mt} - r_f)$ which stands for the excess market portfolio return over r_f, b_{SMB} is the sensitivity coefficient towards the SMB_t factor, SMB_t is the small minus big parameter, b_{HML} is the sensitivity coefficient towards the HML_t factor, HML_t is the high minus low parameter, b_{MOM} is the sensitivity coefficient towards the MOM factor, MOM is the momentum factor and e_{it} is the error term of the regression for asset i.

The parameters SMB and HML were described at subchapter 3.12. The innovation of Carhart’s model is the addition of the momentum variable. The momentum factor in a stock is described as the tendency for the stock price to continue rising if it is going up and to continue declining if it is going down. It is the tendency of an asset to follow a short term memory and follow the recent return direction. The MOM can be calculated by subtracting the equal weighted average of the lowest performing firms from the equal weighed average of the highest performing firms (winners to losers' proxy), during a past lagged period that is usually one month, six months and a year. A stock is showing momentum if its prior 12 month average of returns is positive.

Carhart's model is still used in the interpretation of mutual funds or other funds management efficiency.

3.17. A three-dimensional risk-return relationship based upon the inefficiency of a portfolio: Derivation and Implications (1999-Diacogiannis George P.)

Diacogiannis studies the relationship of risk and return of an asset when the risk of a portfolio not belonging to the efficient frontier is considered. The assumptions made in this study are the following:

1. There is a universe of n assets, with n≥3. The returns on these assets over a given time are denoted by the vector R which follows a multivariate distribution with vector of expected returns μ and variance-covariance matrix V. A portfolio p is a n-vector of weights x_p. That means the portfolio p is a vector of all x_p weights of n assets included in portfolio p. The $x_{i,p}$ stands for the proportion of wealth invested in asset i and the sum of the weights is equal to 1.

$$\sum ix_{i,p} = 1^T x_p = 1 \quad (\mathbf{3.32})$$

The expected return and variance of the return on portfolio p are given by the following equations.

$$E(R_p) = x_p^T \mu \quad (\mathbf{3.33})$$

$$Var(R_p) = V(R_p) = x_p^T V x_p \quad (\mathbf{3.34})$$

2. V is a non-singular, positive definite matrix with a nonzero determinant.
3. The rank of the n by 2 matrix (μ 1) is 2.
4. Short selling of risky securities is permitted.

The properties of a portfolio that does not belong but lies inside the boundary portfolio set are described as follows. Let p be a portfolio which lies inside the boundary portfolio set and a boundary portfolio q, which has the same expected return as portfolio p. The return of portfolio p is equal to the rate of return of the boundary portfolio q plus a residual term that has an expected return equal to zero and its covariance with the rate of return of q portfolio is also equal to zero.

$$R_p = R_q + U_p \quad (\mathbf{3.35})$$

The variance of the return on boundary portfolio q equals the covariance between the rates of return on portfolios q and p.

$$V(R_q) = Cov(R_q, R_p) \quad (\mathbf{3.36})$$

Once the covariance of the residual term with the rate of return of q portfolio is zero, the variance of portfolio p is given by the following equation.

$$V(R_p) = V(R_q) + V(U_p) \quad (\mathbf{3.37})$$

For the same reason, the covariance of the portfolio p returns with the residuals equals the variance of the residuals.

$$Cov(R_p, U_p) = V(U_p) \quad (\mathbf{3.38})$$

In other words, the greater the variance of the residual term is, the greater the correlation between the portfolio p returns and the residuals. Moreover, the covariance between the rate of return of any security j and the rate of return of portfolio p is:

$$Cov(R_j, R_p) = Cov(R_j, R_q + U_p) \;\; or$$

$$Cov(R_j, R_p) = Cov(R_j, R_q) + Cov(R_j, U_p) \quad (\mathbf{3.39})$$

This study concludes that if a portfolio p lies inside the boundary portfolio set but does not belong in it, then:

1. There is a vector $u_p \neq 0$, where 0 is a n-vector of zeros, and:

$$x_p = V^{-1}(\mu \; 1)A^{-1}(\mu_p 1)^T + V^{-1}u_p \quad (\mathbf{3.40})$$

so that the following equation holds.

$$\mu_p = r_{zp}1 - \frac{\mu_p - \mu_{zp}}{V(R_q)}(V(x_p) - u_p) \quad (\mathbf{3.41})$$

where μ_p is the expected return of portfolio p, μ_{zp} is the expected return of the boundary portfolio whose rate of return is uncorrelated with the rate of return of portfolio p and $\mu_p = \mu_q$.

2. The following equation exists:

$$b_p = \frac{V(R_q)}{V(R_p)}b_q + \frac{V(U_p)}{V(R_p)}b_u \quad (\mathbf{3.42})$$

where q is the boundary portfolio, $\mu_p = \mu_q$, b_p is the n-vector with elements $\frac{Cov(R_j,R_p)}{Var(R_p)}$, b_q is the n-vector with elements $\frac{Cov(R_j,R_q)}{Var(R_q)}$, $b_u \neq 0$ is the n-vector with elements $\frac{Cov(R_j,R_u)}{Var(R_u)}$.

Therefore, this analysis reveal that a p portfolio that does not belong but lies inside the boundary portfolio set and hence, is not effective if and only if the expected return of an asset element j is expressed as a linear relationship of systematic risk resulting from the portfolio p and an additional risk associated with how the p portfolio can be moved within the boundary given its ineffectiveness.

3.18. Beta and Returns revisited: Evidence from the German Stock Market (2003- Elsas Ralf, El-Shaer Mahmoud, Theissen Erik)

As discussed in several articles, an ex-post formulation of the CAPM predicts that stocks with a higher beta are expected to have higher returns only when the market return is higher than the return of the riskless asset. If the market return falls short of the risk free rate, stocks with a higher beta have lower returns. Pettengill, Sundaram and Mathur (1995) call this the conditional ex-post relation between betas and return (see subchapter 3.14).

Elsas, El-Shaer and Theissen take the Pettengill, Sundaram and Mathur analysis a step further. Their main objective is to perform Monte Carlo simulations to demonstrate if and how the results of Fama and MacBeth (1973) differ when the conditional relation between beta and returns is taken into account or not and secondly, to empirical examine the relation between beta and returns on the German stock market using monthly stock returns from 1960 to 1995.

The assets for the Monte Carlo simulation were chosen to be 100 random stocks from the period 1981-1995. The traditional two stage test of Fama and MacBeth procedure suffers from the problem that it jointly tests the hypotheses of a relation between beta and realized returns and the hypothesis of a positive market risk premium. The results of Elsas, El-Shaer and Theissen simulation analysis suggest that the conditional test approach is better suited to uncover a relation between betas and realized returns because it avoids the joint hypothesis problem associated with the traditional test procedure.

For that reason, the empirical examination on German stock market was made with a conditional test, using an augmented cross-sectional regression equation.

$$r_{i,t} = \gamma_{0,t} + \gamma_{1,t} D_t b_i + \gamma_{2,t}(1 - D_t) b_i + \varepsilon_{i,t} \quad \mathbf{(3.43)}$$

Where $r_{i,t}$ express the expected return of asset i at time t, $\gamma_{0,t}$ is the conditional expected return on a zero beta portfolio, $\gamma_{1,t}$ is the conditional market risk premium, b_i is the conditional beta of asset i, D_t is a dummy variable taking on the value 1 if the market risk premium on month t is positive or the value 0 if the market risk premium on month t is negative and $\varepsilon_{i,t}$ is the standard error of the regression.

Their results on the German stock market show that the relation between beta and return is statistically significant both in the full sample and in each of the subsamples and they are leading to the prediction by the theory that portfolios with higher betas have higher returns when the market risk premium is positive and lower returns when the market risk premium is negative.

3.19. The Cross-Section of Expected Stock Returns: An Empirical Study in the Athens Stock Exchange (2003- Theriou Nikolaos, Chatzoglou Prodromos, Maditinos Dimitrios and Aggelidis Vasilios)

Theriou, Chatzoglou, Maditinos and Aggelidis explore the ability of the CAPM, as well as the firm specific factors used in the three factor model of Fama and French (size of the firm and book to market), to explain the cross-sectional relationship between average stock returns and risk in Athens Stock Exchange.

For the purpose of this study, they used data for 327 Greek non-financial firms from the period of July 1993 to June 2001. Initially, they had daily closing prices. The daily returns for each stock were calculated using logarithmic approximation. Then, the daily returns were converted into monthly returns. They created portfolios according to beta alone, to book to market value alone, to size alone, to size and beta, to book to market and beta and to book to market and market value, so that they run six different cross sectional and time series regressions.

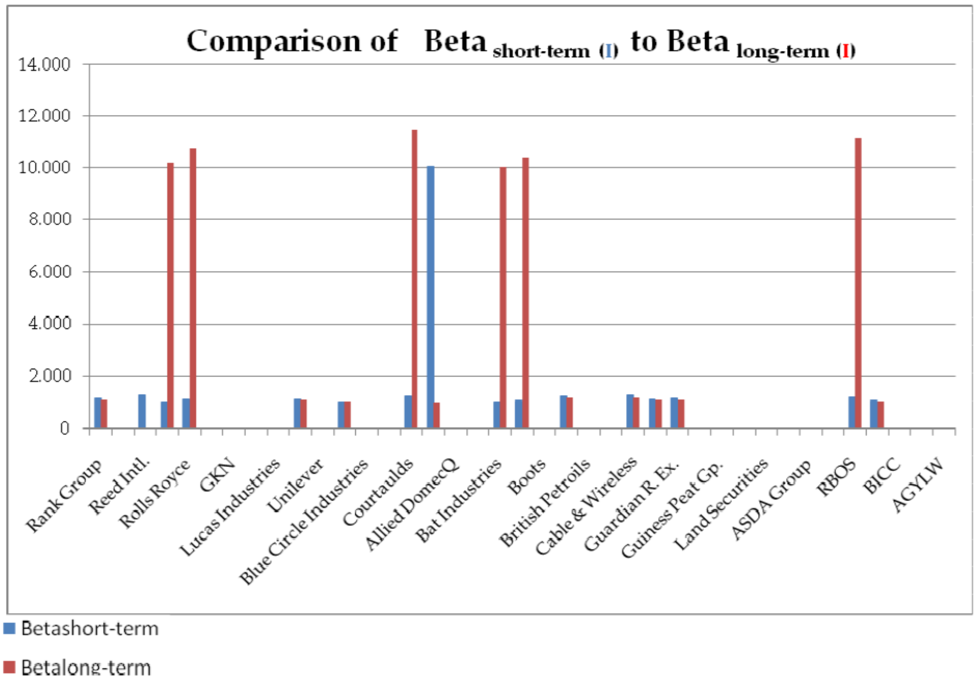
Their findings strongly contrast with the predictions of the CAPM. They found that beta cannot explain cross section variations of average return of Athens Stock Exchange. The cross section of monthly returns indicates that there is a size effect on the cross sectional variation in average stock returns. In fact, average returns vary inversely with firm size, as in the study of Fama and French (1992). In contrast, evidence of book to market effect indicates that average returns vary directly with book to market ratio, but it is found only in the model that this is the only explanatory variable. When other explanatory variables were added in the regression the book to market effect diminishes. Theriou, Chatzoglou, Maditinos and Aggelidis state that the interrelationship of beta, size, and book-to-market equity satisfactorily explains the cross-section of average stock returns although the cross-section of average returns is explained better when size or book to market equity is used alone as explanatory variables.

3.20. An Empirical Evaluation of CAPM's Validity in the British Stock Exchange (2009- Loukeris Nikolaos)

This study investigates the validity of CAPM on the British Stock Exchange as well as the relation of the model to the beta. A regression procedure was performed in 39 stocks from London Stock Exchange on monthly basis for the period of January 1980 to February 1998.

Loukeris found that beta is a significant coefficient of measuring the returns and it is supported by CAPM hence it can be said that beta is compatible to CAPM, although in the previous study we discussed that beta might not be an important factor. Moreover, the correlation coefficient R^2 is relatively low, at 7%, in accordance to previous surveys which have also found a low price for R^2. That led him to the fact that the slope of the SML is different from the slope of SML indicated by CAPM and the CAPM validity is rejected. Finally, Loukeris provided a diagram of companies' beta showing that their systematic risk might be bigger in the long term rather than the short term and a beta index must be created.

Figure 3.8.: A comparison of the different values produced by beta short-term and beta long-term into each company



Source: Loukeris, N. (2009) "An empirical evaluation of CAPM's validity in the British stock exchange", International Journal of Applied Mathematics and Informatics, Vol.3, pp. 1-8

3.21. A Sceptical Appraisal of Asset Pricing Tests (2010- Lewellen Jonathan, Nagel Stefan, Shanken Jay)

The objective of this study is to explain why, despite the seemingly strong evidence that many proposed models can explain the size and B/M effects, the authors remain unconvinced by the results. Reviewing the literature, one see that it seems too easy to explain the size and the book to market effects on models that have little in common with each other, in economically way.

Lewellen, Nagel and Shanken show that obtaining a high cross-sectional R^2 is easy because loadings on almost any proposed factor are likely to line up with expected returns. In fact, all that is required is for a factor to be weakly correlated with small minus big (SMB) or high minus low (HML) but not with the three factor model residuals of the size and book to market portfolios. To illustrate the above statement, they created artificial factors that have the previous qualifications and got an R^2 of 44% for a one factor model, 62% for a three factor model and 69% for a five factor model.

One might wonder if the above results are true, how we get more convincing results when testing asset pricing models. Lewellen, Nagel and Shanken provide four suggestions:

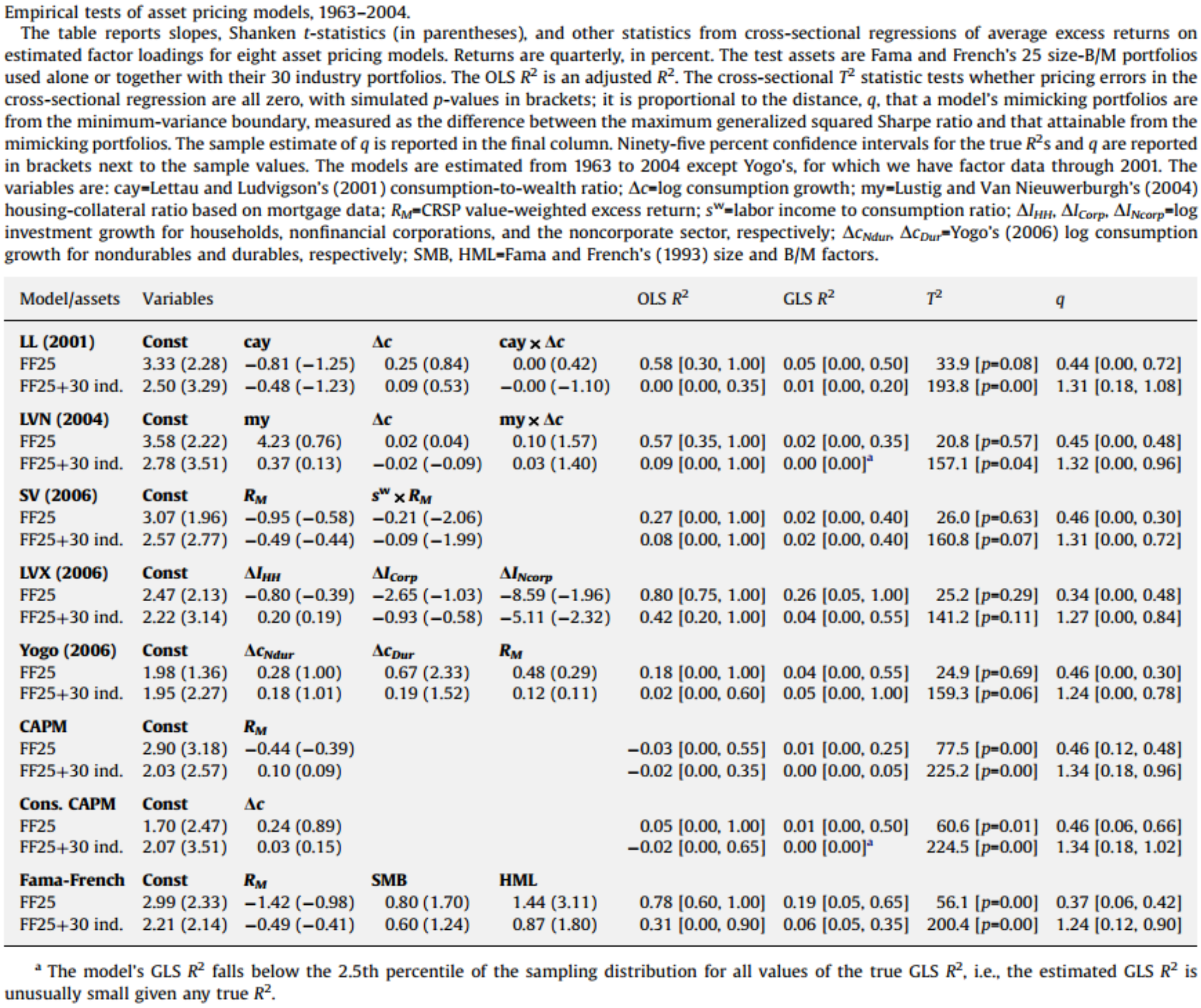
1. Include portfolios in tests sorted by industry or other characteristics.
2. Impose restrictions on the risk premiums when theory provides appropriate guidance.
3. Less severe problems when using generalized least squares (GLS) cross-section regressions, rather than ordinary least squares (OLS).
4. Report confidence intervals (CI) for test statistics. Do not rely only on point estimates and p-values.

Then, using the above suggestions, Lewellen, Nagel and Shanken investigate the following models:

1. Lettau and Ludvigson (LL 2001) conditional consumption CAPM (CCAPM)
2. Lustig and Van Nieuwerburgh’s (LVN 2004) conditional CCAPM
3. Santos and Veronesi’s (SV 2006) conditional CAPM
4. Li, Vassalou, and Xing’s (LVX 2006) investment model
5. Yogo’s (Yogo 2006) durable-consumption CAPM

For comparison they also reported results for three benchmark models: the unconditional CAPM (CAPM), the unconditional CCAPM (Cons. CAPM) and the three-factor model of Fama and French (Fama-French). Figure 3.9 is provided to show the results of Lewellen, Nagel and Shanken.

Figure 3.9.: Results of Lewellen, Nagel and Shanken



Empirical tests of asset pricing models, 1963–2004.

The table reports slopes, Shanken *t*-statistics (in parentheses), and other statistics from cross-sectional regressions of average excess returns on estimated factor loadings for eight asset pricing models. Returns are quarterly, in percent. The test assets are Fama and French's 25 size-B/M portfolios used alone or together with their 30 industry portfolios. The OLS R^2 is an adjusted R^2. The cross-sectional T^2 statistic tests whether pricing errors in the cross-sectional regression are all zero, with simulated *p*-values in brackets; it is proportional to the distance, *q*, that a model's mimicking portfolios are from the minimum-variance boundary, measured as the difference between the maximum generalized squared Sharpe ratio and that attainable from the mimicking portfolios. The sample estimate of *q* is reported in the final column. Ninety-five percent confidence intervals for the true R^2s and *q* are reported in brackets next to the sample values. The models are estimated from 1963 to 2004 except Yogo's, for which we have factor data through 2001. The variables are: cay=Lettau and Ludvigson's (2001) consumption-to-wealth ratio; Δc=log consumption growth; my=Lustig and Van Nieuwerburgh's (2004) housing-collateral ratio based on mortgage data; R_M=CRSP value-weighted excess return; s^w=labor income to consumption ratio; ΔI_{HH}, ΔI_{Corp}, ΔI_{Ncorp}=log investment growth for households, nonfinancial corporations, and the noncorporate sector, respectively; Δc_{Ndur}, Δc_{Dur}=Yogo's (2006) log consumption growth for nondurables and durables, respectively; SMB, HML=Fama and French's (1993) size and B/M factors.

Model/assets	Variables				OLS R^2	GLS R^2	T^2	q
LL (2001)	**Const**	**cay**	**Δc**	**cay × Δc**				
FF25	3.33 (2.28)	−0.81 (−1.25)	0.25 (0.84)	0.00 (0.42)	0.58 [0.30, 1.00]	0.05 [0.00, 0.50]	33.9 [*p*=0.08]	0.44 [0.00, 0.72]
FF25+30 ind.	2.50 (3.29)	−0.48 (−1.23)	0.09 (0.53)	−0.00 (−1.10)	0.00 [0.00, 0.35]	0.01 [0.00, 0.20]	193.8 [*p*=0.00]	1.31 [0.18, 1.08]
LVN (2004)	**Const**	**my**	**Δc**	**my × Δc**				
FF25	3.58 (2.22)	4.23 (0.76)	0.02 (0.04)	0.10 (1.57)	0.57 [0.35, 1.00]	0.02 [0.00, 0.35]	20.8 [*p*=0.57]	0.45 [0.00, 0.48]
FF25+30 ind.	2.78 (3.51)	0.37 (0.13)	−0.02 (−0.09)	0.03 (1.40)	0.09 [0.00, 1.00]	0.00 [0.00][a]	157.1 [*p*=0.04]	1.32 [0.00, 0.96]
SV (2006)	**Const**	**R_M**	**$s^w \times R_M$**					
FF25	3.07 (1.96)	−0.95 (−0.58)	−0.21 (−2.06)		0.27 [0.00, 1.00]	0.02 [0.00, 0.40]	26.0 [*p*=0.63]	0.46 [0.00, 0.30]
FF25+30 ind.	2.57 (2.77)	−0.49 (−0.44)	−0.09 (−1.99)		0.08 [0.00, 1.00]	0.02 [0.00, 0.40]	160.8 [*p*=0.07]	1.31 [0.00, 0.72]
LVX (2006)	**Const**	**ΔI_{HH}**	**ΔI_{Corp}**	**ΔI_{Ncorp}**				
FF25	2.47 (2.13)	−0.80 (−0.39)	−2.65 (−1.03)	−8.59 (−1.96)	0.80 [0.75, 1.00]	0.26 [0.05, 1.00]	25.2 [*p*=0.29]	0.34 [0.00, 0.48]
FF25+30 ind.	2.22 (3.14)	0.20 (0.19)	−0.93 (−0.58)	−5.11 (−2.32)	0.42 [0.20, 1.00]	0.04 [0.00, 0.55]	141.2 [*p*=0.11]	1.27 [0.00, 0.84]
Yogo (2006)	**Const**	**Δc_{Ndur}**	**Δc_{Dur}**	**R_M**				
FF25	1.98 (1.36)	0.28 (1.00)	0.67 (2.33)	0.48 (0.29)	0.18 [0.00, 1.00]	0.04 [0.00, 0.55]	24.9 [*p*=0.69]	0.46 [0.00, 0.30]
FF25+30 ind.	1.95 (2.27)	0.18 (1.01)	0.19 (1.52)	0.12 (0.11)	0.02 [0.00, 0.60]	0.05 [0.00, 1.00]	159.3 [*p*=0.06]	1.24 [0.00, 0.78]
CAPM	**Const**	**R_M**						
FF25	2.90 (3.18)	−0.44 (−0.39)			−0.03 [0.00, 0.55]	0.01 [0.00, 0.25]	77.5 [*p*=0.00]	0.46 [0.12, 0.48]
FF25+30 ind.	2.03 (2.57)	0.10 (0.09)			−0.02 [0.00, 0.35]	0.00 [0.00, 0.05]	225.2 [*p*=0.00]	1.34 [0.18, 0.96]
Cons. CAPM	**Const**	**Δc**						
FF25	1.70 (2.47)	0.24 (0.89)			0.05 [0.00, 1.00]	0.01 [0.00, 0.50]	60.6 [*p*=0.01]	0.46 [0.06, 0.66]
FF25+30 ind.	2.07 (3.51)	0.03 (0.15)			−0.02 [0.00, 0.65]	0.00 [0.00][a]	224.5 [*p*=0.00]	1.34 [0.18, 1.02]
Fama-French	**Const**	**R_M**	**SMB**	**HML**				
FF25	2.99 (2.33)	−1.42 (−0.98)	0.80 (1.70)	1.44 (3.11)	0.78 [0.60, 1.00]	0.19 [0.05, 0.65]	56.1 [*p*=0.00]	0.37 [0.06, 0.42]
FF25+30 ind.	2.21 (2.14)	−0.49 (−0.41)	0.60 (1.24)	0.87 (1.80)	0.31 [0.00, 0.90]	0.06 [0.05, 0.35]	200.4 [*p*=0.00]	1.24 [0.12, 0.90]

[a] The model's GLS R^2 falls below the 2.5th percentile of the sampling distribution for all values of the true GLS R^2, i.e., the estimated GLS R^2 is unusually small given any true R^2.

Source: Lewellen, J., Nagel, S. and Shanken, J. (2010) "A sceptical appraisal of asset-pricing tests", Journal of Financial Economics, Vol. 96, pp.175-194

Lewellen, Nagel and Shanken added industry portfolios in their tests and we can see that this causes dramatically changes on the performance of the models. Figure 3.4. reveals to us many important things such as the sample OLS R^2 is often uninformative about a model's true population performance, none of the models provides much improvement over the simple or consumption CAPM when performance is measured by the GLS R^2, none of the models explains the level of expected returns as the estimated intercepts are all substantially greater than zero. These results over the five models LL 2001, LVN 2004, SV 2006, LVX 2006 and Yogo 2006 were disappointing and this is the main reason why we have not discussed those models in the first place.

3.22. Factors Affecting Expected Stock Returns: Evidence from the Secondary and Tertiary Sectors of Athens Stock Exchange (2010- Artikis Panagiotis G., Vrakas Sotirios G., Karmi Eustathia D.)

Artikis, Vrakas and Karmi investigate the validity of the CAPM and the Fama-French three factor model on 209 companies of the secondary sector and 177 companies of the tertiary sector of Athens Stock Exchange (ASE) for the period 1997-2006 using a time series approach with monthly data.

Six stock portfolios were formed: S/L, S/M, S/H portfolios include stocks with size smaller than the median and low, medium and high book to market value (BE/ME) respectively and B/L, B/M, B/H portfolios include stocks with size bigger than the median and low, medium and high BE/ME respectively. The six portfolios were rebalanced each year so that each company would move across portfolios depending on its size and BE/ME. The results were consistent with Fama and French theory that small size portfolios have on average higher monthly returns as compared to big size portfolios and high BE/ME portfolios reach higher average monthly returns as compared to low BE/ME portfolios.

Furthermore, Artikis, Vrakas and Karmi did step-wise regression analysis to observe the change in the explanatory power of the independent variables and the asset pricing models. For this purpose they used the following regression equations (2FM stands for the two factor model and 3FM stands for the three factor model).

$$CAPM: R_{im} - R_{fm} = a_i + b_i(R_{mm} - R_{fm}) + \varepsilon_{im} \quad (\mathbf{3.44})$$

$$2FM: R_{im} - R_{fm} = a_i + s_i SMB_m + h_i HML_m + \varepsilon_{im} \quad (\mathbf{3.45})$$

$$3FM: R_{im} - R_{fm} = a_i + b_i(R_{mm} - R_{fm}) + s_i SMB_m + h_i HML_m + \varepsilon_{im} \quad (\mathbf{3.46})$$

Where R_{im} is the average realized returns on portfolio i (S/L, S/M, S/H, B/L, B/M and B/H) in month m of year t, R_{fm} is the return on the 12-month Greek Government t-bill in month m of year t, a_i is the intercept, b_i, s_i, h_i represent the regression coefficients for portfolio i on a given explanatory variable, R_{mm} represents the return on ASE General Index in month m of year t, SMB_m represents the return on the portfolio SMB in month m of year t, HML_m represents the return on the mimicking portfolio HML in month m of year t and ε_{im} is the standard error.

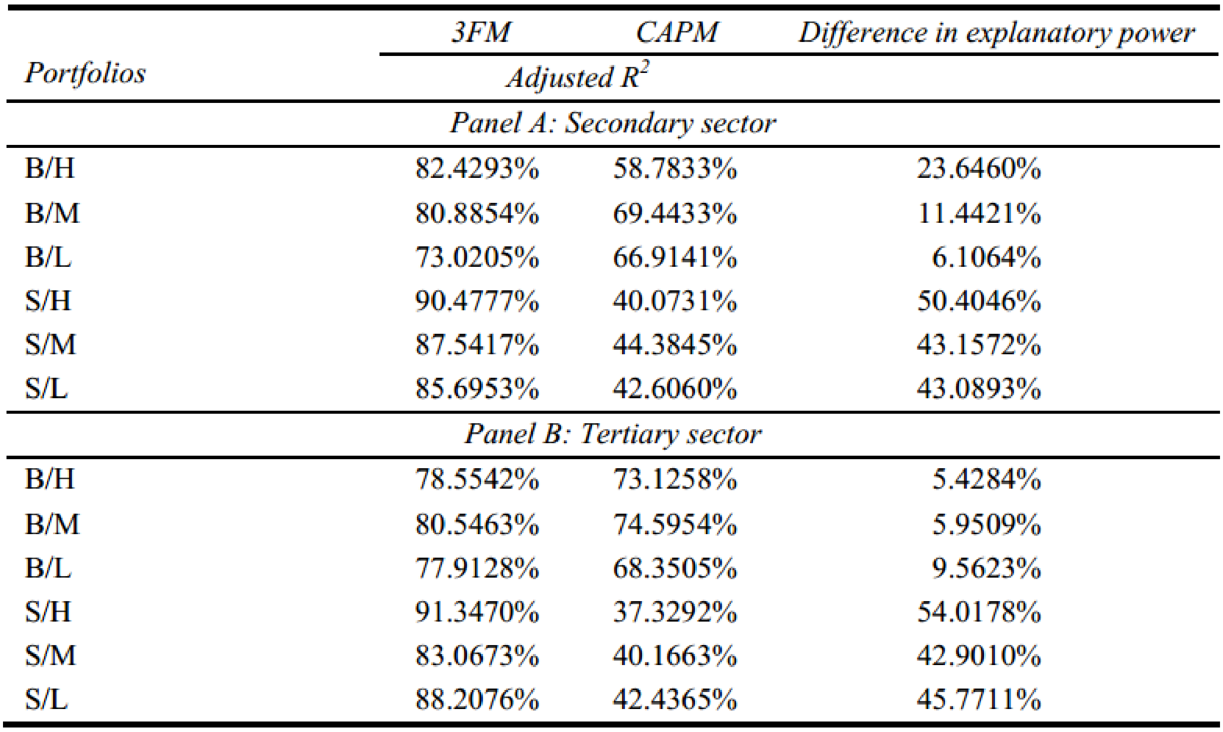
On CAPM regressions, the results showed many similarities between the two sectors of the ASE and market premium explained significantly the variations of average stock returns in both sectors of the ASE. Nevertheless, a big proportion of the volatility of average portfolio returns (more specifically those of small size) is not explained by the market premium. In other words, there are additional risk factors on stock returns of secondary and tertiary sectors of the ASE.

On the other hand, on 2FM regression, the results had substantial differences between the two sectors of the ASE. For the secondary sector, the model was statistically significant at 5% significance level, whereas for the tertiary sector, the model is statistically significant except the B/L portfolio. In the case of SMB factor, for the secondary sector, small-sized portfolios are more sensitive to the risk factor, but large-sized portfolios do not seem to be affected that much by the risk factor. In the case of the HML factor, for the secondary sector, large-sized portfolios of the secondary sector are more sensitive to the risk factor. As far as the tertiary sector is concerned, the only case where the two factors, SMB and HML, explain the variability of the average returns is with small size firms that have a high BE/ME ratio (S/H portfolio). Again, there is a volatility proportion that is not explained by the 2FM.

On 3FM regression, the results reveal that the size premium, in both sectors of the ASE, is greater for portfolios of firms with low capitalization and this offers a clue that the capitalization of the companies is a potential risk factor in stock returns. Moreover, the value premium is greater in high BE/ME ratio portfolios, thus, the BE/ME factor can be considered as another potential risk factor in stock returns. However, Artikis, Vrakas and Karmi state that there are more than three variables that affect the average stock returns of firms listed in the ASE.

Finally, the 3FM has definitely more explanatory than CAPM and Figure 3.10 illustrates this point.

Figure 3.10.: Comparison of the explanatory power: CAPM versus 3FM



Portfolios	*3FM*	*CAPM*	*Difference in explanatory power*
	Adjusted R^2		
	Panel A: Secondary sector		
B/H	82.4293%	58.7833%	23.6460%
B/M	80.8854%	69.4433%	11.4421%
B/L	73.0205%	66.9141%	6.1064%
S/H	90.4777%	40.0731%	50.4046%
S/M	87.5417%	44.3845%	43.1572%
S/L	85.6953%	42.6060%	43.0893%
	Panel B: Tertiary sector		
B/H	78.5542%	73.1258%	5.4284%
B/M	80.5463%	74.5954%	5.9509%
B/L	77.9128%	68.3505%	9.5623%
S/H	91.3470%	37.3292%	54.0178%
S/M	83.0673%	40.1663%	42.9010%
S/L	88.2076%	42.4365%	45.7711%

Source: Artikis, P., Vrakas, S., and Karmi, E. (2010) "Factors Affecting Expected Stock Returns: Evidence from the Secondary & the Tertiary Sectors of the Athens Stock Exchange", International Journal of Financial Services Management, Vol. 4, pp.175-198

3.23. The Market Portfolio May Be Mean-Variance Efficient After All (2010-Levy Moshe and Roll Richard)

Roll (1977) stated that testing the CAPM means testing the mean-variance efficiency of market portfolio. Many previous studies we have discussed, have found that many market proxies are inefficient.

In this paper, Levy and Roll try different variations on sample parameters that would make the market proxy efficient. Mathematically speaking they are looking for an expected return vector μ and a covariance matrix C that both make portfolio m mean-variance efficient and are as close as possible to their sample counterparts (μ^{sam} and σ^{sam} which denote the vector of sample average returns and the vector of sample standard deviations respectively). To consider a parameter set as reasonably close to the sample parameters we require that 95% or more of the parameters are within the 95% confidence intervals of the sample parameters. For that reason, Levy and Roll use a distance meter D which they want to minimize.

$$D\big((\mu,\sigma),(\mu^{sam},\sigma^{sam})\big) = \sqrt{a\frac{1}{N}\sum_{i=1}^{N}\left(\frac{\mu_i-\mu_i^{sam}}{\sigma_i^{sam}}\right)^2 + (1-a)\frac{1}{N}\sum_{i=1}^{N}\left(\frac{\sigma_i-\sigma_i^{sam}}{\sigma_i^{sam}}\right)^2} \quad \mathbf{(3.47)}$$

To solve the above optimization problem, Levy and Roll collected data for the 100 largest US stocks (according to capitalizations of December 2006) for the period January 1997 to December 2006. To find the set of parameters that makes the proxy portfolio efficient and is closest to the sample parameter they used the MATLAB‘s function “fmincon”. At this point, there is no need to present the numerical and statistical parts to understand their results.

Levy and Roll concluded that the reverse optimization problem leads us directly to these parameter sets that both make portfolio m mean-variance efficient and are as close as possible to their sample counterparts. These parameters are consistent with CAPM and CAPM is shown to be valid under these parameters.

3.24. Linear Beta Pricing With Inefficient Benchmarks (2013-Diacogiannis George and Feldman David)

This article can be considered as an expansion of the article "A three-dimensional risk-return relationship based upon the inefficiency of a portfolio: Derivation and implications" of Diacogiannis (1999), which we discussed on subchapter 3.17. In the article "Linear beta pricing with inefficient benchmarks" the 3d model which we proved in chapter 2 is presented. Reviewing the literature, one may notice that the 3d model also appears in the article "The D-CAPM: The Case of Great Britain and France" published in 2010 in International Journal of Economics and Finance, Vol. 2, pp. 25-38 by Artavanis, Diacogiannis and Mylonakis, but in this article there is no mention of inefficient benchmarks in which the 3d model is also applicable. For this reason, we decided to discuss the article "Linear beta pricing with inefficient benchmarks" that contains all the information needed on the 3d model.

For our convenience, we will rewrite the proof of the 3D model. We consider a portfolio p, which lies inside the boundary portfolio set and a boundary portfolio q, such that their expected returns are equal. The return of portfolio p is equal to the rate of return of the boundary portfolio q plus a residual term:

$$R_p = R_q + U_p \quad (\mathbf{3.48})$$

The residual term has expected return of zero and it is also uncorrelated with the rate of return of the boundary portfolio q. In other words, we created q and p in such way that:

$$E(R_p) = E(R_q) \quad (\mathbf{3.49})$$

Thus, $E(U_p) = 0$. Moreover, considering covariances on equation 3.48 reveals the equation 3.50:

$$Cov(R_i, R_p) = Cov(R_i, R_q) + Cov(R_i, U_p) \quad (\mathbf{3.50})$$

The portfolio q is efficient and therefore for portfolio q we may use the CAPM:

$$E(R_i) = r_f + [E(R_q) - r_f]b_{iq} \quad (\mathbf{3.51})$$

But as we know by the beta definition:

$$b_{iq} = \frac{Cov(R_i, R_q)}{Var(R_q)} \quad (\mathbf{3.52})$$

Substituting equation 3.52 to 3.51 we get:

$$E(R_i) = r_f + \left[E\left(R_q\right) - r_f\right]\frac{Cov(R_i, R_q)}{Var(R_q)} \quad (\mathbf{3.53})$$

Substituting equation 3.50 to 3.53 we reveal the following relationship:

$$E(R_i) = r_f + \left[E\left(R_q\right) - r_f\right]\frac{Cov(R_i, R_p)}{Var(R_q)} - \left[E\left(R_q\right) - r_f\right]\frac{Cov(R_i, U_p)}{Var(R_q)} \quad (\mathbf{3.54})$$

Then, we substitute equation 3.49 to 3.54:

$$\begin{aligned} E(R_i) &= r_f + \left[E\left(R_p\right) - r_f\right]\frac{Cov\left(R_i, R_p\right)}{Var\left(R_q\right)} - \left[E\left(R_p\right) - r_f\right]\frac{Cov\left(R_i, U_p\right)}{Var\left(R_q\right)} \quad (\mathbf{3.55}) \\ \rightarrow E(R_i) &= r_f + \left[E\left(R_p\right) - r_f\right]\frac{Cov(R_i, R_p)}{Var(R_q)}\frac{Var(R_p)}{Var(R_p)} \\ &\quad - \left[E\left(R_p\right) - r_f\right]\frac{Cov(R_i, U_p)}{Var(R_q)}\frac{Var(U_p)}{Var(U_p)} \end{aligned}$$

Thus:

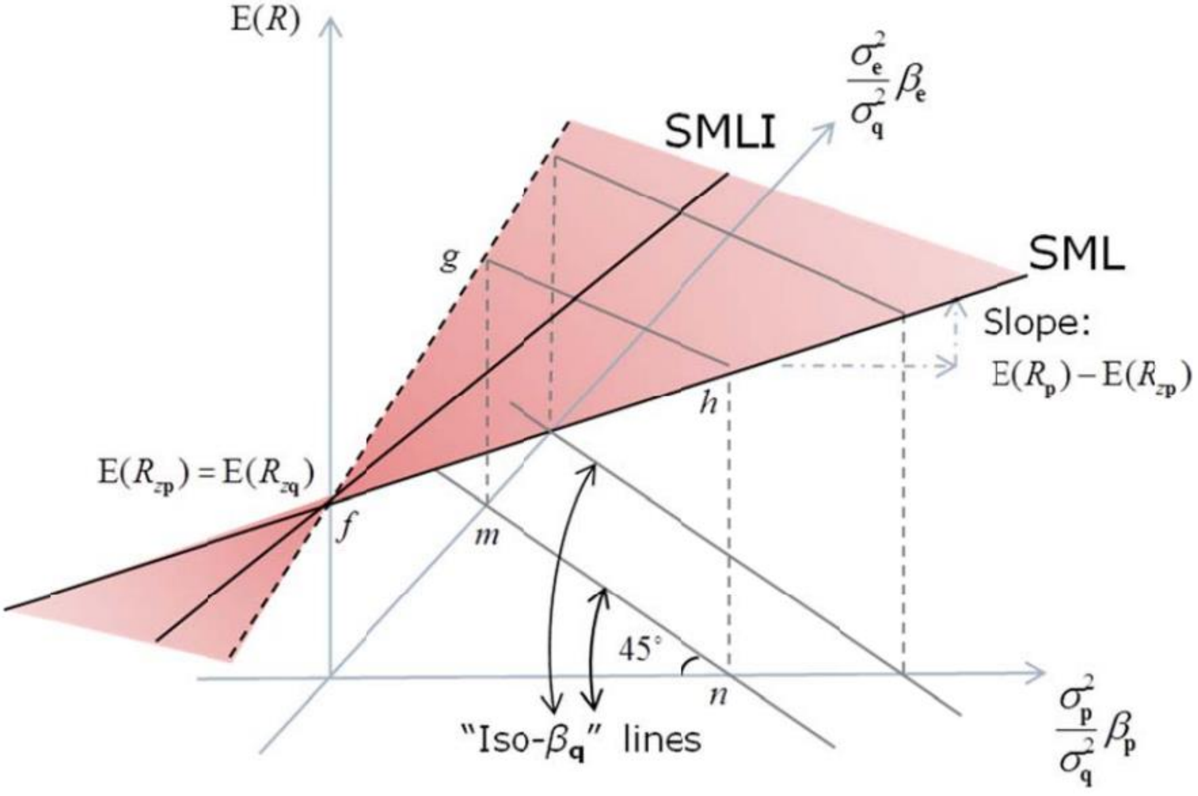
$$E(R_i) = r_f + \left[E\left(R_p\right) - r_f\right]\frac{Var(R_p)}{Var(R_q)}b_{ip} + \left[E\left(R_p\right) - r_f\right]\frac{Var(U_p)}{Var(R_q)}b_{iup} \quad (\mathbf{3.56})$$

Where $b_{ip} = \frac{Cov(R_i,R_p)}{Var(R_p)}$ $(\mathbf{3.57})$ and $b_{iup} = \frac{Cov(R_i,U_p)}{Var(U_p)}$ $(\mathbf{3.58})$

The equation 3.56 is the three dimensional risk-return relationship of inefficient portfolios. This model is a linear pricing beta one, where the efficient benchmark portfolio is written as the sum of two portfolios: one that is inefficient and one that is the difference between an efficient portfolio and the inefficient one.

We have discussed in chapter 2 that one using CAPM over 3D model deletes the right term of the equation and its pricing is wrong. But how wrong may one be by using CAPM or other pricing models over 3D model? Figure 3.11 provides the big picture.

Figure 3.11.: Linear Beta Pricing with Inefficient benchmarks (LBPI)



Source: Diacogiannis, G. and Feldman, D. (2013) "Linear beta pricing with inefficient benchmarks", Quarterly Journal of Finance (forthcoming)

In Figure 3.11, only efficient benchmarks induce the security market lines (SML). A security market line that uses inefficient benchmarks over efficient is called SMLI. We may see now that pricing with inefficient benchmarks not only implies the use of incorrect SMLs and SMLIs, but also ignores the third dimension. While efficient benchmarks induce zero-beta portfolios of the same expected return, any inefficient benchmark induces infinitely many zero-beta portfolios at all expected returns. Market risk premiums are empirically unidentifiable and this is the reason why in previous studies authors came up with inexplicable negative market premiums.

3.25. A Five-Factor Asset Pricing Model (2015-Fama Eugene F. and French Kenneth R.)

Fama and French introduced the three factor model in 1992, but since then there had been another studies that contributed to economic science. Therefore, Fama and French had to adjust the three factor model in a five factor one. As we have stated, the equation of the three factor model is:

$$R_{jt} - r_f = a_j + b_j\left(R_{mt} - r_f\right) + b_{SMB}SMB_t + b_{HML}HML_t + \varepsilon_{jt} \quad (\mathbf{3.59})$$

Where R_{jt}-r_f denotes the excess return of asset j from r_f which is the risk free rate return, a_j is a constant for asset j indicating management performance, b_j is the sensitivity coefficient of asset j towards the R_{mt}-r_f parameter which is the excess market portfolio return from r_f, b_{SMB} is the sensitivity coefficient towards the SMB factor, SMB_t is the small (market capitalization)-minus-big size factor, b_{HML} is the sensitivity coefficient towards the HML factor, HML_t is the high (book to market ratio)-minus-low factor and ε_{jt} is the error term of the regression. SMB represents the factor that is constructed by sorting portfolios, in terms of containing assets with small market capitalization minus portfolios containing big market capitalization (the size proxy). HML represents the factor that is constructed by sorting portfolios in terms of containing assets with high book-to-market value minus portfolios containing low book-to market value (the BE/ME proxy). The sensitivity factors of SMB and HML are evaluated by linear regressions.

The five factor model is the three-factor one with another two factors added. More specifically, the equation of the five factor model is:

$$\begin{aligned} R_{jt} - r_f = a_j + b_j\left(R_{mt} - r_f\right) + b_{SMB}SMB_t + b_{HML}HML_t + b_{RMW}RMW_t \\ + b_{CMA}CMA_t + \varepsilon_{jt} \quad (\mathbf{3.60}) \end{aligned}$$

Where RMW_t is the difference between the returns on diversified portfolios of stocks with robust and weak profitability, CMA_t is the difference between the returns on diversified portfolios of low and high investment stocks, b_{RMW} is the sensitivity to the factor RMW and b_{CMA} is the sensitivity to the factor CMA.

The three-factor model consists of market risk, size and value. We remind that the size effect is that stocks with a small market capitalization earn higher returns than stocks with a large market capitalization and the value effect is the superior performance of stocks with a low price to book value compared with stocks with a high price to book value. As one may notice, Fama and French have added another two quality factors, the profitability and the investment factor. Concerning profitability, stocks with a high operating profitability perform better. As for the investment factor, stocks of companies with high total asset growth have below average returns.

Even though one year passed since the publication of this study, the five-factor model has been criticized. The most outrageous fact is that it had been criticized by the authors in the first place. Fama and French stated that “the model’s main problem is its failure to capture the low average returns on small stocks that invest a lot despite low profitability”. Besides the previous statement, the five-factor model ignores volatility and the momentum factor (see Carhart’s four factor model in subchapter 3.16). To sum up, Fama and French enriched their previous model but still that was not enough.

3.26. (Im)Possible Frontiers: A Comment (2015-Levy Moshe and Roll Richard)

This article is criticizing the NBER working paper “Impossible Frontiers” by Thomas J. Brennan and Andrew W. Lo (2008).

Brennan and Lo did a research in which they proved that CAPM does not hold when a frontier portfolio (that lies in the efficient frontier) constrains of investments with negative weights. In other words, CAPM is not consistent with short position investments on a frontier portfolio. By definition, the market portfolio must lie somewhere in the efficient frontier in order to approve the capital asset pricing model and every component of the market portfolio has a positive weight. When in a set of data, there is not such portfolio, Brennan and Lo call this an “impossible frontier”. Brennan and Lo proved that as the number of assets grows large, nearly all efficient frontiers are impossible. They began with the two asset case (n=2 assets). In that case, for a frontier to be impossible, those two assets must be positively correlated and the asset with the higher expected return must also have the lower risk. On economic grounds, this condition is unnatural and thus, it is possible to avoid impossible frontiers in that case. But, when it comes to the three asset case (n=3 assets), they can give rise to an impossible frontier without any unnatural restrictions on the risks and returns of the assets. Moreover, as the number of assets n grows, Brennan and Lo proved that the probability to come up with an impossible frontier tends to increase in a geometric progression rate.

In 2015, the above results were criticized by Levy and Roll. They proved that with slight variations in sample parameters within estimation error bounds, one can achieve frontiers with positive portfolio segments. First of all, Brennan and Lo used a randomly drawn covariance matrix, but the true parameters are not drawn at random and they are not exactly equal to sample estimates. Secondly, Brennan and Lo made adjustments to the randomly drawn parameters which is a nonsense act, because by construction random parameters have no affiliation with equilibrium asset prices.

Levy and Roll used monthly data for all stocks listed in S&P 500 in December 1995, from January 1980 to December 2005. Then, they randomly drawn 100 stocks and created two portfolios, one value-weighted and one equal-weighted. Levy and Roll realized that no one was on the sample efficient frontier, which had been computed with sample mean returns, sample standard deviations and sample correlations. However, they adjusted the sample mean and the standard deviation to ensure that the value weighted portfolio is mean-variance efficient and afterwards, they did the same to the equal weighted portfolio. Levy and Roll concluded that finding a nearby parameter set within estimation error bounds that ensure a positive portfolio segment on the efficient frontier is easier when the number of assets increases.

3.27. Summary of Literature Review

The following Table summarizes the results of studies discussed above.

Table 3.1.: Summary of Literature Review

N^o	*Author(s)*	*Year*	*Article*	*Objective*	*Data*	*Conclusions*
1	Black, Jensen, Scholes (BJS)	1972	The Capital Asset Pricing Model: Some Empirical Tests	Test the validity of CAPM	Monthly returns of NYSE stocks, 1931-1965	The linear risk-return relationship is supported.
2	Blume, Friend	1973	A New Look at the Capital Asset Pricing Model	Test the validity of CAPM	Daily and monthly returns of NYSE stocks, January 1950 to June 1968.	The results cast serious doubt on the validity on the validity of the market line theory. These results do confirm the linearity of the relationship for NYSE stocks.
3	Fama, French	1973	Risk, Return and Equilibrium: Empirical Tests	Test the validity of CAPM	Monthly returns of NYSE stocks, 1935-1968	The linear risk-return relationship is supported.
4	Merton	1973	An Intertemporal Capital Asset Pricing Model	Present the Intertemporal Capital Asset Pricing Model (ICAPM)		Equation 3.11 represents the ICAPM

5	Friend, Blume	1975	The Demand for Risky Assets	Exploit cross sectional data on household asset holding to assess the nature of household's utility functions	2100 households detailed information on the value of assets, liabilities and income at the end of 1962 and 1963	For some wealth measures, relative risk aversion for the representative decision maker increases slightly, while for others, it decreases slightly.
6	Ross	1976	The Arbitrage Theory of Capital Asset Pricing	Introduce the Arbitrage Pricing Theory (APT)		Equation 3.13 represents the APT model
7	Roll	1977	A Critique of the Asset Pricing Theory's Tests	Criticize older CAPM-tests		If the market portfolio M is efficient, then CAPM is valid and vice versa.
8	Breeden	1979	An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities	Present the Consumption CAPM (CCAPM)		Equation 3.11 represents the CCAPM

9	Reinganum	1981	A New Empirical Perspective on the CAPM	Test whether securities with different estimated betas systematically experience different average rates of return	NYSE and AMEX listed companies/period 1963-1979 for the daily returns, NYSE listed companies/period 1930-1979 for monthly returns.	During the period 1964-1979 the NYSE-AMEX stock portfolios with widely different estimated betas possess statistically indistinguishable average returns
10	Adler, Dumas	1983	International Portfolio Choice and Corporation Finance	Present the International CAPM		Equation 3.17 represents the International CAPM
11	Gibbons, Ross, Shanken	1989	A Test of the Efficiency of a Given Portfolio	Test whether any particular portfolio is ex ante mean-variance efficient	NYSE stocks, 1928-1982	Failed to reject the ex ante efficiency of the equal weighted Index of CRSP when using 10 beta sorted portfolios as in BJS
12	Fama, French	1992	The Cross-Section of Expected Returns	Present the three-factor model		Equation 3.20 represents the three-factor model
13	Jagannathan, Wang	1993	The CAPM is Alive and Well	Take into account the human capital		Equation 3.21 represents CAPM with labor added

14	Pettengill, Sundaram, Mathur	1995	The Conditional Relation between Beta and Returns	Test the validity of CAPM with positive and negative market excess returns	All NYSE securities from January 1926 to December 1990	The results lead to an existing systematic relation between beta and returns. There is a positive trade-off between average portfolio returns and beta
15	Jagannathan, Wang	1996	The Conditional CAPM and the Cross-Section of expected Returns	Present the Conditional CAPM		Equation 3.23 represents Conditional CAPM
16	Carhart	1997	On Persistence In Mutual Funds Performance	Present the four-factor model		Equation 3.31 represents the four-factor model

17	Diacogiannis	1999	A three dimensional Risk-Return Relationship Based upon the Inefficiency of a Portfolio: Derivation and Implications	Study the risk-return relationship based upon the inefficiency of a portfolio		A p portfolio that does not belong but lies inside the boundary portfolio set and hence, is not effective if and only if the expected return of an asset element j is expressed as a linear relationship of systematic risk resulting from the portfolio p and an additional risk associated with how the p portfolio can be moved within the boundary given its ineffectiveness
18	Elsas, El-Shaer, Theissen	2003	Beta and Returns Revised: Evidence from the German Stock Market	Perform Monte Carlo simulations to demonstrate if the results of Fama and MacBeth (1973) differ when the conditional relation between beta and returns is taken into account or not and to empirical examine the relation between beta and returns on the German stock market	German Stock Exchange monthly stock returns from 1960 to 1995	The relation between beta and return is statistically significant. Portfolios with higher betas have higher returns when the market risk premium is positive and lower returns when the market risk premium is negative
19	Theriou, Chatzoglou, Maditinos, Aggelidis	2003	The Cross-Section of Expected Stock Returns: An empirical study in the Athens Stock Exchange	Explore the ability of the CAPM and the three factor model of Fama and French to explain the	327 Greek non financial firms from the period of July 1993 to June 2001	Their findings strongly contrast with the predictions of the CAPM. Beta cannot explain cross section

				cross-sectional relationship between average stock returns and risk in Athens Stock Exchange		variations of average return of Athens Stock Exchange. There is a size effect on the cross sectional variation in average stock returns (average returns vary inversely with firm size)
20	Loukeris	2009	An Empirical Evaluation of CAPM's validity in the British Stock Exchange	Test the validity of CAPM on British Stock Exchange	39 stocks from London Stock Exchange on monthly basis for the period of January 1980 to February 1998	Beta is a significant coefficient of measuring the returns and it is supported by CAPM

21	Lewellen, Nagel, Shanken	2010	A Skeptical Appraisal of Asset Pricing Tests	Explain why, despite the seemingly strong evidence that many proposed models can explain the size and B/M effects, the authors remain unconvinced by the results		Lewellen, Nagel and Shanken provide four suggestions: -Include portfolios in tests sorted by industry or other characteristics. -Impose restrictions on the risk premiums when theory provides appropriate guidance. -Less severe problems when using generalized least squares (GLS) cross-section regressions, rather than ordinary least squares (OLS). -Report confidence intervals (CI) for test statistics. Do not rely only on point estimates and p-values.
22	Artikis, Vrakas, Karmi	2010	Factors Affecting Expected Stock Returns: Evidence from the Secondary and the Tertiary Sectors of Athens Stock Exchange	Investigate the validity of the CAPM and the Fama-French three factor model (3FM)	209 companies of the secondary sector and 177 companies of the tertiary sector of Athens Stock Exchange (ASE) for the period 1997-2006	The 3FM has definitely more explanatory than CAPM

23	Levy, Roll	2010	The Market Portfolio may be Mean-Variance Efficient after all	Try different variations on sample parameters that would make the market proxy efficient		The reverse optimization problem leads us directly to these parameter sets that both make portfolio m mean-variance efficient and are as close as possible to their sample counterparts
24	Diacogiannis, Feldman	2013	Linear Beta Pricing With Inefficient Benchmarks	Present the three-dimensional model		Equation 3.56 represents the three-dimensional model
25	Fama, French	2015	A Five-Factor Asset Pricing Model	Present the five-factor model		Equation 3.60 represents the five-factor model
26	Levy, Roll	2015	(Im)Possible Frontiers: A Comment	Criticize the NBER working paper “Impossible Frontiers” by Thomas J. Brennan and Andrew W. Lo	Brennan and Lo did a research in which they proved that CAPM does not hold when a frontier portfolio (that lies in the efficient frontier) constrains of investments with negative weights	Levy and Roll proved that with slight variations in sample parameters within estimation error bounds, one can achieve frontiers with positive portfolio segments

Chapter 4: Data Selection and Methodology

This chapter provides information not only about the data and the methodology used in this thesis, but also about the statistic tests we are going to use.

4.1. Data Selection

All data were obtained by the Bloomberg database with the subscription of University of Piraeus. For this thesis, daily logarithmic returns of all FTSE 100 Index stocks and FTSE 100 Index itself were obtained for the period January 2006 to June 2016. As for the FTSE 100 stocks, data were collected for the stocks that were included to FTSE 100 Index at September 2016. Table 4.1 presents those firms and their tickers. We choose to test the efficiency of FTSE 100 Index as there was not any paper concerning the efficiency of this index and testing the 3d model. Many previous studies stated that indices were inefficient but we examine this point with updated data and mathematical ways.

Table 4.1.: FTSE 100 Stocks and Tickers

Name	*Field*	*Ticker*
Anglo American PLC	Mining Company	AAL LN
Associated British Foods	Food Possessing Company	ABF LN
Admiral Group	Insurance Company	ADM LN
Ashtead Group PLC	Industrial Distribution and Rental Company	AHT LN
Antofagasta PLC	Base Metals Company	ANTO LN
Aviva PLC	Life Insurance Company	AV/ LN
Astra Zeneca	Pharmaceutical Company	AZN LN
BAE Systems PLC	Aerospace Company	BA/ LN
Babcock International Group PLC	Transportation Support Company	BAB LN
Barclays PLC	Bank Company	BARC LN
British American Tobacco	Tobacco Company	BATS LN
Barratt Developments PLC	Homebuilders Company	BDEV LN
British Land Company PLC	Real Estate Company	BLND LN
BHP Billiton PLC	Steel Raw Material Suppliers Company	BLT LN
Bunzl PLC	Wholesales Company	BNZL LN
British Petroleum PLC	Integrated Oil Company	BP/ LN
Burberry Group PLC	Fashion Company	BRBY LN
BT Group PLC	Telecom Carriers Company	BT/A LN
Coca Cola HBC AG	Beverages Company	CCH LN
Carnival PLC	Cruise Lines Company	CCL LN
Centrica PLC	Utilities Company	CNA LN
Compass Group PLC	Food Services Company	CPG LN
Capita PLC	Commercial Services Company	CPI LN
CRH PLC	Cement and Aggregates Company	CRH LN

Dixons Carphone PLC	Retail and Discretionary Company	DC/ LN
DCC PLC	Refining and Marketing Company	DCC LN
Diageo PLC	Beverages Company	DGE LN
Direct Line Insurance Group PLC	P&C Insurance Company	DLG LN
Experian PLC	Information Services Company	EXPN LN
easyJet PLC	Airline Company	EZJ LN
Fresnillo PLC	Mining Company	FRES LN
GKN PLC	Automotive Industry Company	GKN LN
Glencore PLC	Base Metals Company	GLEN LN
GlaxoSmithKline PLC	Pharmaceutical Company	GSK LN
Hikma Pharmaceuticals PLC	Pharmaceutical Company	HIK LN
Hargreaves Lansdown PLC	Investment Management Company	HL/ LN
Hammerson PLC	Real Estate Company	HMSO LN
HSBC Holdings PLC	Bank Company	HSBA LN
International Airlines Group	Airlines Company	IAG LN
InterContinental Hotels Group PLC	Lodging Company	IHG LN
3i Group PLC	Private Equity Company	III LN
Imperial Brands PLC	Tobacco Company	IMB LN
Informa PLC	Publishing and Broadcasting Company	INF LN
Intu Properties PLC	Real Estate Company	INTU LN
Intertek Group PLC	Commercial Services Company	ITRK LN
ITV plc	Media Company	ITV LN
Johnson Matthey PLC	Specialty Chemicals Company	JMAT LN
Kingfisher PLC	Retail Company	KGF LN
Land Securities Group PLC	Real Estate Company	LAND LN
Legal & General Group PLC	Financial Services Company	LGEN LN
Lloyds Banking Group PLC	Bank Company	LLOY LN
London Stock Exchange Group PLC	Security and Comodity Exchanges	LSE LN
Micro Focus International PLC	Infrastructure Software Company	MCRO LN
Mediclinic International PLC	Health Care Facilities Company	MDC LN
Merlin Entertainments PLC	Entertainment Facilities Company	MERL LN
Marks and Spencer Group PLC	Retail Company	MKS LN
Mondi PLC	Containers and Packaging Company	MNDI LN
Wm Morrison Supermarkets PLC	Food and Drug Stores Company	MRW LN
National Grid PLC	Utility Networks Company	NG/ LN
NEXT PLC	Clothing Company	NXT LN
Old Mutual PLC	Life Insurance Company	OML LN
Provident Financial PLC	Consumer Finance Company	PFG LN
Polymetal International PLC	Mining Company	POLY LN
Paddy Power Betfair PLC	Casinos and Gaming Company	PPB LN
Prudential PLC	Insurance Service Company	PRU LN
Persimmon PLC	Housebuilding Company	PSN LN
Pearson PLC	Publishing Company	PSON LN
Reckitt Benckiser Group PLC	Household Products Company	RB/ LN
Royal Bank of Scotland Group PLC	Bank Company	RBS LN
Royal Dutch Shell PLC Class A	Oil Industry Company	RDSA LN

Royal Dutch Shell PLC Class B	Oil Industry Company	RDSB LN
RELX PLC	Information Services Company	REL LN
Rio Tinto PLC	Steel Raw Material Suppliers Company	RIO LN
Royal Mail PLC	Postal Services Company	RMG LN
Rolls-Royce Holding PLC	Car Manufacturer Company	RR/ LN
Randgold Resources Limited	Mining Company	RRS LN
RSA Insurance Group PLC	Insurance Company	RSA LN
SABMiller PLC	Beverages Company	SAB LN
J Sainsbury PLC	Supermarket Company	SBRY LN
Schroders PLC	Investment Management Company	SDR LN
Sage Group PLC/The	Application Software Company	SGE LN
Shire PLC	Biopharmaceutical Company	SHP LN
SKY PLC	Cable and Satellite Company	SKY LN
Standard Life PLC	Life Insurance Company	SL/ LN
Smiths Group PLC	Factory Automation Equipment Company	SMIN LN
Smith & Nephew PLC	Medical Devices Company	SN/ LN
SSE PLC	Energy Company	SSE LN
Standard Chartered PLC	Financial Services Company	STAN LN
St James's Place PLC	Life Insurance Company	STJ LN
Severn Trent PLC	Utility Networks Company	SVT LN
Travis Perkins PLC	Industrial Distribution and Rental Company	TPK LN
Tesco PLC	Retail Company	TSCO LN
TUI AG	Leisure & Travel Services Company	TUI LN
Taylor Wimpey PLC	Housebuilding Company	TW/ LN
Unilever PLC	Household Products Company	ULVR LN
United Utilities Group PLC	Utility Networks Company	UU/ LN
Vodafone Group PLC	Telecommunications Company	VOD LN
Wolseley PLC	Industrial Distribution and Rental Company	WOS LN
Worldpay Group PLC	Consumer Finance Company	WPG LN
WPP PLC	Advertising and Marketing Company	WPP LN
Whitbread PLC	Lodging Company	WTB LN

4.2. Methodology

The general idea of how to deal with the previous data is to find a methodology that is applicable both on the sample period and on the sub periods we are going to create. We use the Roll‘s methodology (1977) of portfolio analysis to calculate the efficient frontier, where short selling of risking securities is allowed and then, we use three different ways to find whether the market index (in this case, the FTSE 100 Index) is lying in the efficient frontier and thus, it is efficient.

At this point, one may question why we chose the Roll’s methodology (1977). The portfolio analysis, as developed by H. Markowitz (1952, 1957), assumes that the proportions of portfolio funds invested in the securities contained in the portfolio are between zero and one (short selling of risking securities is not allowed). When the weights are non-negative, it means that investors are unable to sell short. However, such an assumption was later relaxed by Black (1972), it was Roll that modified Markowitz’s model by allowing the possibility of short-selling of securities.

Roll (1977) calculated the minimum variance portfolio set by solving the following mathematical optimization problem: Given a number of N individual securities, choose the proportions invested in these securities that minimize the variance of portfolio rate of return subject to two constraints:

(a) The portfolio has a particular level of expected return and

(b) The sum of the proportional allocations of the portfolio wealth invested in securities contained in the portfolio equals unity.

In other words, the minimum variance portfolio set is calculated by solving the following optimization problem: Minimize the portfolio variance [Var(R_p)] subject to constraints:

$$X_p' R = E\left(R_p\right) \quad \mathbf{(4.1)}$$

$$X_p' u = 1 \quad \mathbf{(4.2)}$$

where $X_p = A(N\, x\, 1)$ is a column vector containing the proportions invested in the securities included in portfolio p, $R = A(N\, x\, 1)$ is a column vector of security expected returns, u is the (N x 1) unit vector, $Var\left(R_p\right) = X_p' V X_p \quad \mathbf{(4.3)}$ and V is the (N x N) covariance matrix of N risky securities.

Roll (1977) assumed that the covariance matrix V of all risky security returns under consideration is non-singular and that the return vector R contains at least two different entries. The solution of this optimization problem gives the investment portfolio vector of a minimum variance portfolio as follows:

$$X_p = V^{-1}(Ru)A^{-1}\begin{bmatrix} E\left(R_p\right) \\ 1 \end{bmatrix} \quad \mathbf{(4.4)}$$

Where V^{-1} is the inverse of the covariance matrix, (Ru) is a (N x 2) matrix having in its first column the return vector R and in its second column the unit vector, A is the efficient set's information matrix and $E(R_p)$ is the expected return of the minimum variance portfolio p. The information matrix is always a (2 x 2) square matrix containing the following information:

$$A = \begin{bmatrix} a & b \\ b & c \end{bmatrix} \quad (\mathbf{4.5})$$

where $a = R'V^{-1}R$ $(\mathbf{4.6})$, $b = R'V^{-1}u$ $(\mathbf{4.7})$, $c = u'V^{-1}u$ $(\mathbf{4.8})$. The variance of a minimum variance portfolio p can be expressed as:

$$Var(R_p) = \frac{a - 2bE(R_p) + c[E(R_p)]^2}{ac - b^2} \quad (\mathbf{4.9})$$

The expected return of the global minimum variance portfolio (GMVP) that is the portfolio that has the smallest variance among the minimum variance portfolios can be expressed as:

$$E(R_p) = \frac{b}{c} \quad (\mathbf{4.10})$$

To sum up, one should do the following four step procedure in order to calculate the investment proportion vector defining a minimum variance portfolio:

1. Compute the inverse of the covariance matrix.
2. Calculate the information matrix A and its inverse.
    (a) Find (Ru) and $(Ru)'$.
    (b) Find the product of the matrices $(Ru)'$ and the inverse of the covariance matrix.
    (c) Find the product of the matrices $(Ru)'V^{-1}$ and (Ru).
    (d) Finally, $A = (Ru)'V^{-1}(Ru)$.
3. Compute two different products between matrices:
    (a) The product between V^{-1} and (Ru).
    (b) The product between $V^{-1}(Ru)$ and A^{-1}.
4. Assume a value for the mean return $E(R_p)$ and calculate the corresponding investment proportion vector.

Following the previous steps, one would be able to calculate the efficient frontier.

The main idea is to perform Roll’s methodology (1977) in periods and sub periods with daily, weekly and monthly data, in order to create efficient frontiers for each period and sub period. For this purpose we perform this methodology in:

(a) one period of 10 years with daily, weekly and monthly data,

(b) two periods of 5 years with daily, weekly and monthly data,

(c) five periods of 2 years with daily and weekly data and

(d) ten periods of 1 year with daily data.

We use the commands ‘table2array’ in MATLAB to convert table to a homogeneous array, ‘cov’ to create covariance matrices, ‘inv’ to create inverse matrices.

In each period we consider the firms that exist in it, do negotiate in market and there are available data. More specifically:

(a) For the one period of 10 years we considered all the firms we discussed on chapter 4 except from: CCH LN, DC/ LN, DGE LN, EXPN LN, FRES LN, GLEN LN, HL/ LN, MDC LN, MERL LN, MNDI LN, POLY LN, RMG LN, SL/ LN, TUI LN, WPG LN.

(b) For the two periods of 5 years each, sub period A 2006-2010 includes all the firms we discussed on chapter 4 except from: CCH LN, DLG LN, MDC LN, MERL LN, POLY LN, RMG LN, TUI LN, WPG LN and sub period B 2011-2016 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period A and DC/ LN, EXPN LN, FRES LN, GLEN LN, HL/LN, MNDI LN, SL/LN.

(c) For the five periods of 2 years each, sub period A 2006-2008 includes all the firms we discussed on chapter 4 except from: RMG LN, TUI LN, WPG LN, MERL LN, sub period B 2009-2010 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period A and CCH LN, DLG LN, MDC LN, POLY LN, sub period C 2011-2012 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period B and DC/ LN, GLEN LN, sub period D 2013-2014 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period C and FRES LN, sub period E 2015-2016 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period D and EXPN LN, HL/ LN, MDNI LN, SL/ LN.

(d) For the ten periods of 1 year each, sub period A 2006 includes all the firms we discussed on chapter 4 except from: WPG LN, sub period B 2007 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period A and TUI LN, sub period C 2008 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period B and MERL LN, RMG LN, sub period D 2009 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period C and CCH LN, DLG LN, MDC LN, sub period E 2010 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period D and POLY LN, sub period F 2011 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period E and GLEN LN, sub period G 2012 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period F and DC/ LN, sub period H 2013 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period G, sub period I 2014 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period H and FRES LN, sub period J 2015-2016 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period I and EXPN LN, HL/ LN, MNDI LN, SL/ LN.

After the selection of the appropriate firms, we calculated the logarithmic returns of each company, as well as the return and the standard deviation of the index. We choose to calculate the logarithmic returns over simple returns, in order to achieve a more normal distribution, due to the fact that we faced skewness and excess kurtosis (See subchapter 4.3.2. and Appendix 2: Histograms of stocks and index returns, statistics and Jarque- Bera test). Then, using the right multiplication of matrices we discussed, we created the efficient frontier portfolios in each period and sub periods:

(a) 93 portfolios for the 1 period-10 years-daily data and one extra portfolio with the index return.

(b) 94 portfolios for the 2 periods-5 years-Sub period A-daily data and one extra portfolio with the index return, 93 portfolios for the 2 periods-5 years-Sub period B-daily data and one extra portfolio with the index return.

(c) 93 portfolios for the 5 periods-2 years-Sub period A-daily data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period B-daily data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period C-daily data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period D-daily data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period E-daily data and one extra portfolio with the index return.

(d) 93 portfolios for the 10 periods-1 year-Sub period A-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period B-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period C-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period D-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period E-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period F-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period G-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period H-daily data and one extra portfolio with the index return, 97 portfolios for the 10 periods-1 year-Sub period I-daily data and one extra portfolio with the index return, 94 portfolios for the 10 periods-1 year-Sub period J-daily data and one extra portfolio with the index return.

(e) 93 portfolios for the 1 period-10 years-weekly data and one extra portfolio with the index return.

(f) 93 portfolios for the 2 periods-5 years-Sub period A- weekly data and one extra portfolio with the index return, 93 portfolios for the 2 periods-5 years-Sub period B- weekly data and one extra portfolio with the index return.

(g) 93 portfolios for the 5 periods-2 years-Sub period A- weekly data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period B- weekly data and one extra portfolio with the index return, 94 portfolios for the 5 periods-2 years-Sub period C- weekly data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period D- weekly data and one extra portfolio with the index return, 94 portfolios for the 5 periods-2 years-Sub period E- weekly data and one extra portfolio with the index return.

(h) 93 portfolios for the 1 period-10 years-monthly data and one extra portfolio with the index return.

(i) 94 portfolios for the 2 periods-5 years-Sub period A- monthly data and one extra portfolio with the index return, 93 portfolios for the 2 periods-5 years-Sub period B- monthly data and one extra portfolio with the index return.

Those portfolio were not equally weighted. They were created through Roll’s methodology in order to find the efficient frontier for each period. Weights will be provided in chapter 5 only for the portfolio which has the index mean (expected return) in order to prove the inefficiency of the market index, but weights for other portfolios will be available if needed in excel files.

The next thing, one should do is to find whether a given index lies on the efficient frontier and therefore, is efficient.

We examine the following three different methods in order to prove the efficiency of a given index:

(a) First, we are using Roll's method (1977) for calculating the minimum variance portfolio set and we create a diagram such as Figure 2.9 to prove the inefficiency schematically.

(b) The second way is to find the weights of the efficient portfolio with the same expected return as the market index. If the weights of the efficient portfolio are both positive and negative, then the market index is inefficient due to the fact that the market index is constructed only with positive weights.

(c) The third method to prove the efficiency or the inefficiency of the market index is based upon the model offered by Dr. Diacogiannis and Dr. Feldman (2014). In this case, one should do the following:

$$R_{pq}^2 = \frac{(Cov(R_p, R_q))^2}{(\sigma_p \sigma_q)^2} = \frac{\sigma_q^2}{\sigma_p^2} \quad (\mathbf{4.11})$$

When $R_{pq}^2 < 1$ this proves that p is inefficient in the expected return-standard deviation space. The Equation 4.11 stands because of the following proof that shows that $Cov(R_p, R_q) = \sigma_q^2$. The parameters a, b and c are the same parameters we use in matrix A (4.5). We remind that $E(R)_p = E(R)_q$ and that the portfolio p is inefficient whereas the portfolio q is efficient.

$$Cov(R_p, R_q) = \frac{a - bE(R)_p - bE(R)_p + cE(R)_p E(R)_q}{ac - b^2} = \frac{a - 2bE(R)_p - cE(R)_q^2}{ac - b^2}$$
$$= Var(R_q) = \sigma_q^2 \quad (\mathbf{4.12})$$

The R-squared is equal to variance of the efficient portfolio where $E(R)_p = E(R)_q$, divided by the variance of the index portfolio (inefficient portfolio). If R-squared is equal to one that means the two portfolios are totally the same, with same expected return and standard deviation. If R-squared is less than one that means the index portfolio is on the right side of the efficient frontier which is in our case a proof that the market index is inefficient. We do not consider the case in which R-squared is greater than one, as it is economically incorrect and it violates the assumptions of the efficient frontier.

In order to test the results of R-squared, we test the following:

$$Var(R_p) = Var(R_q) + Var(R_{ut}) => 1 = \frac{Var(R_q)}{Var(R_p)} + \frac{Var(R_{ut})}{Var(R_p)} =>$$

$$1 - R^2 = \frac{Var(R_{ut})}{Var(R_p)} \ (\mathbf{4.14})$$

If the left part of the Equation 4.14 is non zero, then the right part of that equation is non zero. The fraction $\frac{Var(R_{ut})}{Var(R_p)}$ is non zero and therefore $Var(R_{ut}) \neq 0$ which also proves index inefficiency. This is connected with the 3d model as Equation 4.14 holds because:

$$R_p = R_q + U_p \ (\mathbf{4.15})$$

where $Cov(R_q, U_p) = 0 \ \ (\mathbf{4.16})$

Moreover, for daily, weekly and monthly data of one period consisting of 10 years we will perform Fama and MacBeth (1973, see Subsection 3.2) linear regression to prove that CAPM does not hold. More specifically, we will split our 10 years data into 3 sub periods: sub period A consisting of years 2006-2009, sub period B consisting of years 2010-2013 and sub period C consisting of years 2014-2016. In sub period A we create beta portfolios (from the lowest beta portfolio to the highest beta portfolio) basing on sub period A data. In sub period B we calculate portfolio beta based on sub period B data. In sub period C we calculate each portfolio expected return based on sub period C data. Then, we perform the following regression:

$$r_q = \gamma_0 + \gamma_1 b_{pt} + u_{pt} \ (\mathbf{4.17})$$

where the expected value of the error term is equal to zero.

If CAPM (Equation 4.18) holds then γ_0 must be equal to r_z and γ_1 must be equal to r_q-r_z and positive (as the capital market line has a positive slope). We remind that p is the inefficient portfolio (index) and q is the efficient portfolio for those their expected returns are equal.

$$r_p = r_z + b_p(r_q - r_z) \ (\mathbf{4.18})$$

where

$$r_z = \frac{a - br_q}{b - cr_q} \ \ (\mathbf{4.19})$$

where a, b and c is the information of matrix A (4.5) and r_q is the index return. Portfolio z is the minimum variance portfolio for which it holds:

$$Cov(r_q, r_z) = 0 \quad (\mathbf{4.20})$$

We chose to examine the r_z version of CAPM instead of r_f version as r_f line might not be tangent to the efficient frontiers we created.

4.3. Statistical Tests

In this part of the chapter we discuss all the statistical tests we are going to perform on each variable. The tests of this thesis will be performed in MATLAB, Gretl and EViews. Due to the fact that data were downloaded by Bloomberg, they are already seasonally and dividend adjusted.

4.3.1. Basics

In order to perform any statistical test, we first derive the following statistics: mean, median, minimum and maximum values, standard deviation, CV, skewness, kurtosis, 5% and 95% percentile, interquartile range and missing observations. (See Appendix 1: Summary statistics)

4.3.2. Outliers

An outlier may indicate bad data, but it also can be very useful to explain economical facts, given that our sample period contains the economic crisis of 2008 and the Brexit of 2016. In order to decide whether to keep an outlier in our data or not, we first have to detect it. The simplest method is to create a histogram and identify potential outliers. Another method is to test normality. The presence of normality guarantees the absence of serious outliers. One test for the assessment of normality is Jarque- Bera test, which is based on the sample skewness and sample kurtosis. The null hypothesis H_0 is a joint hypothesis of the skewness being zero and the excess kurtosis being zero. The Jarque- Bera test statistic for one variable is expressed as:

$$Jarque - Bera\ t - statistic = \frac{N}{6}\left[S^2 - \frac{(K-3)^2}{4}\right] \quad (\mathbf{4.20})$$

where S is the sample skewness, K is the sample kurtosis and N is the sample size. For sample sizes of 2000 or larger, this test statistic is compared to a chi-squared distribution with 2 degrees of freedom; normality is rejected if the test statistic is greater than the chi-squared value. (See Appendix 2: Histograms of stocks and index returns, statistics and Jarque- Bera test)

4.3.3. Unit Roots

In order to know if shocks have permanent (stochastic trend, unit root) or transitory (deterministic trend) effects we have to perform a unit root test. For this purpose, we will perform the Augmented Dickey-Fuller test (ADF). The null hypothesis H_0 of the above tests is that there is a unit root and the H_1 confirms stationarity. (See Appendix 3: Unit Roots test)

Chapter 5: Results Analysis

In this chapter, we perform the tests and the methodology we discussed in chapter 4 and we explain the results. The daily prices of stocks and index were downloaded from the Bloomberg terminal and they served a base on creating weekly and monthly prices, as well as daily, weekly and monthly returns.

5.1. Roll's Methodology

The main idea, as we described on chapter 4, is to perform Roll's methodology (1977) in periods and sub periods with daily, weekly and monthly data, in order to create efficient frontiers for each period and sub period. For this purpose we perform this methodology in:

(A) one period of 10 years with daily, weekly and monthly data,

(B) two periods of 5 years with daily, weekly and monthly data,

(C) five periods of 2 years with daily and weekly data and

(D) ten periods of 1 year with daily data.

We use the commands 'Table2array' in MATLAB to convert Table to a homogeneous array, 'cov' to create covariance matrices, 'inv' to create inverse matrices.

In each period we consider the firms that exist in it, do negotiate in market and there are available data. More specifically:

(A) For the one period of 10 years we considered all the firms we discussed on chapter 4 except from: CCH LN, DC/ LN, DGE LN, EXPN LN, FRES LN, GLEN LN, HL/ LN, MDC LN, MERL LN, MNDI LN, POLY LN, RMG LN, SL/ LN, TUI LN, WPG LN.

(B) For the two periods of 5 years each, sub period A 2006-2010 includes all the firms we discussed on chapter 4 except from: CCH LN, DLG LN, MDC LN, MERL LN, POLY LN, RMG LN, TUI LN, WPG LN and sub period B 2011-2016 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period A and DC/ LN, EXPN LN, FRES LN, GLEN LN, HL/LN, MNDI LN, SL/LN.

(C) For the five periods of 2 years each, sub period A 2006-2008 includes all the firms we discussed on chapter 4 except from: RMG LN, TUI LN, WPG LN, MERL LN, sub period B 2009-2010 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period A and CCH LN, DLG LN, MDC LN, POLY LN, sub period C 2011-2012 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period B and DC/ LN, GLEN LN, sub period D 2013-2014 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period C and FRES LN, sub period E 2015-2016 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period D and EXPN LN, HL/ LN, MDNI LN, SL/ LN.

(D) For the ten periods of 1 year each, sub period A 2006 includes all the firms we discussed on chapter 4 except from: WPG LN, sub period B 2007 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period A and TUI LN, sub period C 2008 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period B and MERL LN, RMG LN, sub period D 2009 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period C and CCH LN, DLG LN, MDC LN, sub period E 2010 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period D and POLY LN, sub period F 2011 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period E and GLEN LN, sub period G 2012 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period F and DC/ LN, sub period H 2013 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period G, sub period I 2014 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period H and FRES LN, sub period J 2015-2016 includes all the firms we discussed on chapter 4 except from: the firms we excluded on sub period I and EXPN LN, HL/ LN, MNDI LN, SL/ LN.

After the selection of the appropriate firms, we calculated the logarithmic returns of each company, as well as the return and the standard deviation of the index. We choose to calculate the logarithmic returns over simple returns, in order to achieve a more normal distribution, due to the fact that we faced skewness and excess kurtosis (See subchapter 4.3.2. and Appendix 2: Histograms of stocks and index returns, statistics and Jarque- Bera test). Then, using the right multiplication of matrices we discussed, we created the efficient frontier portfolios in each period and sub periods:

(A) 93 portfolios for the 1 period-10 years-daily data and one extra portfolio with the index return.

(B) 94 portfolios for the 2 periods-5 years-Sub period A-daily data and one extra portfolio with the index return, 93 portfolios for the 2 periods-5 years-Sub period B-daily data and one extra portfolio with the index return.

(C) 93 portfolios for the 5 periods-2 years-Sub period A-daily data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period B-daily data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period C-daily data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period D-daily data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period E-daily data and one extra portfolio with the index return.

(D) 93 portfolios for the 10 periods-1 year-Sub period A-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period B-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period C-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period D-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period E-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period F-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period G-daily data and one extra portfolio with the index return, 93 portfolios for the 10 periods-1 year-Sub period H-daily data and one extra portfolio with the index return, 97 portfolios for the 10 periods-1 year-Sub period I-daily data and one extra portfolio with the index return, 94 portfolios for the 10 periods-1 year-Sub period J-daily data and one extra portfolio with the index return.

(E) 93 portfolios for the 1 period-10 years-weekly data and one extra portfolio with the index return.

(F) 93 portfolios for the 2 periods-5 years-Sub period A- weekly data and one extra portfolio with the index return, 93 portfolios for the 2 periods-5 years-Sub period B- weekly data and one extra portfolio with the index return.

(G) 93 portfolios for the 5 periods-2 years-Sub period A- weekly data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period B- weekly data and one extra portfolio with the index return, 94 portfolios for the 5 periods-2 years-Sub period C- weekly data and one extra portfolio with the index return, 93 portfolios for the 5 periods-2 years-Sub period D- weekly data and one extra portfolio with the index return, 94 portfolios for the 5 periods-2 years-Sub period E- weekly data and one extra portfolio with the index return.

(H) 93 portfolios for the 1 period-10 years-monthly data and one extra portfolio with the index return.

(I) 94 portfolios for the 2 periods-5 years-Sub period A- monthly data and one extra portfolio with the index return, 93 portfolios for the 2 periods-5 years-Sub period B- monthly data and one extra portfolio with the index return.

Those portfolio were not equally weighted. They were created through Roll's methodology in order to find the efficient frontier for each period. Weights will be provided in next subchapter only for the portfolio which has the index mean (expected return) in order to prove the inefficiency of the market index, however weights for other portfolios will be available if needed in excel files.

5.2. FTSE 100 Index Efficiency

At this point, we created the efficient frontier for each period and sub period with daily, weekly and monthly data. In this part of the chapter, we investigate if the market index is in the efficient frontier with three different ways, which we described in chapter 4.

(d) First, we are using Roll's method (1977) for calculating the minimum variance portfolio set and we create a diagram such as Figure 2.9 to prove the inefficiency schematically. From now on, this is **method 1**.

(e) The second way is to find the weights of the efficient portfolio with the same expected return as the market index. If the weights of the efficient portfolio are both positive and negative, then the market portfolio is inefficient due to the fact that the market portfolio is constructed only with positive weights. From now on, this is **method 2**.

(f) The third method to prove the efficiency of the market index is by using the mathematics developed by Dr. Diacogiannis and Dr. Feldman (2014). From now on, this is **method 3**. We attempt to see whether the R-squared is lower than one, a result that will help us to see whether the variance of the residuals is zero or not zero.

Moreover, for daily and monthly data of one period consisting of 10 years we will perform Fama and MacBeth (1973, See Subchapter 3.2) linear regression to prove that CAPM does not hold, as we explained in chapter 4.

5.2.1. 1 period-10 years

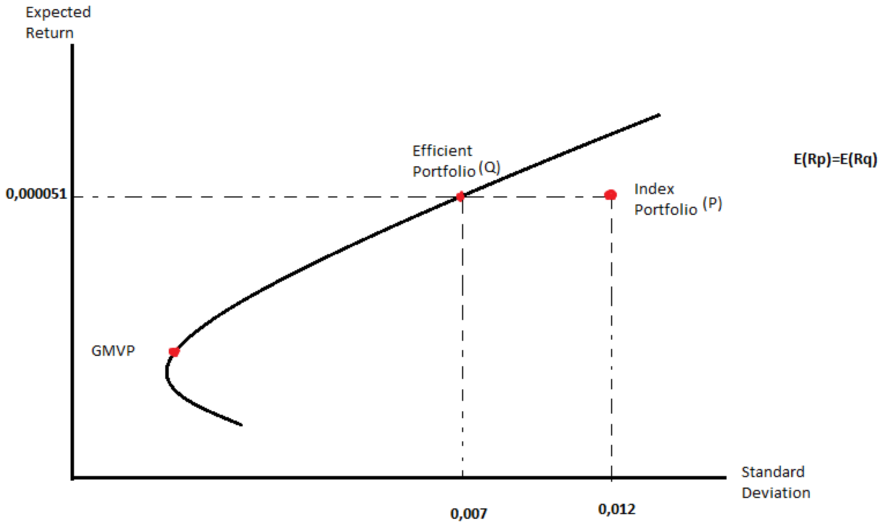
In this period, we worked with daily, monthly and weekly data, as we described above, excluding the companies that did not have data for the entire period. We calculated returns and then weights using Roll's methodology (1977). The last step is to provide evidence that FTSE 100 is or is not efficient with method 1,2 and 3.

5.2.1.1. Daily data (1 period-10 years)

Method 1: Schematically

We provide the Figure 5.1 in order to prove the inefficiency of the market portfolio. GMVP analysis: return 0.00042197, standard deviation 0.0074183.

Figure 5.1.: Efficient frontier and FTSE 100 Index Portfolio (1 period-10 years-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.1. provides us the weights of the efficient portfolio Q.

Table 5.1.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (1 period-10 years-daily data)

Firm	Weights
AAL LN	-0,015960921
ABF LN	0,018835723
ADM LN	-0,013262535
AHT LN	-0,011473463
ANTO LN	-0,007635419
AV/ LN	0,021072302
AZN LN	0,006518012
BA/ LN	0,024806005
BAB LN	0,027899399
BARC LN	-0,037500046
BATS LN	-0,054072514
BDEV LN	-0,001412743
BLND LN	0,008230563
BLT LN	-0,042370234
BNZL LN	0,015821987
BP/ LN	0,084536974
BRBY LN	-0,010819429
BT/A LN	-0,003976005
CCL LN	0,014345844
CNA LN	0,043020305
CPG LN	-0,027206328
CPI LN	0,08414954
CRH LN	-0,032093995
DCC LN	0,055576823
DLG LN	-0,001996705
EZJ LN	-0,002520259
GKN LN	-0,006265026
GSK LN	0,1484342
HIK LN	0,03722281
HMSO LN	-0,016126467
HSBA LN	0,138539487
IAG LN	0,032108556
IHG LN	-0,006484519
III LN	0,010705711

IMB LN	0,086831459
INF LN	0,009437625
INTU LN	0,032651622
ITRK LN	-0,000107947
ITV LN	0,006819477
JMAT LN	0,004521906
KGF LN	-0,009362416
LAND LN	0,0421674
LGEN LN	-0,000718063
LLOY LN	0,005382681
LSE LN	-0,016560926
MCRO LN	0,011204308
MKS LN	0,052210066
MRW LN	0,047979503
NG/ LN	0,033150719
NXT LN	-0,010671886
OML LN	-0,041350598
PFG LN	0,06653485
PPB LN	0,055408242
PRU LN	-0,097370202
PSN LN	-0,004794272
PSON LN	0,077088649
RB/ LN	0,032566822
RBS LN	0,024779811
RDSA LN	0,096198159
RDSB LN	-0,100422142
REL LN	0,007647277
RIO LN	-0,000349658
RR/ LN	-0,0152705
RRS LN	0,062251132
RSA LN	0,066828587
SAB LN	-0,024166463
SBRY LN	0,01144728
SDR LN	-0,109528495
SGE LN	0,01423871
SHP LN	-0,046292066
SKY LN	0,041396612
SMIN LN	0,033409155
SN/ LN	0,039491563
SSE LN	0,051512164
STAN LN	-0,017942733
STJ LN	-0,023081986

SVT LN	0,029120498
TPK LN	0,008052626
TSCO LN	0,036331939
TW/ LN	0,005914435
ULVR LN	-0,00708981
UU/ LN	0,050597533
VOD LN	0,005540211
WOS LN	-0,031982732
WPP LN	-0,058062052
WTB LN	-0,01423571
Sum	1
Portfolio variance	6,19165E-05
Portfolio standard deviation	0,007868703

We may notice both positive and negative weights, therefore the market portfolio is not efficient.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}007868703]^2}{[0{,}012548238]^2} = 0{,}393224674483325 < 1 \ (\mathbf{5.1})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.6067 \neq 0 \ (\mathbf{5.2})$$

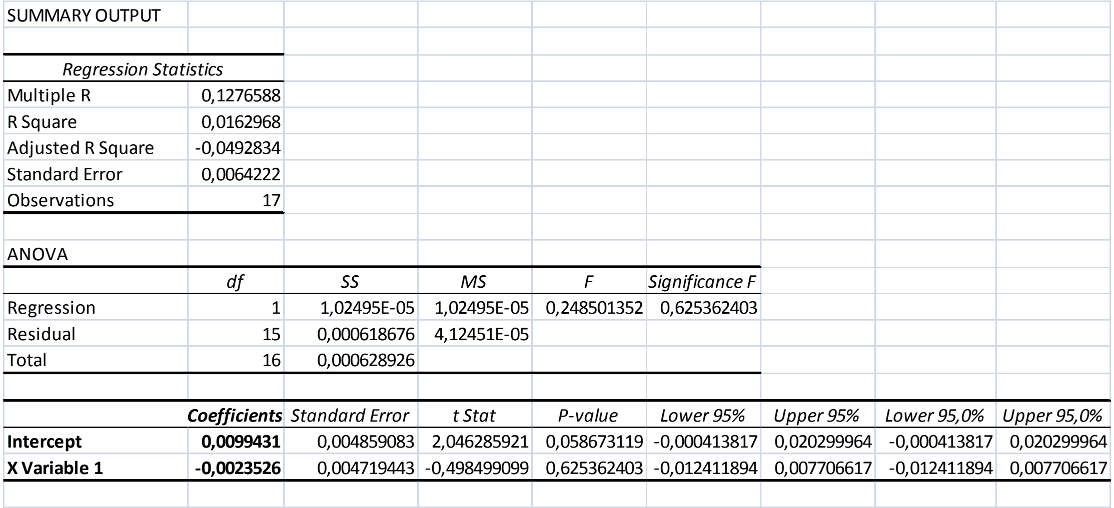
Using daily data for one period of ten years (2006-2016) we proved schematically, by calculating weights and mathematically that FTSE 100 Index is inefficient.

Fama and MacBeth (1973) Linear Regression

In period A (2006-2009) we calculate stock betas based on data of period A and create 17 equally weighted portfolios of five stocks each, except from the 17th portfolio which has six stocks, based on the betas we calculated. Portfolio 1 has the lowest beta stocks and portfolio 17 has the highest beta stocks.

In period B (2010-2013) we calculate each portfolio's beta based on data of period B and in period C (2014-2016) we calculate each portfolios' return based on data of period C. Then we run a regression with depended variable "return" and independent variable "beta", with robusted standard errors in order to deal with any heteroscedasticity or autocorrelation problem we might have, as we explained in chapter 4.

Table 5.2.: Fama and MacBeth (1973) linear regression on daily data (2006-2016)



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,1276588
R Square	0,0162968
Adjusted R Square	-0,0492834
Standard Error	0,0064222
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1,02495E-05	1,02495E-05	0,248501352	0,625362403
Residual	15	0,000618676	4,12451E-05		
Total	16	0,000628926			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	**0,0099431**	0,004859083	2,046285921	0,058673119	-0,000413817	0,020299964	-0,000413817	0,020299964
X Variable 1	**-0,0023526**	0,004719443	-0,498499099	0,625362403	-0,012411894	0,007706617	-0,012411894	0,007706617

Intercept stands for γ_0 and x variable 1 for γ_1. We calculate r_z and r_m-r_z from Roll's methodology.

Table 5.3.: Calculation of r_z and r_m-r_z (daily data)

Matrix A=(Ru)'*InV*(Ru)		**R index(2010-2016)**
0,02322573	7,667804505	0,000112004
7,667804505	18171,0705	
rz	**0,003970995**	
rm-rz	**-0,003858991**	

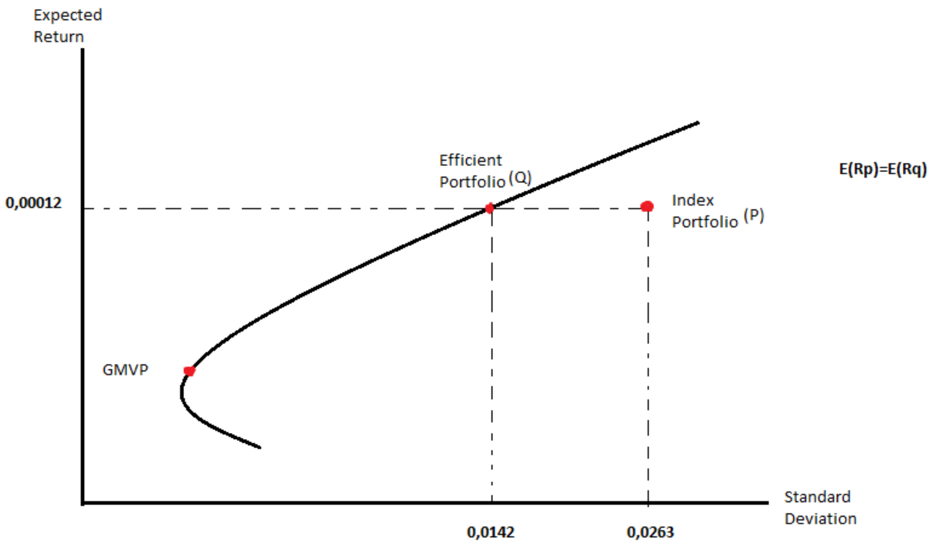
It is obvious that the two prices are not identical: $\gamma_0 \neq r_z$ and $\gamma_1 \neq r_m - r_z$. Moreover, γ_1 should have a positive value, however its value is negative and not of statistical importance. The reason that CAPM does not hold is because we omitted one factor (see Equation 3.56 of the 3d model) and the second reason is that CAPM's beta is not weighted.

5.2.1.2. Weekly data (1 period-10 years)

Method 1: Schematically

We provide the Figure 5.2 in order to prove the inefficiency of the market portfolio. GMVP analysis: return 0.001569, standard deviation 0.0136479.

Figure 5.2.: Efficient frontier and FTSE 100 Index Portfolio (1 period-10 years-weekly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier even with weekly data.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. We remind that if there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.4. provides us the weights of the efficient portfolio Q.

Table 5.4.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (1 period-10 years-weekly data)

Firm	Weights
AAL LN	0,016402
ABF LN	0,032324
ADM LN	-0,01549
AHT LN	0,032508
ANTO LN	-0,01246
AV/ LN	-0,01517
AZN LN	-0,00574
BA/ LN	0,029622
BAB LN	0,060189
BARC LN	-0,03961
BATS LN	-0,15647
BDEV LN	-0,03939
BLND LN	0,124017
BLT LN	-0,0349
BNZL LN	0,010781
BP/ LN	0,064765
BRBY LN	-0,02804
BT/A LN	0,020715
CCL LN	0,017657
CNA LN	0,057762
CPG LN	-0,0861
CPI LN	0,100004
CRH LN	-0,0073
DCC LN	0,013598
DLG LN	0,088281
EZJ LN	-0,00571
GKN LN	-0,00871
GSK LN	0,123672
HIK LN	0,03445
HMSO LN	-0,08259
HSBA LN	0,154959
IAG LN	-0,0124
IHG LN	-0,00194
III LN	0,013614
IMB LN	0,077812
INF LN	-0,00298
INTU LN	0,086651
ITRK LN	0,047622

ITV LN	0,0178
JMAT LN	-0,05216
KGF LN	0,034743
LAND LN	-0,0036
LGEN LN	-0,01494
LLOY LN	0,008108
LSE LN	-0,01139
MCRO LN	-0,00347
MKS LN	0,052624
MRW LN	0,048862
NG/ LN	0,044838
NXT LN	-0,01159
OML LN	-0,08522
PFG LN	0,074402
PPB LN	0,007926
PRU LN	-0,08369
PSN LN	0,010999
PSON LN	0,070789
RB/ LN	0,08569
RBS LN	0,018843
RDSA LN	-0,06496
RDSB LN	0,047175
REL LN	-0,0292
RIO LN	-0,00493
RR/ LN	-0,03003
RRS LN	0,07898
RSA LN	0,068273
SAB LN	-0,04096
SBRY LN	-0,01153
SDR LN	-0,15124
SGE LN	0,024783
SHP LN	-0,01172
SKY LN	0,086601
SMIN LN	-0,00932
SN/ LN	0,028939
SSE LN	0,090812
STAN LN	0,021092
STJ LN	0,015575
SVT LN	-0,02582
TPK LN	0,058361
TSCO LN	-0,01432
TW/ LN	0,004268

ULVR LN	0,036711
UU/ LN	0,052224
VOD LN	0,039289
WOS LN	-0,01603
WPP LN	-0,06946
WTB LN	-0,03554
Sum	1
Portfolio variance	0,000204
Portfolio standard deviation	0,014293

We may notice again both positive and negative weights, therefore the market portfolio is not efficient.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0142926051]^2}{[0{,}0263701254]^2} = 0{,}293763883 < 1 \ (\mathbf{5.3})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.7062 \neq 0 \ \ (\mathbf{5.4})$$

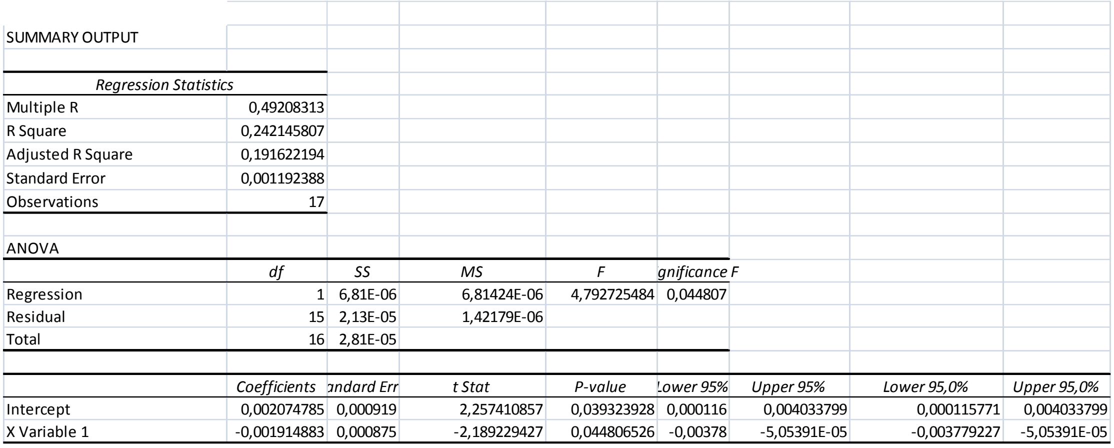
Using weekly data for one period of ten years (2006-2016) we proved with three different ways that FTSE 100 Index is inefficient.

Fama and MacBeth (1973) Linear Regression

In period A (2006-2009) we calculate stock betas based on data of period A and create 17 equally weighted portfolios of five stocks each, except from the 17th portfolio which has six stocks, based on the betas we calculated. Portfolio 1 has the lowest beta stocks and portfolio 17 has the highest beta stocks.

In period B (2010-2013) we calculate each portfolios' beta based on data of period B and in period C (2014-2016) we calculate each portfolios' return based on data of period C. Then we run a regression with depended variable "return" and independent variable "beta", with robusted standard errors in order to deal with any heteroscedasticity or autocorrelation problem we might have, as we explained in chapter 4.

Table 5.5.: Fama and MacBeth (1973) linear regression on weekly data (2006-2016)



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,49208313
R Square	0,242145807
Adjusted R Square	0,191622194
Standard Error	0,001192388
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	1	6,81E-06	6,81424E-06	4,792725484	0,044807
Residual	15	2,13E-05	1,42179E-06		
Total	16	2,81E-05			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	0,002074785	0,000919	2,257410857	0,039323928	0,000116	0,004033799	0,000115771	0,004033799
X Variable 1	-0,001914883	0,000875	-2,189229427	0,044806526	-0,00378	-5,05391E-05	-0,003779227	-5,05391E-05

Intercept stands for γ_0 and x variable 1 for γ_1. We calculate r_z and r_m-r_z from Roll's methodology.

Table 5.6.: Calculation of r_z and r_m-r_z (weekly data)

Matrix A=(Ru)'*InV*(Ru)		**R index(2010-2016)**
0,128986531	8,427482	0,000378
8,427481556	5368,626	
rz	**0,019662**	
rm-rz	**-0,01928**	

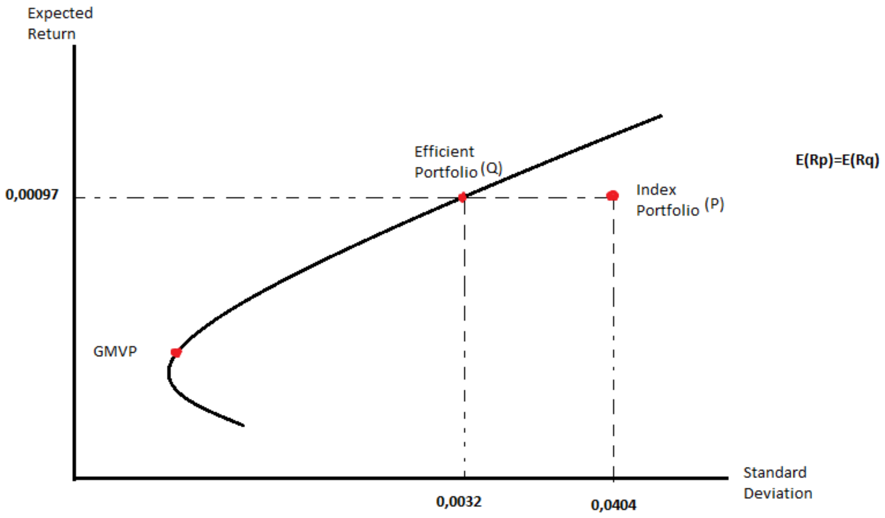
It is obvious that the two prices are not identical: $\gamma_0 \neq r_z$ and $\gamma_1 \neq r_m - r_z$. Moreover, γ_1 should have a positive value, however its value is negative and not of statistical importance. The reason that CAPM does not hold is because we omitted one factor (see Equation 3.56 of the 3d model) and the second reason is that CAPM's beta is not weighted.

5.2.1.3. Monthly data (1 period-10 years)

Method 1: Schematically

We provide the Figure 5.3 in order to prove the inefficiency of the market portfolio. GMVP analysis: return 0.0061441, standard deviation 0.002404.

Figure 5.3.: Efficient frontier and FTSE 100 Index Portfolio (1 period-10 years-monthly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier even with monthly data.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. We remind that if there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.7. provides us the weights of the efficient portfolio Q.

Table 5.7.: Weights of the efficient portfolio Q $E(R_P)=E(R_q)$ (1 period-10 years-monthly data)

Firm	Weights
AAL LN	0,181912
ABF LN	-0,05632
ADM LN	-0,46828
AHT LN	0,261809
ANTO LN	-0,07921
AV/ LN	0,403884
AZN LN	-0,06403
BA/ LN	0,202293
BAB LN	-0,29771
BARC LN	0,020274
BATS LN	-0,7528
BDEV LN	-0,0501
BLND LN	0,185748
BLT LN	0,467407
BNZL LN	0,51263
BP/ LN	-0,0239
BRBY LN	0,229125
BT/A LN	0,044236
CCL LN	-0,15826
CNA LN	-0,12729
CPG LN	0,119229
CPI LN	0,082326
CRH LN	-0,26362
DCC LN	-0,07488
DLG LN	0,300878
EZJ LN	-0,24404
GKN LN	-0,28099
GSK LN	-0,43779
HIK LN	-0,02299
HMSO LN	0,571826
HSBA LN	0,133702
IAG LN	0,403215
IHG LN	0,040698
III LN	-0,15262
IMB LN	0,084719
INF LN	0,000892
INTU LN	-0,40246
ITRK LN	0,035343

ITV LN	0,029845
JMAT LN	-0,01968
KGF LN	0,208431
LAND LN	-0,60061
LGEN LN	0,10321
LLOY LN	0,257039
LSE LN	0,090079
MCRO LN	-0,01799
MKS LN	-0,02913
MRW LN	0,329084
NG/ LN	-0,4445
NXT LN	0,098607
OML LN	-0,00652
PFG LN	0,259526
PPB LN	-0,35457
PRU LN	-0,2856
PSN LN	0,329364
PSON LN	0,267822
RB/ LN	0,493815
RBS LN	0,03134
RDSA LN	-2,24263
RDSB LN	1,758034
REL LN	-0,09814
RIO LN	-0,11403
RR/ LN	0,249121
RRS LN	0,062112
RSA LN	0,041395
SAB LN	0,239125
SBRY LN	-0,38627
SDR LN	-0,23939
SGE LN	-0,3302
SHP LN	-0,01946
SKY LN	-0,07758
SMIN LN	-0,12735
SN/ LN	0,065968
SSE LN	0,753101
STAN LN	-0,35579
STJ LN	-0,32738
SVT LN	0,072702
TPK LN	-0,01666
TSCO LN	0,391511
TW/ LN	-0,21601

ULVR LN	0,620022
UU/ LN	0,047488
VOD LN	0,489427
WOS LN	-0,24928
WPP LN	0,069116
WTB LN	-0,12335
Sum	1
Portfolio variance	1,05E-05
Portfolio standard deviation	0,003236

We may notice again both positive and negative weights, therefore the market portfolio is not efficient.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0032356368]^2}{[0{,}040457243]^2} = 0{,}006396272 < 1 \ (\mathbf{5.5})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.9936 \neq 0 \ (\mathbf{5.6})$$

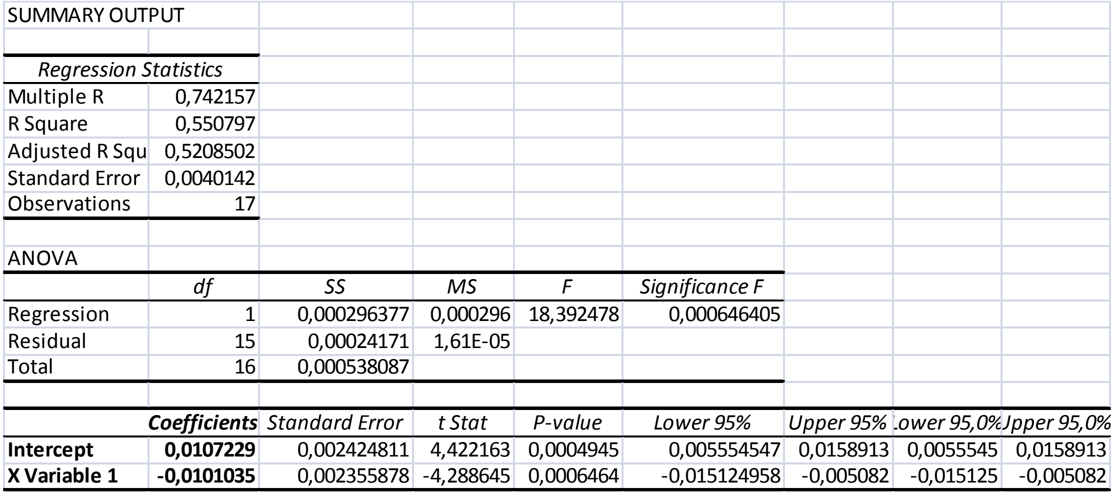
Using monthly data for one period of ten years (2006-2016) we proved with three different ways that FTSE 100 Index is inefficient. We faced the same result even with daily and weekly data for the exact same period.

Fama and MacBeth (1973) Linear Regression

In period A (2006-2009) we calculate stock betas based on data of period A and create 17 equally weighted portfolios of five stocks each, except from the 17th portfolio which has six stocks, based on the betas we calculated. Portfolio 1 has the lowest beta stocks and portfolio 17 has the highest beta stocks.

In period B (2010-2013) we calculate each portfolios' beta based on data of period B and in period C (2014-2016) we calculate each portfolios' return based on data of period C. Then we run a regression with depended variable "return" and independent variable "beta", with robusted standard errors in order to deal with any heteroscedasticity or autocorrelation problem we might have, as we explained in chapter 4.

Table 5.8.: Fama and MacBeth (1973) linear regression on monthly data (2006-2016)



SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0,742157							
R Square	0,550797							
Adjusted R Squ	0,5208502							
Standard Error	0,0040142							
Observations	17							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	0,000296377	0,000296	18,392478	0,000646405			
Residual	15	0,00024171	1,61E-05					
Total	16	0,000538087						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*.ower 95,0%*	*Jpper 95,0%*
Intercept	**0,0107229**	0,002424811	4,422163	0,0004945	0,005554547	0,0158913	0,0055545	0,0158913
X Variable 1	**-0,0101035**	0,002355878	-4,288645	0,0006464	-0,015124958	-0,005082	-0,015125	-0,005082

Intercept stands for γ_0 and x variable 1 for γ_1. We calculate r_z and r_m-r_z from Roll's methodology.

Table 5.9.: Calculation of r_z and r_m-r_z (monthly data)

Matrix A=(Ru)'*InV*(Ru)		**R index(2010-2016)**
12,236401	1062,7045	0,002355
1062,7045	172962,15	
rz	**0,014852**	
rm-rz	**0,012497**	

It is obvious that the two prices are not identical: $\gamma_0 \neq r_z$ and $\gamma_1 \neq r_m - r_z$. Moreover, γ_1 should have a positive value, however its value is negative and not of statistical importance. The reason that CAPM does not hold is because we omitted one factor (see Equation 3.56 of the 3d model) and the second reason is that CAPM's beta is not weighted.

5.2.2. 2 periods-5 years

In those periods, we worked with daily, monthly and weekly data, as we described above, excluding the companies that did not have data for the entire sub period. Sub period A contains all the data from 2006 to 2010 and sub period B from 2011 to 2016. We calculated returns and then weights using Roll's methodology (1977). The last step is to provide evidence that FTSE 100 is or is not efficient.

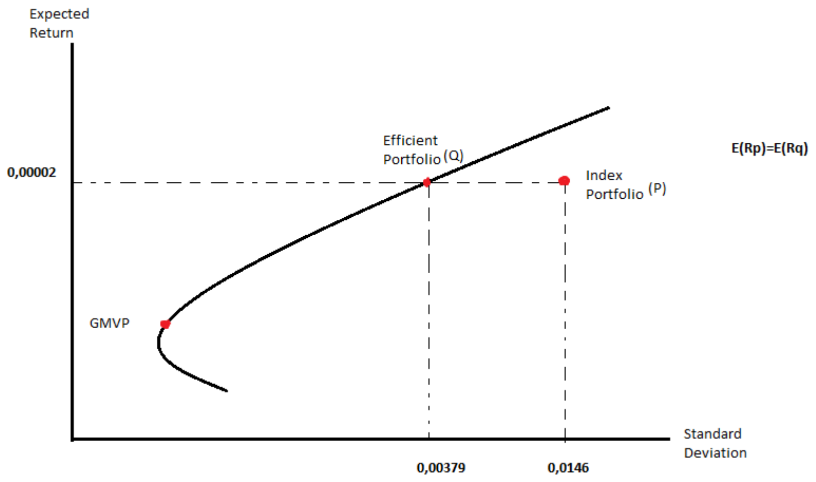
5.2.2.1. Daily data (2 periods-5 years)

Sub period A

Method 1: Schematically

We begin the results analysis with the **sub period A** providing the Figure 5.4 prove the inefficiency of the market portfolio. GMVP analysis: return -0.0003540, standard deviation 0.0033387.

Figure 5.4.: Efficient frontier and FTSE 100 Index Portfolio (2 periods-5 years-Sub period A (2006-2010)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier for the sub period A.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.10. provides us the weights of the efficient portfolio Q.

Table 5.10.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (2 periods-5 years-Sub period A (2006-2010)-daily data)

Firm	Weights
AAL LN	-0,159131
ABF LN	0,101954
ADM LN	0,092938
AHT LN	-0,174856
ANTO LN	0,142086
AV/ LN	-0,084027
AZN LN	-0,050562
BA/ LN	-0,151649
BAB LN	0,112326
BARC LN	0,070614
BATS LN	-0,169306
BDEV LN	0,004332
BLND LN	-0,351945
BLT LN	0,086969
BNZL LN	-0,037203
BP/ LN	-0,020078
BRBY LN	-0,328767
BT/A LN	0,091479
CCL LN	-0,464627
CNA LN	0,001006
CPG LN	0,051288
CPI LN	0,000305
CRH LN	0,053719
DC/ LN	0,055697
DCC LN	0,054179
DGE LN	0,026414
EXPN LN	0,020573
EZJ LN	0,303389

FRES LN	0,393598
GKN LN	0,277158
GLEN LN	-0,136456
GSK LN	0,510825
HIK LN	-0,034807
HL/ LN	0,154265
HMSO LN	0,175581
HSBA LN	-0,006539
IAG LN	0,117682
IHG LN	-0,053298
III LN	0,059883
IMB LN	0,17209
INF LN	0,037054
INTU LN	0,18
ITRK LN	-0,032425
ITV LN	-0,115317
JMAT LN	0,292332
KGF LN	-0,068799
LAND LN	0,260975
LGEN LN	-0,219504
LLOY LN	0,08364
LSE LN	-0,184689
MCRO LN	-0,130692
MKS LN	0,080249
MNDI LN	0,047451
MRW LN	-0,522027
NG/ LN	-0,076949
NXT LN	-0,12736
OML LN	-0,099495
PFG LN	0,206451
PPB LN	-0,04007
PRU LN	-0,043554
PSN LN	-0,061669
PSON LN	-0,015423
RB/ LN	0,004691
RBS LN	0,078431
RDSA LN	-0,111437
RDSB LN	0,114491
REL LN	-0,178991
RIO LN	0,040501
RR/ LN	0,024275
RRS LN	0,033551

RSA LN	-0,12588
SAB LN	-0,129759
SBRY LN	0,255379
SDR LN	-0,018949
SGE LN	0,102459
SHP LN	-0,373403
SKY LN	0,089413
SL/ LN	0,012812
SMIN LN	0,194264
SN/ LN	0,15948
SSE LN	0,172058
STAN LN	-0,088568
STJ LN	0,120114
SVT LN	0,029168
TPK LN	-0,054911
TSCO LN	0,174174
TW/ LN	0,036024
ULVR LN	0,087016
UU/ LN	-0,044634
VOD LN	0,018074
WOS LN	-0,052912
WPP LN	0,076247
WTB LN	-0,000455
Sum	1
Portfolio variance	1,44E-05
Portfolio standard deviation	0,003793

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period A.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}00379278]^2}{[0{,}014699012]^2} = 0{,}066579452 < 1 \ (\mathbf{5.7})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.9334 \neq 0 \ \ (\mathbf{5.8})$$

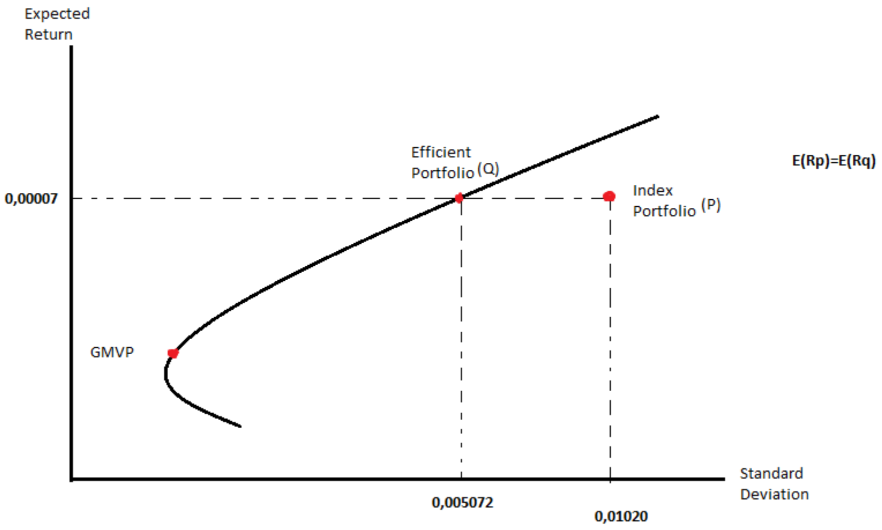
Using daily data for the sub period A we proved with three different ways that FTSE 100 Index is inefficient.

Sub period B

Method 1: Schematically

We repeat the same steps for the **sub period B** providing the Figure 5.5 prove the inefficiency of the market portfolio. GMVP analysis: return 0.00413814, standard deviation 0.0005549904.

Figure 5.5.: Efficient frontier and FTSE 100 Index Portfolio (2 periods-5 years-Sub period B (2011-2016)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period B.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.11. provides us the weights of the efficient portfolio Q.

Table 5.11.: Weights of the efficient portfolio Q E(R_p)=E(R_q) (2 periods-5 years-Sub period B (2011-2016)-daily data)

Firm	**Weights**
AAL LN	-0,050188176
ABF LN	-0,321636727
ADM LN	-0,051340953
AHT LN	-0,198991903
ANTO LN	0,123141684
AV/ LN	0,050371416
AZN LN	1,990185901
BA/ LN	-0,59370157
BAB LN	-0,219124891
BARC LN	0,293188778
BATS LN	0,021088553
BDEV LN	0,063490821
BLND LN	0,158695186
BLT LN	0,039328655
BNZL LN	-0,586709504
BP/ LN	-0,844344076
BRBY LN	0,506813151
BT/A LN	0,507159367
CCL LN	1,107696174
CNA LN	-2,666551903
CPG LN	1,537291933
CPI LN	4,395415511
CRH LN	0,000407065
DCC LN	-0,778575969
DGE LN	-0,311263724
EZJ LN	0,382378557
GKN LN	0,100095394
GSK LN	-4,382307558
HIK LN	-0,138886796
HMSO LN	-0,08962165
HSBA LN	0,153821419
IAG LN	0,383025894
IHG LN	0,326670239
III LN	-0,287742889
IMB LN	0,063324193
INF LN	-0,904717232
INTU LN	-0,165178191

ITRK LN	0,044327088
ITV LN	-0,296693519
JMAT LN	0,15514392
KGF LN	-0,202540592
LAND LN	0,130399049
LGEN LN	0,023552739
LLOY LN	0,441087743
LSE LN	-0,760596066
MCRO LN	0,764858577
MKS LN	-0,62487071
MRW LN	0,567858004
NG/ LN	0,393405595
NXT LN	-0,162369919
OML LN	0,523522503
PFG LN	0,714706266
PPB LN	-0,979515982
PRU LN	-1,175558357
PSN LN	-0,307097353
PSON LN	-0,010465206
RB/ LN	1,436778826
RBS LN	0,421232922
RDSA LN	-1,40472649
RDSB LN	2,844643789
REL LN	0,05741448
RIO LN	0,211482192
RR/ LN	0,160744583
RRS LN	0,077334741
RSA LN	0,147275268
SAB LN	-0,042589245
SBRY LN	0,074871364
SDR LN	-0,011984917
SGE LN	-0,098460683
SHP LN	0,173766564
SKY LN	-0,391833414
SMIN LN	-0,003044852
SN/ LN	0,098815152
SSE LN	0,164363934
STAN LN	-0,894559788
STJ LN	-0,908823951
SVT LN	0,470474398
TPK LN	-0,612416457

TSCO LN	-0,029825033
TW/ LN	-0,031105002
ULVR LN	-0,01099329
UU/ LN	0,212140425
VOD LN	0,250335345
WOS LN	-0,142389948
WPP LN	0,011603536
WTB LN	-0,082384403
Sum	1
Portfolio variance	2,57275E-05
Portfolio standard deviation	0,005072228

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period B.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0050722]^2}{[0{,}0102063263]^2} = 0{,}246978184 < 1 \ (\mathbf{5.9})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.7530 \neq 0 \ \ (\mathbf{5.10})$$

Using daily data for the sub period B we proved with three different ways that FTSE 100 Index is inefficient. Therefore, at this point of research one should notice that the index is inefficient for both periods and sub periods.

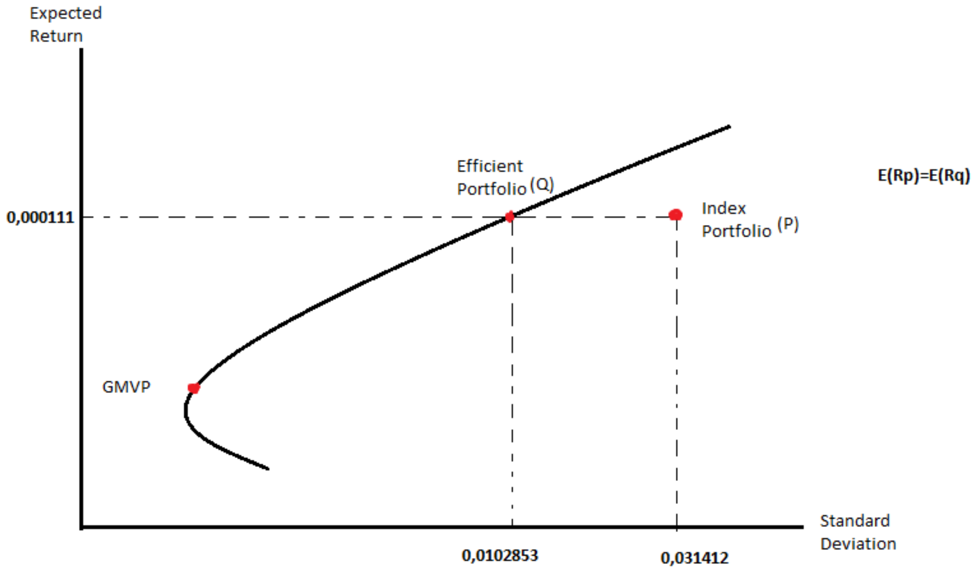
5.2.2.2. Weekly data (2 periods-5 years)

Sub period A

Method 1: Schematically

We begin the results analysis with the **sub period A** providing the Figure 5.6 prove the inefficiency of the market portfolio. GMVP analysis: return 0.00092536, standard deviation 0.01015.

Figure 5.6.: Efficient frontier and FTSE 100 Index Portfolio (2 periods-5 years-Sub period A (2006-2010)-weekly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier for the sub period A.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.12. provides us the weights of the efficient portfolio Q.

Table 5.12.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (2 periods-5 years-Sub period A (2006-2010)-weekly data)

Firm	**Weights**
AAL LN	0,007729
ABF LN	0,074369
ADM LN	-0,00083
AHT LN	0,034448
ANTO LN	-0,04117
AV/ LN	-0,07812
AZN LN	-0,06101
BA/ LN	0,008245
BAB LN	0,059005
BARC LN	-0,01607
BATS LN	-0,07154
BDEV LN	-0,02773
BLND LN	0,033215
BLT LN	-0,01576
BNZL LN	-0,00114
BP/ LN	0,05263
BRBY LN	-0,04179
BT/A LN	0,022152
CCL LN	-0,00256
CNA LN	-0,00795
CPG LN	-0,05428
CPI LN	0,059457
CRH LN	-0,01323
DC/ LN	0,014349
DCC LN	-0,00624
DGE LN	0,014359
EXPN LN	0,077576
EZJ LN	-0,02344
FRES LN	-0,00525
GKN LN	0,007415
GLEN LN	0,040115
GSK LN	0,078376
HIK LN	0,061427
HL/ LN	0,029883
HMSO LN	-0,03116
HSBA LN	0,119276
IAG LN	-0,0242
IHG LN	0,018567

III LN	0,011967
IMB LN	0,088298
INF LN	0,017364
INTU LN	0,024005
ITRK LN	0,000264
ITV LN	-0,00608
JMAT LN	-0,03062
KGF LN	0,035396
LAND LN	0,013573
LGEN LN	0,013083
LLOY LN	-0,00542
LSE LN	0,021644
MCRO LN	0,00275
MKS LN	0,036147
MNDI LN	0,053172
MRW LN	0,047901
NG/ LN	0,040236
NXT LN	-0,04501
OML LN	-0,02082
PFG LN	0,064982
PPB LN	-0,00039
PRU LN	-0,03782
PSN LN	0,032274
PSON LN	0,041878
RB/ LN	0,122909
RBS LN	0,014721
RDSA LN	-0,20088
RDSB LN	0,174914
REL LN	0,018636
RIO LN	-0,02472
RR/ LN	-0,03438
RRS LN	0,073996
RSA LN	0,036862
SAB LN	0,037507
SBRY LN	-0,03163
SDR LN	-0,08546
SGE LN	0,031589
SHP LN	0,041935
SKY LN	0,101509
SL/ LN	0,080211
SMIN LN	-0,03076
SN/ LN	0,067921

SSE LN	-0,01535
STAN LN	-0,03928
STJ LN	-0,02035
SVT LN	0,025954
TPK LN	0,049668
TSCO LN	-0,05957
TW/ LN	0,005227
ULVR LN	-0,078
UU/ LN	0,093439
VOD LN	0,068989
WOS LN	-0,01066
WPP LN	-0,07694
WTB LN	-0,02589
Sum	1
Portfolio variance	0,000106
Portfolio standard deviation	0,010285

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period A.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0102853]^2}{[0{,}0314127]^2} = 0{,}107208625 < 1 \; (\mathbf{5.11})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\big(R_p\big)} = 0.8927 \neq 0 \;\; (\mathbf{5.12})$$

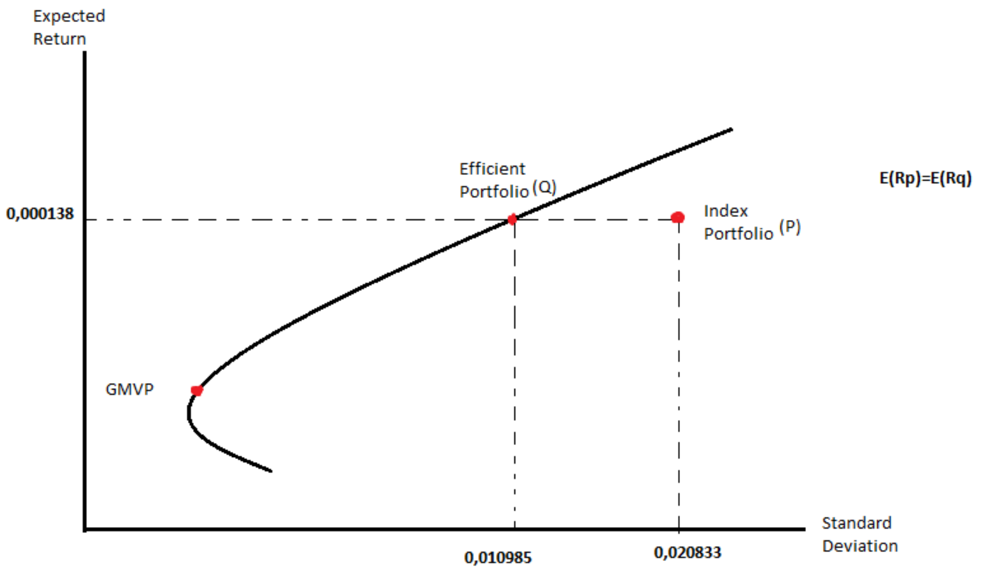
Using weekly data for the sub period A we proved with three different ways that FTSE 100 Index is inefficient.

Sub period B

Method 1: Schematically

We repeat the same steps for the **sub period B** providing the Figure 5.7 prove the inefficiency of the market portfolio. GMVP analysis: return 0.001701142, standard deviation 0.0105287.

Figure 5.7.: Efficient frontier and FTSE 100 Index Portfolio (2 periods-5 years-Sub period B (2011-2016)-weekly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period B.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.13. provides us the weights of the efficient portfolio Q.

Table 5.13.: Weights of the efficient portfolio Q E(R_p)=E(R_q) (2 periods-5 years-Sub period B (2011-2016)-weekly data)

Firm	Weights
AAL LN	0,00924
ABF LN	-0,0406
ADM LN	0,026457
AHT LN	-0,02306
ANTO LN	0,021908
AV/ LN	0,020823
AZN LN	0,037811
BA/ LN	-0,05224
BAB LN	0,034706
BARC LN	-0,01928
BATS LN	-0,15051
BDEV LN	-0,10256
BLND LN	0,010432
BLT LN	-0,11376
BNZL LN	0,093697
BP/ LN	0,031862
BRBY LN	0,012849
BT/A LN	0,061474
CCL LN	-1,2E-05
CNA LN	0,033199
CPG LN	0,018266
CPI LN	0,076875
CRH LN	0,011585
DCC LN	0,070668
DGE LN	0,038255
EZJ LN	0,042326
GKN LN	-0,07789
GSK LN	0,081346
HIK LN	0,043625
HMSO LN	-0,05587
HSBA LN	0,019213
IAG LN	0,019559
IHG LN	-0,00378
III LN	-0,02639
IMB LN	0,021171
INF LN	-0,01009
INTU LN	0,05187

ITRK LN	0,051147
ITV LN	0,061448
JMAT LN	-0,02903
KGF LN	0,020685
LAND LN	0,032312
LGEN LN	0,025594
LLOY LN	0,029661
LSE LN	-0,08842
MCRO LN	0,039872
MKS LN	0,002291
MRW LN	0,120953
NG/ LN	0,16162
NXT LN	0,104099
OML LN	-0,10925
PFG LN	0,012485
PPB LN	0,003359
PRU LN	-0,12793
PSN LN	0,042611
PSON LN	0,050881
RB/ LN	0,012645
RBS LN	0,067385
RDSA LN	-0,04343
RDSB LN	0,007667
REL LN	-0,0196
RIO LN	0,115776
RR/ LN	0,0136
RRS LN	0,06481
RSA LN	0,088482
SAB LN	0,03088
SBRY LN	-0,00092
SDR LN	-0,0066
SGE LN	0,020139
SHP LN	0,004141
SKY LN	0,038721
SMIN LN	-0,00155
SN/ LN	-0,01463
SSE LN	0,157892
STAN LN	0,035696
STJ LN	-0,01371
SVT LN	0,042277
TPK LN	-0,04865

TSCO LN	-0,05325
TW/ LN	-0,06493
ULVR LN	0,067867
UU/ LN	-0,095
VOD LN	0,024976
WOS LN	-0,05735
WPP LN	-0,06813
WTB LN	0,07724
Sum	1
Portfolio variance	0,000121
Portfolio standard deviation	0,010986

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period B.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}01098580]^2}{[0{,}0208338]^2} = 0{,}2780506987 < 1 \ (\mathbf{5.13})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.7219 \neq 0 \quad (\mathbf{5.14})$$

Using weekly data for the sub period B we proved with three different ways that FTSE 100 Index is inefficient.

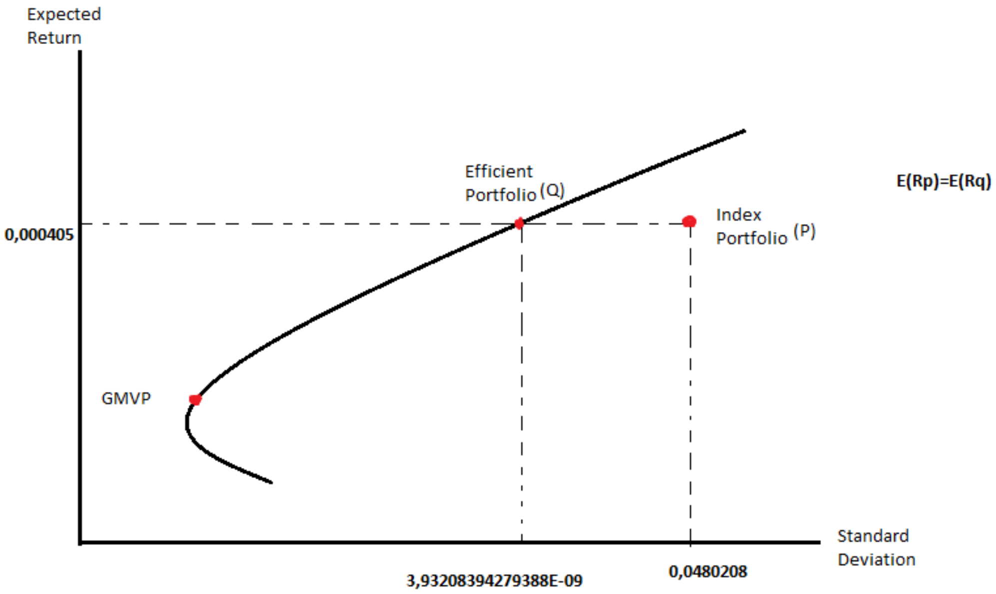
5.2.2.3. Monthly data (2 periods-5 years)

Sub period A

Method 1: Schematically

We begin the results analysis with the **sub period A** providing the Figure 5.8 prove the inefficiency of the market portfolio. GMVP analysis: return 0.05518220, standard deviation 2.02648097463064E-09.

Figure 5.8.: Efficient frontier and FTSE 100 Index Portfolio (2 periods-5 years-Sub period A (2006-2010)-monthly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier for the sub period A.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.14. provides us the weights of the efficient portfolio Q.

Table 5.14.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (2 periods-5 years-Sub period A (2006-2010)-monthly data)

Firm	Weights
AAL LN	0,393966
ABF LN	-1,73227
ADM LN	0,773279
AHT LN	-0,63366
ANTO LN	0,259305
AV/ LN	0,340233
AZN LN	0,45626
BA/ LN	0,40797
BAB LN	-0,4229
BARC LN	-0,235
BATS LN	-2,0945
BDEV LN	-0,44922
BLND LN	0,647413
BLT LN	-0,47625
BNZL LN	0,195375
BP/ LN	0,266451
BRBY LN	0,839494
BT/A LN	-0,46643
CCL LN	-0,60601
CNA LN	-1,15422
CPG LN	1,006915
CPI LN	1,59664
CRH LN	-0,3397
DC/ LN	-0,66646
DCC LN	-0,37091
DGE LN	1,599584
EXPN LN	-0,87446
EZJ LN	-0,17379
FRES LN	0,037862
GKN LN	0,140326
GLEN LN	0,11098
GSK LN	-0,35452
HIK LN	-0,05557
HL/ LN	0,074825
HMSO LN	0,612133
HSBA LN	0,847136
IAG LN	0,734992
IHG LN	-0,49225

III LN	-0,2153
IMB LN	0,517932
INF LN	-0,10042
INTU LN	-0,47077
ITRK LN	-0,05029
ITV LN	0,639993
JMAT LN	0,511371
KGF LN	0,297464
LAND LN	-1,15773
LGEN LN	-0,73068
LLOY LN	0,162471
LSE LN	0,070722
MCRO LN	-0,40072
MKS LN	-1,0532
MNDI LN	0,055716
MRW LN	1,046872
NG/ LN	-2,11562
NXT LN	0,945997
OML LN	-0,35291
PFG LN	1,232966
PPB LN	-0,28799
PRU LN	-0,17427
PSN LN	0,832429
PSON LN	0,051065
RB/ LN	-0,60759
RBS LN	-0,04118
RDSA LN	1,034944
RDSB LN	-0,81588
REL LN	0,752562
RIO LN	-0,35698
RR/ LN	0,125987
RRS LN	-0,46806
RSA LN	-0,54546
SAB LN	0,828981
SBRY LN	-1,24173
SDR LN	-0,39282
SGE LN	1,128311
SHP LN	0,271438
SKY LN	-0,38222
SL/ LN	0,422695
SMIN LN	-0,35621
SN/ LN	0,657535

SSE LN	0,430363
STAN LN	0,178209
STJ LN	0,260866
SVT LN	2,015712
TPK LN	0,141588
TSCO LN	-0,38713
TW/ LN	0,026331
ULVR LN	-1,35532
UU/ LN	-1,44454
VOD LN	2,02942
WOS LN	0,301771
WPP LN	-0,03312
WTB LN	-0,17661
Sum	1
Portfolio variance	-1,5E-17
Portfolio standard deviation	3,93E-09

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period A.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[3{,}93208394279388\mathrm{E}-09]^2}{[0{,}0480208765528542]^2} = 6{,}70479331844782E-15 < 1 \ (\mathbf{5.15})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.9999 \neq 0 \quad (\mathbf{5.16})$$

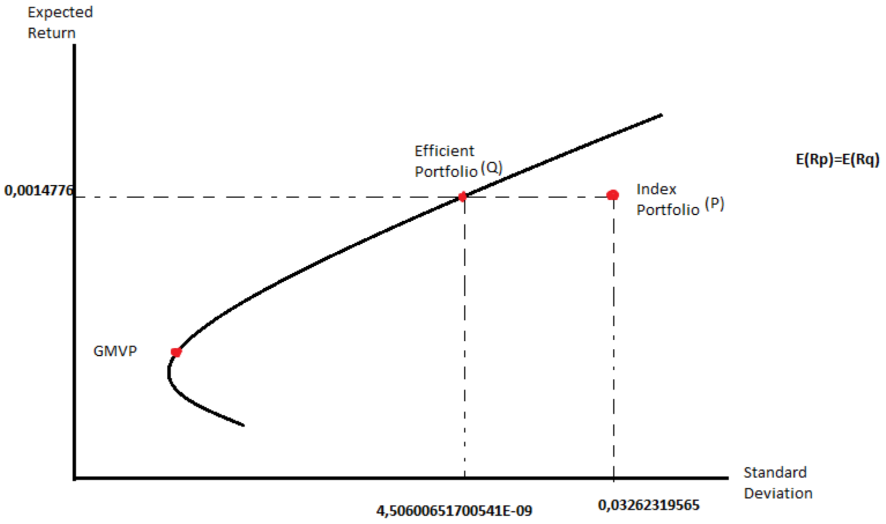
Using monthly data for the sub period A we proved with three different ways that FTSE 100 Index is inefficient.

Sub period B

Method 1: Schematically

We repeat the same steps for the **sub period B** providing the Figure 5.9 prove the inefficiency of the market portfolio. GMVP analysis: return 0.02499605, standard deviation 1.00649184144109E-09.

Figure 5.9.: Efficient frontier and FTSE 100 Index Portfolio (2 periods-5 years-Sub period B (2011-2016)-monthly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period B.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.15. provides us the weights of the efficient portfolio Q.

Table 5.15.: Weights of the efficient portfolio Q E(R_p)=E(R_q) (2 periods-5 years-Sub period B (2011-2016)-weekly data)

Firm	**Weights**
AAL LN	-0,60024
ABF LN	-0,03224
ADM LN	0,063875
AHT LN	0,795119
ANTO LN	0,709928
AV/ LN	0,726742
AZN LN	0,565041
BA/ LN	-0,13451
BAB LN	-0,37246
BARC LN	0,580431
BATS LN	-0,62394
BDEV LN	-0,43632
BLND LN	0,772865
BLT LN	-1,65573
BNZL LN	2,268285
BP/ LN	-1,32117
BRBY LN	0,746439
BT/A LN	0,59542
CCL LN	-0,38022
CNA LN	1,280077
CPG LN	1,41568
CPI LN	0,498892
CRH LN	0,719849
DCC LN	0,498975
DGE LN	0,62373
EZJ LN	0,324636
GKN LN	-2,41584
GSK LN	2,794378
HIK LN	-0,66648
HMSO LN	-0,97703
HSBA LN	-2,06366
IAG LN	-0,20516
IHG LN	-0,92084
III LN	-1,64384
IMB LN	0,430116
INF LN	-0,75701
INTU LN	-1,07619

ITRK LN	-0,72107
ITV LN	-0,62154
JMAT LN	0,142228
KGF LN	-0,78173
LAND LN	2,197286
LGEN LN	0,186803
LLOY LN	0,447946
LSE LN	0,610194
MCRO LN	0,506002
MKS LN	-0,43683
MRW LN	-1,22889
NG/ LN	0,360775
NXT LN	-1,10195
OML LN	-0,11725
PFG LN	-0,05577
PPB LN	-1,10615
PRU LN	-0,37916
PSN LN	0,168001
PSON LN	0,0285
RB/ LN	1,528544
RBS LN	0,980194
RDSA LN	2,527974
RDSB LN	-1,83518
REL LN	1,297523
RIO LN	0,647757
RR/ LN	0,678317
RRS LN	0,741973
RSA LN	0,15506
SAB LN	-1,46554
SBRY LN	0,155968
SDR LN	0,200427
SGE LN	-0,66073
SHP LN	-1,22454
SKY LN	1,490281
SMIN LN	0,278353
SN/ LN	-0,29521
SSE LN	-1,59271
STAN LN	1,108614
STJ LN	-1,2399
SVT LN	-0,90568
TPK LN	1,477836

TSCO LN	0,552386
TW/ LN	0,545626
ULVR LN	-0,70983
UU/ LN	0,785062
VOD LN	0,018994
WOS LN	-1,37946
WPP LN	-0,61479
WTB LN	-0,47229
Sum	1
Portfolio variance	2,03E-17
Portfolio standard deviation	4,51E-09

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period B.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[4{,}50600651700541\mathrm{E}-09]^2}{[0{,}0326231956526138]^2} = 1{,}90779027019584E-14 < 1 \ (\mathbf{5.17})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.9999 \neq 0 \quad (\mathbf{5.18})$$

Using monthly data for the sub period B we proved with three different ways that FTSE 100 Index is inefficient.

5.2.3. 5 periods-2 years

In those periods, we worked with daily and weekly data, excluding the companies that did not have data for the entire period. Sub period A contains all the data from 2006 to 2008, sub period B from 2009 to 2010, sub period C from 2011 to 2012, sub period D from 2013 to 2014 and sub period E from 2015 to 2016. We calculated returns and then weights using Roll's methodology (1977). The last step is to provide evidence that FTSE 100 is or is not efficient.

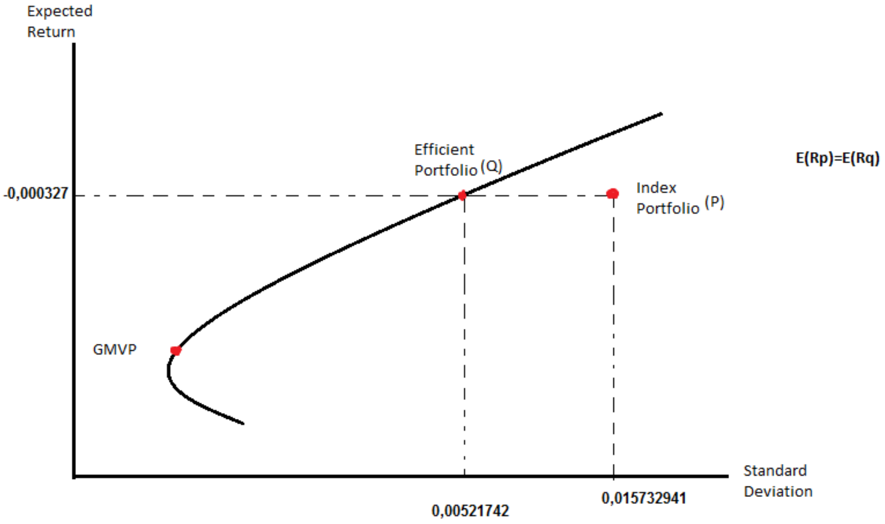
5.2.3.1. Daily data (5 periods-2 years)

Sub period A

Method 1: Schematically

We begin the results analysis with the **sub period A** providing the Figure 5.10 prove the inefficiency of the market portfolio. GMVP analysis: return 0.00029572, standard deviation 0.0047885328.

Figure 5.10.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years-Sub period A (2006-2008)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier for the sub period A.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.16. provides us the weights of the efficient portfolio Q.

Table 5.16.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years-Sub period A (2006-2008)-daily data)

Firm	Weights
AAL LN	0,019127
ABF LN	0,069905
ADM LN	-0,02679
AHT LN	0,010418
ANTO LN	-0,01864
AV/ LN	0,009483
AZN LN	-0,02695
BA/ LN	0,005866
BAB LN	0,004467
BARC LN	-0,03292
BATS LN	-0,01569
BDEV LN	0,017174
BLND LN	-0,02613
BLT LN	-0,041
BNZL LN	0,050084
BP/ LN	0,023456
BRBY LN	-0,00301
BT/A LN	0,04656
CCH LN	0,113294
CCL LN	0,015407
CNA LN	0,021105
CPG LN	-0,04341
CPI LN	0,003274
CRH LN	-0,00305
DC/ LN	0,026631
DCC LN	0,04038
DGE LN	0,071637
DLG LN	0,169311
EXPN LN	0,048547
EZJ LN	-0,00209
FRES LN	0,012953

GKN LN	0,01235
GLEN LN	0,05573
GSK LN	0,041128
HIK LN	0,036404
HL/ LN	0,015623
HMSO LN	0,004536
HSBA LN	0,134615
IAG LN	-0,02901
IHG LN	0,030329
III LN	0,045386
IMB LN	0,040408
INF LN	0,029864
INTU LN	-0,01021
ITRK LN	0,010681
ITV LN	0,03695
JMAT LN	0,028678
KGF LN	-0,00452
LAND LN	0,022455
LGEN LN	-0,01644
LLOY LN	-0,01429
LSE LN	0,008108
MCRO LN	-0,00534
MDC LN	0,035427
MKS LN	0,020681
MNDI LN	0,032319
MRW LN	-0,01457
NG/ LN	0,014176
NXT LN	-0,03048
OML LN	-0,01839
PFG LN	0,039015
POLY LN	0,037605
PPB LN	0,007737
PRU LN	-0,04384
PSN LN	0,00376
PSON LN	-0,00231
RB/ LN	0,019481
RBS LN	0,033295
RDSA LN	-0,16897
RDSB LN	0,159233
REL LN	0,02008
RIO LN	-0,00772
RR/ LN	-0,03739

RRS LN	0,022748
RSA LN	-0,0056
SAB LN	-0,01652
SBRY LN	-0,03118
SDR LN	-0,0548
SGE LN	0,028206
SHP LN	-0,0067
SKY LN	-0,04324
SL/ LN	0,029395
SMIN LN	0,010064
SN/ LN	0,032638
SSE LN	-0,0399
STAN LN	-0,03374
STJ LN	-0,01104
SVT LN	0,036224
TPK LN	0,006724
TSCO LN	0,008121
TW/ LN	0,000642
ULVR LN	-0,01439
UU/ LN	0,034094
VOD LN	-0,00646
WOS LN	-0,01259
WPP LN	-0,05051
WTB LN	0,005848
Sum	1
Portfolio variance	2,72E-05
Portfolio standard deviation	0,005217

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period A.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}00521742151]^2}{[0{,}015732941]^2} = 0{,}109974506 < 1 \ (\mathbf{5.19})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.8900 \neq 0 \quad (\mathbf{5.20})$$

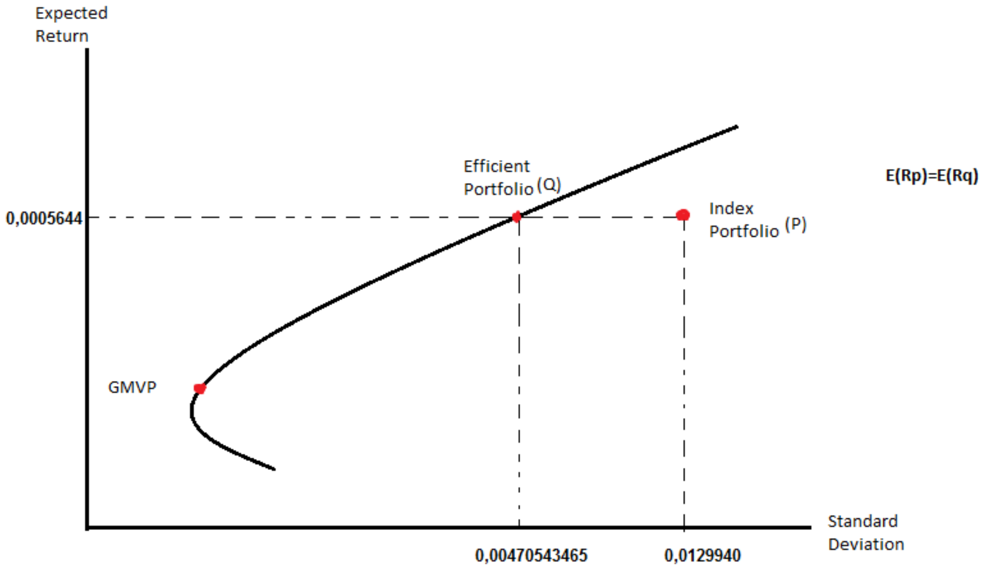
Using daily data for the sub period A we proved with three different ways that FTSE 100 Index is inefficient.

Sub period B

Method 1: Schematically

We repeat the same steps for the **sub period B** providing the Figure 5.11 prove the inefficiency of the market portfolio. GMVP analysis: return 0.0004174488, standard deviation 0.004685377.

Figure 5.11.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years-Sub period B (2008-2010)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period B.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.17. provides us the weights of the efficient portfolio Q.

Table 5.17.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years-Sub period B (2008-2010)-daily data)

Firm	**Weights**
AAL LN	-0,03595
ABF LN	0,005244
ADM LN	0,066677
AHT LN	0,029983
ANTO LN	-0,00796
AV/ LN	-0,01497
AZN LN	0,0241
BA/ LN	0,01945
BAB LN	-0,00387
BARC LN	-0,00667
BATS LN	0,003778
BDEV LN	0,005149
BLND LN	0,009844
BLT LN	0,017395
BNZL LN	0,048637
BP/ LN	0,01935
BRBY LN	0,004386
BT/A LN	-0,00035
CCL LN	-0,01171
CNA LN	-0,0085
CPG LN	-0,02403
CPI LN	0,007179
CRH LN	-0,03995
DC/ LN	0,080266
DCC LN	0,023443
DGE LN	0,014569
EXPN LN	0,116268
EZJ LN	0,007755
FRES LN	0,031314
GKN LN	0,009567
GLEN LN	0,00897
GSK LN	0,019589
HIK LN	0,040381
HL/ LN	0,054749
HMSO LN	-0,00432
HSBA LN	-0,00781
IAG LN	-0,0111
IHG LN	-0,00054

III LN	-0,00293
IMB LN	0,046905
INF LN	-0,02467
INTU LN	0,014053
ITRK LN	-0,00306
ITV LN	-0,00217
JMAT LN	-0,01605
KGF LN	0,000582
LAND LN	-0,00241
LGEN LN	0,008333
LLOY LN	0,003644
LSE LN	0,031483
MCRO LN	0,006349
MKS LN	-0,02619
MNDI LN	0,03506
MRW LN	0,024079
NG/ LN	0,026544
NXT LN	0,053901
OML LN	-0,01382
PFG LN	0,046866
PPB LN	0,031835
PRU LN	-0,00275
PSN LN	-0,00835
PSON LN	0,039059
RB/ LN	0,019524
RBS LN	0,000557
RDSA LN	0,00068
RDSB LN	-0,03044
REL LN	0,004958
RIO LN	-0,00368
RR/ LN	-0,02123
RRS LN	0,046409
RSA LN	-0,00197
SAB LN	-0,05359
SBRY LN	-0,05332
SDR LN	0,020615
SGE LN	0,008578
SHP LN	0,009539
SKY LN	0,022744
SL/ LN	0,096507
SMIN LN	0,028762
SN/ LN	0,040278

SSE LN	0,041745
STAN LN	0,005134
STJ LN	0,002105
SVT LN	0,061946
TPK LN	-0,00519
TSCO LN	0,032634
TW/ LN	-0,00272
ULVR LN	-0,00905
UU/ LN	0,00056
VOD LN	0,041774
WOS LN	-0,01234
WPP LN	-0,00754
WTB LN	-0,04058
Sum	1
Portfolio variance	2,21E-05
Portfolio standard deviation	0,004705

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period B.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}004705434]^2}{[0{,}012994067]^2} = 0{,}13113218259 < 1\ (\mathbf{5.21})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.8688 \neq 0\ \ (\mathbf{5.22})$$

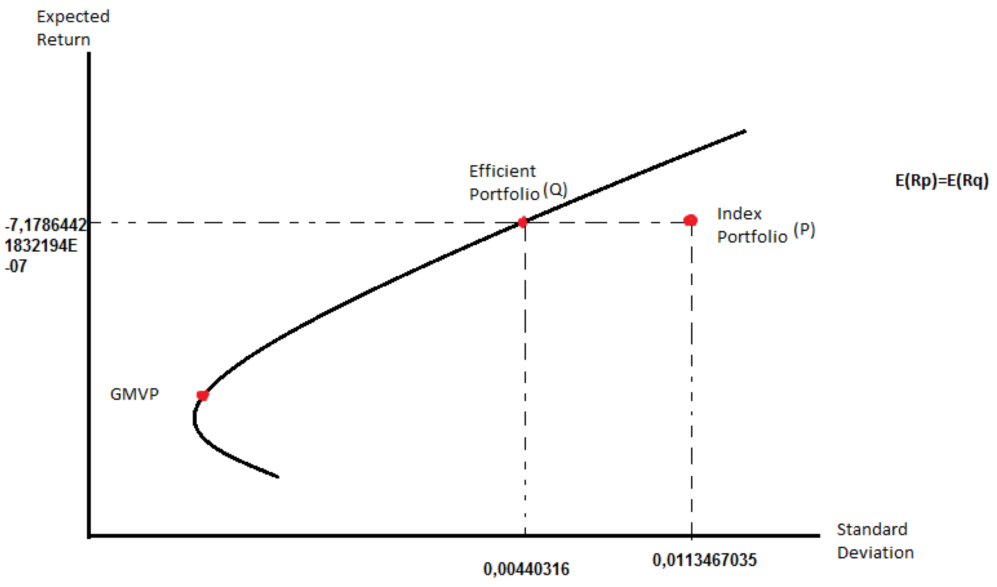
Using daily data for the sub period B we proved with three different ways that FTSE 100 Index is inefficient.

Sub period C

Method 1: Schematically

We repeat the same steps for the **sub period C** providing the Figure 5.12 prove the inefficiency of the market portfolio. GMVP analysis: return 0.00058506, standard deviation 0.00405905.

Figure 5.12.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years-Sub period C (2011-2012)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period C.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.18. provides us the weights of the efficient portfolio Q.

Table 5.18.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years-Sub period C (2011-2012)-daily data)

Firm	Weights
AAL LN	0,004966221
ABF LN	0,086451796
ADM LN	0,002901314
AHT LN	-0,037793889
ANTO LN	-0,030947623
AV/ LN	-0,027536734
AZN LN	-0,010250833
BA/ LN	0,013885594
BAB LN	0,002871045
BARC LN	-0,029810524
BATS LN	-0,022675951
BDEV LN	-0,011857788
BLND LN	0,056383995
BLT LN	-0,00929067
BNZL LN	-0,033890835
BP/ LN	0,015362685
BRBY LN	0,000492632
BT/A LN	-0,022963184
CCL LN	0,010572096
CNA LN	0,033390799
CPG LN	0,019839974
CPI LN	0,054793572
CRH LN	-0,020243946
DCC LN	0,060424909
DGE LN	0,003499053
EXPN LN	0,105977107
EZJ LN	-0,002562606
FRES LN	0,05039976
GKN LN	0,001892476
GSK LN	0,065485829
HIK LN	0,016181872
HL/ LN	0,02359338
HMSO LN	-0,033510328
HSBA LN	0,006072003
IAG LN	0,051822
IHG LN	-0,010543179
III LN	0,029416317
IMB LN	0,000294415

INF LN	0,00316129
INTU LN	-0,023689407
ITRK LN	-0,010802097
ITV LN	-0,027252184
JMAT LN	9,92989E-05
KGF LN	0,010121142
LAND LN	0,016765526
LGEN LN	-0,04707494
LLOY LN	0,018483538
LSE LN	-0,012487507
MCRO LN	0,007320872
MKS LN	-0,046971568
MNDI LN	0,075105775
MRW LN	0,068832765
NG/ LN	0,052923807
NXT LN	-0,010778732
OML LN	-0,027981781
PFG LN	0,077254808
PPB LN	0,003879333
PRU LN	-0,035977353
PSN LN	-0,00473585
PSON LN	0,028974636
RB/ LN	0,014212531
RBS LN	0,008744614
RDSA LN	0,219114665
RDSB LN	-0,242270179
REL LN	0,049476371
RIO LN	0,029220728
RR/ LN	-0,046156337
RRS LN	0,026131487
RSA LN	0,057758855
SAB LN	-0,058029305
SBRY LN	-0,009336533
SDR LN	0,011346748
SGE LN	0,04709676
SHP LN	0,006188516
SKY LN	0,030994481
SL/ LN	0,042112101
SMIN LN	0,02047052
SN/ LN	0,015363976
SSE LN	0,032920157
STAN LN	0,019156202

STJ LN	0,012644506
SVT LN	-0,003304458
TPK LN	0,002925145
TSCO LN	0,054903089
TW/ LN	-0,037698657
ULVR LN	0,028988671
UU/ LN	0,043121542
VOD LN	0,055424157
WOS LN	0,000566864
WPP LN	0,020164979
WTB LN	0,019483678
Sum	1
Portfolio variance	1,93878E-05
Portfolio standard deviation	0,004403162

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period C.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0044031622]^2}{[0{,}0113467]^2} = 0{,}15058785701 < 1 \; (\mathbf{5.23})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.8494 \neq 0 \quad (\mathbf{5.24})$$

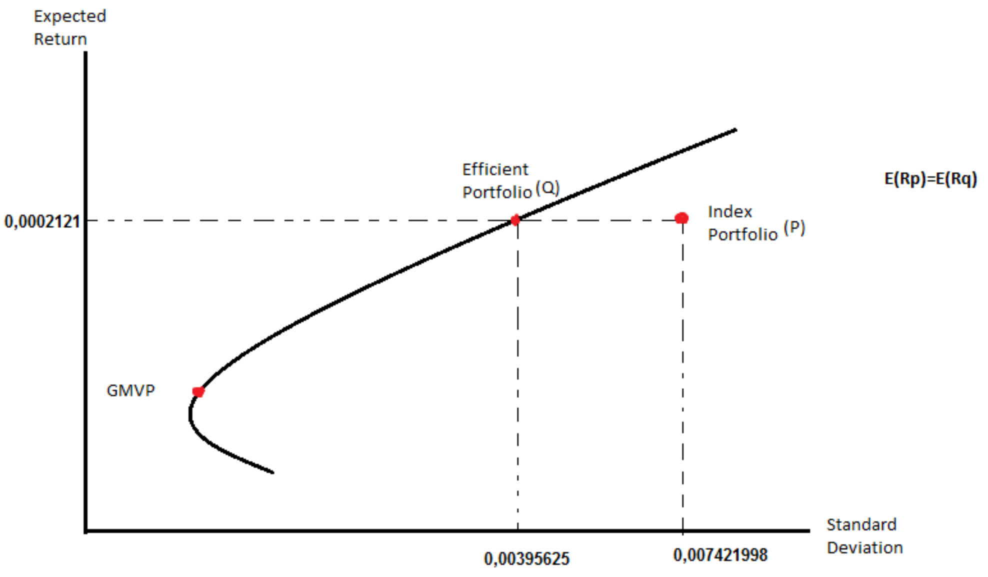
Using daily data for the sub period C we proved with three different ways that FTSE 100 Index is inefficient.

Sub period D

Method 1: Schematically

We repeat the same steps for the **sub period D** providing the Figure 5.13 prove the inefficiency of the market portfolio. GMVP analysis: return 0.000279549, standard deviation 0.000279549.

Figure 5.13.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years-Sub period D (2013-2014)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period D.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.19. provides us the weights of the efficient portfolio Q.

Table 5.19.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years-Sub period D (2013-2014)-daily data)

Firm	Weights
AAL LN	0,002836
ABF LN	-0,01161
ADM LN	0,019198
AHT LN	-0,01642
ANTO LN	-0,01422
AV/ LN	0,000723
AZN LN	0,029009
BA/ LN	0,011389
BAB LN	-0,02924
BARC LN	-0,00595
BATS LN	0,015116
BDEV LN	0,020058
BLND LN	0,031531
BLT LN	-0,00263
BNZL LN	0,070009
BP/ LN	0,028467
BRBY LN	0,010355
BT/A LN	-0,0002
CCL LN	0,007121
CNA LN	0,022752
CPG LN	0,042189
CPI LN	-0,01737
CRH LN	-0,0243
DCC LN	0,068903
DGE LN	0,031509
EXPN LN	0,095534
EZJ LN	-0,01305
GKN LN	-0,05459
GSK LN	-0,0032
HIK LN	0,007489
HL/ LN	0,042192
HMSO LN	-0,05354
HSBA LN	0,013587
IAG LN	0,046761
IHG LN	0,005996
III LN	-0,02136
IMB LN	0,069599
INF LN	0,02469

INTU LN	0,095948
ITRK LN	0,038997
ITV LN	-0,00371
JMAT LN	0,031059
KGF LN	0,026821
LAND LN	0,006596
LGEN LN	0,000298
LLOY LN	0,068707
LSE LN	-0,03782
MCRO LN	0,020224
MKS LN	-0,00491
MNDI LN	0,044671
MRW LN	0,040235
NG/ LN	0,077521
NXT LN	0,01834
OML LN	-0,10207
PFG LN	0,024819
PPB LN	0,044769
PRU LN	-0,02053
PSN LN	-0,0526
PSON LN	0,006859
RB/ LN	0,003529
RBS LN	-0,00222
RDSA LN	0,072339
RDSB LN	-0,04956
REL LN	0,03376
RIO LN	0,038465
RR/ LN	0,023516
RRS LN	0,021914
RSA LN	0,040101
SAB LN	-0,05599
SBRY LN	-0,00525
SDR LN	-0,03974
SGE LN	0,021318
SHP LN	-0,0092
SKY LN	0,027515
SL/ LN	0,079501
SMIN LN	-0,0331
SN/ LN	0,02559
SSE LN	0,070092
STAN LN	0,026884
STJ LN	0,006732

SVT LN	0,001298
TPK LN	0,004459
TSCO LN	-0,02859
TW/ LN	-0,00567
ULVR LN	-0,00226
UU/ LN	0,009509
VOD LN	0,006492
WOS LN	-0,02647
WPP LN	-0,02853
WTB LN	-1,8E-06
Sum	1
Portfolio variance	1,57E-05
Portfolio standard deviation	0,003956

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period D.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}00395625]^2}{[0{,}0074219]^2} = 0{,}2841366643 < 1 \ (\mathbf{5.25})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.7158 \neq 0 \quad (\mathbf{5.26})$$

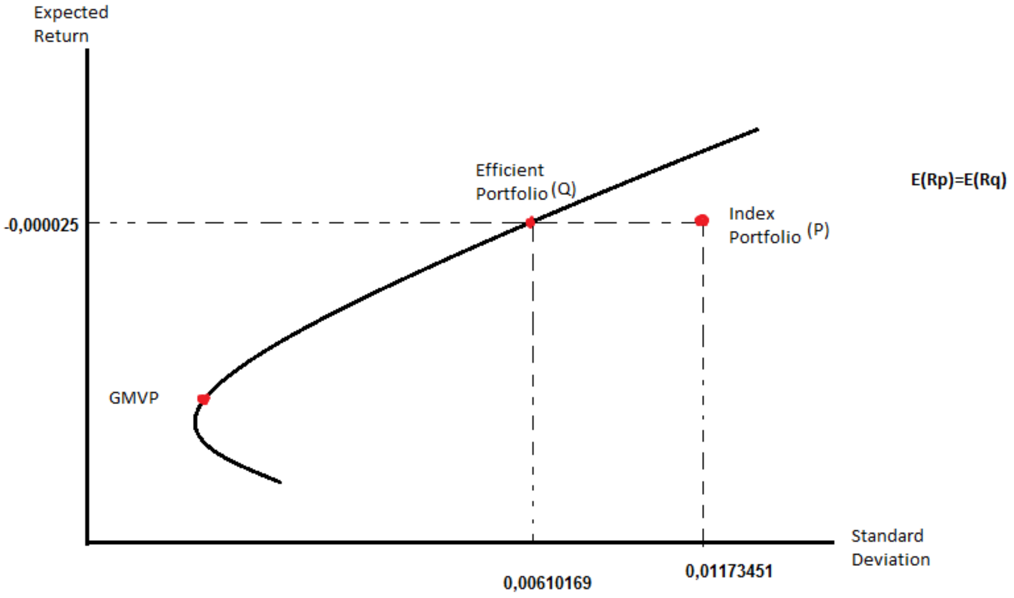
Using daily data for the sub period D we proved with three different ways that FTSE 100 Index is inefficient.

Sub period E

Method 1: Schematically

We repeat the same steps for the **sub period E** providing the Figure 5.14 prove the inefficiency of the market portfolio. GMVP analysis: return 0.000406358, standard deviation 0.00599571012.

Figure 5.14.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years-Sub period E (2015-2016)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period E.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.20. provides us the weights of the efficient portfolio Q.

Table 5.20.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years-Sub period E (2015-2016)-daily data)

Firm	**Weights**
AAL LN	-0,03352
ABF LN	-0,04166
ADM LN	0,076716
AHT LN	-0,02579
ANTO LN	0,00872
AV/ LN	-0,06639
AZN LN	0,066183
BA/ LN	0,016956
BAB LN	0,083692
BARC LN	-0,06519
BATS LN	-0,05807
BDEV LN	-0,04432
BLND LN	0,107702
BLT LN	-0,1632
BNZL LN	0,042906
BP/ LN	-0,01507
BRBY LN	-0,01525
BT/A LN	-0,00955
CCL LN	-0,04293
CNA LN	-0,01181
CPG LN	0,034996
CPI LN	0,010153
CRH LN	-0,03028
DCC LN	0,013536
DGE LN	-0,01962
EZJ LN	0,041155
GKN LN	-0,00062
GSK LN	-0,00855
HIK LN	0,027751
HMSO LN	0,156267
HSBA LN	0,126884
IAG LN	0,095964
IHG LN	0,006611
III LN	-0,00405
IMB LN	0,046517
INF LN	-0,04738
INTU LN	-0,1145
ITRK LN	0,021641

ITV LN	-0,02571
JMAT LN	0,007947
KGF LN	0,004758
LAND LN	-0,13379
LGEN LN	0,033606
LLOY LN	0,071913
LSE LN	0,033328
MCRO LN	0,04085
MKS LN	0,056085
MRW LN	0,053644
NG/ LN	0,148008
NXT LN	0,101334
OML LN	-0,05103
PFG LN	-0,01568
PPB LN	0,061922
PRU LN	-0,04263
PSN LN	0,004131
PSON LN	0,046056
RB/ LN	-0,06179
RBS LN	0,07656
RDSA LN	0,000809
RDSB LN	0,005408
REL LN	0,042102
RIO LN	0,194146
RR/ LN	0,023429
RRS LN	0,088405
RSA LN	-0,00329
SAB LN	0,116049
SBRY LN	0,004294
SDR LN	-0,11001
SGE LN	0,087961
SHP LN	0,015147
SKY LN	0,05204
SMIN LN	0,029908
SN/ LN	-0,00432
SSE LN	0,013214
STAN LN	0,017528
STJ LN	-0,10909
SVT LN	0,171919
TPK LN	0,057734
TSCO LN	-0,00715
TW/ LN	-0,07425

ULVR LN	0,02204
UU/ LN	-0,16413
VOD LN	-0,04203
WOS LN	0,040459
WPP LN	-0,15345
WTB LN	0,109019
Sum	1
Portfolio variance	3,72E-05
Portfolio standard deviation	0,006102

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period E.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0061016940]^2}{[0{,}011734511]^2} = 0{,}270377691 < 1 \ (\mathbf{5.27})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.7296 \neq 0 \quad (\mathbf{5.28})$$

Using daily data for the sub period E we proved with three different ways that FTSE 100 Index is inefficient and this holds true for all the sub periods we examined at this point.

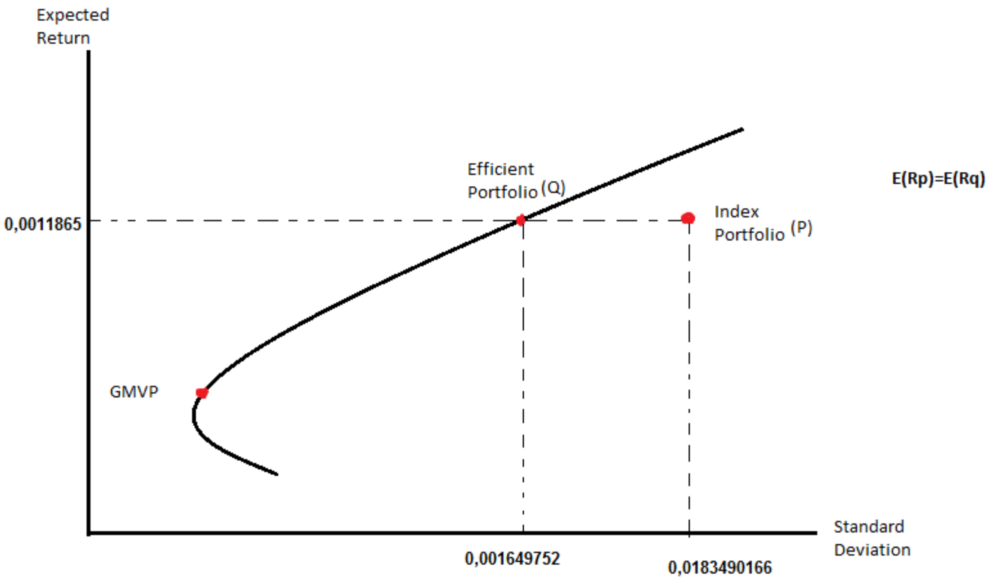
5.2.3.2. Weekly data (5 periods-2 years)

Sub period A

Method 1: Schematically

We begin the results analysis with the **sub period A** providing the Figure 5.15 prove the inefficiency of the market portfolio. GMVP analysis: return 0.0072162074, standard deviation 0.00120246.

Figure 5.15.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years-Sub period A (2006-2008)-weekly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier for the sub period A.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.21. provides us the weights of the efficient portfolio Q.

Table 5.21.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years-Sub period A (2006-2008)-weekly data)

Firm	**Weights**
AAL LN	-0,09482
ABF LN	0,155216
ADM LN	0,166256
AHT LN	-0,05351
ANTO LN	-0,0986
AV/ LN	-0,07631
AZN LN	-0,09548
BA/ LN	0,117538
BAB LN	-0,05105
BARC LN	0,010998
BATS LN	0,11027
BDEV LN	-0,04397
BLND LN	-0,21743
BLT LN	0,315178
BNZL LN	-0,03227
BP/ LN	0,14577
BRBY LN	-0,02928
BT/A LN	0,316503
CCH LN	0,056742
CCL LN	0,119804
CNA LN	-0,0383
CPG LN	0,033884
CPI LN	-0,03316
CRH LN	0,089936
DC/ LN	-0,02124
DCC LN	0,192781
DGE LN	0,164467
DLG LN	0,305093
EXPN LN	0,107093
EZJ LN	-0,09942
FRES LN	0,036361
GKN LN	0,079267
GLEN LN	-0,00711
GSK LN	0,052242
HIK LN	-0,01247
HL/ LN	0,082508
HMSO LN	0,210504
HSBA LN	-0,22431

IAG LN	0,177009
IHG LN	-0,10447
III LN	-0,06368
IMB LN	-0,24065
INF LN	-0,01402
INTU LN	-0,34075
ITRK LN	0,057722
ITV LN	-0,16156
JMAT LN	0,054563
KGF LN	-0,04457
LAND LN	0,259736
LGEN LN	0,270986
LLOY LN	-0,11077
LSE LN	-0,02708
MCRO LN	0,025048
MDC LN	0,066002
MERL LN	-0,03678
MKS LN	0,170813
MNDI LN	-0,02238
MRW LN	-0,02111
NG/ LN	0,180059
NXT LN	-0,20843
OML LN	-0,03651
PFG LN	-0,09706
POLY LN	0,09017
PPB LN	-0,17877
PRU LN	-0,43078
PSN LN	0,111446
PSON LN	-0,18788
RB/ LN	-0,22244
RBS LN	0,069267
RDSA LN	-0,25429
RDSB LN	0,402511
REL LN	0,206678
RIO LN	0,061017
RMG LN	0,112607
RR/ LN	-0,15231
RRS LN	-0,10104
RSA LN	0,298603
SAB LN	-0,00531
SBRY LN	0,194679
SDR LN	0,008258

SGE LN	0,216578
SHP LN	-0,05593
SKY LN	0,206542
SL/ LN	0,008509
SMIN LN	-0,13509
SN/ LN	-0,09062
SSE LN	-0,05857
STAN LN	-0,22055
STJ LN	-0,04016
SVT LN	0,027126
TPK LN	-0,11
TSCO LN	0,152124
TW/ LN	-0,07716
ULVR LN	0,063514
UU/ LN	-0,16256
VOD LN	-0,05118
WOS LN	0,237806
WPP LN	-0,26272
WTB LN	-0,04186
Sum	1
Portfolio variance	2,72E-06
Portfolio standard deviation	0,00165

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period A.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}00164975]^2}{[0{,}01834901]^2} = 0{,}00808373 < 1 \ (\mathbf{5.29})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.9919 \neq 0 \ \ (\mathbf{5.30})$$

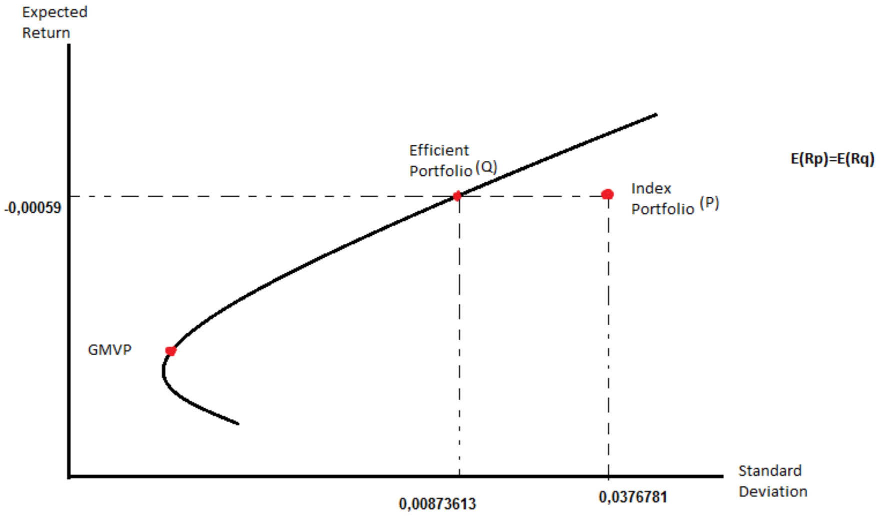
Using weekly data for the sub period A we proved with three different ways that FTSE 100 Index is inefficient.

Sub period B

Method 1: Schematically

We repeat the same steps for the **sub period B** providing the Figure 5.16 prove the inefficiency of the market portfolio. GMVP analysis: return 0.0012195803, standard deviation 0.00836638.

Figure 5.16.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years-Sub period B (2008-2010)-weekly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period B.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.22. provides us the weights of the efficient portfolio Q.

Table 5.22.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years-Sub period B (2008-2010)-weekly data)

Firm	Weights
AAL LN	-0,00773
ABF LN	-0,02935
ADM LN	0,008049
AHT LN	0,029616
ANTO LN	-0,02208
AV/ LN	-0,05905
AZN LN	-0,13203
BA/ LN	0,018975
BAB LN	0,015956
BARC LN	-0,02462
BATS LN	-0,1422
BDEV LN	-0,01942
BLND LN	0,088868
BLT LN	-0,03305
BNZL LN	-0,04276
BP/ LN	0,046948
BRBY LN	-0,00512
BT/A LN	0,026118
CCL LN	-0,00391
CNA LN	0,0069
CPG LN	-0,02955
CPI LN	0,102466
CRH LN	0,033795
DC/ LN	0,049349
DCC LN	0,035502
DGE LN	0,049051
EXPN LN	0,060091
EZJ LN	-0,03293
FRES LN	0,011561
GKN LN	-0,01828
GLEN LN	0,023209
GSK LN	0,082833
HIK LN	0,060663
HL/ LN	0,056605
HMSO LN	-0,05987
HSBA LN	0,033873
IAG LN	-0,05221
IHG LN	0,028269

III LN	0,059629
IMB LN	0,134819
INF LN	-0,02823
INTU LN	0,030009
ITRK LN	-0,0093
ITV LN	-0,00192
JMAT LN	0,029838
KGF LN	-0,00546
LAND LN	0,061291
LGEN LN	-0,00307
LLOY LN	-0,04031
LSE LN	-0,01424
MCRO LN	-0,04389
MKS LN	0,051294
MNDI LN	0,040269
MRW LN	0,150436
NG/ LN	0,107695
NXT LN	-0,07834
OML LN	0,047175
PFG LN	0,0636
PPB LN	-0,01158
PRU LN	-0,02064
PSN LN	0,001487
PSON LN	0,122451
RB/ LN	0,078012
RBS LN	0,02586
RDSA LN	-0,49918
RDSB LN	0,35173
REL LN	0,081749
RIO LN	-0,03132
RR/ LN	-0,05659
RRS LN	0,111077
RSA LN	0,122101
SAB LN	-0,0429
SBRY LN	-0,01417
SDR LN	-0,08519
SGE LN	0,168851
SHP LN	0,084323
SKY LN	0,028778
SL/ LN	0,041507
SMIN LN	-0,0688
SN/ LN	-0,01411

SSE LN	0,032132
STAN LN	0,037731
STJ LN	0,008518
SVT LN	-0,01479
TPK LN	0,056146
TSCO LN	-0,133
TW/ LN	0,001316
ULVR LN	-0,05129
UU/ LN	0,132438
VOD LN	0,025703
WOS LN	-0,01827
WPP LN	-0,14468
WTB LN	-0,01126
Sum	1
Portfolio variance	7,63E-05
Portfolio standard deviation	0,008736

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period B.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}008736136]^2}{[0{,}037678145]^2} = 0{,}053760059 < 1 \ (\mathbf{5.31})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.9462 \neq 0 \quad (\mathbf{5.32})$$

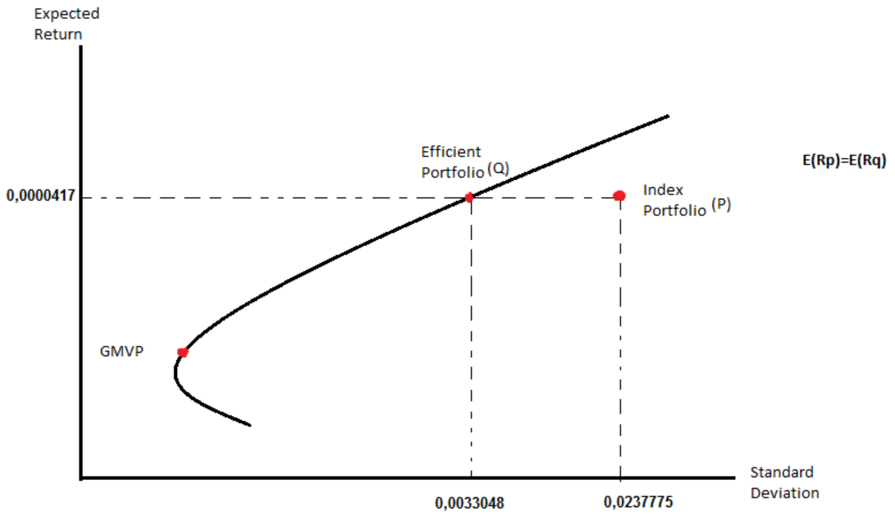
Using weekly data for the sub period B we proved with three different ways that FTSE 100 Index is inefficient.

Sub period C

Method 1: Schematically

We repeat the same steps for the **sub period C** providing the Figure 5.17 prove the inefficiency of the market portfolio. GMVP analysis: return -0.000769727, standard deviation 0.003296289.

Figure 5.17.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years-Sub period C (2011-2012)-weekly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period C.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.23. provides us the weights of the efficient portfolio Q.

Table 5.23.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years-Sub period C (2011-2012)-weekly data)

Firm	Weights
AAL LN	0,107265
ABF LN	0,210631
ADM LN	0,007431
AHT LN	-0,03035
ANTO LN	0,001893
AV/ LN	-0,07399
AZN LN	0,059921
BA/ LN	-0,18763
BAB LN	0,128279
BARC LN	-0,01099
BATS LN	-0,07869
BDEV LN	0,015045
BLND LN	0,130092
BLT LN	0,004474
BNZL LN	0,316393
BP/ LN	0,134557
BRBY LN	0,005673
BT/A LN	0,076745
CCL LN	-0,11119
CNA LN	0,115247
CPG LN	0,078823
CPI LN	0,000779
CRH LN	-0,0374
DCC LN	0,106534
DGE LN	-0,25566
EXPN LN	0,121704
EZJ LN	0,034526
FRES LN	0,063902
GKN LN	-0,15933
GSK LN	0,127775
HIK LN	-0,03074
HL/ LN	-0,03796
HMSO LN	-0,10279
HSBA LN	-0,05355
IAG LN	0,077158
IHG LN	-0,0637
III LN	0,146035
IMB LN	0,099891

INF LN	0,057341
INTU LN	0,053557
ITRK LN	0,156355
ITV LN	-0,00198
JMAT LN	-0,14473
KGF LN	-0,04504
LAND LN	-0,05934
LGEN LN	0,054653
LLOY LN	-0,07258
LSE LN	-0,0752
MCRO LN	0,047076
MKS LN	-0,09964
MNDI LN	0,095572
MRW LN	-0,18467
NG/ LN	0,277488
NXT LN	-0,0031
OML LN	-0,01188
PFG LN	-0,09258
PPB LN	-0,13044
PRU LN	0,141609
PSN LN	0,060742
PSON LN	-0,03272
RB/ LN	-0,05691
RBS LN	0,169485
RDSA LN	-0,85028
RDSB LN	0,773579
REL LN	0,119829
RIO LN	-0,10635
RR/ LN	-0,08662
RRS LN	0,152541
RSA LN	0,085552
SAB LN	-0,26316
SBRY LN	0,094514
SDR LN	-0,05658
SGE LN	0,006974
SHP LN	0,085571
SKY LN	-0,05773
SL/ LN	0,092083
SMIN LN	0,071172
SN/ LN	0,016283
SSE LN	-0,02075
STAN LN	0,009822

STJ LN	0,063893
SVT LN	0,258477
TPK LN	0,044433
TSCO LN	0,121961
TW/ LN	-0,14311
ULVR LN	0,027507
UU/ LN	-0,43722
VOD LN	0,075107
WOS LN	-0,12523
WPP LN	0,013159
WTB LN	-0,00528
Sum	1
Portfolio variance	1,09E-05
Portfolio standard deviation	0,003305

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period C.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0033048]^2}{[0{,}0237775731]^2} = 0{,}019317721 < 1 \; (\mathbf{5.33})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.9806 \neq 0 \;\; (\mathbf{5.34})$$

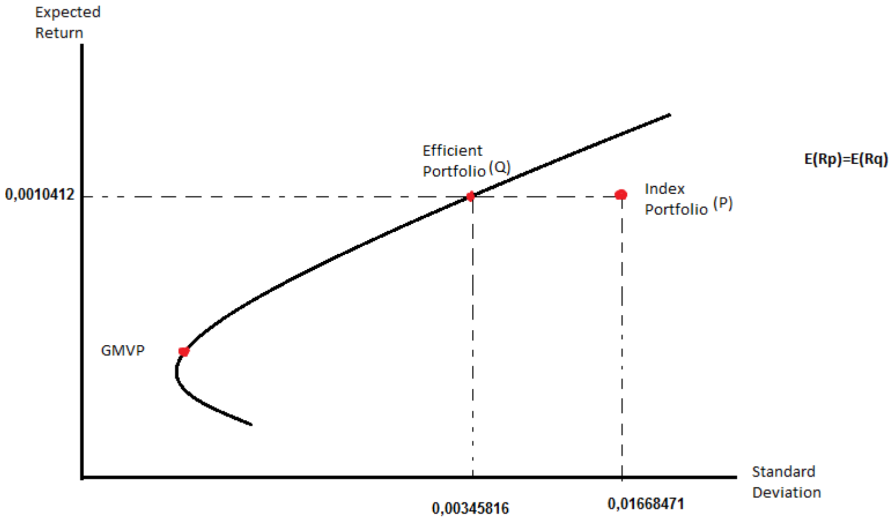
Using weekly data for the sub period C we proved with three different ways that FTSE 100 Index is inefficient.

Sub period D

Method 1: Schematically

We repeat the same steps for the **sub period D** providing the Figure 5.18 prove the inefficiency of the market portfolio. GMVP analysis: return 0.004051435, standard deviation 0.00296774.

Figure 5.18.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years-Sub period D (2013-2014)-weekly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period D.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.24. provides us the weights of the efficient portfolio Q.

Table 5.24.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years-Sub period D (2013-2014)-weekly data)

Firm	Weights
AAL LN	0,152618
ABF LN	-0,26683
ADM LN	0,164153
AHT LN	0,182135
ANTO LN	0,016689
AV/ LN	0,26542
AZN LN	-0,13952
BA/ LN	-0,16481
BAB LN	-0,04353
BARC LN	0,017886
BATS LN	-0,34694
BDEV LN	-0,10294
BLND LN	-0,17954
BLT LN	-0,18507
BNZL LN	0,527424
BP/ LN	0,043633
BRBY LN	0,203686
BT/A LN	0,363386
CCL LN	0,117758
CNA LN	-0,29272
CPG LN	-0,15683
CPI LN	-0,02598
CRH LN	0,00539
DCC LN	-0,10407
DGE LN	0,495493
EXPN LN	0,05794
EZJ LN	0,177614
GKN LN	0,047955
GSK LN	-0,04402
HIK LN	-0,07219
HL/ LN	0,144767
HMSO LN	0,394662
HSBA LN	-0,26201
IAG LN	-0,16379
IHG LN	-0,1379
III LN	-0,1362
IMB LN	0,160787
INF LN	0,087903

INTU LN	-0,33768
ITRK LN	0,020187
ITV LN	-0,27629
JMAT LN	0,224037
KGF LN	-0,22154
LAND LN	-0,10173
LGEN LN	0,047874
LLOY LN	0,026538
LSE LN	-0,37536
MCRO LN	0,059351
MKS LN	0,003477
MNDI LN	-0,0349
MRW LN	0,153771
NG/ LN	0,445335
NXT LN	0,10791
OML LN	0,001492
PFG LN	0,08617
PPB LN	-0,07106
PRU LN	-0,04884
PSN LN	0,016761
PSON LN	0,02909
RB/ LN	0,169889
RBS LN	0,00376
RDSA LN	-0,19224
RDSB LN	-0,18277
REL LN	-0,22652
RIO LN	0,048972
RR/ LN	0,183273
RRS LN	0,232567
RSA LN	0,05709
SAB LN	0,457822
SBRY LN	-0,04675
SDR LN	-0,02334
SGE LN	0,039484
SHP LN	-0,07429
SKY LN	-0,00539
SL/ LN	-0,0074
SMIN LN	0,345798
SN/ LN	0,283081
SSE LN	0,218689
STAN LN	-0,02608
STJ LN	0,092546

SVT LN	0,040205
TPK LN	0,164413
TSCO LN	-0,26649
TW/ LN	0,118929
ULVR LN	-0,48161
UU/ LN	-0,02106
VOD LN	0,130676
WOS LN	-0,34945
WPP LN	-0,10868
WTB LN	-0,13212
Sum	1
Portfolio variance	1,2E-05
Portfolio standard deviation	0,003458

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period D.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0034581]^2}{[0{,}0166847]^2} = 0{,}04295886 < 1 \ (\mathbf{5.35})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.9570 \neq 0 \ \ (\mathbf{5.36})$$

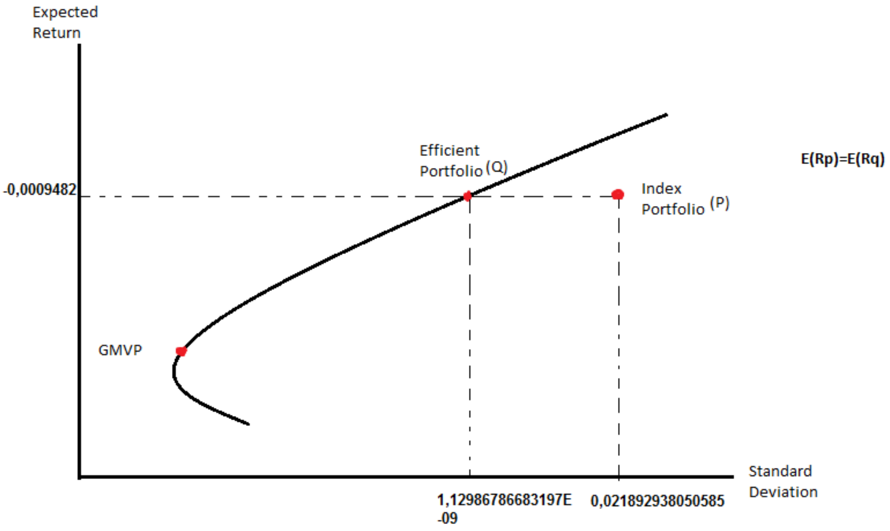
Using weekly data for the sub period D we proved with three different ways that FTSE 100 Index is inefficient.

Sub period E

Method 1: Schematically

We repeat the same steps for the **sub period E** providing the Figure 5.19 prove the inefficiency of the market portfolio. GMVP analysis: return -0.005213679, standard deviation 1.37764001138132E-09.

Figure 5.19.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years-Sub period E (2015-2016)-weekly data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period E.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.25. provides us the weights of the efficient portfolio Q.

Table 5.25.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years-Sub period E (2015-2016)-weekly data)

Firm	Weights
AAL LN	-0,22344
ABF LN	0,683405
ADM LN	0,491629
AHT LN	-0,212
ANTO LN	0,199448
AV/ LN	0,203564
AZN LN	0,00354
BA/ LN	0,557296
BAB LN	0,028333
BARC LN	-0,21967
BATS LN	-1,64278
BDEV LN	-0,58772
BLND LN	-1,60788
BLT LN	0,354107
BNZL LN	-0,10647
BP/ LN	0,070981
BRBY LN	-0,08945
BT/A LN	-0,04702
CCL LN	-0,0504
CNA LN	0,512803
CPG LN	-0,30681
CPI LN	0,409815
CRH LN	0,208655
DCC LN	0,011506
DGE LN	-0,27534
EZJ LN	0,049904
GKN LN	-0,13676
GSK LN	-0,41405
HIK LN	0,496609
HMSO LN	0,678535
HSBA LN	0,23596
IAG LN	-0,11179
IHG LN	-0,30411
III LN	-0,62583
IMB LN	-0,83236
INF LN	0,607365
INTU LN	-0,92913
ITRK LN	-0,10896

ITV LN	-0,11795
JMAT LN	-0,16443
KGF LN	0,2482
LAND LN	0,637882
LGEN LN	0,520863
LLOY LN	-0,49572
LSE LN	0,145899
MCRO LN	0,172702
MKS LN	-0,38217
MRW LN	1,105825
NG/ LN	0,119592
NXT LN	0,383572
OML LN	0,407406
PFG LN	-0,14641
PPB LN	0,175275
PRU LN	0,090245
PSN LN	0,872847
PSON LN	-0,24453
RB/ LN	-0,69677
RBS LN	-0,55844
RDSA LN	2,8119
RDSB LN	-1,91874
REL LN	0,040564
RIO LN	0,27878
RR/ LN	-0,3294
RRS LN	-0,36829
RSA LN	-0,43307
SAB LN	0,692835
SBRY LN	-0,16923
SDR LN	0,597608
SGE LN	-0,17925
SHP LN	0,099435
SKY LN	-1,34093
SMIN LN	-0,57341
SN/ LN	-0,52837
SSE LN	-0,24185
STAN LN	-0,03523
STJ LN	-0,88354
SVT LN	1,521066
TPK LN	1,200305
TSCO LN	-0,39446
TW/ LN	-0,06394

ULVR LN	-0,1619
UU/ LN	0,171789
VOD LN	0,276555
WOS LN	0,129374
WPP LN	0,453787
WTB LN	1,302209
Sum	1
Portfolio variance	1,28E-18
Portfolio standard deviation	1,13E-09

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period E.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[1{,}12986786683197\mathrm{E}-09]^2}{[0{,}02189293]^2} = 2{,}6634663778253E-15 < 1 \ (\mathbf{5.37})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.9999 \neq 0 \quad (\mathbf{5.38})$$

Using weekly data for the sub period E we proved with three different ways that FTSE 100 Index is inefficient and this holds true for all the sub periods we examined at this point.

5.2.4. 10 periods-1 year

In those periods, we worked with daily data, excluding the companies that did not have data for the entire period. Sub period A contains all the data of 2006, sub period B of 2007, sub period C of 2008, sub period D of 2009, sub period E of 2010, sub period F of 2011, sub period G of 2012, sub period H of 2013, sub period I of 2014, sub period J from 2015 to 2016. We calculated returns and then weights using Roll's methodology (1977). The last step is to provide evidence that FTSE 100 is or is not efficient.

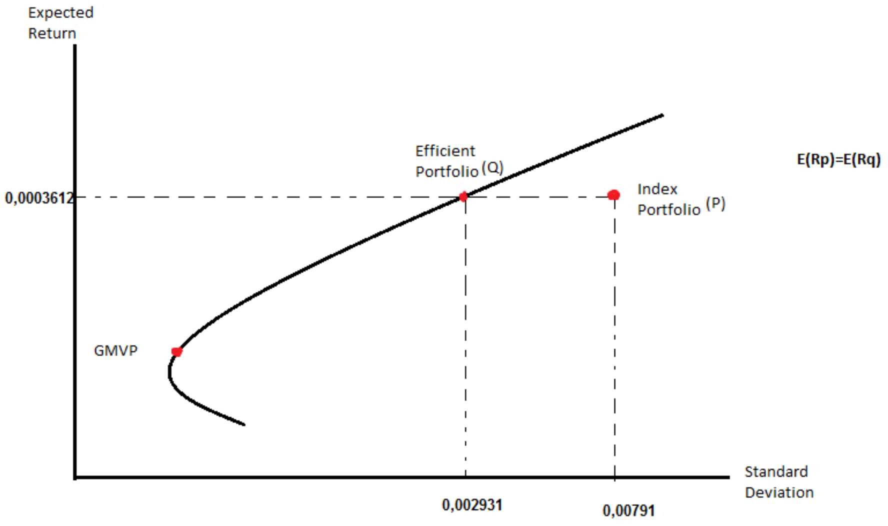
5.2.4.1. Daily data (10 periods-1 years)

Sub period A

Method 1: Schematically

We begin the results analysis with the **sub period A** providing the Figure 5.20 prove the inefficiency of the market portfolio. GMVP analysis: return 0.00053056, standard deviation 0.00292232.

Figure 5.20.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year-Sub period A (2006)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier for the sub period A.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.26. provides us the weights of the efficient portfolio Q.

Table 5.26.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (10 periods-1 year-Sub period A (2006-2008)-daily data)

Firm	Weights
AAL LN	0,022072
ABF LN	0,087411
ADM LN	-0,01847
AHT LN	0,006619
ANTO LN	-0,03684
AV/ LN	-0,04324
AZN LN	-0,04757
BA/ LN	-0,01449
BAB LN	0,001804
BARC LN	-0,07185
BATS LN	-0,00137
BDEV LN	0,023297
BLND LN	-0,00365
BLT LN	-0,01046
BNZL LN	0,022223
BP/ LN	0,037051
BRBY LN	0,034926
BT/A LN	0,029678
CCH LN	0,026958
CCL LN	0,027458
CNA LN	-0,00856
CPG LN	0,019824
CPI LN	0,029717
CRH LN	-0,03706
DC/ LN	0,019102
DCC LN	0,03139
DGE LN	0,070205
DLG LN	0,083012
EXPN LN	0,041224
EZJ LN	0,003698
FRES LN	0,008551

GKN LN	-0,01397
GLEN LN	-0,00451
GSK LN	0,064901
HIK LN	0,019244
HL/ LN	-0,00012
HMSO LN	0,025
HSBA LN	0,156039
IAG LN	0,011978
IHG LN	0,002717
III LN	0,003097
IMB LN	0,037762
INF LN	0,00836
INTU LN	-0,07307
ITRK LN	0,010473
ITV LN	-0,00184
JMAT LN	0,074737
KGF LN	-0,03245
LAND LN	0,025013
LGEN LN	0,000979
LLOY LN	-0,01388
LSE LN	0,014976
MCRO LN	0,002767
MDC LN	0,025081
MERL LN	0,060961
MKS LN	0,022827
MNDI LN	0,021898
MRW LN	-0,02486
NG/ LN	0,069077
NXT LN	-0,03385
OML LN	-0,06131
PFG LN	0,02256
POLY LN	0,001918
PPB LN	0,03472
PRU LN	0,018438
PSN LN	-0,06172
PSON LN	-0,01566
RB/ LN	0,044762
RBS LN	0,059953
RDSA LN	-0,0588
RDSB LN	0,116136
REL LN	0,060952
RIO LN	-0,00403

RMG LN	0,010537
RR/ LN	-0,04121
RRS LN	0,000194
RSA LN	0,016445
SAB LN	-0,04165
SBRY LN	-0,03553
SDR LN	-0,01244
SGE LN	-0,01126
SHP LN	-0,02271
SKY LN	0,072988
SL/ LN	0,056127
SMIN LN	0,024669
SN/ LN	0,037839
SSE LN	-0,01436
STAN LN	-0,04224
STJ LN	0,008136
SVT LN	-0,01435
TPK LN	0,018817
TSCO LN	0,049456
TUI LN	0,042825
TW/ LN	-0,00745
ULVR LN	-0,03773
UU/ LN	0,070997
VOD LN	-0,03841
WOS LN	0,034128
WPP LN	-0,07658
WTB LN	0,002843
Sum	1
Portfolio variance	8,59E-06
Portfolio standard deviation	0,002931

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period A.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}00293132]^2}{[0{,}007910167]^2} = 0{,}13732756 < 1 \quad (\mathbf{5.39})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.8626 \neq 0 \quad (\mathbf{5.40})$$

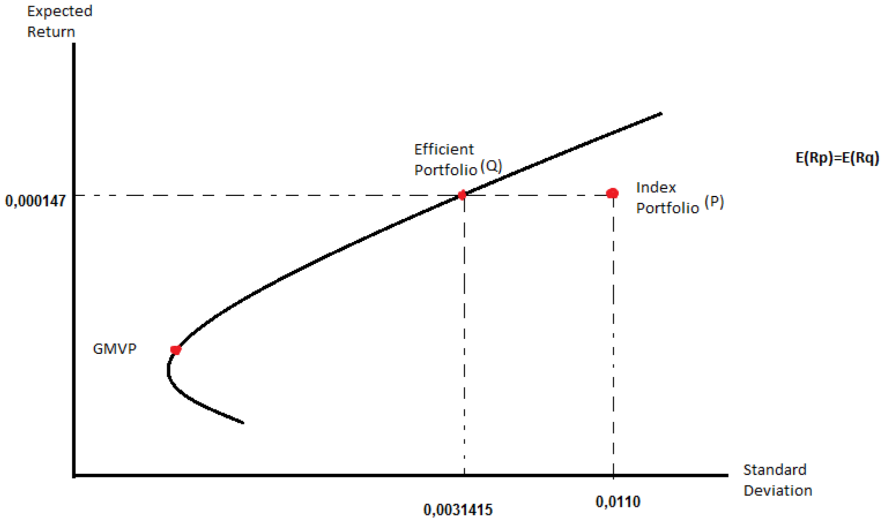
Using daily data for the sub period A we proved with three different ways that FTSE 100 Index is inefficient.

Sub period B

Method 1: Schematically

We repeat the same steps for the **sub period B** providing the Figure 5.21 prove the inefficiency of the market portfolio. GMVP analysis: return 0.0004088, standard deviation 0.00311962.

Figure 5.21.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year-Sub period B (2007)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period B.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.27. provides us the weights of the efficient portfolio Q.

Table 5.27.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (10 periods-1 year-Sub period B (2007)-daily data)

Firm	Weights
AAL LN	0,010667
ABF LN	0,051502
ADM LN	0,006493
AHT LN	0,012512
ANTO LN	-0,03754
AV/ LN	0,087242
AZN LN	-0,01235
BA/ LN	0,04395
BAB LN	0,005749
BARC LN	-0,02051
BATS LN	0,013702
BDEV LN	-0,03003
BLND LN	0,030304
BLT LN	-0,02543
BNZL LN	0,017532
BP/ LN	0,085128
BRBY LN	-0,03154
BT/A LN	0,024275
CCH LN	0,073462
CCL LN	0,001842
CNA LN	0,026202
CPG LN	-0,03801
CPI LN	-0,02909
CRH LN	0,057973
DC/ LN	0,003836
DCC LN	0,023587
DGE LN	0,045866
DLG LN	0,144107
EXPN LN	0,013671
EZJ LN	-0,02198
FRES LN	0,008281
GKN LN	0,055981
GLEN LN	0,047805
GSK LN	0,041093
HIK LN	0,026146
HL/ LN	0,005593
HMSO LN	0,003061
HSBA LN	0,146536

IAG LN	-0,01686
IHG LN	0,033595
III LN	0,001351
IMB LN	0,011084
INF LN	0,003995
INTU LN	-0,00077
ITRK LN	0,048645
ITV LN	0,067067
JMAT LN	-0,02351
KGF LN	0,007165
LAND LN	-0,00224
LGEN LN	-0,03892
LLOY LN	0,004227
LSE LN	0,036685
MCRO LN	0,016235
MDC LN	0,035863
MERL LN	0,1166
MKS LN	-0,01345
MNDI LN	0,013951
MRW LN	-0,00897
NG/ LN	-0,07823
NXT LN	-0,01825
OML LN	-0,05602
PFG LN	0,016323
POLY LN	0,012016
PPB LN	0,008824
PRU LN	-0,05592
PSN LN	0,067462
PSON LN	0,033092
RB/ LN	0,088164
RBS LN	-0,05607
RDSA LN	0,01691
RDSB LN	-0,03594
REL LN	-0,09446
RIO LN	-0,00589
RMG LN	0,047815
RR/ LN	0,017993
RRS LN	-0,01189
RSA LN	-0,0294
SAB LN	-0,03747
SBRY LN	0,014417
SDR LN	-0,04521

SGE LN	0,008196
SHP LN	0,027808
SKY LN	0,002687
SL/ LN	0,020622
SMIN LN	-0,00992
SN/ LN	-0,0254
SSE LN	-0,03998
STAN LN	0,012067
STJ LN	-0,04642
SVT LN	0,043625
TPK LN	-0,01758
TSCO LN	-0,03447
TW/ LN	-0,03871
ULVR LN	-0,02897
UU/ LN	0,082162
VOD LN	0,05065
WOS LN	-0,04344
WPP LN	0,081704
WTB LN	-0,00229
Sum	1
Portfolio variance	9,87E-06
Portfolio standard deviation	0,003142

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period B.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0031415]^2}{[0{,}011000915]^2} = 0{,}081550091 < 1 \ (\mathbf{5.41})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.9184 \neq 0 \ \ (\mathbf{5.42})$$

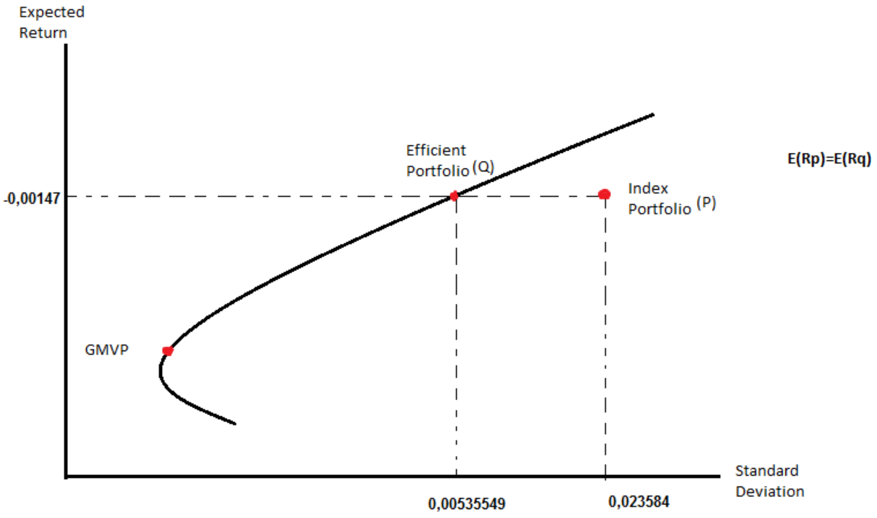
Using daily data for the sub period B we proved with three different ways that FTSE 100 Index is inefficient.

Sub period C

Method 1: Schematically

We repeat the same steps for the **sub period C** providing the Figure 5.22 prove the inefficiency of the market portfolio. GMVP analysis: return 0.0006664, standard deviation 0.0038030.

Figure 5.22.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year-Sub period C (2008)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period C.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.28. provides us the weights of the efficient portfolio Q.

Table 5.28.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (10 periods-1 year-Sub period C (2008)-daily data)

Firm	Weights
AAL LN	0,036588
ABF LN	0,035665
ADM LN	-0,00842
AHT LN	0,007038
ANTO LN	-0,00634
AV/ LN	0,002746
AZN LN	-0,07771
BA/ LN	0,045405
BAB LN	0,023505
BARC LN	-0,03068
BATS LN	-0,0193
BDEV LN	0,009035
BLND LN	-0,00467
BLT LN	-0,07483
BNZL LN	0,030453
BP/ LN	-0,00286
BRBY LN	0,011626
BT/A LN	0,059791
CCH LN	0,12365
CCL LN	0,011633
CNA LN	0,063807
CPG LN	-0,09611
CPI LN	0,063118
CRH LN	-0,02206
DC/ LN	2,58E-05
DCC LN	0,04135
DGE LN	0,088783
DLG LN	0,167004
EXPN LN	0,025462
EZJ LN	0,009928
FRES LN	0,021901
GKN LN	-0,00118
GLEN LN	0,123015
GSK LN	0,016539
HIK LN	0,046377
HL/ LN	0,027472
HMSO LN	0,039412
HSBA LN	0,068222

IAG LN	-0,04563
IHG LN	0,042098
III LN	0,044743
IMB LN	0,037187
INF LN	0,020316
INTU LN	-0,01493
ITRK LN	0,071754
ITV LN	-0,00458
JMAT LN	0,057751
KGF LN	-0,05528
LAND LN	0,023822
LGEN LN	-0,02759
LLOY LN	-0,02043
LSE LN	0,069154
MCRO LN	-0,01658
MDC LN	0,061135
MKS LN	0,058468
MNDI LN	0,014724
MRW LN	0,007993
NG/ LN	0,10099
NXT LN	-0,00966
OML LN	0,02714
PFG LN	-0,01228
POLY LN	0,073838
PPB LN	0,012837
PRU LN	-0,042
PSN LN	-0,00346
PSON LN	-0,03597
RB/ LN	0,035911
RBS LN	0,054099
RDSA LN	-0,10424
RDSB LN	0,050125
REL LN	0,037424
RIO LN	-0,00876
RR/ LN	-0,04745
RRS LN	0,030975
RSA LN	-0,01823
SAB LN	-0,02224
SBRY LN	-0,08294
SDR LN	-0,05214
SGE LN	0,024303
SHP LN	-0,01028

SKY LN	-0,10584
SL/ LN	0,005163
SMIN LN	-0,00316
SN/ LN	-0,00113
SSE LN	-0,01423
STAN LN	-0,02824
STJ LN	0,001224
SVT LN	0,038684
TPK LN	0,021139
TSCO LN	0,011476
TW/ LN	0,000375
ULVR LN	-0,04785
UU/ LN	0,010471
VOD LN	0,005146
WOS LN	-0,00142
WPP LN	-0,0923
WTB LN	0,022996
Sum	1
Portfolio variance	2,87E-05
Portfolio standard deviation	0,005355

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period C.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}00535549]^2}{[0{,}023584326]^2} = 0{,}051564613 < 1 \ (\mathbf{5.43})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.9484 \neq 0 \ \ (\mathbf{5.44})$$

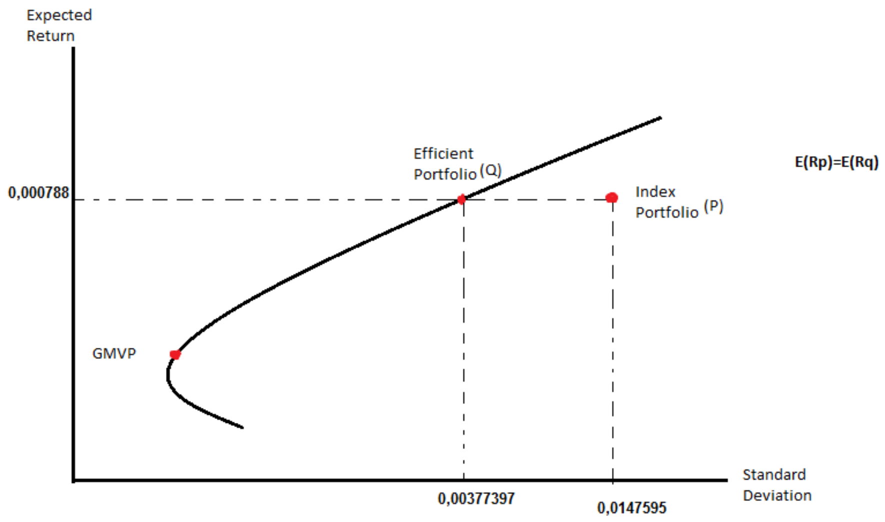
Using daily data for the sub period C we proved with three different ways that FTSE 100 Index is inefficient.

Sub period D

Method 1: Schematically

We repeat the same steps for the **sub period D** providing the Figure 5.23 prove the inefficiency of the market portfolio. GMVP analysis: return 0.0008135, standard deviation 0.00377366.

Figure 5.23.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year-Sub period D (2009)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period D.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.29. provides us the weights of the efficient portfolio Q.

Table 5.29.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (10 periods-1 year-Sub period D (2009)-daily data)

Firm	Weights
AAL LN	-0,02654
ABF LN	0,018199
ADM LN	0,043126
AHT LN	0,030418
ANTO LN	-0,00237
AV/ LN	-0,00275
AZN LN	0,010132
BA/ LN	0,035057
BAB LN	-0,01045
BARC LN	-0,00436
BATS LN	0,021942
BDEV LN	0,009487
BLND LN	0,004842
BLT LN	0,030206
BNZL LN	0,032893
BP/ LN	0,069904
BRBY LN	0,002391
BT/A LN	0,029115
CCL LN	-4,7E-05
CNA LN	-0,01084
CPG LN	-0,01801
CPI LN	-0,03237
CRH LN	-0,02189
DC/ LN	0,06168
DCC LN	0,008488
DGE LN	-0,02721
EXPN LN	0,115133
EZJ LN	-0,00433
FRES LN	0,014688
GKN LN	0,01901
GLEN LN	0,058413
GSK LN	0,013006
HIK LN	0,028977
HL/ LN	0,119284
HMSO LN	-0,05291
HSBA LN	-0,02742
IAG LN	-0,00443
IHG LN	-0,0166

III LN	-0,01823
IMB LN	0,036565
INF LN	-0,0009
INTU LN	0,023226
ITRK LN	-0,01756
ITV LN	0,001616
JMAT LN	-0,01545
KGF LN	-0,01572
LAND LN	0,032119
LGEN LN	0,01272
LLOY LN	0,005722
LSE LN	0,016584
MCRO LN	0,007201
MKS LN	-0,01718
MNDI LN	0,071338
MRW LN	0,018589
NG/ LN	0,047898
NXT LN	0,082467
OML LN	-0,02276
PFG LN	0,097845
POLY LN	0,047506
PPB LN	0,028003
PRU LN	-0,01767
PSN LN	-0,01
PSON LN	0,012762
RB/ LN	0,02969
RBS LN	-0,00366
RDSA LN	0,009276
RDSB LN	-0,04093
REL LN	-0,02451
RIO LN	-0,00425
RR/ LN	-0,04094
RRS LN	0,02247
RSA LN	0,002481
SAB LN	-0,05274
SBRY LN	-0,01786
SDR LN	0,016878
SGE LN	0,015077
SHP LN	-0,00705
SKY LN	0,004594
SL/ LN	0,08531
SMIN LN	0,022924

SN/ LN	0,028365
SSE LN	0,061894
STAN LN	0,016844
STJ LN	-0,00132
SVT LN	0,05966
TPK LN	-0,0186
TSCO LN	0,019356
TW/ LN	-0,0058
ULVR LN	0,019491
UU/ LN	-0,05804
VOD LN	-0,0199
WOS LN	-0,00626
WPP LN	-0,00285
WTB LN	-0,03016
Sum	1
Portfolio variance	1,42E-05
Portfolio standard deviation	0,003774

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period D.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}00377397]^2}{[0{,}01475958]^2} = 0{,}06538076 < 1 \; (\mathbf{5.45})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.9346 \neq 0 \;\; (\mathbf{5.46})$$

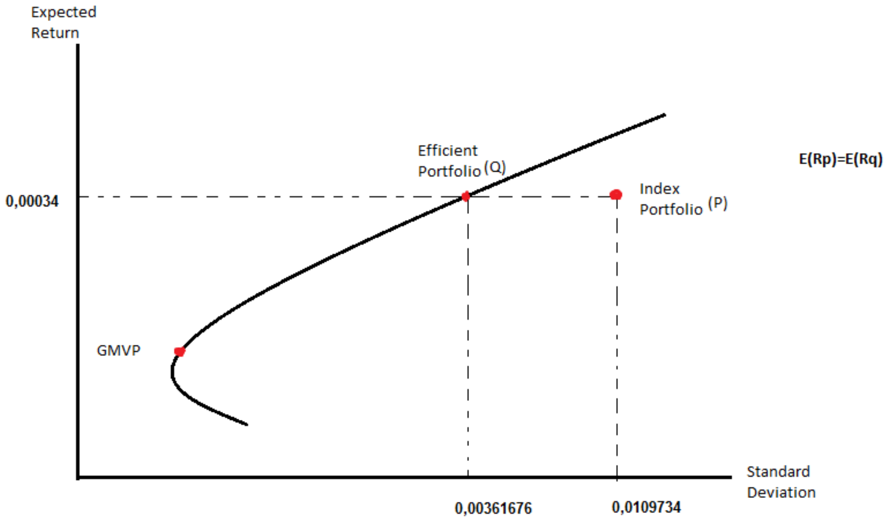
Using daily data for the sub period D we proved with three different ways that FTSE 100 Index is inefficient.

Sub period E

Method 1: Schematically

We repeat the same steps for the **sub period E** providing the Figure 5.24 prove the inefficiency of the market portfolio. GMVP analysis: return 0.00025668, standard deviation 0.00361377.

Figure 5.24.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year-Sub period E (2010)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period E.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.30. provides us the weights of the efficient portfolio Q.

Table 5.30.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (10 periods-1 year-Sub period E (2010)-daily data)

Firm	Weights
AAL LN	-0,00559
ABF LN	-0,01652
ADM LN	0,088823
AHT LN	0,04295
ANTO LN	-0,037
AV/ LN	-0,03236
AZN LN	0,015755
BA/ LN	0,017427
BAB LN	-0,01322
BARC LN	-0,01629
BATS LN	-0,03174
BDEV LN	-0,03613
BLND LN	0,067153
BLT LN	-0,00281
BNZL LN	0,054115
BP/ LN	0,024269
BRBY LN	-0,00368
BT/A LN	-0,04116
CCL LN	-0,04029
CNA LN	0,032749
CPG LN	0,011408
CPI LN	-0,01522
CRH LN	-0,04697
DC/ LN	0,071454
DCC LN	0,033773
DGE LN	0,037591
EXPN LN	0,093437
EZJ LN	0,019331
FRES LN	0,041825
GKN LN	-0,02128
GLEN LN	0,001933
GSK LN	0,035635
HIK LN	0,04532
HL/ LN	0,018047
HMSO LN	0,041718
HSBA LN	0,03781
IAG LN	-0,02551
IHG LN	0,000537

III LN	-0,01513
IMB LN	0,03481
INF LN	-0,04635
INTU LN	-0,03756
ITRK LN	-0,00873
ITV LN	-0,01716
JMAT LN	-0,0454
KGF LN	-0,02875
LAND LN	-0,07241
LGEN LN	-0,04183
LLOY LN	0,027065
LSE LN	0,014417
MCRO LN	0,005262
MKS LN	-0,05163
MNDI LN	-0,00348
MRW LN	0,044599
NG/ LN	0,036108
NXT LN	0,04982
OML LN	-0,05521
PFG LN	-0,00313
PPB LN	0,035313
PRU LN	0,054954
PSN LN	0,027174
PSON LN	0,03946
RB/ LN	0,043294
RBS LN	0,018301
RDSA LN	0,084756
RDSB LN	-0,09491
REL LN	0,028115
RIO LN	0,013064
RR/ LN	0,010223
RRS LN	0,055825
RSA LN	0,04963
SAB LN	-0,09411
SBRY LN	-0,0207
SDR LN	0,039741
SGE LN	-0,0185
SHP LN	0,049283
SKY LN	0,048168
SL/ LN	0,094291
SMIN LN	0,021314
SN/ LN	0,036068

SSE LN	0,00062
STAN LN	0,004098
STJ LN	0,013871
SVT LN	-0,00884
TPK LN	0,021409
TSCO LN	0,084521
TW/ LN	-0,00028
ULVR LN	-0,01713
UU/ LN	0,076199
VOD LN	0,097229
WOS LN	0,005348
WPP LN	-0,00126
WTB LN	-0,02914
Sum	1
Portfolio variance	1,31E-05
Portfolio standard deviation	0,003617

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period E.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0036167]^2}{[0{,}0109734]^2} = 0{,}108632 < 1 \ (\mathbf{5.47})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.8913 \neq 0 \ \ (\mathbf{5.48})$$

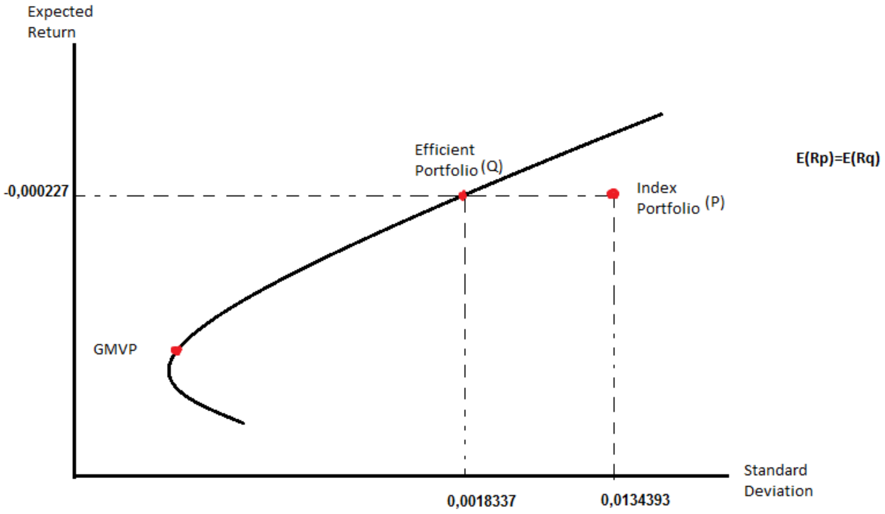
Using daily data for the sub period E we proved with three different ways that FTSE 100 Index is inefficient.

Sub period F

Method 1: Schematically

We repeat the same steps for the **sub period F** providing the Figure 5.25 prove the inefficiency of the market portfolio. GMVP analysis: return 0.00011794, standard deviation 0.0016088.

Figure 5.25.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year-Sub period F (2011)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period F.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.31. provides us the weights of the efficient portfolio Q.

Table 5.31.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (10 periods-1 year-Sub period F (2011)-daily data)

Firm	Weights
AAL LN	-0,36645
ABF LN	0,15894
ADM LN	0,004621
AHT LN	0,010908
ANTO LN	0,053889
AV/ LN	-0,00745
AZN LN	-0,42689
BA/ LN	0,093611
BAB LN	0,353128
BARC LN	-0,01982
BATS LN	-0,18063
BDEV LN	-0,01387
BLND LN	0,044288
BLT LN	0,022116
BNZL LN	0,090057
BP/ LN	0,217581
BRBY LN	0,120138
BT/A LN	-0,14167
CCL LN	0,272652
CNA LN	0,357717
CPG LN	-0,33984
CPI LN	-0,34945
CRH LN	0,064279
DC/ LN	0,1722
DCC LN	0,24315
DGE LN	-0,03726
EXPN LN	-0,05075
EZJ LN	0,339447
FRES LN	0,178104
GKN LN	0,025721
GSK LN	0,239489
HIK LN	-0,17717
HL/ LN	0,138048
HMSO LN	0,000237
HSBA LN	0,009908
IAG LN	0,17559
IHG LN	0,068176
III LN	0,090738

IMB LN	0,036411
INF LN	-0,01379
INTU LN	-0,05823
ITRK LN	-0,1869
ITV LN	0,123294
JMAT LN	0,006727
KGF LN	-0,20828
LAND LN	-0,12418
LGEN LN	0,032256
LLOY LN	-0,08989
LSE LN	0,056781
MCRO LN	-0,00826
MKS LN	0,032909
MNDI LN	0,014336
MRW LN	-0,01768
NG/ LN	0,020099
NXT LN	0,068306
OML LN	-0,20709
PFG LN	0,075976
PPB LN	-0,00147
PRU LN	-0,10531
PSN LN	0,005143
PSON LN	-0,01351
RB/ LN	0,022402
RBS LN	-0,09723
RDSA LN	-0,02942
RDSB LN	0,079353
REL LN	-0,07196
RIO LN	0,025156
RR/ LN	0,008922
RRS LN	0,281469
RSA LN	0,317747
SAB LN	-0,11665
SBRY LN	-0,0863
SDR LN	0,02338
SGE LN	0,061468
SHP LN	-0,01912
SKY LN	-0,01025
SL/ LN	-0,03169
SMIN LN	-0,1614
SN/ LN	0,07988
SSE LN	-0,03178

STAN LN	0,535389
STJ LN	-0,18045
SVT LN	-0,06691
TPK LN	0,074701
TSCO LN	-0,07098
TW/ LN	-0,07276
ULVR LN	-0,01265
UU/ LN	-0,01189
VOD LN	0,038801
WOS LN	-0,01791
WPP LN	-0,30173
WTB LN	-0,02868
Sum	1
Portfolio variance	3,36E-06
Portfolio standard deviation	0,001834

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period F.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0018337]^2}{[0{,}0134393]^2} = 0{,}01861664 < 1 \ (\mathbf{5.49})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.9813 \neq 0 \quad (\mathbf{5.50})$$

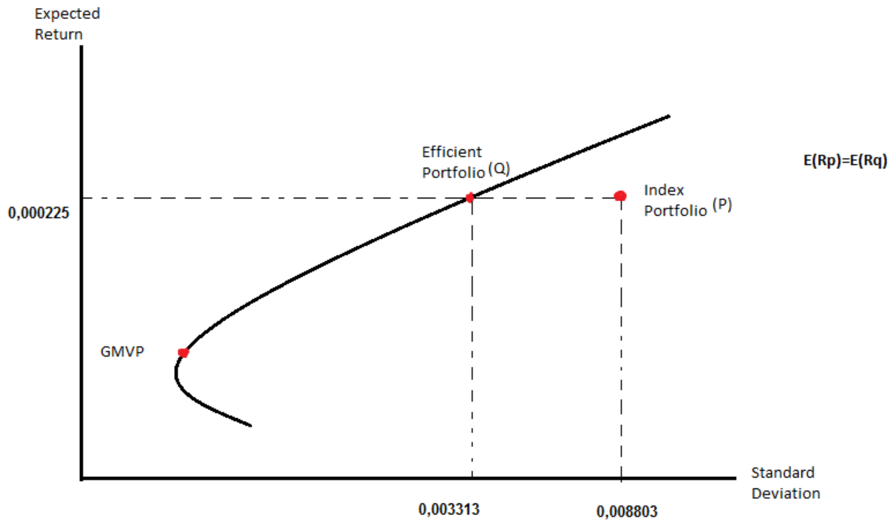
Using daily data for the sub period F we proved with three different ways that FTSE 100 Index is inefficient.

Sub period G

Method 1: Schematically

We repeat the same steps for the **sub period G** providing the Figure 5.26 prove the inefficiency of the market portfolio. GMVP analysis: return 0.00053151, standard deviation 0.00327427.

Figure 5.26.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year-Sub period G (2012)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period G.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.32. provides us the weights of the efficient portfolio Q.

Table 5.32.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (10 periods-1 year-Sub period G (2012)-daily data)

Firm	**Weights**
AAL LN	0,013897
ABF LN	0,046729
ADM LN	-0,00937
AHT LN	-0,02478
ANTO LN	0,015157
AV/ LN	-0,01655
AZN LN	-0,00944
BA/ LN	0,010529
BAB LN	0,042341
BARC LN	-0,03449
BATS LN	0,013482
BDEV LN	-0,02434
BLND LN	0,048927
BLT LN	0,028203
BNZL LN	-0,03617
BP/ LN	-0,02628
BRBY LN	0,007802
BT/A LN	-0,04207
CCL LN	0,001387
CNA LN	0,044044
CPG LN	-0,04354
CPI LN	-0,02287
CRH LN	0,009527
DCC LN	0,047087
DGE LN	-0,02995
EXPN LN	0,112917
EZJ LN	0,007766
FRES LN	0,062641
GKN LN	0,004971
GSK LN	0,078794
HIK LN	0,017008
HL/ LN	0,040702
HMSO LN	0,023495
HSBA LN	-0,05361
IAG LN	0,024126
IHG LN	-0,03913
III LN	-0,02687
IMB LN	0,026552

INF LN	0,007478
INTU LN	-0,06282
ITRK LN	-0,01142
ITV LN	-0,00797
JMAT LN	-0,01835
KGF LN	0,068065
LAND LN	0,05229
LGEN LN	0,037959
LLOY LN	0,00223
LSE LN	-0,02221
MCRO LN	0,023247
MKS LN	-0,05293
MNDI LN	0,078941
MRW LN	0,108019
NG/ LN	0,088301
NXT LN	0,027533
OML LN	-0,01651
PFG LN	0,037694
PPB LN	0,052389
PRU LN	-0,02516
PSN LN	0,011809
PSON LN	-0,02853
RB/ LN	0,04283
RBS LN	0,04538
RDSA LN	-0,00342
RDSB LN	0,051003
REL LN	0,002297
RIO LN	-0,02458
RR/ LN	0,03415
RRS LN	0,002713
RSA LN	0,01092
SAB LN	-0,01302
SBRY LN	-0,00658
SDR LN	0,01205
SGE LN	0,061686
SHP LN	0,012035
SKY LN	0,044997
SL/ LN	0,054043
SMIN LN	-0,00721
SN/ LN	0,023763
SSE LN	0,022733
STAN LN	-0,00029

STJ LN	0,027966
SVT LN	-0,00672
TPK LN	-0,00201
TSCO LN	-0,02924
TW/ LN	-0,03483
ULVR LN	-0,01285
UU/ LN	0,024008
VOD LN	0,03121
WOS LN	-0,03112
WPP LN	0,0126
WTB LN	0,016786
Sum	1
Portfolio variance	1,1E-05
Portfolio standard deviation	0,003314

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period G.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0033135]^2}{[0{,}0088032]^2} = 0{,}1416789 < 1 \ (\mathbf{5.51})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.8583 \neq 0 \ \ (\mathbf{5.52})$$

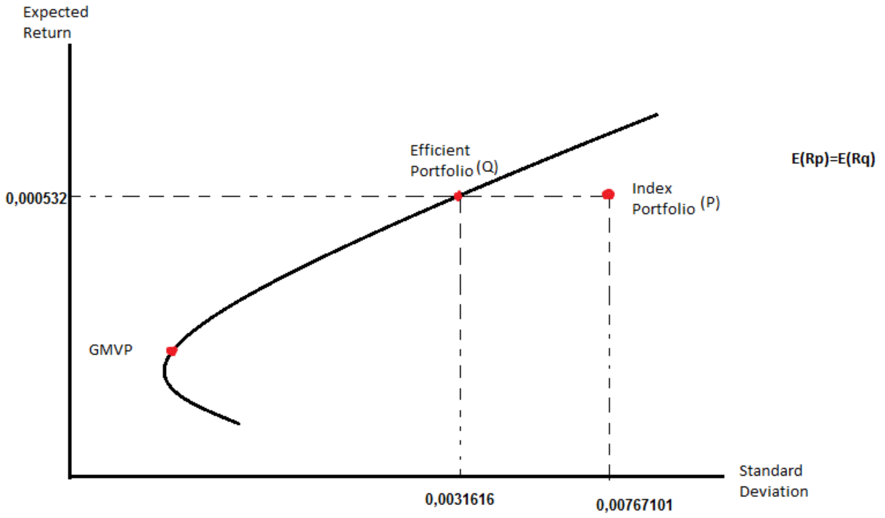
Using daily data for the sub period G we proved with three different ways that FTSE 100 Index is inefficient.

Sub period H

Method 1: Schematically

We repeat the same steps for the **sub period H** providing the Figure 5.27 prove the inefficiency of the market portfolio. GMVP analysis: return 0.000301, standard deviation 0.0028252.

Figure 5.27.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year-Sub period H (2013)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period H.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.33. provides us the weights of the efficient portfolio Q.

Table 5.33.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (10 periods-1 year-Sub period H (2013)-daily data)

Firm	Weights
AAL LN	-0,14955
ABF LN	-0,26587
ADM LN	0,404191
AHT LN	-0,34183
ANTO LN	0,073302
AV/ LN	0,231073
AZN LN	-0,02255
BA/ LN	-0,16413
BAB LN	-0,02466
BARC LN	0,10248
BATS LN	0,041973
BDEV LN	0,085189
BLND LN	-0,09375
BLT LN	-0,23258
BNZL LN	0,067587
BP/ LN	0,033146
BRBY LN	-1,02116
BT/A LN	0,075296
CCL LN	-0,09348
CNA LN	-0,32669
CPG LN	-0,09045
CPI LN	0,243319
CRH LN	-0,41208
DCC LN	-0,13967
DGE LN	0,209162
EXPN LN	0,229689
EZJ LN	-0,12089
FRES LN	-0,20044
GKN LN	0,220208
GSK LN	-0,00896
HIK LN	0,210365
HL/ LN	-0,40081
HMSO LN	0,078992
HSBA LN	-0,5013
IAG LN	-0,15569
IHG LN	0,153903
III LN	0,489964
IMB LN	-0,1576

INF LN	0,011675
INTU LN	-0,23519
ITRK LN	-0,17243
ITV LN	-0,70757
JMAT LN	0,972518
KGF LN	0,169896
LAND LN	0,202262
LGEN LN	0,181456
LLOY LN	0,66472
LSE LN	-0,87378
MCRO LN	0,461305
MKS LN	-0,70362
MNDI LN	0,078371
MRW LN	0,164121
NG/ LN	-0,27433
NXT LN	0,127559
OML LN	0,004898
PFG LN	0,430926
PPB LN	0,147102
PRU LN	0,61612
PSN LN	0,084812
PSON LN	0,284906
RB/ LN	0,201091
RBS LN	-0,04569
RDSA LN	0,020182
RDSB LN	-0,00086
REL LN	0,144777
RIO LN	-0,01483
RR/ LN	0,736818
RRS LN	0,08543
RSA LN	-0,12851
SAB LN	0,108112
SBRY LN	-0,36223
SDR LN	0,336575
SGE LN	-0,20148
SHP LN	0,286705
SKY LN	0,804591
SL/ LN	0,117462
SMIN LN	0,062095
SN/ LN	-0,08047
SSE LN	-0,25679
STAN LN	-0,12626

STJ LN	-0,14461
SVT LN	-0,22145
TPK LN	-0,59251
TSCO LN	0,391221
TW/ LN	-0,06084
ULVR LN	-0,09465
UU/ LN	0,730375
VOD LN	-0,6075
WOS LN	0,478264
WPP LN	-0,76662
WTB LN	0,540202
Sum	1
Portfolio variance	1E-05
Portfolio standard deviation	0,003162

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period H.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0031616]^2}{[0{,}007671]^2} = 0{,}169867 < 1 \; (\mathbf{5.53})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.8301 \neq 0 \quad (\mathbf{5.54})$$

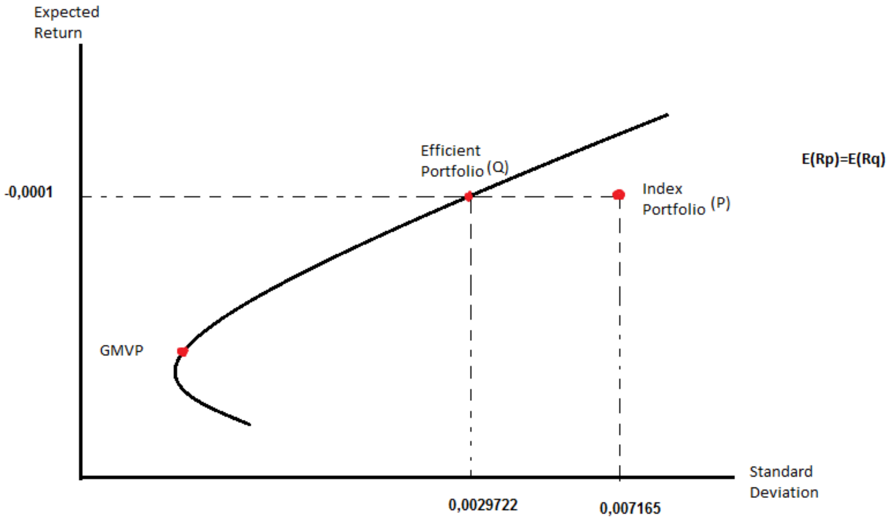
Using daily data for the sub period H we proved with three different ways that FTSE 100 Index is inefficient.

Sub period I

Method 1: Schematically

We repeat the same steps for the **sub period I** providing the Figure 5.28 prove the inefficiency of the market portfolio. GMVP analysis: return -0.034786, standard deviation 0.0095765.

Figure 5.28.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year-Sub period I (2014)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period I.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.34. provides us the weights of the efficient portfolio Q.

Table 5.34.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (10 periods-1 year-Sub period I (2014)-daily data)

Firm	Weights
AAL LN	0,123297
ABF LN	-0,03668
ADM LN	-0,03144
AHT LN	-0,11602
ANTO LN	-0,01123
AV/ LN	0,045057
AZN LN	0,068494
BA/ LN	-0,0292
BAB LN	0,048641
BARC LN	0,021831
BATS LN	0,256764
BDEV LN	-0,02104
BLND LN	-0,15345
BLT LN	-0,01903
BNZL LN	0,282593
BP/ LN	0,111572
BRBY LN	-0,11155
BT/A LN	0,18056
CCL LN	0,049545
CNA LN	0,009435
CPG LN	0,286057
CPI LN	0,006256
CRH LN	0,081813
DCC LN	0,224407
DGE LN	0,054177
EXPN LN	0,26602
EZJ LN	0,045245
GKN LN	-0,21307
GSK LN	0,026444
HIK LN	-0,02342
HL/ LN	0,031037
HMSO LN	-0,01965
HSBA LN	-0,20571
IAG LN	0,071371
IHG LN	0,038811
III LN	-0,35476
IMB LN	0,070911
INF LN	-0,08602

INTU LN	0,012661
ITRK LN	0,040292
ITV LN	-0,04017
JMAT LN	-0,18296
KGF LN	-0,41519
LAND LN	-0,00127
LGEN LN	-0,13284
LLOY LN	-0,16347
LSE LN	0,29947
MCRO LN	0,034286
MKS LN	0,375549
MNDI LN	-0,04619
MRW LN	-0,01252
NG/ LN	0,020045
NXT LN	-0,19919
OML LN	-0,0084
PFG LN	-0,02515
PPB LN	0,297687
PRU LN	0,139123
PSN LN	0,043571
PSON LN	-0,01511
RB/ LN	0,017533
RBS LN	0,001394
RDSA LN	0,416829
RDSB LN	-0,28446
REL LN	0,036429
RIO LN	-0,08767
RR/ LN	0,236792
RRS LN	-0,10024
RSA LN	0,278569
SAB LN	-0,40303
SBRY LN	-0,0227
SDR LN	-0,11576
SGE LN	0,042659
SHP LN	-0,09537
SKY LN	-0,10593
SL/ LN	0,009757
SMIN LN	-0,06558
SN/ LN	-0,15372
SSE LN	0,050599
STAN LN	0,221469
STJ LN	-0,16379

SVT LN	-0,0741
TPK LN	0,178142
TSCO LN	-0,07822
TW/ LN	0,021752
ULVR LN	0,089519
UU/ LN	-0,01404
VOD LN	0,14764
WOS LN	0,021369
WPP LN	0,00352
WTB LN	0,002334
Sum	1
Portfolio variance	8,83E-06
Portfolio standard deviation	0,002972

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period I.

<u>Method 3: R-squared</u>

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0029722]^2}{[0{,}0071651]^2} = 0{,}172069 < 1 \ (\mathbf{5.55})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var\left(R_p\right)} = 0.8279 \neq 0 \quad (\mathbf{5.56})$$

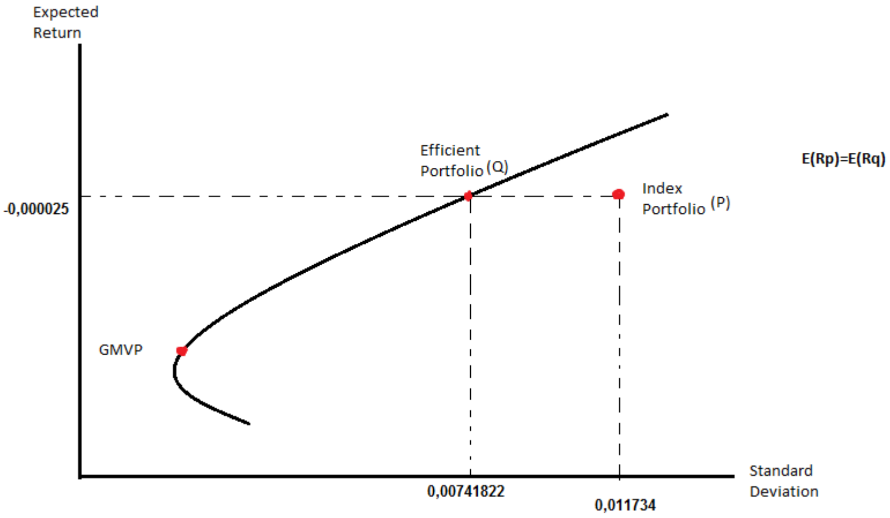
Using daily data for the sub period I we proved with three different ways that FTSE 100 Index is inefficient.

Sub period J

Method 1: Schematically

We repeat the same steps for the **sub period J** providing the Figure 5.29 prove the inefficiency of the market portfolio. GMVP analysis: return -0.0029519, standard deviation 0.0056611.

Figure 5.29.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year-Sub period J (2015-2016)-daily data)



Schematically, it is obvious that the market portfolio is not lying in the efficient frontier also for the sub period J.

Method 2: Calculating weights

The second way to prove the inefficiency is by calculating the weights of the efficient portfolio Q that has the same mean as the index portfolio. If there are both positive and negative weights, then the index portfolio is inefficient as the index portfolio must have only positive weights. The Table 5.35. provides us the weights of the efficient portfolio Q.

Table 5.35.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (10 periods-1 year-Sub period J (2015-2016)-daily data)

Firm	**Weights**
AAL LN	-0,11447
ABF LN	0,158835
ADM LN	-0,41125
AHT LN	-0,07065
ANTO LN	0,10121
AV/ LN	-0,09349
AZN LN	0,083833
BA/ LN	-0,29266
BAB LN	-0,27742
BARC LN	-0,13834
BATS LN	-0,35343
BDEV LN	0,05785
BLND LN	0,069059
BLT LN	0,032642
BNZL LN	-0,048
BP/ LN	-0,02219
BRBY LN	-0,01996
BT/A LN	-0,00932
CCL LN	-0,52118
CNA LN	0,506373
CPG LN	-0,19553
CPI LN	0,152378
CRH LN	0,123461
DCC LN	-0,49698
DGE LN	0,292134
EZJ LN	0,09003
GKN LN	0,287848
GSK LN	0,252128
HIK LN	0,540471
HMSO LN	0,236948
HSBA LN	-0,25468
IAG LN	-0,17312
IHG LN	0,110894
III LN	-0,05075
IMB LN	0,018029
INF LN	-0,2031
INTU LN	0,202665
ITRK LN	0,034742

ITV LN	-0,02937
JMAT LN	0,845125
KGF LN	0,054145
LAND LN	0,062236
LGEN LN	-0,23923
LLOY LN	-0,13154
LSE LN	0,209705
MCRO LN	0,102451
MKS LN	-0,3759
MRW LN	-0,01344
NG/ LN	0,764483
NXT LN	-1,19163
OML LN	-0,08686
PFG LN	-0,16458
PPB LN	0,636465
PRU LN	-0,23641
PSN LN	0,045072
PSON LN	-0,0433
RB/ LN	0,341263
RBS LN	0,026903
RDSA LN	-0,00573
RDSB LN	-0,026
REL LN	-0,01448
RIO LN	-0,06597
RR/ LN	0,142481
RRS LN	0,262578
RSA LN	0,79025
SAB LN	0,222558
SBRY LN	0,128171
SDR LN	0,123491
SGE LN	-0,4443
SHP LN	-0,46429
SKY LN	0,452754
SMIN LN	-0,03331
SN/ LN	-0,23382
SSE LN	0,386728
STAN LN	-0,1949
STJ LN	-0,13328
SVT LN	-0,91052
TPK LN	1,211629
TSCO LN	0,16202
TW/ LN	-0,02733

ULVR LN	0,071888
UU/ LN	-0,46319
VOD LN	0,068573
WOS LN	-0,79518
WPP LN	0,562578
WTB LN	0,045981
Sum	1
Portfolio variance	5,5E-05
Portfolio standard deviation	0,007418

We may notice both positive and negative weights, therefore the market portfolio is not efficient for the sub period J.

Method 3: R-squared

The third way to prove this inefficiency is by using the R-squared.

$$R^2 = \frac{Var(R_q)}{Var(R_p)} = \frac{[0{,}0074182]^2}{[0{,}01173451]^2} = 0{,}399640 < 1 \ (\mathbf{5.57})$$

Testing the Equation 4.14:

$$\frac{Var(R_{ut})}{Var(R_p)} = 0.6003 \neq 0 \quad (\mathbf{5.58})$$

Using daily data for the sub period J we proved with three different ways that FTSE 100 Index is inefficient and this holds true for all the sub periods we examined in this chapter.

Those results lead us to the fact that FTSE 100 Index is inefficient and that the asset pricing model one should use is a model that treats the index as inefficient. Reviewing the literature (see chapter 3 and subchapter 3.24), the only model that fits is the 3D model of Dr. George Diacogiannis and Dr. David Feldman. The following table presents the results of the statistical method.

Table 5.36.: R-squared for periods and sub periods

Period-Years	**Sub period**	**Data**	**R^2**	$\boldsymbol{\frac{Var(R_{ut})}{Var(R_p)}}$
1-10	-	Daily	0.3932	0.6067
1-10	-	Weekly	0.2937	0.7062
1-10	-	Monthly	0.0063	0.9936
2-5	A (2006-2010)	Daily	0.0665	0.9334

2-5	B (2011-2016)	Daily	0.2469	0.7530
2-5	A (2006-2010)	Weekly	0.1072	0.8927
2-5	B (2011-2016)	Weekly	0.278	0.7219
2-5	A (2006-2010)	Monthly	6.704793E-15	0.9999
2-5	B (2011-2016)	Monthly	1.90779027E-14	0.9999
5-2	A (2006-2008)	Daily	0.1099	0.8900
5-2	B (2009-2010)	Daily	0.1311	0.8688
5-2	C (2011-2012)	Daily	0.1505	0.8494
5-2	D (2013-2014)	Daily	0.2841	0.7158
5-2	E (2015-2016)	Daily	0.2703	0.7296
5-2	A (2006-2008)	Weekly	0.0080	0.9919
5-2	B (2009-2010)	Weekly	0.0537	0.9462
5-2	C (2011-2012)	Weekly	0.0193	0.9806
5-2	D (2013-2014)	Weekly	0.0429	0.9570
5-2	**E (2015-2016)**	**Weekly**	**2.66346637E-15**	**0.9999**
10-1	A (2006)	Daily	0.1373	0.8626
10-1	B (2007)	Daily	0.0815	0.9184
10-1	C (2008)	Daily	0.0515	0.9484
10-1	D (2009)	Daily	0.0653	0.9346
10-1	E (2010)	Daily	0.1086	0.8913
10-1	F (2011)	Daily	0.018	0.9813
10-1	G (2012)	Daily	0.1416	0.8583
10-1	H (2013)	Daily	0.1698	0.8301
10-1	I (2014)	Daily	0.1720	0.8279
10-1	**J (2015-2016)**	**Daily**	**0.3996**	**0.6003**

We may notice the minimum R-squared when we split the weekly data in 5 periods of 2 years each at sub period E (2015-1016) and the maximum R-squared when we split the daily data in 10 periods of 1 year each at sub period J (2015-2016).

Chapter 6: Conclusion

The purpose of this thesis is to prove the inefficiency of the FTSE 100 index, so that the 3d model holds. If there is a chance that the market index is inefficient then the appropriate model for asset pricing should be one model that confronts the index as inefficient. Reviewing the bibliography there is not any model apart from the 3d model we mentioned.

We choose to test the efficiency of FTSE 100 Index as there was not any paper concerning the efficiency of this index and testing the 3d model. Many previous studies stated that indices were inefficient but we examine this point with updated data and mathematical ways.

The daily data concerning FTSE 100 Index prices and stock prices listed on FTSE 100 from June 2006 to June 2016 were received from Bloomberg terminal database. From these data, we calculated daily logarithmic returns, weekly prices and logarithmic returns and monthly prices and logarithmic returns (as implied by Jarque-Bera test). Splitting data to periods and sub periods with daily, weekly and monthly prices and returns, we followed Roll's methodology in order to create the efficient frontier portfolios. For this purpose we perform this methodology in:

(E) one period of 10 years with daily, weekly and monthly data,

(F) two periods of 5 years with daily, weekly and monthly data,

(G) five periods of 2 years with daily and weekly data and

(H) ten periods of 1 year with daily data.

The next part was to find if the index return and standard deviation was in the efficient frontier by the following three ways:

(g) First, we are using Roll's method (1977) for calculating the minimum variance portfolio set and we create a diagram such as Figure 2.9 to prove the inefficiency schematically. An index mean-standard deviation point lying outside the efficient frontier proves inefficiency.

(h) The second way is to find the weights of the efficient portfolio with the same expected return as the market index. If the weights of the efficient portfolio are both positive and negative, then the market index is inefficient due to the fact that the market index is constructed only with positive weights.

(i) The third method to prove the efficiency of the market index is by using statistical methods. An R-squared less than one prove inefficiency. We attempt to see whether the R-squared is lower than one, a result that will help us to see whether the variance of the residuals is zero or non-zero.

Moreover, for daily and monthly data of one period consisting of 10 years we will perform Fama and MacBeth (1973, See Subchapter 3.2) linear regression to prove that CAPM does not hold.

Indeed, there was not a period or sub period in which the index was efficient with any of three ways. Fama and MacBeth linear regression with daily, weekly and monthly data offers a proof that CAPM does not hold not only because it omits one variable that 3d model contains, but also because CAPM's beta is not weighted.

The restrictions of this thesis were the following: we use Roll's methodology (1977) only for FTSE 100 Index and years 2006-2016. Based on our restrictions and our results we will provide the following suggestions for further research. In a similar research one should follow the same procedure for another UK index or other country indices, for the same period or another time period. Taking into account previous studies, one should test whether the Fama-French factors are those that cause the inefficiency of the index. If not, what causes this inefficiency? Macro factors (such as gross domestic product and inflation) and micro factors (such as firm specific factors) should be tested separately.

Appendix 1: Summary Statistics

In this appendix, we will provide summary statistics for each stock returns. We justify one missing observation for the returns. More missing observations mean that the stock does not negotiate in the London stock exchange anymore.

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'UKXIndex' (2651 valid observations)

Mean	5.1020e-005
Median	0.00035512
Minimum	-0.092656
Maximum	0.093843
Standard deviation	0.012548
C.V.	245.95
Skewness	-0.13037
Ex. kurtosis	7.1127
5% percentile	-0.020147
95% percentile	0.018374
Interquartile range	0.012048
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'AALLNEquity' (2651 valid observations)

Mean	-0.00040032
Median	-0.00019875
Minimum	-0.22465
Maximum	0.20532
Standard deviation	0.032532
C.V.	81.266
Skewness	-0.023587
Ex. kurtosis	5.3221
5% percentile	-0.050468
95% percentile	0.047105
Interquartile range	0.033515
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'ABFLNEquity' (2651 valid observations)

Mean	0.00044286
Median	0.00033904
Minimum	-0.16624
Maximum	0.084498
Standard deviation	0.014565
C.V.	32.889
Skewness	-0.48157
Ex. kurtosis	9.8353
5% percentile	-0.021537
95% percentile	0.021650
Interquartile range	0.014849
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'ADMLNEquity' (2651 valid observations)

Mean	0.00055451
Median	0.00054333
Minimum	-0.29582
Maximum	0.22717
Standard deviation	0.020790
C.V.	37.492
Skewness	-0.98814
Ex. kurtosis	27.649
5% percentile	-0.030376
95% percentile	0.031113
Interquartile range	0.018435
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'AHTLNEquity' (2651 valid observations)

Mean	0.00069191
Median	0.0000
Minimum	-0.25187
Maximum	0.18789
Standard deviation	0.029773
C.V.	43.030
Skewness	-0.11822
Ex. kurtosis	7.3652
5% percentile	-0.044353
95% percentile	0.045161
Interquartile range	0.030893
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'ANTOLNEquity' (2651 valid observations)

Mean	7.4456e-005
Median	0.0000
Minimum	-0.19223
Maximum	0.20072
Standard deviation	0.030540
C.V.	410.18
Skewness	0.10587
Ex. kurtosis	3.9017
5% percentile	-0.050284
95% percentile	0.048245
Interquartile range	0.031424
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'AVLNEquity' (2651 valid observations)

Mean	-0.00022118
Median	0.0000
Minimum	-0.40599
Maximum	0.22392
Standard deviation	0.027503
C.V.	124.35
Skewness	-1.1825
Ex. kurtosis	24.498
5% percentile	-0.039857
95% percentile	0.038784
Interquartile range	0.022474
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'AZNLNEquity' (2651 valid observations)

Mean	0.00016688
Median	0.00016685
Minimum	-0.11780
Maximum	0.13431
Standard deviation	0.015119
C.V.	90.594
Skewness	-0.14670
Ex. kurtosis	8.0549
5% percentile	-0.022538
95% percentile	0.023354
Interquartile range	0.015042
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'BALNEquity' (2651 valid observations)

Mean	0.00011481
Median	0.00065295
Minimum	-0.098697
Maximum	0.10091
Standard deviation	0.016630
C.V.	144.85
Skewness	-0.18467
Ex. kurtosis	3.9890
5% percentile	-0.025843
95% percentile	0.026454
Interquartile range	0.00011481
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'BABLNEquity' (2651 valid observations)

Mean	0.00055913
Median	0.0000
Minimum	-0.11417
Maximum	0.15573
Standard deviation	0.017975
C.V.	32.148
Skewness	0.51421
Ex. kurtosis	8.2323
5% percentile	-0.025550
95% percentile	0.027355
Interquartile range	0.018212
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'BARCLNEquity' (2651 valid observations)

Mean	-0.00052369
Median	-0.00056290
Minimum	-0.28564
Maximum	0.54951
Standard deviation	0.034151
C.V.	65.212
Skewness	1.1755
Ex. kurtosis	34.384
5% percentile	-0.046255
95% percentile	0.047292
Interquartile range	0.026594
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'BATSLNEquity' (2651 valid observations)

Mean	0.00049292
Median	0.00021846
Minimum	-0.10467
Maximum	0.12029
Standard deviation	0.013749
C.V.	27.893
Skewness	0.11086
Ex. kurtosis	8.0184
5% percentile	-0.020310
95% percentile	0.021124
Interquartile range	0.014846
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'BDEVLNEquity' (2651 valid observations)

Mean	-0.00018159
Median	0.0000
Minimum	-0.34352
Maximum	0.32542
Standard deviation	0.035407
C.V.	194.98
Skewness	-0.32546
Ex. kurtosis	13.614
5% percentile	-0.050199
95% percentile	0.050462
Interquartile range	0.031215
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'BLNDLNEquity' (2651 valid observations)

Mean	-0.00014466
Median	0.0000
Minimum	-0.21742
Maximum	0.11222
Standard deviation	0.020610
C.V.	142.47
Skewness	-0.59826
Ex. kurtosis	8.5605
5% percentile	-0.030422
95% percentile	0.029911
Interquartile range	0.019732
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'BLTLNEquity' (2651 valid observations)

Mean	1.8112e-005
Median	0.0000
Minimum	-0.16252
Maximum	0.20607
Standard deviation	0.026539
C.V.	1465.3
Skewness	0.055245
Ex. kurtosis	4.5403
5% percentile	-0.041377
95% percentile	0.040385
Interquartile range	0.027915
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'BNZLLNEquity' (2651 valid observations)

Mean	0.00047876
Median	0.00064371
Minimum	-0.10526
Maximum	0.079292
Standard deviation	0.013882
C.V.	28.996
Skewness	-0.26616
Ex. kurtosis	4.9273
5% percentile	-0.020284
95% percentile	0.021429
Interquartile range	0.014538
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'BPLNEquity' (2651 valid observations)

Mean	-0.00014116
Median	-0.00010616
Minimum	-0.14037
Maximum	0.10583
Standard deviation	0.017469
C.V.	123.75
Skewness	-0.081308
Ex. kurtosis	5.8152
5% percentile	-0.026870
95% percentile	0.026652
Interquartile range	0.016974
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'BRBYLNEquity' (2651 valid observations)

Mean	0.00037151
Median	0.00054363
Minimum	-0.23411
Maximum	0.12452
Standard deviation	0.023507
C.V.	63.275
Skewness	-0.53272
Ex. kurtosis	7.9221
5% percentile	-0.035477
95% percentile	0.036079
Interquartile range	0.022868
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'BTALNEquity' (2651 valid observations)

Mean	0.00023397
Median	0.00027067
Minimum	-0.21073
Maximum	0.11867
Standard deviation	0.019298
C.V.	82.480
Skewness	-0.76049
Ex. kurtosis	11.957
5% percentile	-0.025787
95% percentile	0.028438
Interquartile range	0.019256
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'CCHLNEquity' (802 valid observations)

Mean	-0.00018392
Median	0.0000
Minimum	-0.075928
Maximum	0.070755
Standard deviation	0.017593
C.V.	95.656
Skewness	-0.15455
Ex. kurtosis	2.1876
5% percentile	-0.031362
95% percentile	0.027511
Interquartile range	0.017724
Missing obs.	1850

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'CCLLNEquity' (2651 valid observations)

Mean	3.0896e-006
Median	0.0000
Minimum	-0.17983
Maximum	0.13634
Standard deviation	0.020438
C.V.	6615.1
Skewness	-0.39022
Ex. kurtosis	6.9677
5% percentile	-0.030654
95% percentile	0.031842
Interquartile range	0.019561
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'CNALNEquity' (2651 valid observations)

Mean	-1.4109e-006
Median	0.00026677
Minimum	-0.12481
Maximum	0.13933
Standard deviation	0.015947
C.V.	113.03
Skewness	-0.071303
Ex. kurtosis	7.1628
5% percentile	-0.024831
95% percentile	0.022851
Interquartile range	0.016618
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'CPGLNEquity' (2651 valid observations)

Mean	0.00067011
Median	0.00067295
Minimum	-0.11143
Maximum	0.089243
Standard deviation	0.016082
C.V.	23.999
Skewness	-0.11668
Ex. kurtosis	5.5081
5% percentile	-0.023122
95% percentile	0.024157
Interquartile range	0.016294
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'CPILNEquity' (2651 valid observations)

Mean	0.00029846
Median	0.00066732
Minimum	-0.15373
Maximum	0.088634
Standard deviation	0.014900
C.V.	49.922
Skewness	-0.50141
Ex. kurtosis	7.9260
5% percentile	-0.021655
95% percentile	0.021975
Interquartile range	0.015435
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'CRHLNEquity' (2651 valid observations)

Mean	0.00012368
Median	0.0000
Minimum	-0.17926
Maximum	0.12686
Standard deviation	0.024044
C.V.	194.41
Skewness	-0.21316
Ex. kurtosis	3.4615
5% percentile	-0.038092
95% percentile	0.037938
Interquartile range	0.026317
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'DCLNEquity' (1582 valid observations)

Mean	0.00053165
Median	0.0000
Minimum	-0.67960
Maximum	0.14269
Standard deviation	0.026417
C.V.	49.688
Skewness	-10.721
Ex. kurtosis	278.20
5% percentile	-0.028050
95% percentile	0.033706
Interquartile range	0.020951
Missing obs.	1070

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'DCCLNEquity' (2651 valid observations)

Mean	0.00063027
Median	0.00035302
Minimum	-0.094452
Maximum	0.12087
Standard deviation	0.017517
C.V.	27.793
Skewness	0.20238
Ex. kurtosis	3.7394
5% percentile	-0.026068
95% percentile	0.029017
Interquartile range	0.017889
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'DGELNEquity' (2651 valid observations)

Mean	0.00034052
Median	0.0000
Minimum	-0.097805
Maximum	0.094852
Standard deviation	0.012782
C.V.	37.537
Skewness	0.15353
Ex. kurtosis	4.7240
5% percentile	-0.019649
95% percentile	0.019793
Interquartile range	0.014523
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'DLGLNEquity' (940 valid observations)

Mean	0.00062890
Median	0.0013760
Minimum	-0.096425
Maximum	0.071657
Standard deviation	0.012789
C.V.	20.335
Skewness	-0.98406
Ex. kurtosis	9.0091
5% percentile	-0.018587
95% percentile	0.018182
Interquartile range	0.013162
Missing obs.	1712

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'EXPNLNEquity' (2458 valid observations)

Mean	0.00037625
Median	0.0000
Minimum	-0.10017
Maximum	0.12554
Standard deviation	0.017775
C.V.	47.243
Skewness	0.043856
Ex. kurtosis	4.8606
5% percentile	-0.027141
95% percentile	0.028253
Interquartile range	0.017527
Missing obs.	194

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'EZJLNEquity' (2651 valid observations)

Mean	0.00036403
Median	0.00061331
Minimum	-0.25251
Maximum	0.16284
Standard deviation	0.025136
C.V.	69.048
Skewness	-0.49987
Ex. kurtosis	8.5569
5% percentile	-0.036879
95% percentile	0.037585
Interquartile range	0.024997
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'FRESLNEquity' (2058 valid observations)

Mean	0.00052766
Median	0.0000
Minimum	-0.22136
Maximum	0.20532
Standard deviation	0.031711
C.V.	60.097
Skewness	-0.080819
Ex. kurtosis	5.1431
5% percentile	-0.046571
95% percentile	0.049317
Interquartile range	0.033279
Missing obs.	594

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'GKNLNEquity' (2651 valid observations)

Mean	0.00011640
Median	0.0000
Minimum	-0.18421
Maximum	0.17519
Standard deviation	0.026471
C.V.	227.41
Skewness	0.0031705
Ex. kurtosis	5.3065
5% percentile	-0.041602
95% percentile	0.039850
Interquartile range	0.025720
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'GLENLNEquity' (1294 valid observations)

Mean	-0.00095698
Median	0.0000
Minimum	-0.34839
Maximum	0.19106
Standard deviation	0.031326
C.V.	32.734
Skewness	-0.83340
Ex. kurtosis	16.356
5% percentile	-0.046417
95% percentile	0.045465
Interquartile range	0.027294
Missing obs.	1358

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'GSKLNEquity' (2651 valid observations)

Mean	3.6635e-005
Median	0.0000
Minimum	-0.084748
Maximum	0.087053
Standard deviation	0.013087
C.V.	357.22
Skewness	0.034186
Ex. kurtosis	4.0725
5% percentile	-0.020082
95% percentile	0.019756
Interquartile range	0.014408
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'HIKLNEquity' (2651 valid observations)

Mean	0.00068785
Median	0.00053605
Minimum	-0.17625
Maximum	0.13129
Standard deviation	0.020088
C.V.	29.203
Skewness	-0.29967
Ex. kurtosis	7.3423
5% percentile	-0.030148
95% percentile	0.031975
Interquartile range	0.018844
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'HLLNEquity' (2308 valid observations)

Mean	0.00088826
Median	0.00052493
Minimum	-0.16732
Maximum	0.26955
Standard deviation	0.023488
C.V.	26.443
Skewness	0.67110
Ex. kurtosis	11.816
5% percentile	-0.035021
95% percentile	0.035953
Interquartile range	0.023913
Missing obs.	344

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'HMSOLNEquity' (2651 valid observations)

Mean	-9.5073e-005
Median	0.0000
Minimum	-0.13985
Maximum	0.10715
Standard deviation	0.020214
C.V.	212.61
Skewness	-0.33479
Ex. kurtosis	4.8418
5% percentile	-0.031407
95% percentile	0.030311
Interquartile range	0.018892
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'HSBALNEquity' (2651 valid observations)

Mean	-0.00020984
Median	-0.00031314
Minimum	-0.20799
Maximum	0.14423
Standard deviation	0.018150
C.V.	86.494
Skewness	-0.29551
Ex. kurtosis	14.274
5% percentile	-0.025793
95% percentile	0.025842
Interquartile range	0.015689
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'IAGLNEquity' (2650 valid observations)

Mean	3.6374e-005
Median	0.00066337
Minimum	-0.25538
Maximum	0.11739
Standard deviation	0.026831
C.V.	737.64
Skewness	-0.55493
Ex. kurtosis	5.4061
5% percentile	-0.041789
95% percentile	0.042465
Interquartile range	0.029067
Missing obs.	2

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'IHGLNEquity' (2651 valid observations)

Mean	0.00020363
Median	0.0000
Minimum	-0.17563
Maximum	0.097990
Standard deviation	0.020452
C.V.	100.43
Skewness	-0.47996
Ex. kurtosis	6.3911
5% percentile	-0.032612
95% percentile	0.031210
Interquartile range	0.019368
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'IIILNEquity' (2651 valid observations)

Mean	-0.00012013
Median	0.00033462
Minimum	-0.17934
Maximum	0.19187
Standard deviation	0.023703
C.V.	197.32
Skewness	-0.52254
Ex. kurtosis	10.800
5% percentile	-0.033192
95% percentile	0.032129
Interquartile range	0.021143
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'IMBLNEquity' (2651 valid observations)

Mean	0.00037298
Median	0.00043169
Minimum	-0.098462
Maximum	0.096899
Standard deviation	0.014408
C.V.	38.629
Skewness	0.0032152
Ex. kurtosis	4.4926
5% percentile	-0.021507
95% percentile	0.022889
Interquartile range	0.015403
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'INFLNEquity' (2651 valid observations)

Mean	0.00025478
Median	0.0000
Minimum	-0.16410
Maximum	0.19397
Standard deviation	0.021590
C.V.	84.742
Skewness	0.11429
Ex. kurtosis	7.8589
5% percentile	-0.032008
95% percentile	0.033594
Interquartile range	0.019925
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'INTULNEquity' (2651 valid observations)

Mean	-0.00030503
Median	0.00026035
Minimum	-0.16947
Maximum	0.12153
Standard deviation	0.020327
C.V.	66.640
Skewness	-0.30533
Ex. kurtosis	6.6310
5% percentile	-0.031505
95% percentile	0.028422
Interquartile range	0.019434
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'ITRKLNEquity' (2651 valid observations)

Mean	0.00060538
Median	0.00052315
Minimum	-0.13448
Maximum	0.10614
Standard deviation	0.017110
C.V.	28.264
Skewness	-0.27415
Ex. kurtosis	5.5074
5% percentile	-0.025960
95% percentile	0.026774
Interquartile range	0.017564
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'ITVLNEquity' (2651 valid observations)

Mean	0.00017084
Median	0.0000
Minimum	-0.22863
Maximum	0.25005
Standard deviation	0.025168
C.V.	147.32
Skewness	0.22731
Ex. kurtosis	10.535
5% percentile	-0.037128
95% percentile	0.037169
Interquartile range	0.024318
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'JMATLNEquity' (2651 valid observations)

Mean	0.00020615
Median	0.00032441
Minimum	-0.11551
Maximum	0.14111
Standard deviation	0.019985
C.V.	96.947
Skewness	0.022932
Ex. kurtosis	4.0331
5% percentile	-0.031552
95% percentile	0.030593
Interquartile range	0.020383
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'KGFLNEquity' (2651 valid observations)

Mean	0.00012020
Median	0.0000
Minimum	-0.10504
Maximum	0.097798
Standard deviation	0.020354
C.V.	169.34
Skewness	-0.011331
Ex. kurtosis	2.8025
5% percentile	-0.033015
95% percentile	0.032611
Interquartile range	0.020897
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'LANDLNEquity' (2651 valid observations)

Mean	-0.00013970
Median	0.0000
Minimum	-0.16897
Maximum	0.12097
Standard deviation	0.019295
C.V.	138.12
Skewness	-0.37280
Ex. kurtosis	7.5144
5% percentile	-0.028023
95% percentile	0.027692
Interquartile range	0.018357
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'LGENLNEquity' (2651 valid observations)

Mean	0.00016312
Median	0.0000
Minimum	-0.34076
Maximum	0.24300
Standard deviation	0.026734
C.V.	163.89
Skewness	-0.59424
Ex. kurtosis	20.976
5% percentile	-0.035712
95% percentile	0.035594
Interquartile range	0.020737
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'LLOYLNEquity' (2651 valid observations)

Mean	-0.00056687
Median	-0.00020536
Minimum	-0.41463
Maximum	0.40797
Standard deviation	0.034791
C.V.	61.374
Skewness	-1.0459
Ex. kurtosis	32.465
5% percentile	-0.044480
95% percentile	0.043425
Interquartile range	0.023881
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'LSELNEquity' (2651 valid observations)

Mean	0.00049784
Median	0.0000
Minimum	-0.18047
Maximum	0.26673
Standard deviation	0.024633
C.V.	49.479
Skewness	0.53604
Ex. kurtosis	11.645
5% percentile	-0.035276
95% percentile	0.035531
Interquartile range	0.021033
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'MCROLNEquity' (2651 valid observations)

Mean	0.00083156
Median	0.00085390
Minimum	-0.55771
Maximum	0.19080
Standard deviation	0.027833
C.V.	33.470
Skewness	-3.9325
Ex. kurtosis	78.334
5% percentile	-0.033227
95% percentile	0.036456
Interquartile range	0.021302
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'MDCLNEquity' (766 valid observations)

Mean	0.00084091
Median	0.0000
Minimum	-0.32608
Maximum	0.15480
Standard deviation	0.023187
C.V.	27.573
Skewness	-3.1354
Ex. kurtosis	54.334
5% percentile	-0.027565
95% percentile	0.032295
Interquartile range	0.017282
Missing obs.	1886

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'MERLLNEquity' (667 valid observations)

Mean	0.00050207
Median	0.0000
Minimum	-0.057305
Maximum	0.096752
Standard deviation	0.014271
C.V.	28.423
Skewness	0.32240
Ex. kurtosis	4.1320
5% percentile	-0.021416
95% percentile	0.023842
Interquartile range	0.016464
Missing obs.	1985

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'MKSLNEquity' (2651 valid observations)

Mean	-0.00016761
Median	0.0000
Minimum	-0.28141
Maximum	0.11252
Standard deviation	0.019750
C.V.	117.83
Skewness	-1.5341
Ex. kurtosis	22.744
5% percentile	-0.029292
95% percentile	0.029549
Interquartile range	0.019814
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'MNDILNEquity' (2274 valid observations)

Mean	0.00045121
Median	0.00088479
Minimum	-0.15931
Maximum	0.22686
Standard deviation	0.023379
C.V.	51.814
Skewness	0.11565
Ex. kurtosis	6.2472
5% percentile	-0.037256
95% percentile	0.035917
Interquartile range	0.024747
Missing obs.	378

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'MRWLNEquity' (2651 valid observations)

Mean	-1.5479e-005
Median	0.0000
Minimum	-0.12705
Maximum	0.083119
Standard deviation	0.015978
C.V.	1032.2
Skewness	-0.049400
Ex. kurtosis	4.7532
5% percentile	-0.024387
95% percentile	0.024808
Interquartile range	0.015940
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'NGLNEquity' (2651 valid observations)

Mean	0.00028736
Median	0.00072333
Minimum	-0.094497
Maximum	0.15325
Standard deviation	0.013375
C.V.	46.546
Skewness	-0.17228
Ex. kurtosis	12.743
5% percentile	-0.019208
95% percentile	0.019958
Interquartile range	0.012822
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'NXTLNEquity' (2651 valid observations)

Mean	0.00044310
Median	0.00049468
Minimum	-0.16358
Maximum	0.11748
Standard deviation	0.019561
C.V.	44.146
Skewness	-0.16575
Ex. kurtosis	7.4016
5% percentile	-0.029813
95% percentile	0.030188
Interquartile range	0.016906
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'OMLLNEquity' (2651 valid observations)

Mean	2.0482e-005
Median	0.0000
Minimum	-0.24389
Maximum	0.26434
Standard deviation	0.027928
C.V.	1363.5
Skewness	-0.18749
Ex. kurtosis	12.488
5% percentile	-0.039542
95% percentile	0.039536
Interquartile range	0.023281
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'PFGLNEquity' (2651 valid observations)

Mean	0.00043763
Median	0.0000
Minimum	-0.17509
Maximum	0.10153
Standard deviation	0.017580
C.V.	40.170
Skewness	-0.25499
Ex. kurtosis	8.4970
5% percentile	-0.026859
95% percentile	0.026387
Interquartile range	0.017623
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'POLYLNEquity' (1179 valid observations)

Mean	0.00010968
Median	0.00068517
Minimum	-0.14104
Maximum	0.11179
Standard deviation	0.025108
C.V.	228.92
Skewness	-0.17239
Ex. kurtosis	2.7844
5% percentile	-0.039526
95% percentile	0.040509
Interquartile range	0.027723
Missing obs.	1473

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'PPBLNEquity' (2651 valid observations)

Mean	0.00079222
Median	0.00040554
Minimum	-0.086542
Maximum	0.17979
Standard deviation	0.019321
C.V.	24.388
Skewness	0.28753
Ex. kurtosis	5.0642
5% percentile	-0.029110
95% percentile	0.031679
Interquartile range	0.020183
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'PRULNEquity' (2651 valid observations)

Mean	0.00030533
Median	0.0000
Minimum	-0.22314
Maximum	0.21072
Standard deviation	0.027587
C.V.	90.349
Skewness	0.21848
Ex. kurtosis	12.475
5% percentile	-0.036963
95% percentile	0.039123
Interquartile range	0.024013
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'PSNLNEquity' (2651 valid observations)

Mean	5.1900e-005
Median	0.0000
Minimum	-0.32227
Maximum	0.16283
Standard deviation	0.028330
C.V.	545.86
Skewness	-0.61663
Ex. kurtosis	10.944
5% percentile	-0.042728
95% percentile	0.042388
Interquartile range	0.025629
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'PSONLNEquity' (2651 valid observations)

Mean	0.00012896
Median	0.0000
Minimum	-0.17377
Maximum	0.16054
Standard deviation	0.016009
C.V.	124.14
Skewness	0.016617
Ex. kurtosis	11.213
5% percentile	-0.024355
95% percentile	0.024483
Interquartile range	0.017399
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'RBLNEquity' (2651 valid observations)

Mean	0.00052309
Median	0.00021802
Minimum	-0.077496
Maximum	0.099743
Standard deviation	0.013658
C.V.	26.110
Skewness	0.21359
Ex. kurtosis	4.4821
5% percentile	-0.019892
95% percentile	0.021634
Interquartile range	0.014937
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'RBSLNEquity' (2651 valid observations)

Mean	-0.0012742
Median	-0.00076542
Minimum	-1.0957
Maximum	0.30505
Standard deviation	0.040938
C.V.	32.128
Skewness	-7.7788
Ex. kurtosis	205.21
5% percentile	-0.049068
95% percentile	0.046599
Interquartile range	0.027529
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'RDSALNEquity' (2651 valid observations)

Mean	4.2982e-005
Median	0.00023549
Minimum	-0.097888
Maximum	0.12857
Standard deviation	0.016104
C.V.	374.68
Skewness	0.14587
Ex. kurtosis	5.8431
5% percentile	-0.024537
95% percentile	0.024042
Interquartile range	0.016385
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'RDSBLNEquity' (2651 valid observations)

Mean	2.7505e-005
Median	0.00023510
Minimum	-0.098147
Maximum	0.13214
Standard deviation	0.016753
C.V.	609.09
Skewness	0.12091
Ex. kurtosis	5.8199
5% percentile	-0.025287
95% percentile	0.025455
Interquartile range	0.016862
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'RELLNEquity' (2651 valid observations)

Mean	0.00029116
Median	0.0000
Minimum	-0.16522
Maximum	0.10665
Standard deviation	0.015045
C.V.	51.672
Skewness	-0.72668
Ex. kurtosis	11.456
5% percentile	-0.022221
95% percentile	0.022653
Interquartile range	0.015122
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'RIOLNEquity' (2651 valid observations)

Mean	1.0173e-005
Median	0.00015680
Minimum	-0.45783
Maximum	0.19678
Standard deviation	0.030198
C.V.	2968.4
Skewness	-1.1682
Ex. kurtosis	24.362
5% percentile	-0.042851
95% percentile	0.042071
Interquartile range	0.027916
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'RMGLNEquity' (687 valid observations)

Mean	0.00060773
Median	0.0000
Minimum	-0.10247
Maximum	0.32120
Standard deviation	0.021041
C.V.	34.623
Skewness	4.8884
Ex. kurtosis	78.791
5% percentile	-0.026117
95% percentile	0.027863
Interquartile range	0.019087
Missing obs.	1965

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'RRLNEquity' (2651 valid observations)

Mean	0.00018604
Median	0.0000
Minimum	-0.21772
Maximum	0.13400
Standard deviation	0.020175
C.V.	108.45
Skewness	-0.50604
Ex. kurtosis	9.7815
5% percentile	-0.029202
95% percentile	0.031486
Interquartile range	0.020026
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'RRSLNEquity' (2651 valid observations)

Mean	0.00081319
Median	0.0000
Minimum	-0.16237
Maximum	0.20225
Standard deviation	0.027408
C.V.	33.704
Skewness	0.23048
Ex. kurtosis	4.0885
5% percentile	-0.040942
95% percentile	0.045360
Interquartile range	0.028272
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'RSALNEquity' (2651 valid observations)

Mean	-4.8563e-005
Median	0.0000
Minimum	-0.23375
Maximum	0.16918
Standard deviation	0.018829
C.V.	387.72
Skewness	-0.54147
Ex. kurtosis	16.770
5% percentile	-0.028191
95% percentile	0.027726
Interquartile range	0.016973
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'SABLNEquity' (2651 valid observations)

Mean	0.00052588
Median	0.0000
Minimum	-0.089119
Maximum	0.18138
Standard deviation	0.016654
C.V.	31.669
Skewness	0.73136
Ex. kurtosis	8.7378
5% percentile	-0.024751
95% percentile	0.026826
Interquartile range	0.016570
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'SBRYLNEquity' (2651 valid observations)

Mean	-0.00012288
Median	0.0000
Minimum	-0.23219
Maximum	0.12988
Standard deviation	0.017890
C.V.	145.59
Skewness	-0.85558
Ex. kurtosis	17.815
5% percentile	-0.026562
95% percentile	0.024194
Interquartile range	0.016568
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'SDRLNEquity' (2651 valid observations)

Mean	0.00033729
Median	0.00063391
Minimum	-0.29025
Maximum	0.28030
Standard deviation	0.023609
C.V.	69.998
Skewness	-0.23225
Ex. kurtosis	19.457
5% percentile	-0.035842
95% percentile	0.035679
Interquartile range	0.021789
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'SGELNEquity' (2651 valid observations)

Mean	0.00032573
Median	0.00053842
Minimum	-0.089359
Maximum	0.094984
Standard deviation	0.016547
C.V.	50.800
Skewness	0.19826
Ex. kurtosis	3.2619
5% percentile	-0.026782
95% percentile	0.025659
Interquartile range	0.017203
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'SHPLNEquity' (2651 valid observations)

Mean	0.00069055
Median	0.00055172
Minimum	-0.24776
Maximum	0.15644
Standard deviation	0.018523
C.V.	26.823
Skewness	-0.64262
Ex. kurtosis	17.313
5% percentile	-0.026276
95% percentile	0.027657
Interquartile range	0.018548
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'SKYLNEquity' (2651 valid observations)

Mean	0.00020116
Median	0.0000
Minimum	-0.12351
Maximum	0.15332
Standard deviation	0.016156
C.V.	80.312
Skewness	0.15906
Ex. kurtosis	10.122
5% percentile	-0.023100
95% percentile	0.024211
Interquartile range	0.014884
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'SLLNEquity' (2522 valid observations)

Mean	1.7236e-005
Median	0.0000
Minimum	-0.18998
Maximum	0.18656
Standard deviation	0.023146
C.V.	1342.9
Skewness	0.16373
Ex. kurtosis	10.698
5% percentile	-0.034372
95% percentile	0.032213
Interquartile range	0.020816
Missing obs.	130

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'SMINLNEquity' (2651 valid observations)

Mean	-0.00011222
Median	0.0000
Minimum	-0.39866
Maximum	0.10945
Standard deviation	0.018807
C.V.	167.58
Skewness	-3.7958
Ex. kurtosis	79.641
5% percentile	-0.026689
95% percentile	0.025457
Interquartile range	0.018492
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'SNLNEquity' (2651 valid observations)

Mean	0.00032416
Median	0.0000
Minimum	-0.13900
Maximum	0.091106
Standard deviation	0.016072
C.V.	49.580
Skewness	-0.066750
Ex. kurtosis	6.3317
5% percentile	-0.023047
95% percentile	0.025040
Interquartile range	0.015886
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'SSELNEquity' (2651 valid observations)

Mean	0.00015753
Median	0.0000
Minimum	-0.12975
Maximum	0.13471
Standard deviation	0.014009
C.V.	88.933
Skewness	-0.37409
Ex. kurtosis	9.3854
5% percentile	-0.021824
95% percentile	0.019831
Interquartile range	0.014046
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'STANLNEquity' (2651 valid observations)

Mean	-0.00023571
Median	-0.00027504
Minimum	-0.17947
Maximum	0.26237
Standard deviation	0.026249
C.V.	111.36
Skewness	0.31600
Ex. kurtosis	10.468
5% percentile	-0.037876
95% percentile	0.038347
Interquartile range	0.023636
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'STJLNEquity' (2651 valid observations)

Mean	0.00040469
Median	0.00063311
Minimum	-0.17649
Maximum	0.23940
Standard deviation	0.023707
C.V.	58.580
Skewness	0.11464
Ex. kurtosis	8.2919
5% percentile	-0.035970
95% percentile	0.036755
Interquartile range	0.023029
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'SVTLNEquity' (2651 valid observations)

Mean	0.00022747
Median	0.0000
Minimum	-0.16049
Maximum	0.15171
Standard deviation	0.014511
C.V.	63.791
Skewness	-0.14554
Ex. kurtosis	15.016
5% percentile	-0.020989
95% percentile	0.020941
Interquartile range	0.014691
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'TPKLNEquity' (2651 valid observations)

Mean	0.00011082
Median	0.00054157
Minimum	-0.37602
Maximum	0.14493
Standard deviation	0.026202
C.V.	236.45
Skewness	-1.2197
Ex. kurtosis	20.816
5% percentile	-0.039302
95% percentile	0.037128
Interquartile range	0.023277
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'TSCOLNEquity' (2651 valid observations)

Mean	-0.00023402
Median	-0.00040593
Minimum	-0.17420
Maximum	0.13952
Standard deviation	0.016853
C.V.	72.017
Skewness	-0.24171
Ex. kurtosis	9.8303
5% percentile	-0.025095
95% percentile	0.024845
Interquartile range	0.017512
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30 for the variable 'TUILNEquity' (386 valid observations)

Mean	-0.00072620
Median	0.0000
Minimum	-0.10898
Maximum	0.063940
Standard deviation	0.019517
C.V.	26.875
Skewness	-0.71239
Ex. kurtosis	3.5047
5% percentile	-0.031891
95% percentile	0.029283
Interquartile range	0.022696
Missing obs.	2266

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'TWLNEquity' (2651 valid observations)

Mean	-0.00029451
Median	0.0000
Minimum	-0.53901
Maximum	0.54832
Standard deviation	0.041352
C.V.	140.41
Skewness	-0.59611
Ex. kurtosis	36.446
5% percentile	-0.051157
95% percentile	0.049722
Interquartile range	0.029447
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'ULVRLNEquity' (2651 valid observations)

Mean	0.00038363
Median	0.00047858
Minimum	-0.084246
Maximum	0.093648
Standard deviation	0.013942
C.V.	36.342
Skewness	-0.0020364
Ex. kurtosis	4.2014
5% percentile	-0.021128
95% percentile	0.022451
Interquartile range	0.014668
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'UULNEquity' (2651 valid observations)

Mean	6.3702e-005
Median	0.0000
Minimum	-0.28324
Maximum	0.10810
Standard deviation	0.014349
C.V.	225.24
Skewness	-2.9182
Ex. kurtosis	60.292
5% percentile	-0.020419
95% percentile	0.020464
Interquartile range	0.014443
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'VODLNEquity' (2651 valid observations)

Mean	8.6846e-005
Median	0.0000
Minimum	-0.15901
Maximum	0.090753
Standard deviation	0.017319
C.V.	199.42
Skewness	-0.67094
Ex. kurtosis	9.4016
5% percentile	-0.025709
95% percentile	0.025247
Interquartile range	0.018133
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'WOSLNEquity' (2651 valid observations)

Mean	-0.00012919
Median	0.0000
Minimum	-0.35269
Maximum	0.14305
Standard deviation	0.026318
C.V.	203.71
Skewness	-0.96968
Ex. kurtosis	18.078
5% percentile	-0.038323
95% percentile	0.037685
Interquartile range	0.023146
Missing obs.	1

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'WPGLNEquity' (181 valid observations)

Mean	0.00068541
Median	0.0010286
Minimum	-0.090814
Maximum	0.099091
Standard deviation	0.020971
C.V.	30.596
Skewness	-0.12914
Ex. kurtosis	5.5728
5% percentile	-0.030051
95% percentile	0.039379
Interquartile range	0.018649
Missing obs.	2471

Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'WPPLNEquity' (2651 valid observations)

Mean	0.00033563
Median	0.00060514
Minimum	-0.11092
Maximum	0.096096
Standard deviation	0.017657
C.V.	52.610
Skewness	-0.19324
Ex. kurtosis	3.7971
5% percentile	-0.027074
95% percentile	0.027832
Interquartile range	0.018774
Missing obs.	1

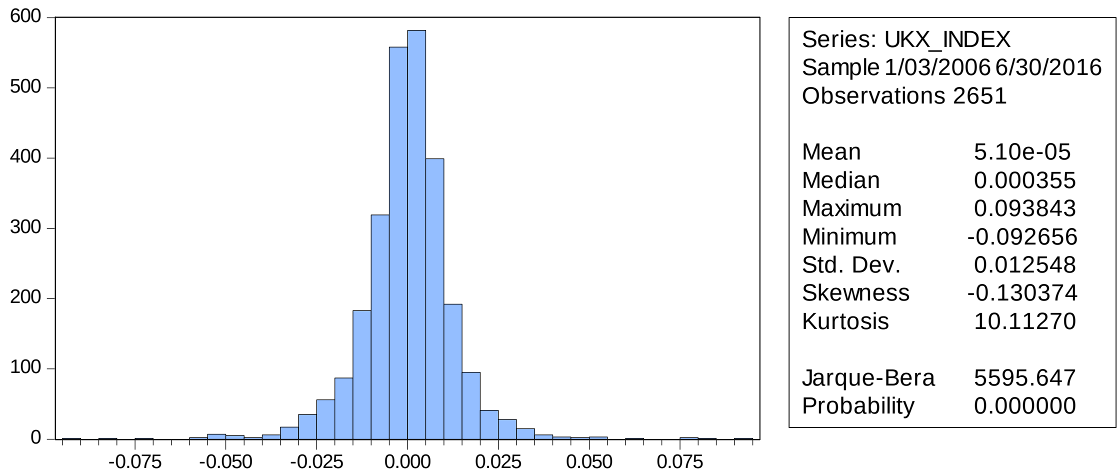
Summary statistics, using the observations 2006-01-03 - 2016-06-30
for the variable 'WTBLNEquity' (2651 valid observations)

Mean	0.00038356
Median	0.00038858
Minimum	-0.13534
Maximum	0.16578
Standard deviation	0.018815
C.V.	49.052
Skewness	-0.17693
Ex. kurtosis	7.0886
5% percentile	-0.027624
95% percentile	0.028928
Interquartile range	0.018378
Missing obs.	1

Appendix 2: Histograms of stocks and index returns, statistics and Jarque- Bera test

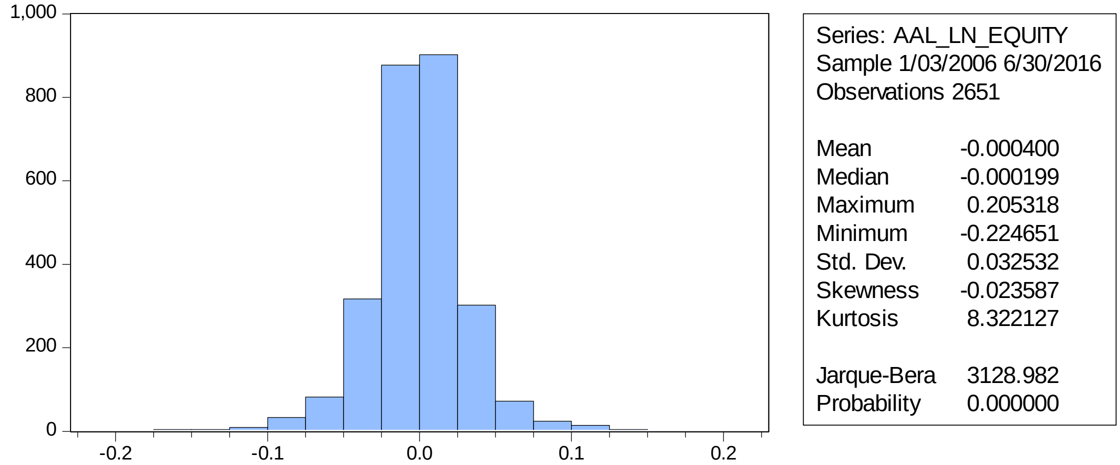
In this appendix we perform the Jarque- Bera test on stock and index returns. The null hypothesis H_0 is a joint hypothesis of the skewness being zero and the excess kurtosis being zero. For sample sizes of 2000 or larger, this test statistic is compared to a chi-squared distribution with 2 degrees of freedom (normality is rejected if the test statistic is greater than the chi-squared value). Eviews gives us the opportunity to see the kurtosis and the skewness in order to test normality, rather than comparing Jarque-Bera test to chi-squared distribution.

It is obvious that there is no normality in most stocks' returns, as they present excess kurtosis while most of their skewnesses approximate zero, which has been already proved in the economic community and for that reason, we will use logarithmic returns instead of simple returns, as logarithmic returns approach normality.



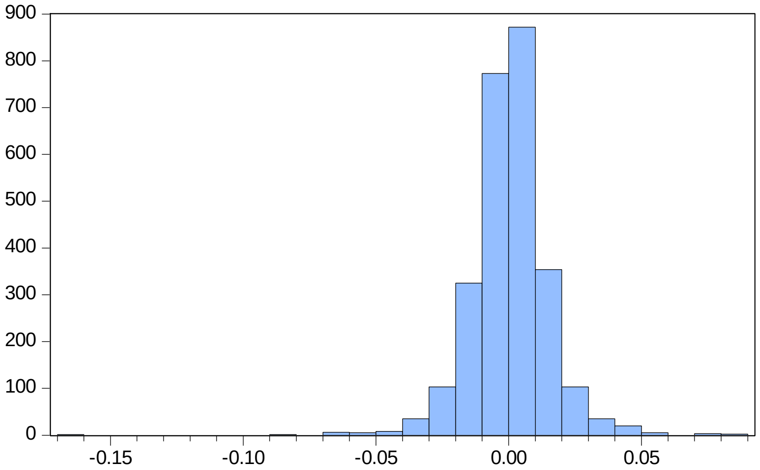
Series: UKX_INDEX
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	5.10e-05
Median	0.000355
Maximum	0.093843
Minimum	-0.092656
Std. Dev.	0.012548
Skewness	-0.130374
Kurtosis	10.11270
Jarque-Bera	5595.647
Probability	0.000000



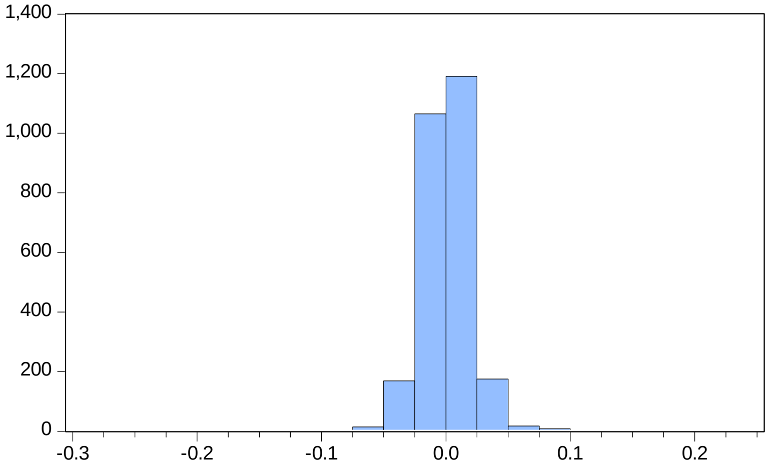
Series: AAL_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	-0.000400
Median	-0.000199
Maximum	0.205318
Minimum	-0.224651
Std. Dev.	0.032532
Skewness	-0.023587
Kurtosis	8.322127
Jarque-Bera	3128.982
Probability	0.000000



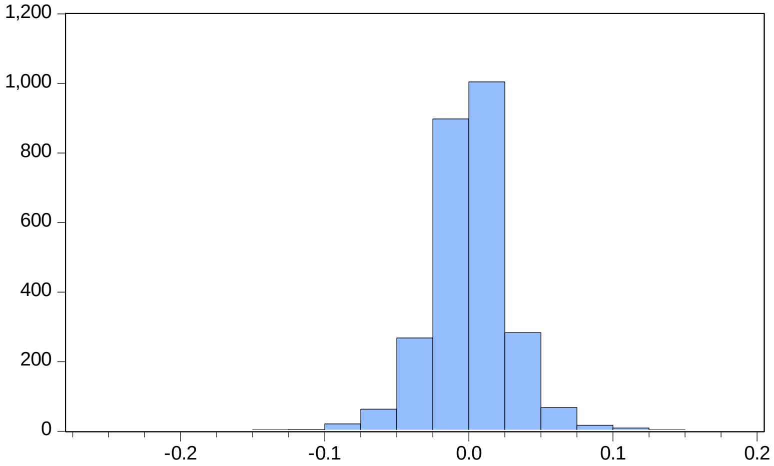
Series: ABF_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000443
Median	0.000339
Maximum	0.084498
Minimum	-0.166235
Std. Dev.	0.014565
Skewness	-0.481573
Kurtosis	12.83529
Jarque-Bera	10787.43
Probability	0.000000



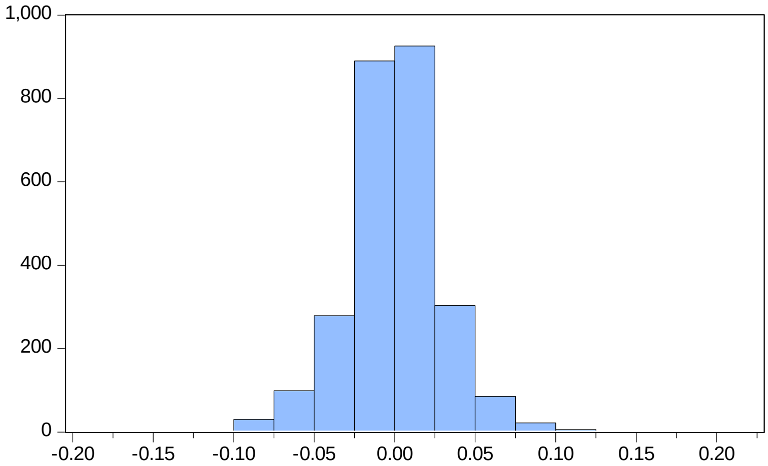
Series: ADM_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000555
Median	0.000543
Maximum	0.227165
Minimum	-0.295818
Std. Dev.	0.020790
Skewness	-0.988139
Kurtosis	30.64921
Jarque-Bera	84874.45
Probability	0.000000



Series: AHT_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

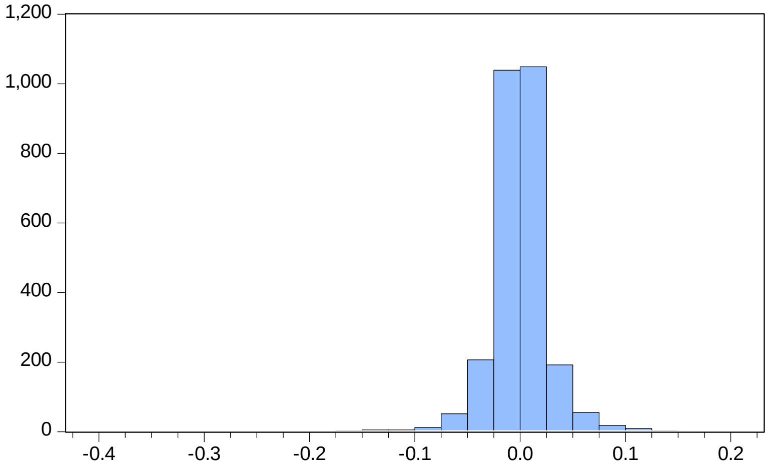
Mean	0.000692
Median	0.000000
Maximum	0.187893
Minimum	-0.251873
Std. Dev.	0.029773
Skewness	-0.118218
Kurtosis	10.36522
Jarque-Bera	5998.151
Probability	0.000000



```
Series: ANTO_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          7.45e-05
Median        0.000000
Maximum       0.200724
Minimum      -0.192232
Std. Dev.     0.030540
Skewness      0.105870
Kurtosis      6.901700

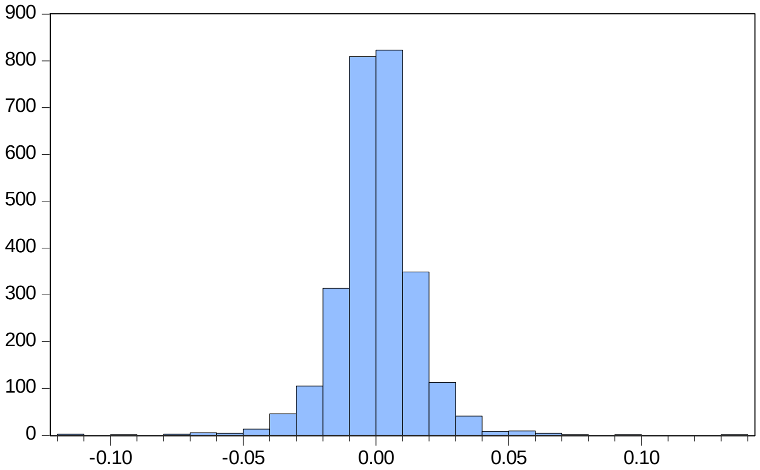
Jarque-Bera   1686.488
Probability   0.000000
```



```
Series: AV__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean         -0.000221
Median        0.000000
Maximum       0.223915
Minimum      -0.405992
Std. Dev.     0.027503
Skewness     -1.182470
Kurtosis      27.49787

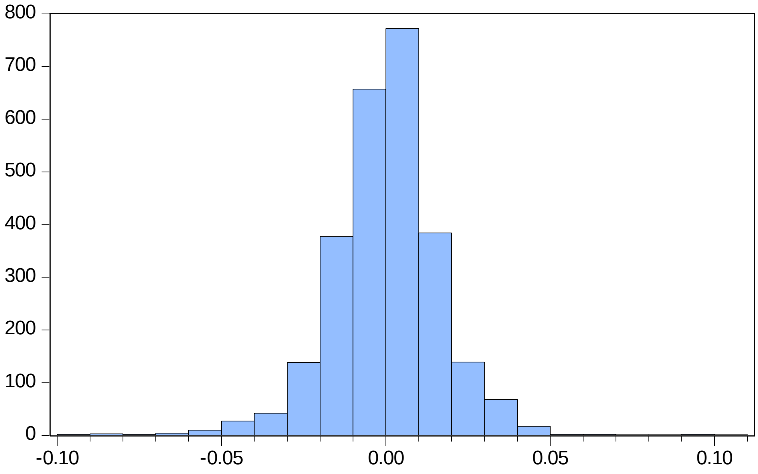
Jarque-Bera   66908.90
Probability   0.000000
```



```
Series: AZN_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000167
Median        0.000167
Maximum       0.134312
Minimum      -0.117796
Std. Dev.     0.015119
Skewness     -0.146697
Kurtosis      11.05489

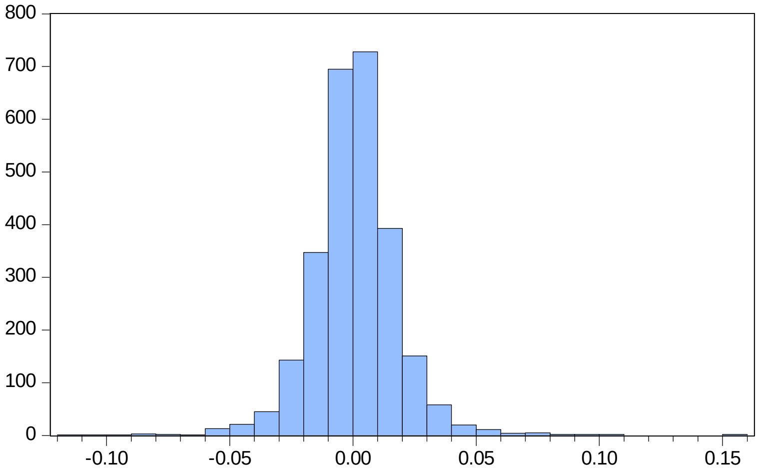
Jarque-Bera   7176.189
Probability   0.000000
```



```
Series: BA__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000115
Median        0.000653
Maximum       0.100909
Minimum      -0.098697
Std. Dev.     0.016630
Skewness     -0.184669
Kurtosis      6.989046

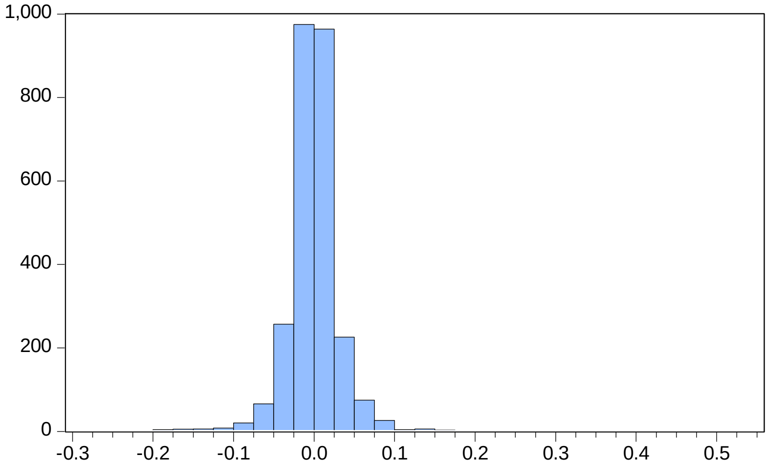
Jarque-Bera   1772.735
Probability   0.000000
```



```
Series: BAB_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000559
Median        0.000000
Maximum       0.155735
Minimum      -0.114174
Std. Dev.     0.017975
Skewness      0.514213
Kurtosis      11.23227

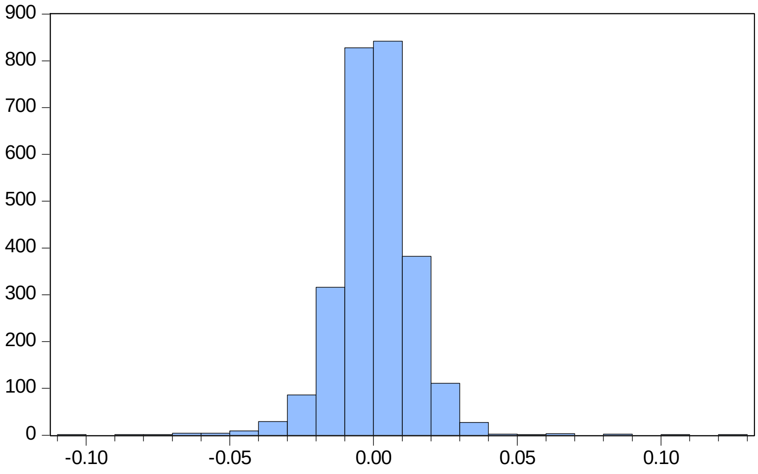
Jarque-Bera   7602.626
Probability   0.000000
```



```
Series: BARC_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean         -0.000524
Median       -0.000563
Maximum       0.549513
Minimum      -0.285636
Std. Dev.     0.034151
Skewness      1.175547
Kurtosis      37.38374

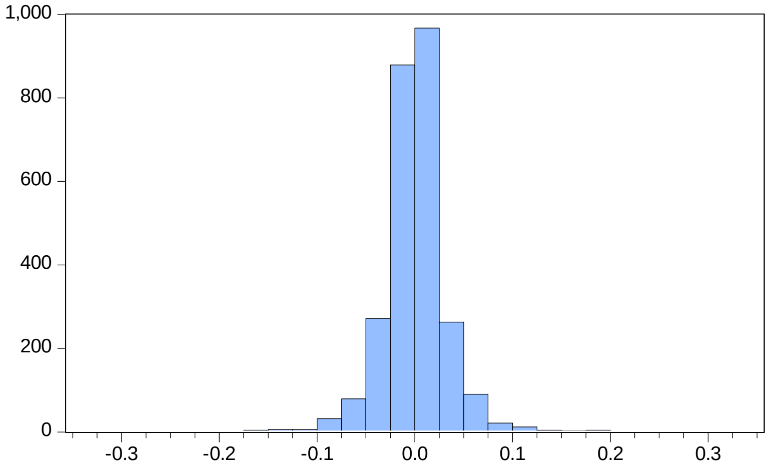
Jarque-Bera   131199.0
Probability   0.000000
```



```
Series: BATS_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000493
Median        0.000218
Maximum       0.120286
Minimum      -0.104671
Std. Dev.     0.013749
Skewness      0.110865
Kurtosis      11.01839

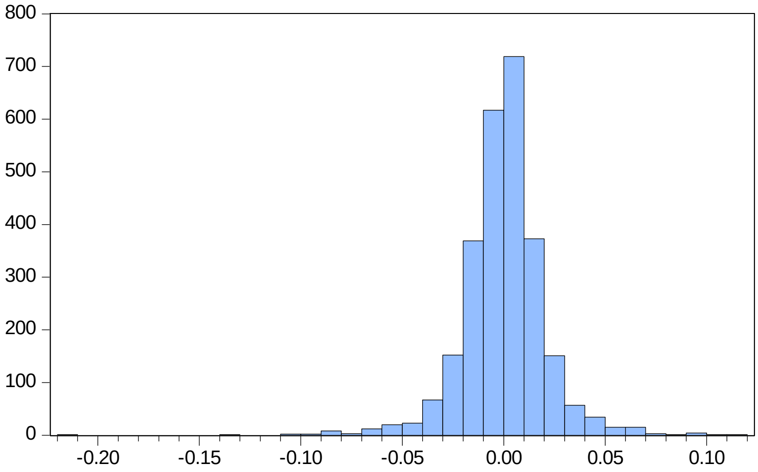
Jarque-Bera   7107.297
Probability   0.000000
```



```
Series: BDEV_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean         -0.000182
Median        0.000000
Maximum       0.325418
Minimum      -0.343521
Std. Dev.     0.035407
Skewness     -0.325461
Kurtosis      16.61433

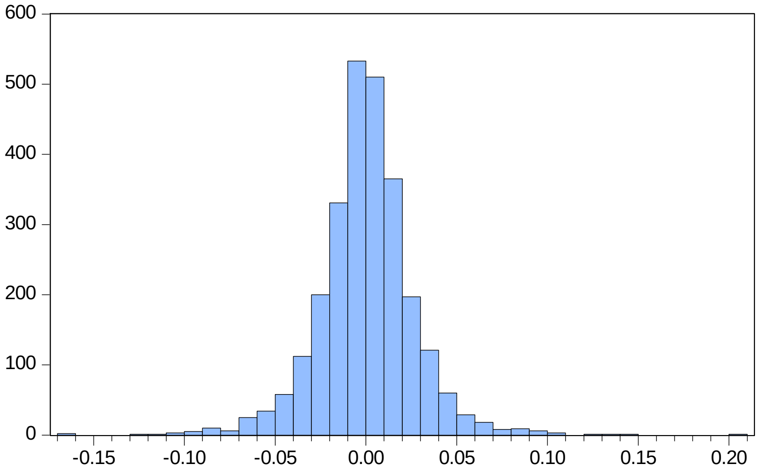
Jarque-Bera   20520.26
Probability   0.000000
```



```
Series: BLND_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean         -0.000145
Median        0.000000
Maximum       0.112221
Minimum      -0.217422
Std. Dev.     0.020610
Skewness     -0.598258
Kurtosis      11.56047

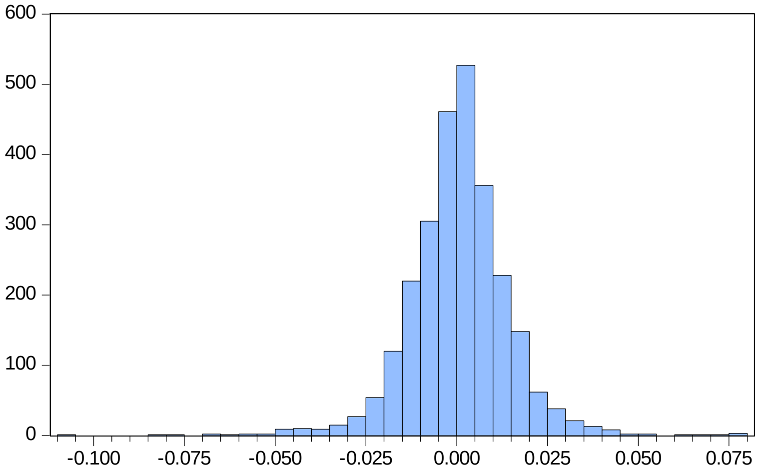
Jarque-Bera   8252.712
Probability   0.000000
```



```
Series: BLT_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean            1.81e-05
Median          0.000000
Maximum         0.206072
Minimum        -0.162518
Std. Dev.       0.026539
Skewness        0.055245
Kurtosis        7.540313

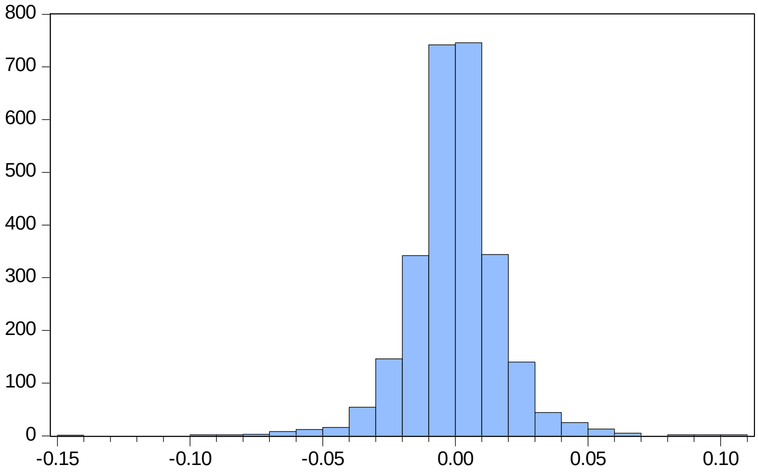
Jarque-Bera     2278.385
Probability     0.000000
```



```
Series: BNZL_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean            0.000479
Median          0.000644
Maximum         0.079292
Minimum        -0.105257
Std. Dev.       0.013882
Skewness       -0.266165
Kurtosis        7.927291

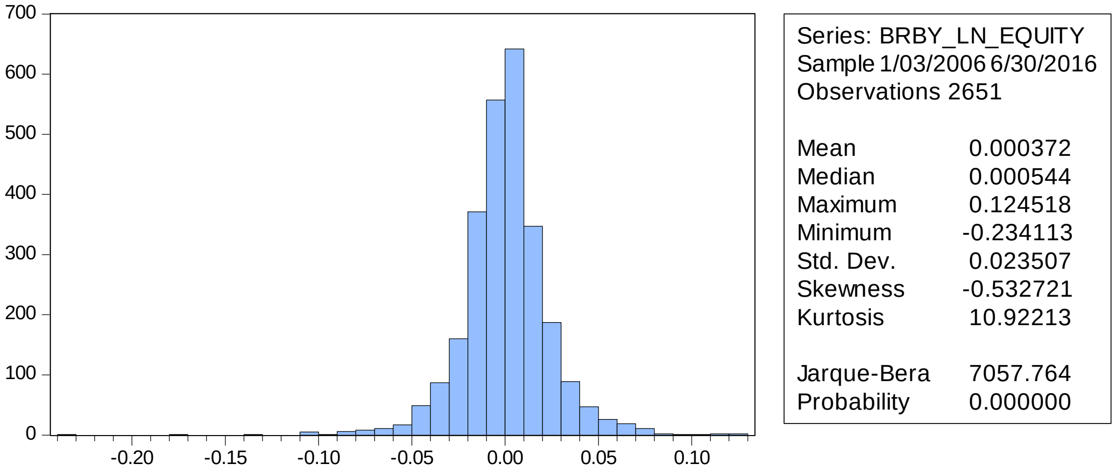
Jarque-Bera     2713.031
Probability     0.000000
```



```
Series: BP__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean           -0.000141
Median         -0.000106
Maximum         0.105826
Minimum        -0.140368
Std. Dev.       0.017469
Skewness       -0.081308
Kurtosis        8.815150

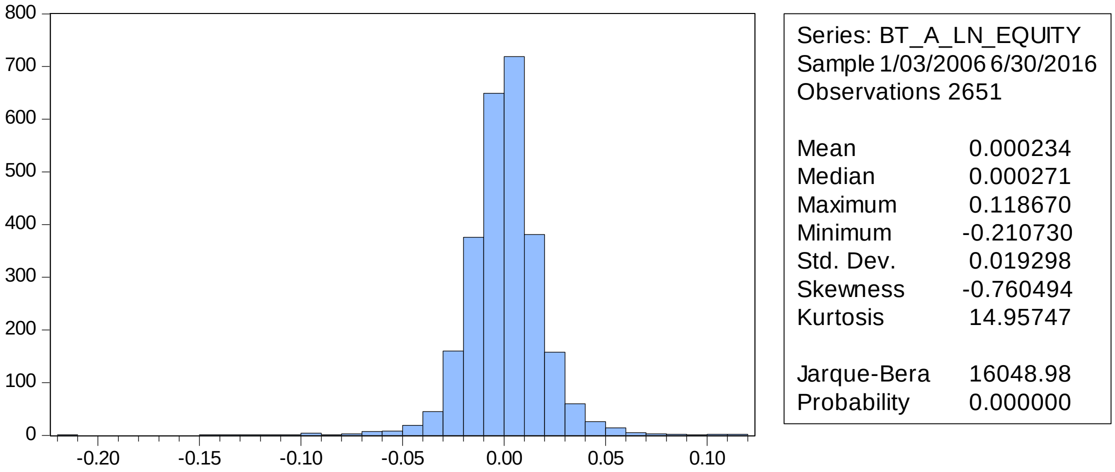
Jarque-Bera     3738.177
Probability     0.000000
```



```
Series: BRBY_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000372
Median        0.000544
Maximum       0.124518
Minimum      -0.234113
Std. Dev.     0.023507
Skewness     -0.532721
Kurtosis      10.92213

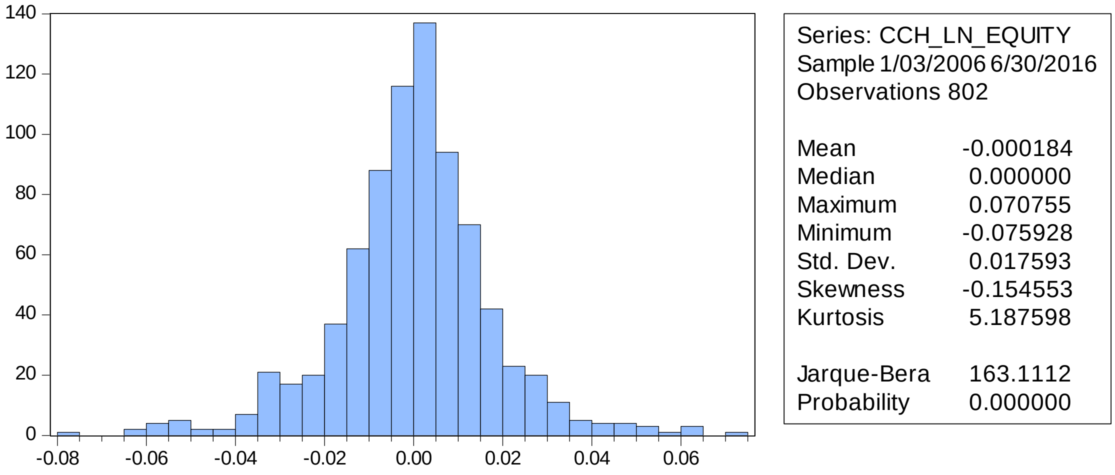
Jarque-Bera   7057.764
Probability   0.000000
```



```
Series: BT_A_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000234
Median        0.000271
Maximum       0.118670
Minimum      -0.210730
Std. Dev.     0.019298
Skewness     -0.760494
Kurtosis      14.95747

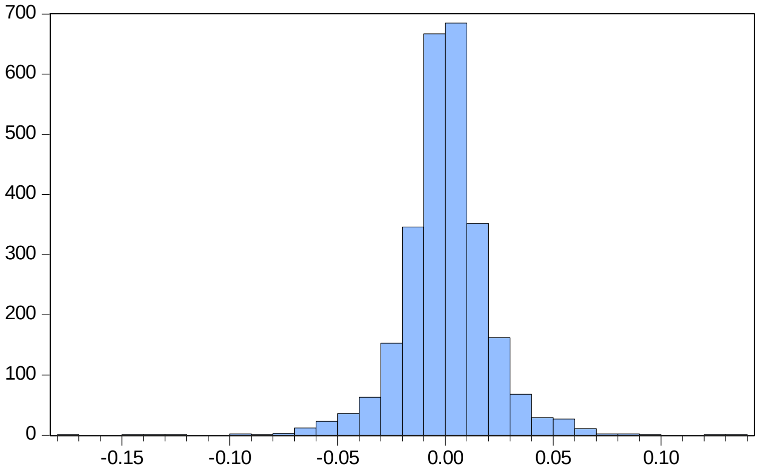
Jarque-Bera   16048.98
Probability   0.000000
```



```
Series: CCH_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 802

Mean         -0.000184
Median        0.000000
Maximum       0.070755
Minimum      -0.075928
Std. Dev.     0.017593
Skewness     -0.154553
Kurtosis      5.187598

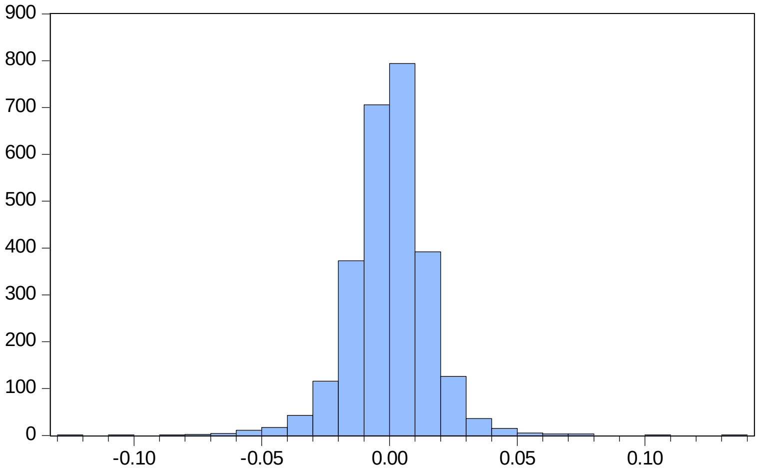
Jarque-Bera   163.1112
Probability   0.000000
```



```
Series: CCL_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean         3.09e-06
Median       0.000000
Maximum      0.136344
Minimum     -0.179834
Std. Dev.    0.020438
Skewness    -0.390217
Kurtosis     9.967728

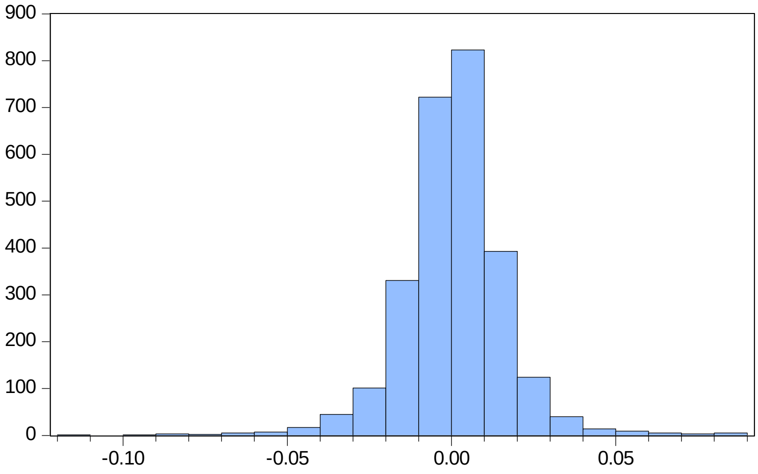
Jarque-Bera  5429.945
Probability  0.000000
```



```
Series: CNA_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean        -1.41e-06
Median       0.000267
Maximum      0.139329
Minimum     -0.124811
Std. Dev.    0.015947
Skewness    -0.071303
Kurtosis     10.16284

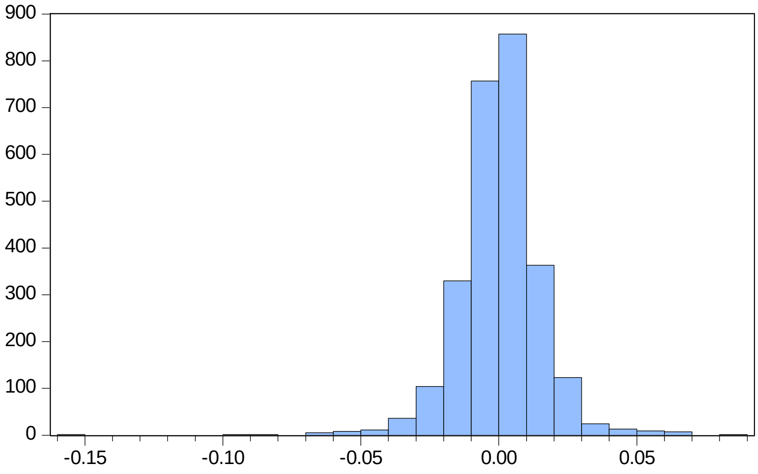
Jarque-Bera  5669.456
Probability  0.000000
```



```
Series: CPG_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean         0.000670
Median       0.000673
Maximum      0.089243
Minimum     -0.111428
Std. Dev.    0.016082
Skewness    -0.116675
Kurtosis     8.508095

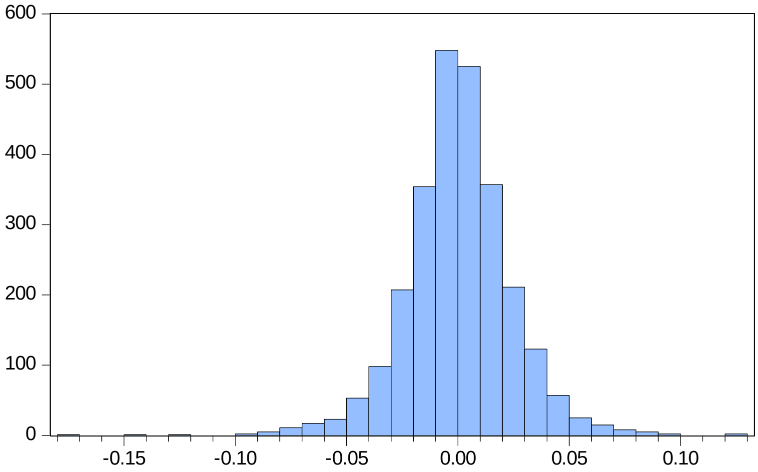
Jarque-Bera  3357.222
Probability  0.000000
```



```
Series: CPI_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000298
Median        0.000667
Maximum       0.088634
Minimum      -0.153730
Std. Dev.     0.014900
Skewness     -0.501415
Kurtosis      10.92604

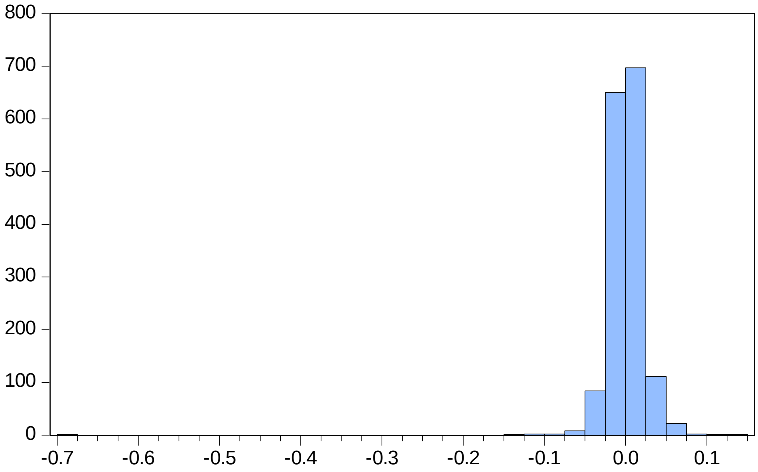
Jarque-Bera   7050.317
Probability   0.000000
```



```
Series: CRH_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000124
Median        0.000000
Maximum       0.126864
Minimum      -0.179258
Std. Dev.     0.024044
Skewness     -0.213161
Kurtosis      6.461471

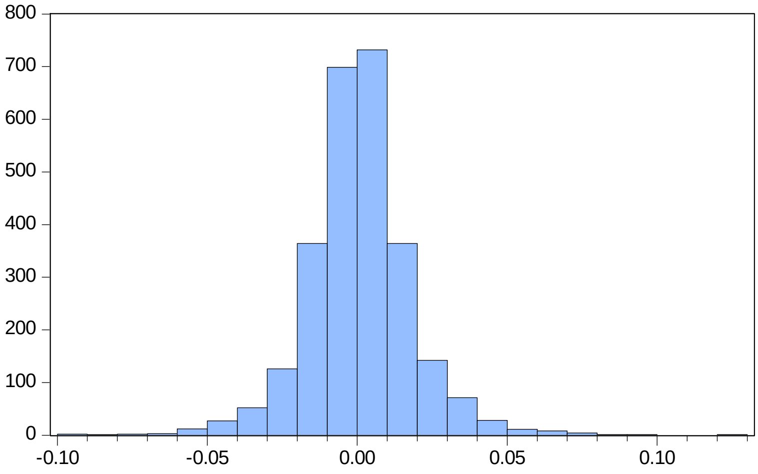
Jarque-Bera   1343.564
Probability   0.000000
```



```
Series: DC__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 1582

Mean          0.000532
Median        0.000000
Maximum       0.142692
Minimum      -0.679603
Std. Dev.     0.026417
Skewness     -10.72083
Kurtosis      281.1981

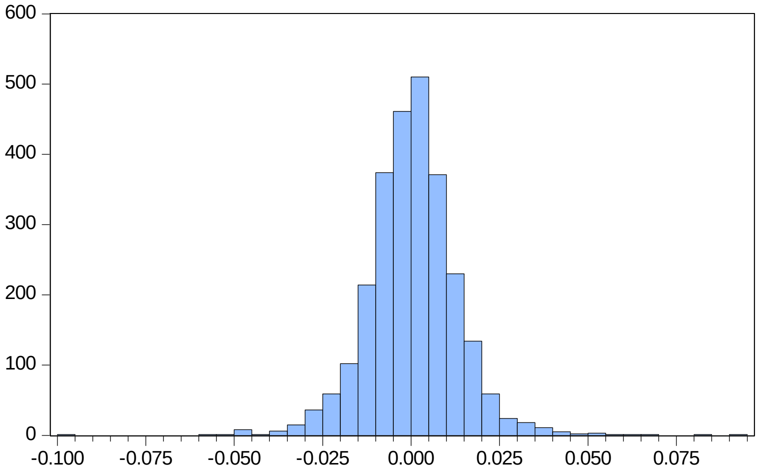
Jarque-Bera   5131870.
Probability   0.000000
```



```
Series: DCC_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000630
Median        0.000353
Maximum       0.120866
Minimum      -0.094452
Std. Dev.     0.017517
Skewness      0.202377
Kurtosis      6.739445

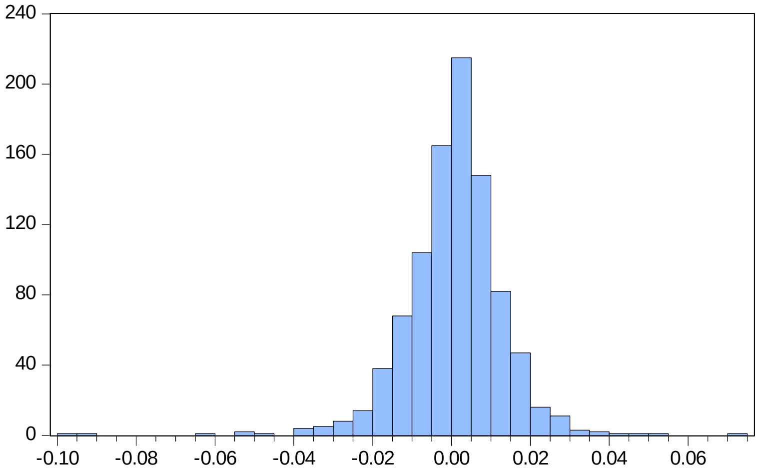
Jarque-Bera   1562.684
Probability   0.000000
```



```
Series: DGE_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000341
Median        0.000000
Maximum       0.094852
Minimum      -0.097805
Std. Dev.     0.012782
Skewness      0.153529
Kurtosis      7.724049

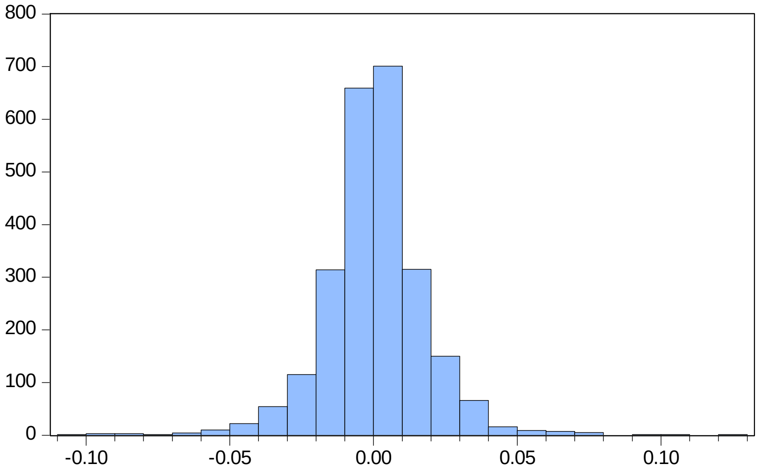
Jarque-Bera   2475.473
Probability   0.000000
```



```
Series: DLG_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 940

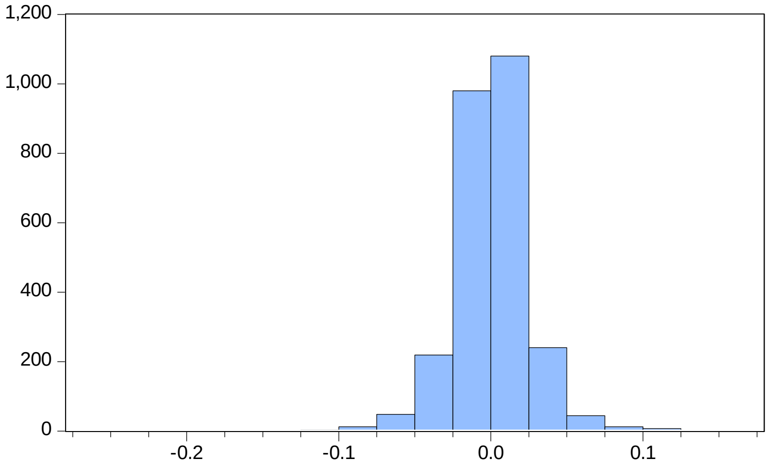
Mean          0.000629
Median        0.001376
Maximum       0.071657
Minimum      -0.096425
Std. Dev.     0.012789
Skewness     -0.984062
Kurtosis      12.00908

Jarque-Bera   3330.618
Probability   0.000000
```



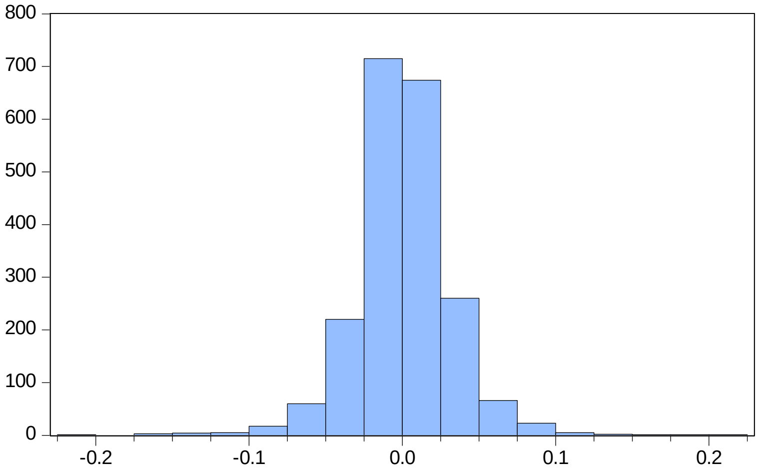
Series: EXPN_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2458

Mean	0.000376
Median	0.000000
Maximum	0.125538
Minimum	-0.100167
Std. Dev.	0.017775
Skewness	0.043856
Kurtosis	7.860552
Jarque-Bera	2420.378
Probability	0.000000



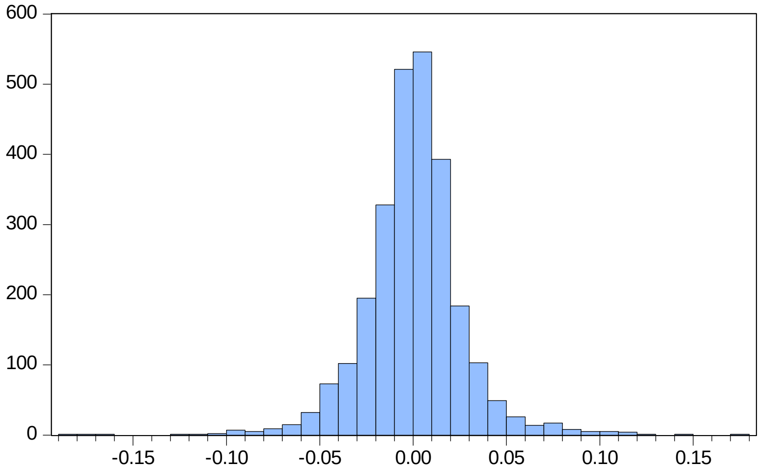
Series: EZJ_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000364
Median	0.000613
Maximum	0.162841
Minimum	-0.252512
Std. Dev.	0.025136
Skewness	-0.499870
Kurtosis	11.55694
Jarque-Bera	8198.291
Probability	0.000000



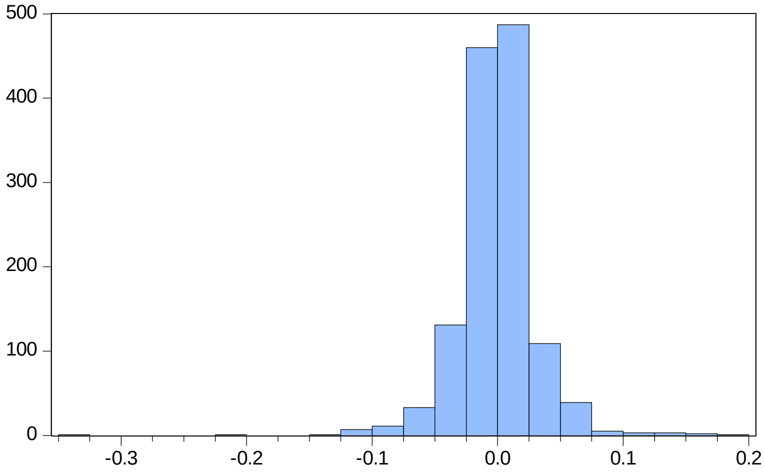
Series: FRES_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2058

Mean	0.000528
Median	0.000000
Maximum	0.205322
Minimum	-0.221364
Std. Dev.	0.031711
Skewness	-0.080819
Kurtosis	8.143077
Jarque-Bera	2270.434
Probability	0.000000



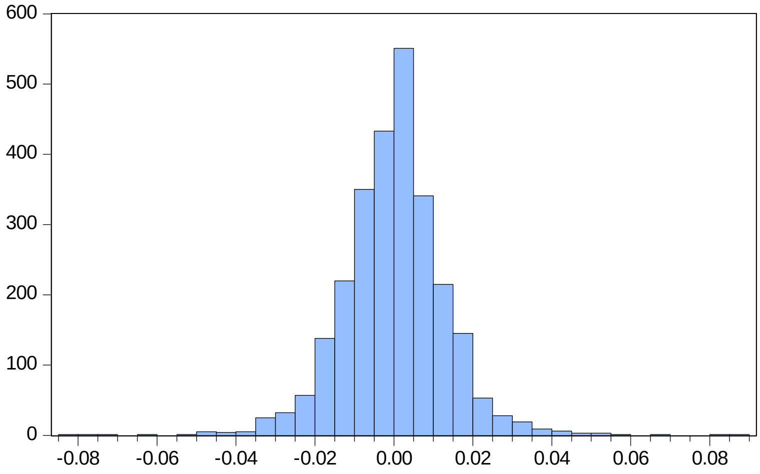
Series: GKN_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000116
Median	0.000000
Maximum	0.175193
Minimum	-0.184206
Std. Dev.	0.026471
Skewness	0.003170
Kurtosis	8.306483
Jarque-Bera	3110.374
Probability	0.000000



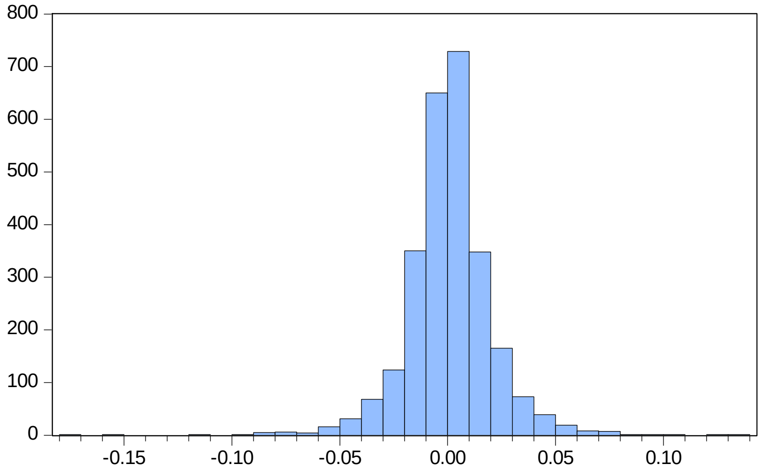
Series: GLEN_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 1294

Mean	-0.000957
Median	0.000000
Maximum	0.191055
Minimum	-0.348392
Std. Dev.	0.031326
Skewness	-0.833400
Kurtosis	19.35579
Jarque-Bera	14573.14
Probability	0.000000



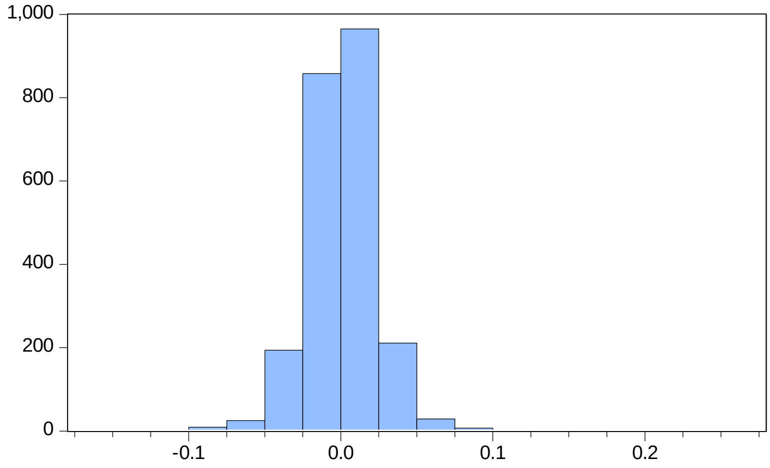
Series: GSK_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	3.66e-05
Median	0.000000
Maximum	0.087053
Minimum	-0.084748
Std. Dev.	0.013087
Skewness	0.034186
Kurtosis	7.072524
Jarque-Bera	1832.518
Probability	0.000000



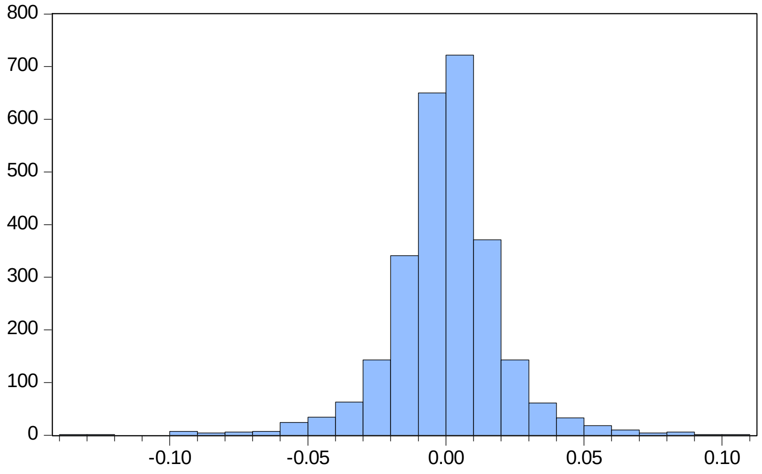
Series: HIK_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000688
Median	0.000536
Maximum	0.131290
Minimum	-0.176250
Std. Dev.	0.020088
Skewness	-0.299666
Kurtosis	10.34226
Jarque-Bera	5994.343
Probability	0.000000



Series: HL__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2308

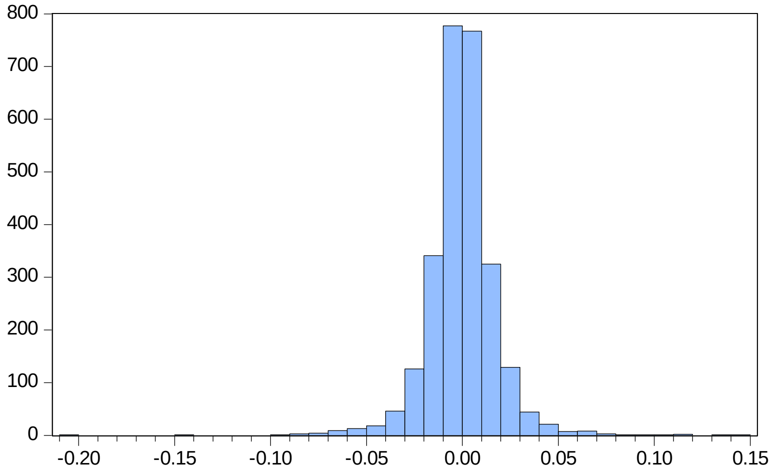
Mean	0.000888
Median	0.000525
Maximum	0.269550
Minimum	-0.167316
Std. Dev.	0.023488
Skewness	0.671096
Kurtosis	14.81648
Jarque-Bera	13600.92
Probability	0.000000



```
Series: HMSO_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          -9.51e-05
Median         0.000000
Maximum        0.107154
Minimum       -0.139847
Std. Dev.      0.020214
Skewness      -0.334791
Kurtosis       7.841791

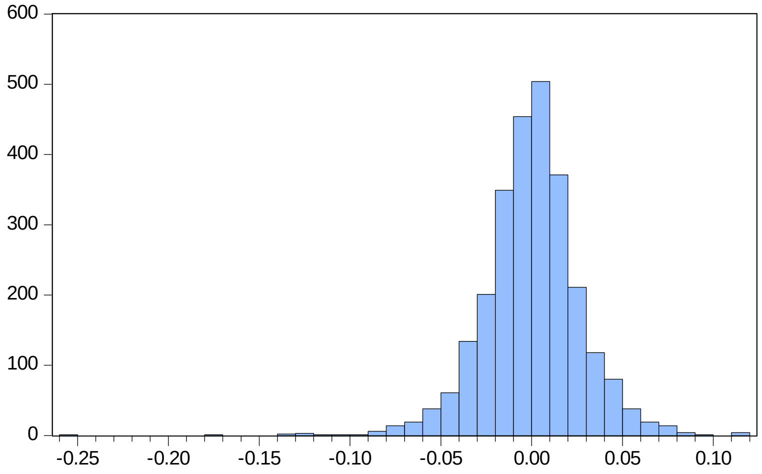
Jarque-Bera    2638.991
Probability    0.000000
```



```
Series: HSBA_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          -0.000210
Median        -0.000313
Maximum        0.144230
Minimum       -0.207992
Std. Dev.      0.018150
Skewness      -0.295514
Kurtosis       17.27418

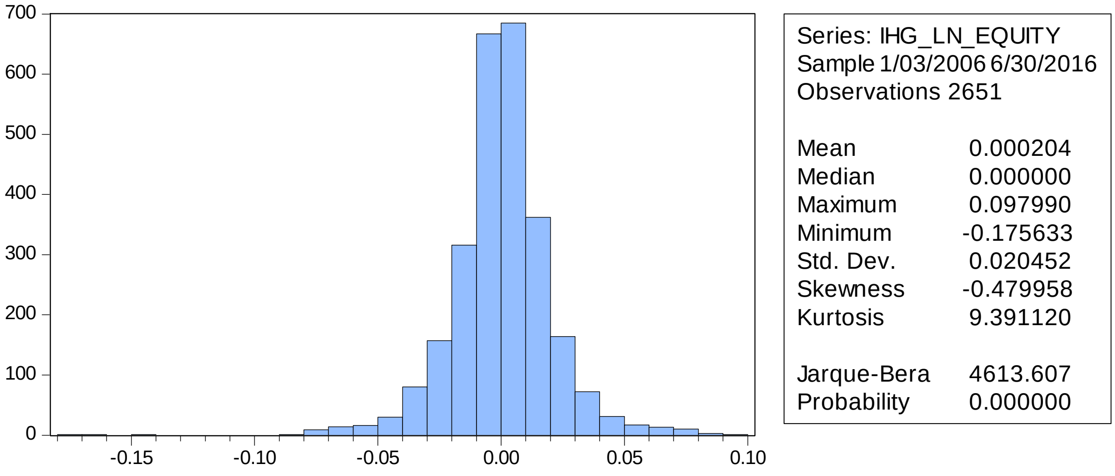
Jarque-Bera    22544.72
Probability    0.000000
```



```
Series: IAG_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2650

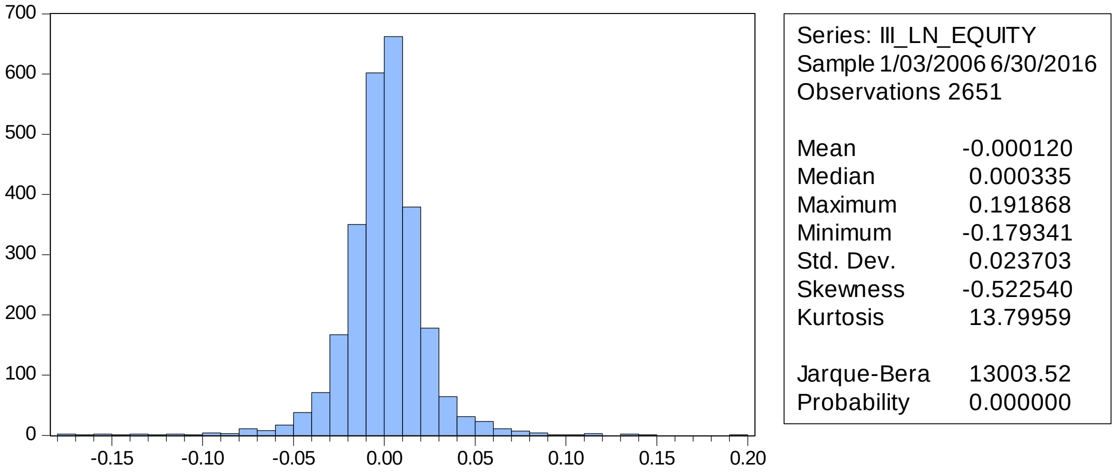
Mean           3.64e-05
Median         0.000663
Maximum        0.117385
Minimum       -0.255381
Std. Dev.      0.026831
Skewness      -0.554935
Kurtosis       8.406065

Jarque-Bera    3362.999
Probability    0.000000
```



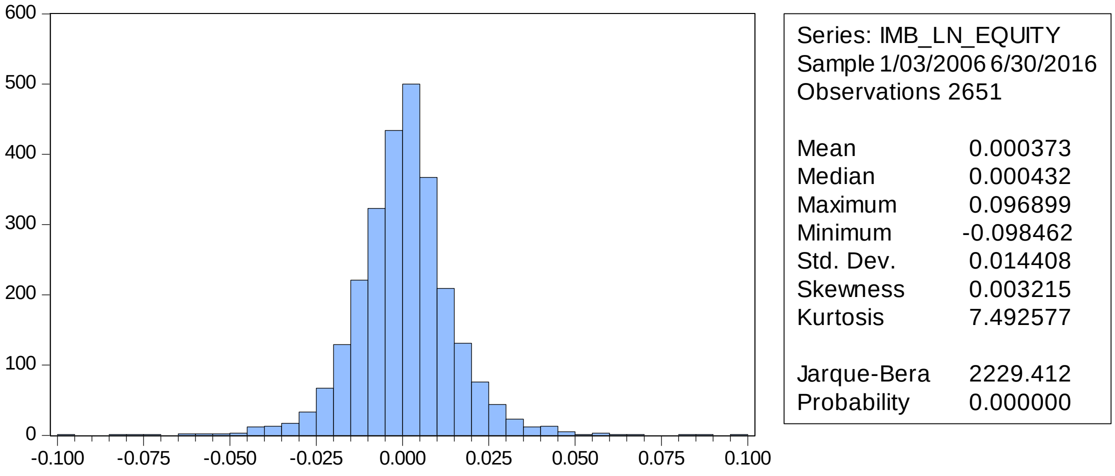
Series: IHG_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000204
Median	0.000000
Maximum	0.097990
Minimum	-0.175633
Std. Dev.	0.020452
Skewness	-0.479958
Kurtosis	9.391120
Jarque-Bera	4613.607
Probability	0.000000



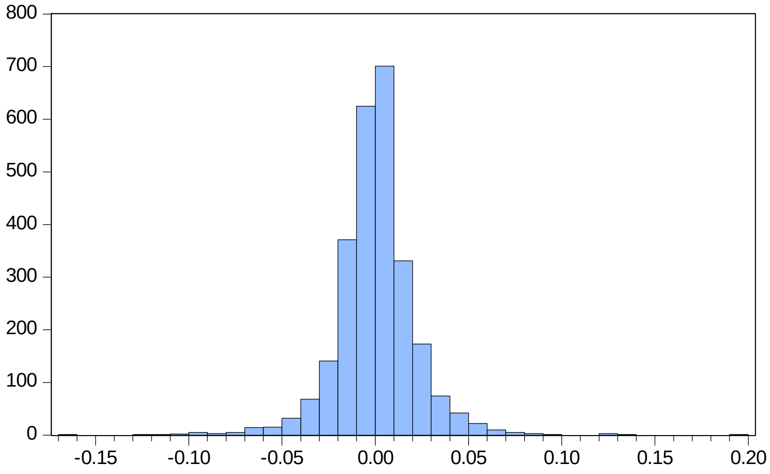
Series: III_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	-0.000120
Median	0.000335
Maximum	0.191868
Minimum	-0.179341
Std. Dev.	0.023703
Skewness	-0.522540
Kurtosis	13.79959
Jarque-Bera	13003.52
Probability	0.000000



Series: IMB_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

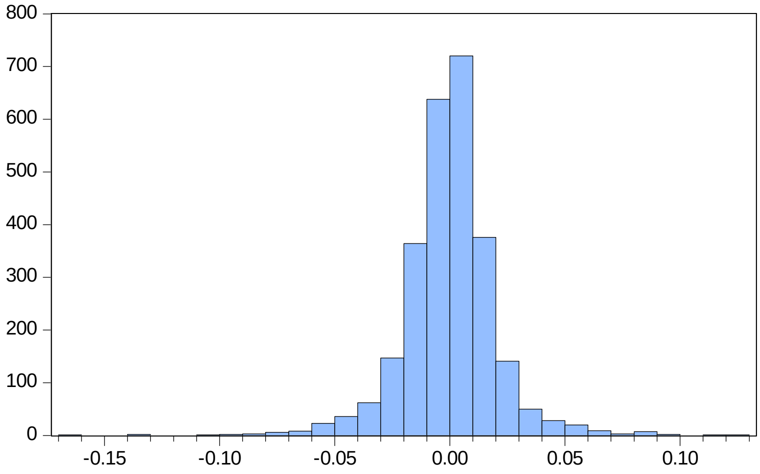
Mean	0.000373
Median	0.000432
Maximum	0.096899
Minimum	-0.098462
Std. Dev.	0.014408
Skewness	0.003215
Kurtosis	7.492577
Jarque-Bera	2229.412
Probability	0.000000



```
Series: INF_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000255
Median        0.000000
Maximum       0.193968
Minimum      -0.164099
Std. Dev.     0.021590
Skewness      0.114289
Kurtosis      10.85888

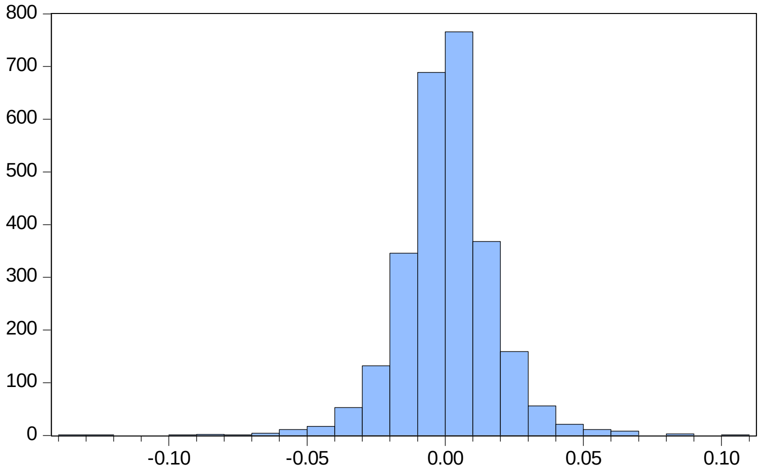
Jarque-Bera   6827.891
Probability   0.000000
```



```
Series: INTU_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean         -0.000305
Median        0.000260
Maximum       0.121530
Minimum      -0.169469
Std. Dev.     0.020327
Skewness     -0.305332
Kurtosis      9.630970

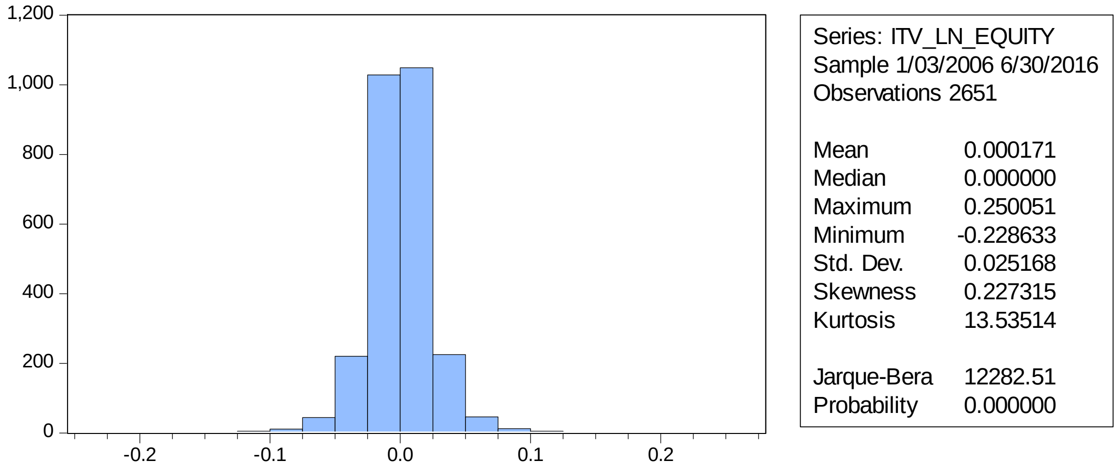
Jarque-Bera   4898.017
Probability   0.000000
```



```
Series: ITRK_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000605
Median        0.000523
Maximum       0.106137
Minimum      -0.134478
Std. Dev.     0.017110
Skewness     -0.274150
Kurtosis      8.507412

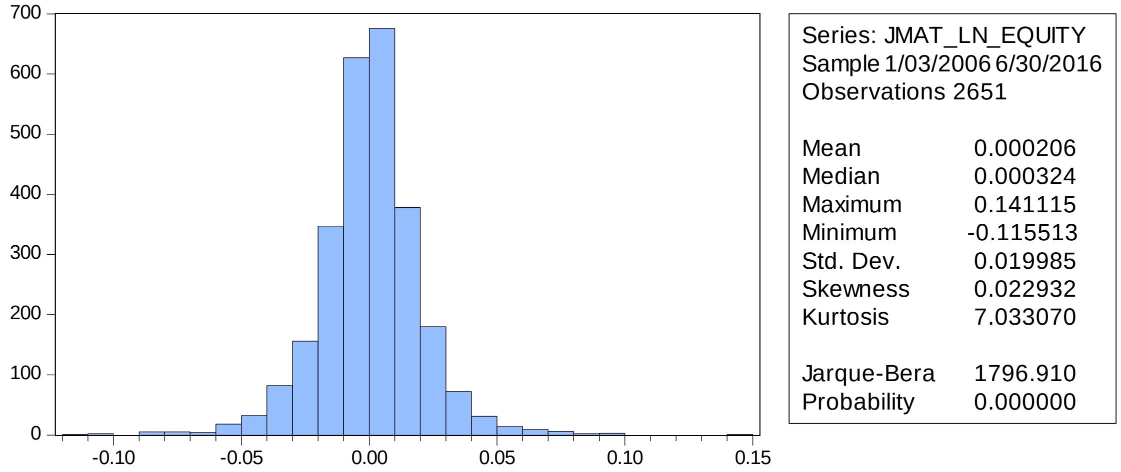
Jarque-Bera   3383.584
Probability   0.000000
```



```
Series: ITV_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000171
Median        0.000000
Maximum       0.250051
Minimum      -0.228633
Std. Dev.     0.025168
Skewness      0.227315
Kurtosis      13.53514

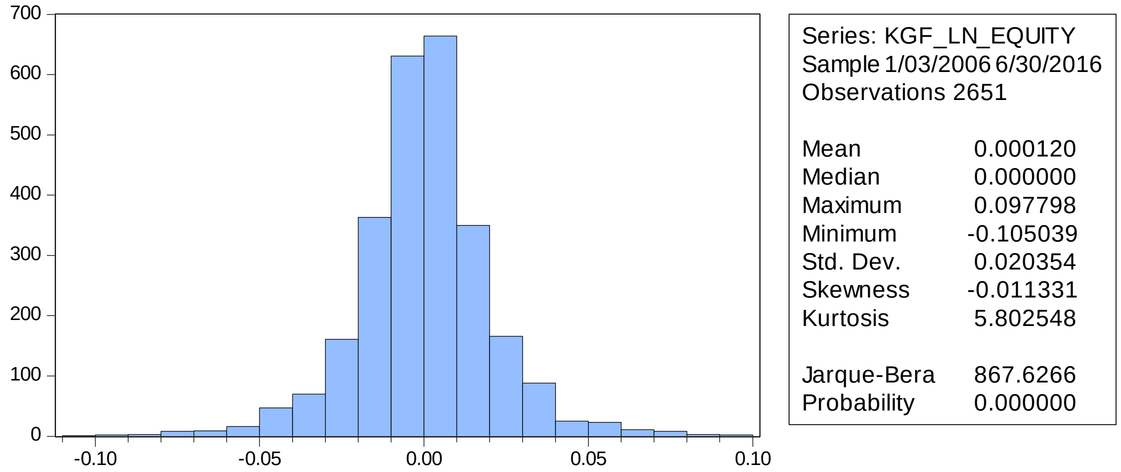
Jarque-Bera   12282.51
Probability   0.000000
```



```
Series: JMAT_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000206
Median        0.000324
Maximum       0.141115
Minimum      -0.115513
Std. Dev.     0.019985
Skewness      0.022932
Kurtosis      7.033070

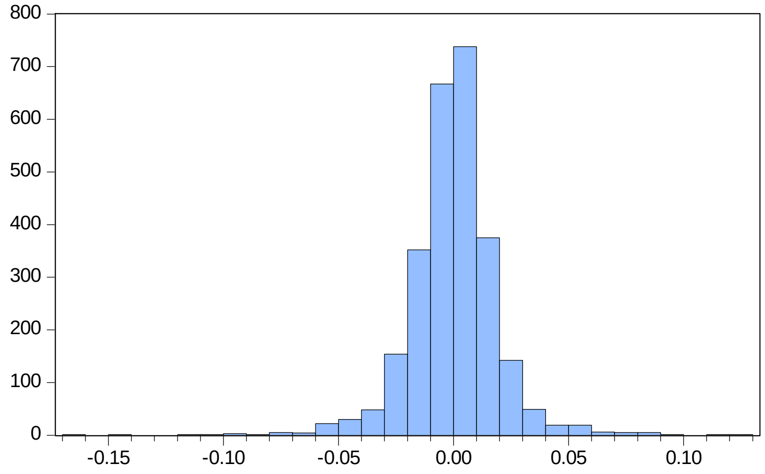
Jarque-Bera   1796.910
Probability   0.000000
```



```
Series: KGF_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

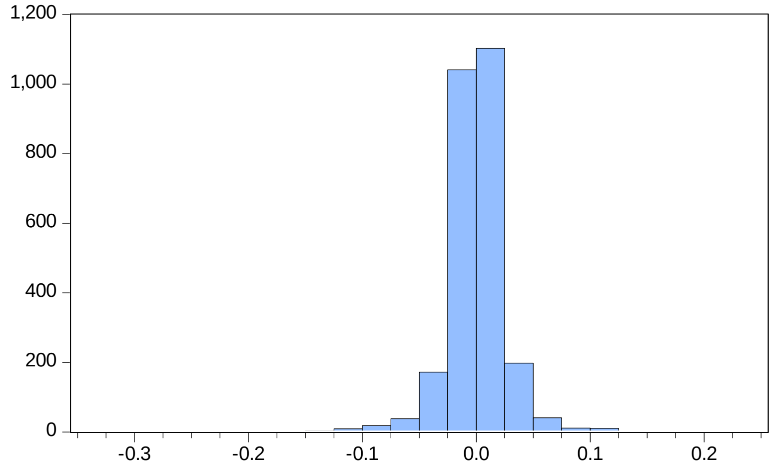
Mean          0.000120
Median        0.000000
Maximum       0.097798
Minimum      -0.105039
Std. Dev.     0.020354
Skewness     -0.011331
Kurtosis      5.802548

Jarque-Bera   867.6266
Probability   0.000000
```



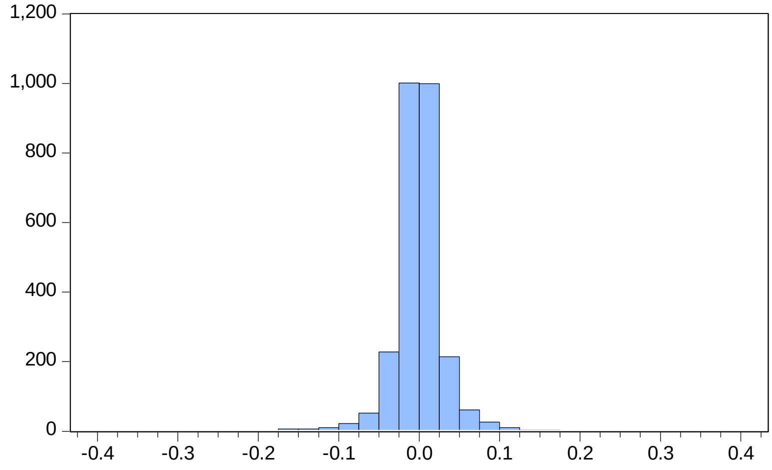
Series: LAND_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	-0.000140
Median	0.000000
Maximum	0.120973
Minimum	-0.168966
Std. Dev.	0.019295
Skewness	-0.372798
Kurtosis	10.51439
Jarque-Bera	6298.549
Probability	0.000000



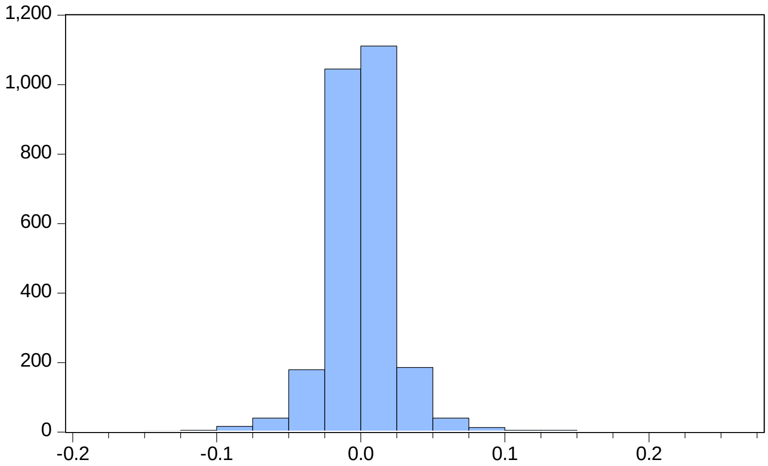
Series: LGEN_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000163
Median	0.000000
Maximum	0.243002
Minimum	-0.340759
Std. Dev.	0.026734
Skewness	-0.594244
Kurtosis	23.97649
Jarque-Bera	48759.13
Probability	0.000000



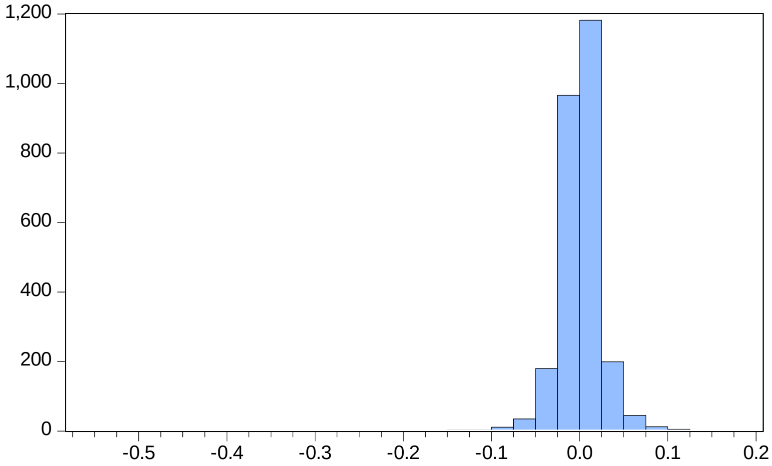
Series: LLOY_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	-0.000567
Median	-0.000205
Maximum	0.407966
Minimum	-0.414634
Std. Dev.	0.034791
Skewness	-1.045855
Kurtosis	35.46545
Jarque-Bera	116906.9
Probability	0.000000



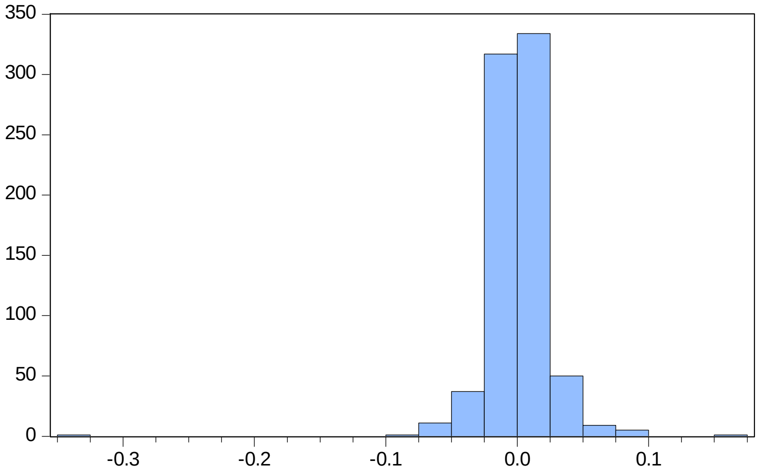
Series: LSE_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000498
Median	0.000000
Maximum	0.266726
Minimum	-0.180474
Std. Dev.	0.024633
Skewness	0.536038
Kurtosis	14.64514
Jarque-Bera	15106.13
Probability	0.000000



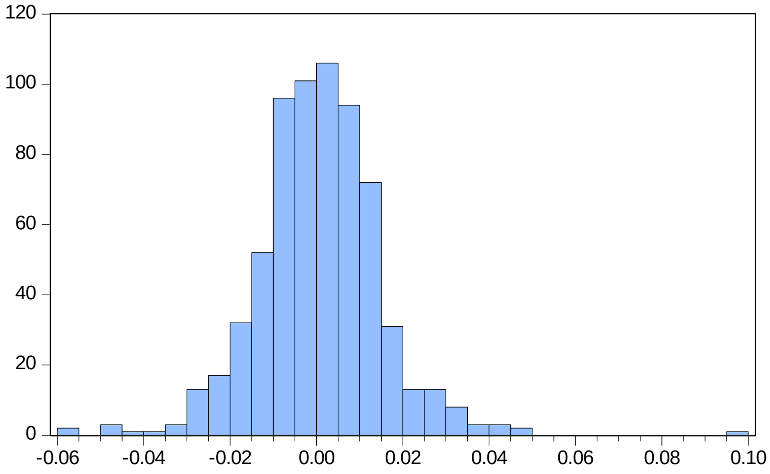
Series: MCRO_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000832
Median	0.000854
Maximum	0.190796
Minimum	-0.557711
Std. Dev.	0.027833
Skewness	-3.932497
Kurtosis	81.33379
Jarque-Bera	684625.2
Probability	0.000000



Series: MDC_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 766

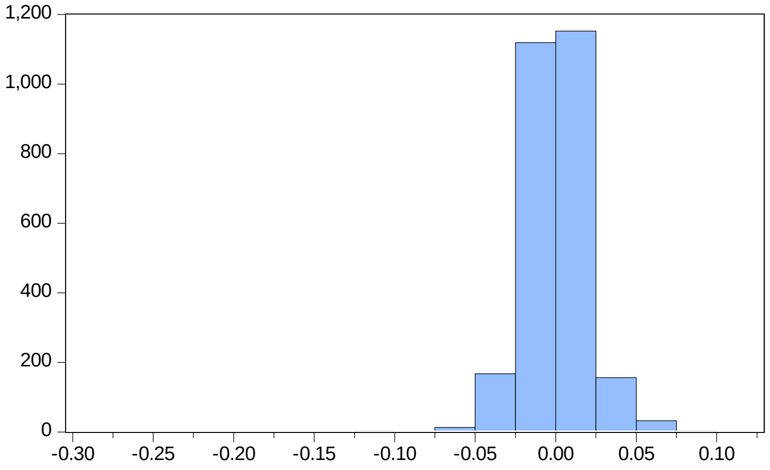
Mean	0.000841
Median	0.000000
Maximum	0.154797
Minimum	-0.326081
Std. Dev.	0.023187
Skewness	-3.135376
Kurtosis	57.33435
Jarque-Bera	95480.12
Probability	0.000000



```
Series: MERL_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 667

Mean          0.000502
Median        0.000000
Maximum       0.096752
Minimum      -0.057305
Std. Dev.     0.014271
Skewness      0.322403
Kurtosis      7.131957

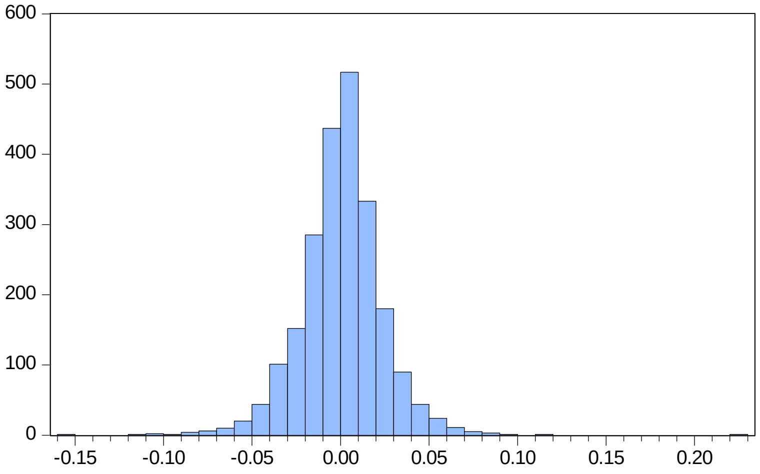
Jarque-Bera   486.0441
Probability   0.000000
```



```
Series: MKS_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean         -0.000168
Median        0.000000
Maximum       0.112518
Minimum      -0.281412
Std. Dev.     0.019750
Skewness     -1.534116
Kurtosis      25.74386

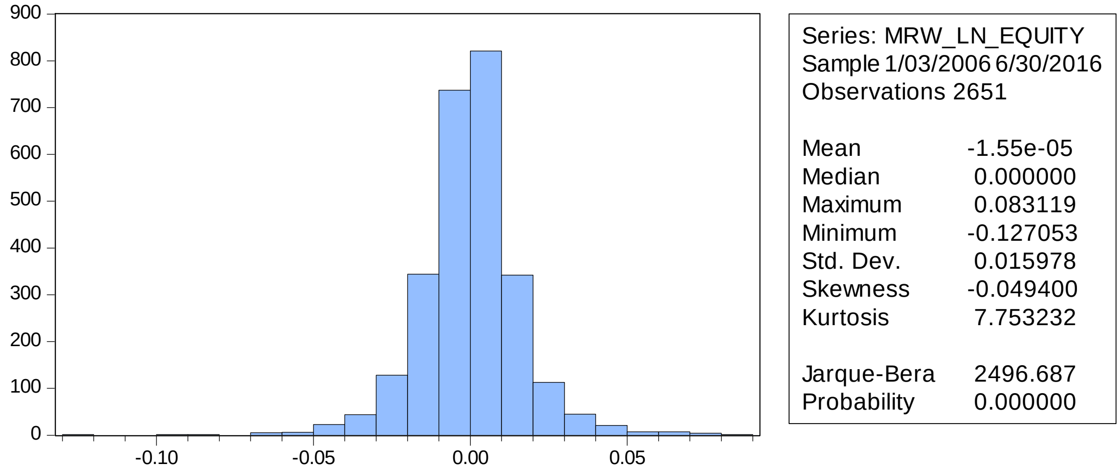
Jarque-Bera   58178.12
Probability   0.000000
```



```
Series: MNDI_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2274

Mean          0.000451
Median        0.000885
Maximum       0.226863
Minimum      -0.159307
Std. Dev.     0.023379
Skewness      0.115649
Kurtosis      9.247203

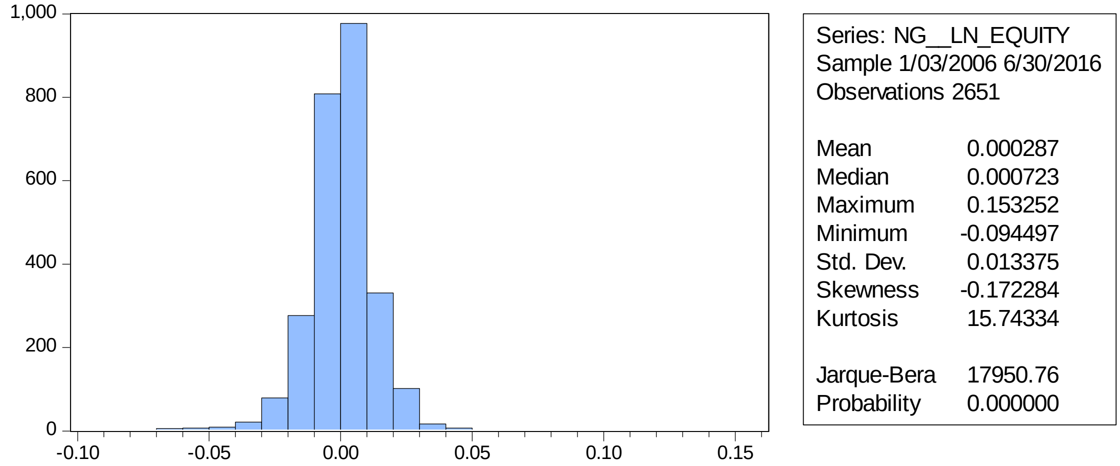
Jarque-Bera   3702.929
Probability   0.000000
```



```
Series: MRW_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          -1.55e-05
Median         0.000000
Maximum        0.083119
Minimum       -0.127053
Std. Dev.      0.015978
Skewness      -0.049400
Kurtosis       7.753232

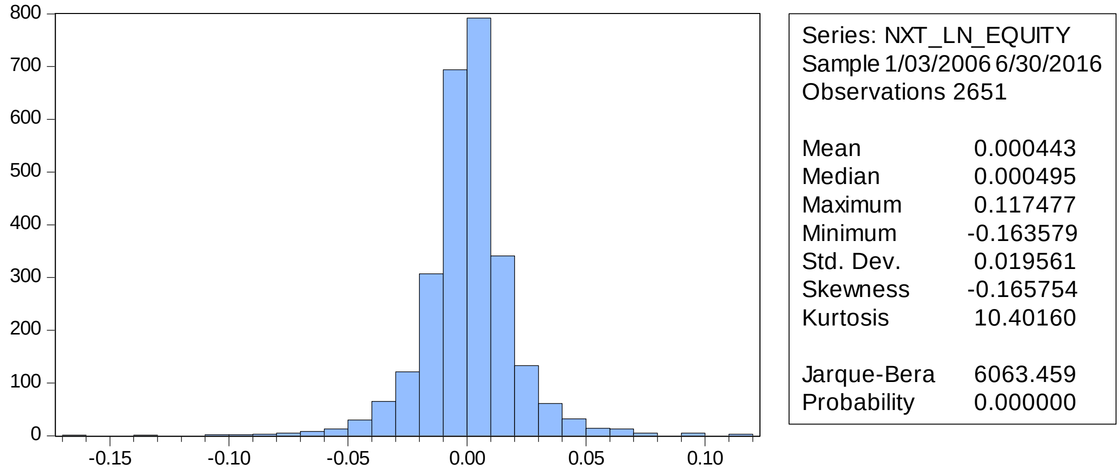
Jarque-Bera    2496.687
Probability    0.000000
```



```
Series: NG__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean           0.000287
Median         0.000723
Maximum        0.153252
Minimum       -0.094497
Std. Dev.      0.013375
Skewness      -0.172284
Kurtosis       15.74334

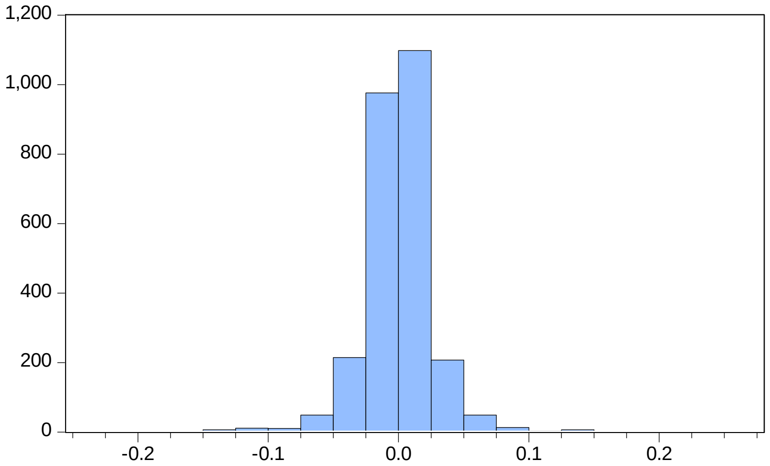
Jarque-Bera    17950.76
Probability    0.000000
```



```
Series: NXT_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

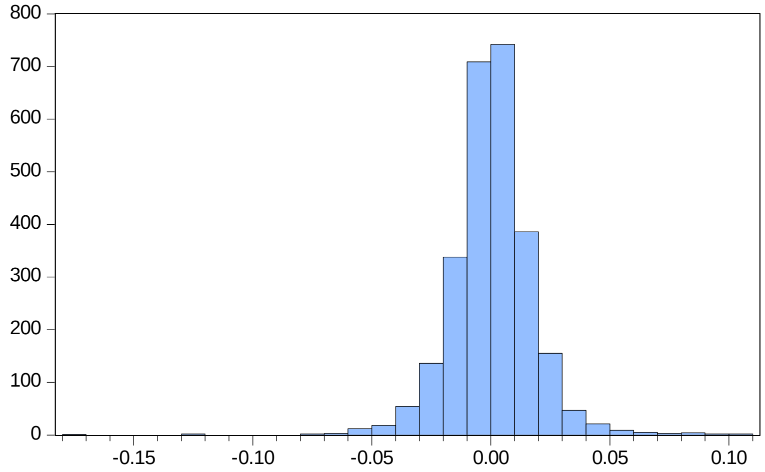
Mean           0.000443
Median         0.000495
Maximum        0.117477
Minimum       -0.163579
Std. Dev.      0.019561
Skewness      -0.165754
Kurtosis       10.40160

Jarque-Bera    6063.459
Probability    0.000000
```



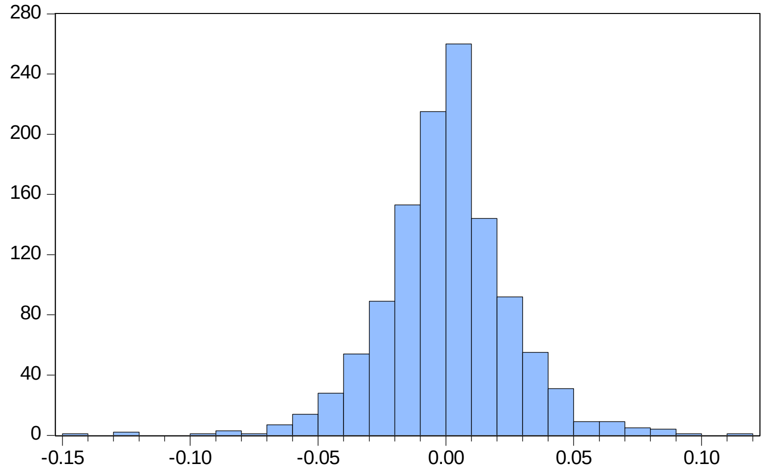
Series: OML_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	2.05e-05
Median	0.000000
Maximum	0.264342
Minimum	-0.243891
Std. Dev.	0.027928
Skewness	-0.187492
Kurtosis	15.48782
Jarque-Bera	17241.01
Probability	0.000000



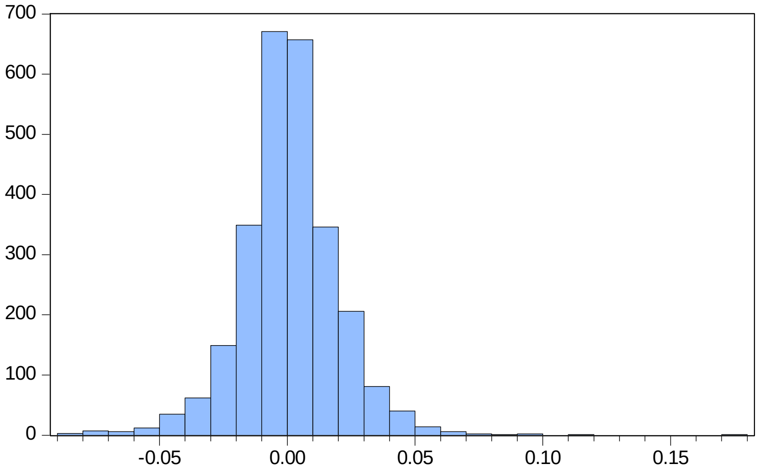
Series: PFG_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000438
Median	0.000000
Maximum	0.101533
Minimum	-0.175088
Std. Dev.	0.017580
Skewness	-0.254995
Kurtosis	11.49702
Jarque-Bera	8003.746
Probability	0.000000



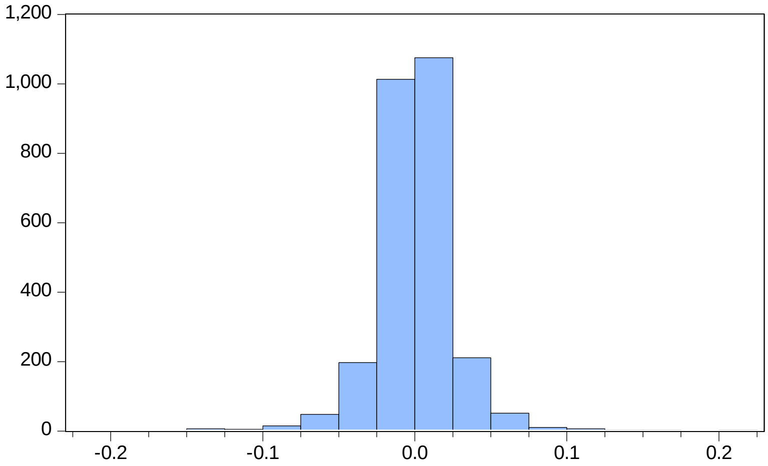
Series: POLY_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 1179

Mean	0.000110
Median	0.000685
Maximum	0.111791
Minimum	-0.141043
Std. Dev.	0.025108
Skewness	-0.172389
Kurtosis	5.784433
Jarque-Bera	386.7089
Probability	0.000000



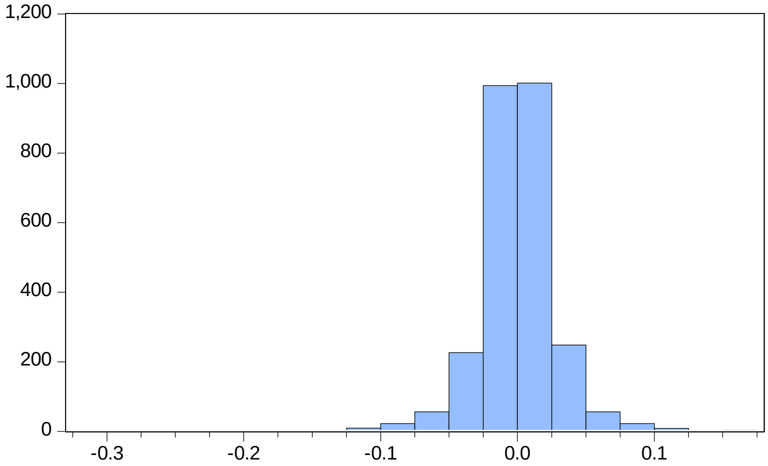
Series: PPB_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000792
Median	0.000406
Maximum	0.179789
Minimum	-0.086542
Std. Dev.	0.019321
Skewness	0.287529
Kurtosis	8.064184
Jarque-Bera	2869.337
Probability	0.000000



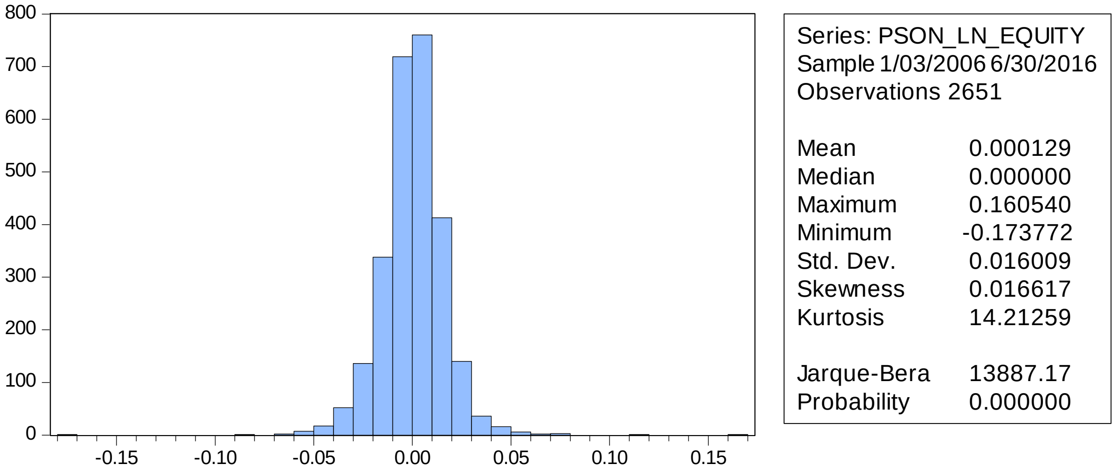
Series: PRU_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000305
Median	0.000000
Maximum	0.210721
Minimum	-0.223144
Std. Dev.	0.027587
Skewness	0.218477
Kurtosis	15.47523
Jarque-Bera	17211.86
Probability	0.000000



Series: PSN_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

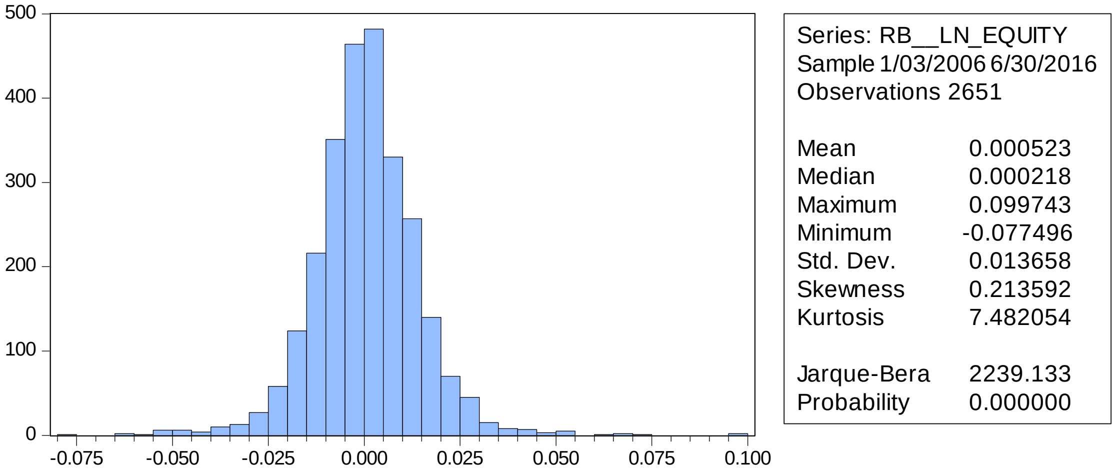
Mean	5.19e-05
Median	0.000000
Maximum	0.162830
Minimum	-0.322274
Std. Dev.	0.028330
Skewness	-0.616635
Kurtosis	13.94405
Jarque-Bera	13397.85
Probability	0.000000



```
Series: PSON_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000129
Median        0.000000
Maximum       0.160540
Minimum      -0.173772
Std. Dev.     0.016009
Skewness      0.016617
Kurtosis      14.21259

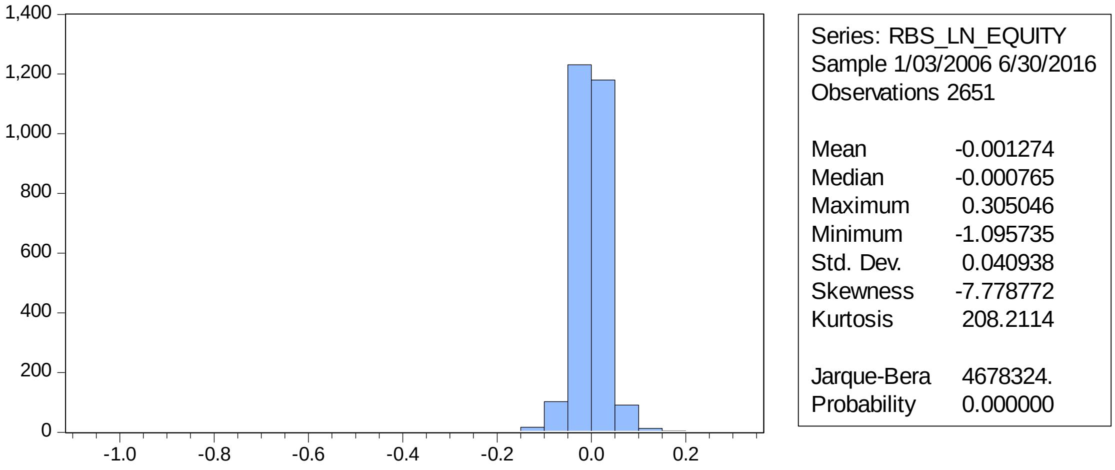
Jarque-Bera   13887.17
Probability   0.000000
```



```
Series: RB__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000523
Median        0.000218
Maximum       0.099743
Minimum      -0.077496
Std. Dev.     0.013658
Skewness      0.213592
Kurtosis      7.482054

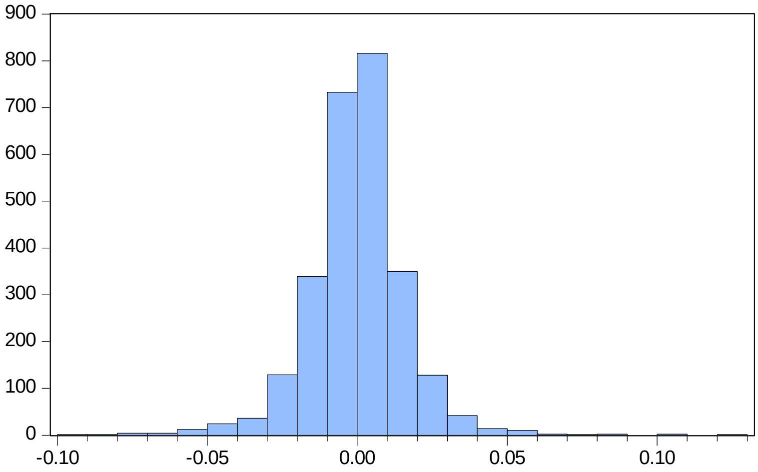
Jarque-Bera   2239.133
Probability   0.000000
```



```
Series: RBS_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean         -0.001274
Median       -0.000765
Maximum       0.305046
Minimum      -1.095735
Std. Dev.     0.040938
Skewness     -7.778772
Kurtosis      208.2114

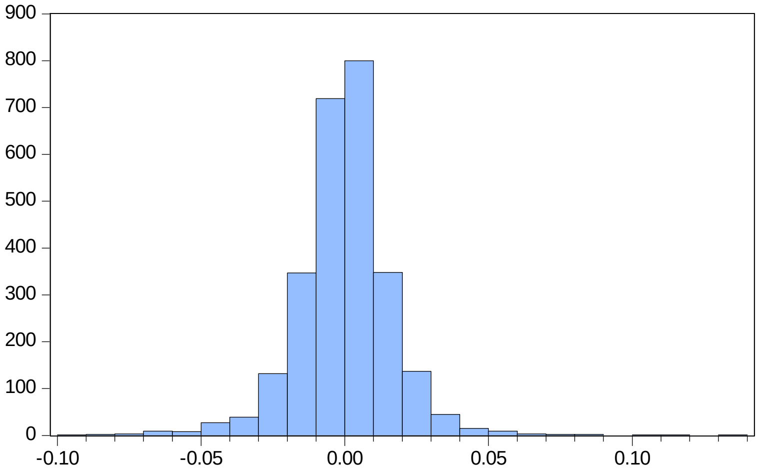
Jarque-Bera   4678324.
Probability   0.000000
```



```
Series: RDSA_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          4.30e-05
Median        0.000235
Maximum       0.128570
Minimum      -0.097888
Std. Dev.     0.016104
Skewness      0.145869
Kurtosis      8.843114

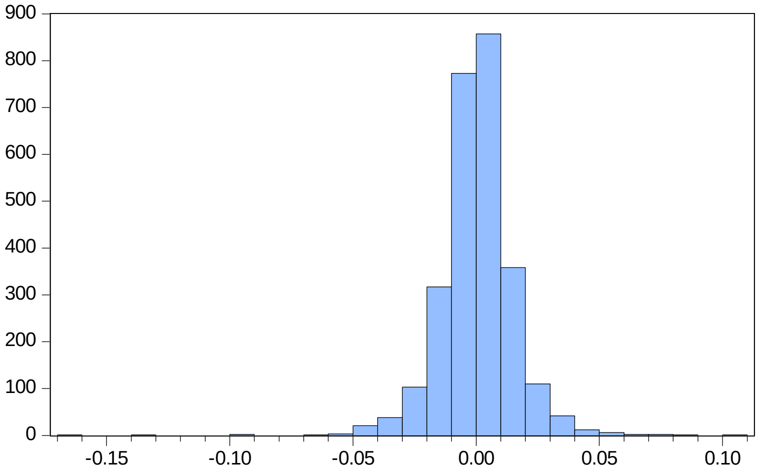
Jarque-Bera   3780.668
Probability   0.000000
```



```
Series: RDSB_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          2.75e-05
Median        0.000235
Maximum       0.132139
Minimum      -0.098147
Std. Dev.     0.016753
Skewness      0.120908
Kurtosis      8.819942

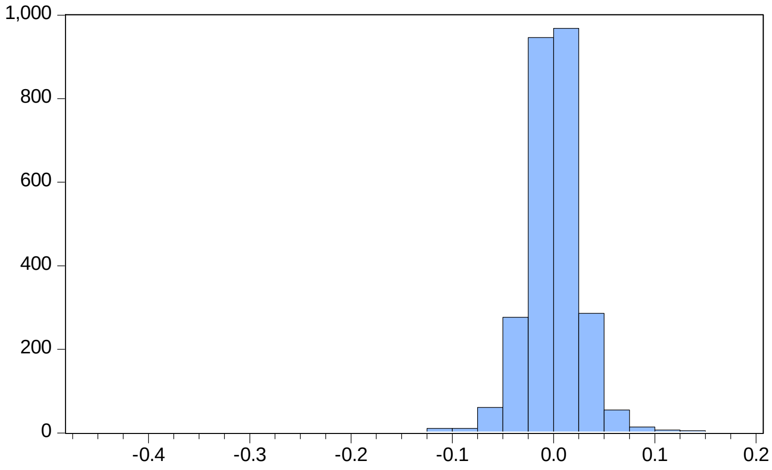
Jarque-Bera   3747.874
Probability   0.000000
```



```
Series: REL_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

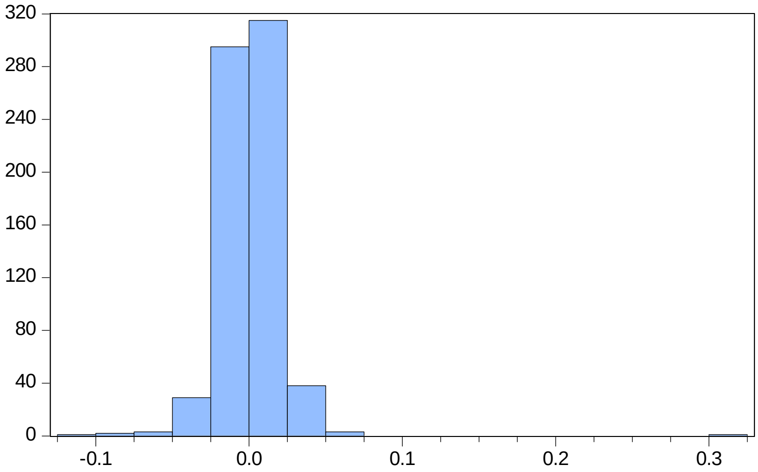
Mean          0.000291
Median        0.000000
Maximum       0.106651
Minimum      -0.165224
Std. Dev.     0.015045
Skewness     -0.726684
Kurtosis      14.45593

Jarque-Bera   14729.68
Probability   0.000000
```



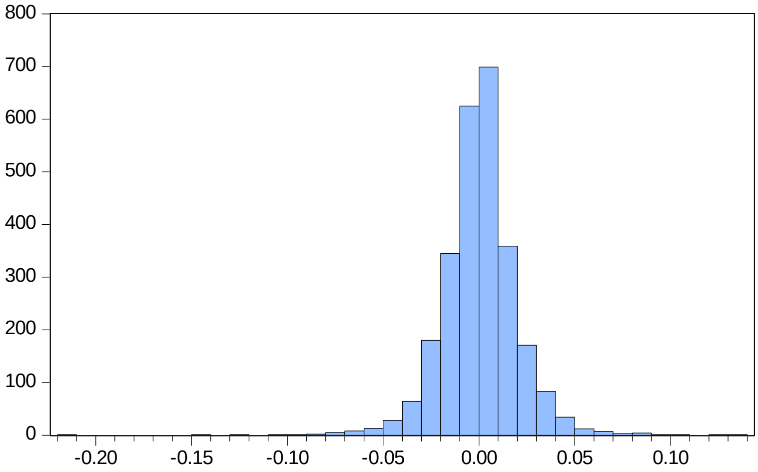
Series: RIO_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	1.02e-05
Median	0.000157
Maximum	0.196776
Minimum	-0.457833
Std. Dev.	0.030198
Skewness	-1.168160
Kurtosis	27.36180
Jarque-Bera	66159.66
Probability	0.000000



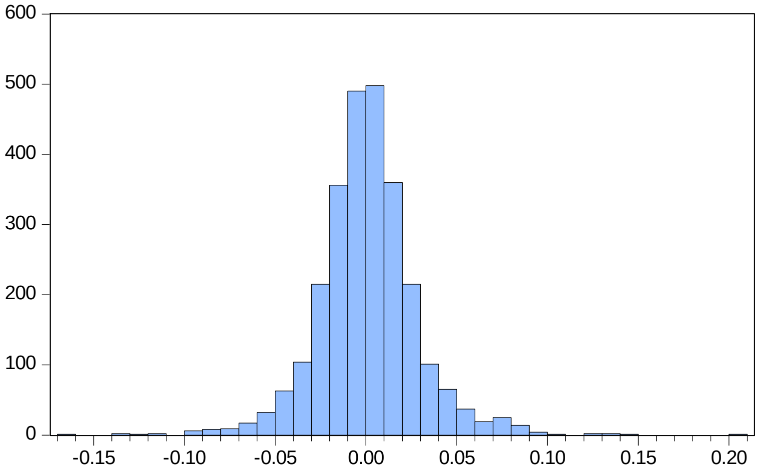
Series: RMG_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 687

Mean	0.000608
Median	0.000000
Maximum	0.321205
Minimum	-0.102466
Std. Dev.	0.021041
Skewness	4.888401
Kurtosis	81.79150
Jarque-Bera	180443.0
Probability	0.000000



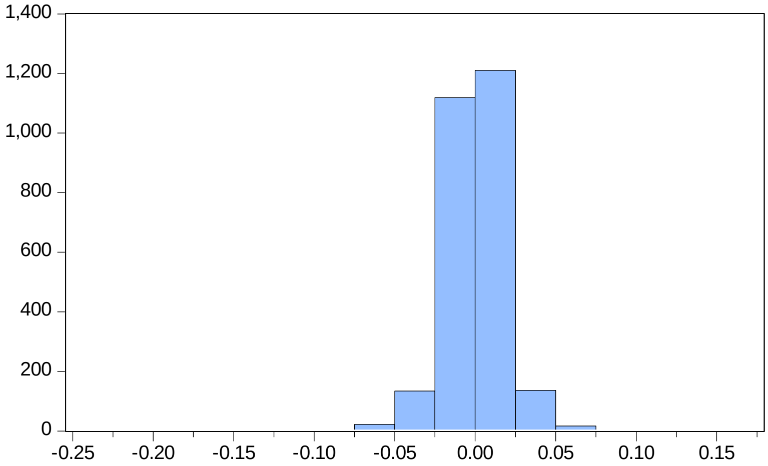
Series: RR__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000186
Median	0.000000
Maximum	0.134003
Minimum	-0.217723
Std. Dev.	0.020175
Skewness	-0.506041
Kurtosis	12.78146
Jarque-Bera	10681.46
Probability	0.000000



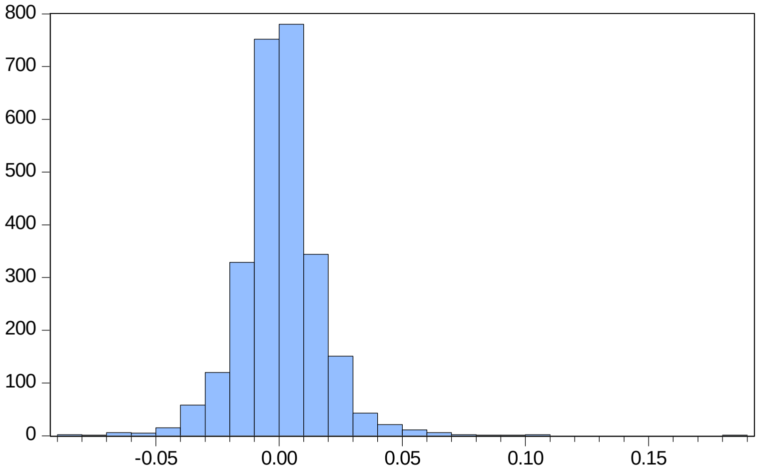
Series: RRS_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000813
Median	0.000000
Maximum	0.202246
Minimum	-0.162373
Std. Dev.	0.027408
Skewness	0.230477
Kurtosis	7.088502
Jarque-Bera	1869.874
Probability	0.000000



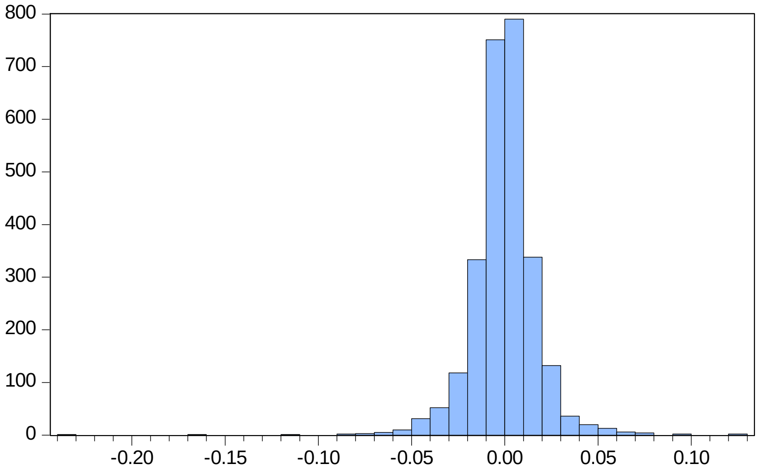
Series: RSA_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	-4.86e-05
Median	0.000000
Maximum	0.169178
Minimum	-0.233749
Std. Dev.	0.018829
Skewness	-0.541466
Kurtosis	19.76996
Jarque-Bera	31193.91
Probability	0.000000



Series: SAB_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

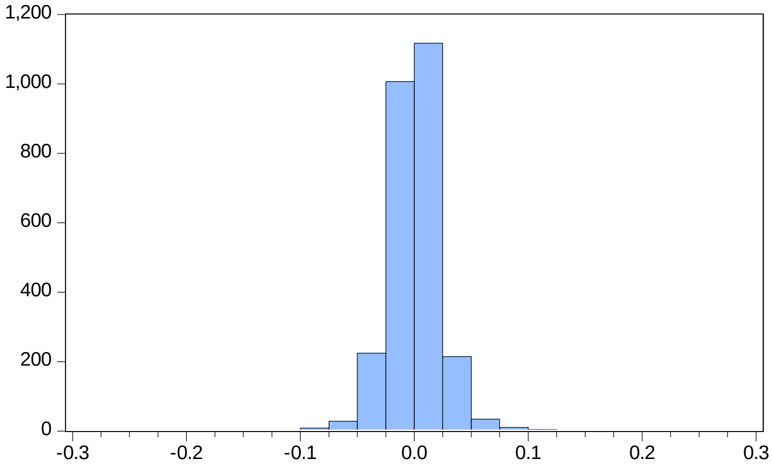
Mean	0.000526
Median	0.000000
Maximum	0.181381
Minimum	-0.089119
Std. Dev.	0.016654
Skewness	0.731358
Kurtosis	11.73779
Jarque-Bera	8669.706
Probability	0.000000



```
Series: SBRY_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          -0.000123
Median         0.000000
Maximum        0.129875
Minimum       -0.232193
Std. Dev.      0.017890
Skewness      -0.855575
Kurtosis       20.81503

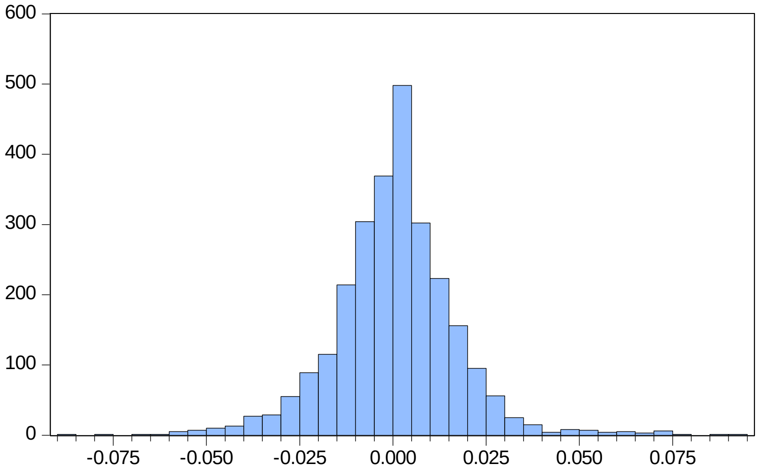
Jarque-Bera    35380.16
Probability    0.000000
```



```
Series: SDR_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          0.000337
Median        0.000634
Maximum       0.280302
Minimum      -0.290252
Std. Dev.     0.023609
Skewness     -0.232248
Kurtosis      22.45749

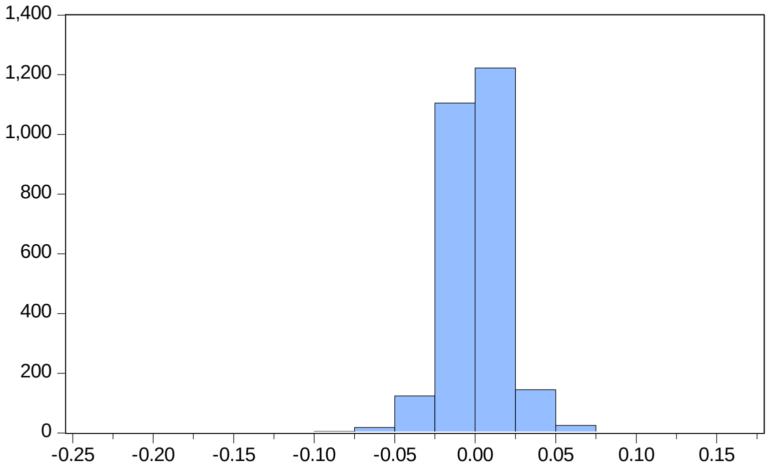
Jarque-Bera   41842.68
Probability   0.000000
```



```
Series: SGE_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

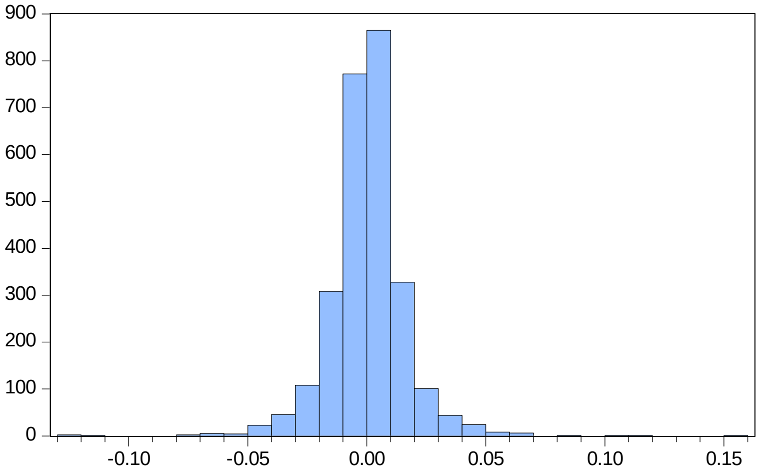
Mean           0.000326
Median         0.000538
Maximum        0.094984
Minimum       -0.089359
Std. Dev.      0.016547
Skewness       0.198264
Kurtosis       6.261928

Jarque-Bera    1192.664
Probability    0.000000
```



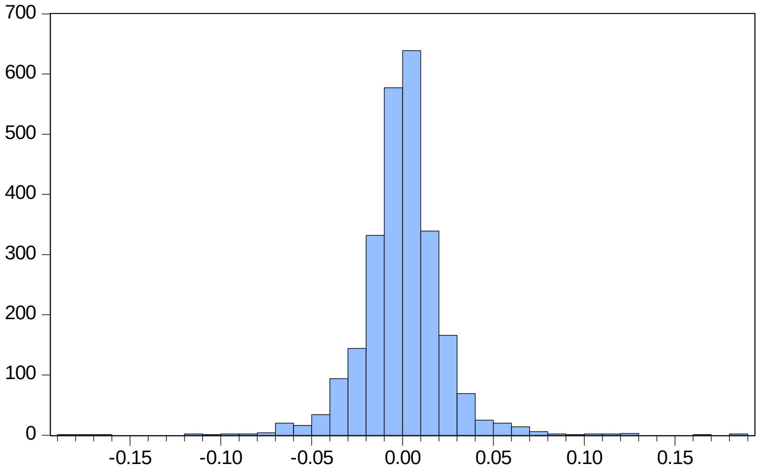
Series: SHP_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000691
Median	0.000552
Maximum	0.156441
Minimum	-0.247763
Std. Dev.	0.018523
Skewness	-0.642620
Kurtosis	20.31294
Jarque-Bera	33291.00
Probability	0.000000



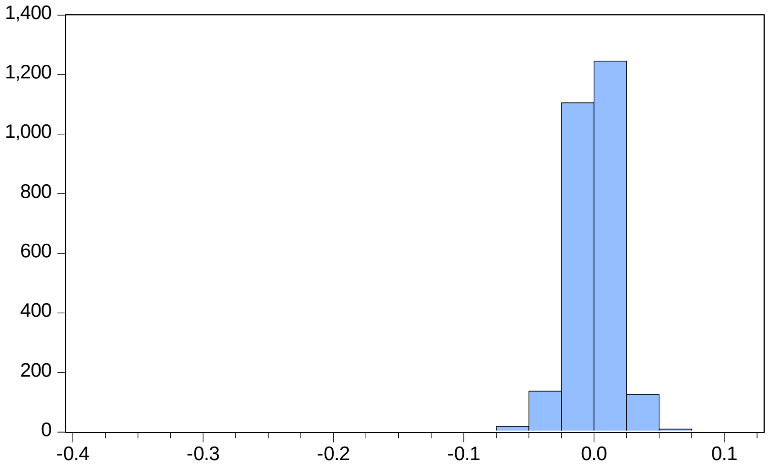
Series: SKY_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000201
Median	0.000000
Maximum	0.153318
Minimum	-0.123508
Std. Dev.	0.016156
Skewness	0.159059
Kurtosis	13.12218
Jarque-Bera	11328.58
Probability	0.000000



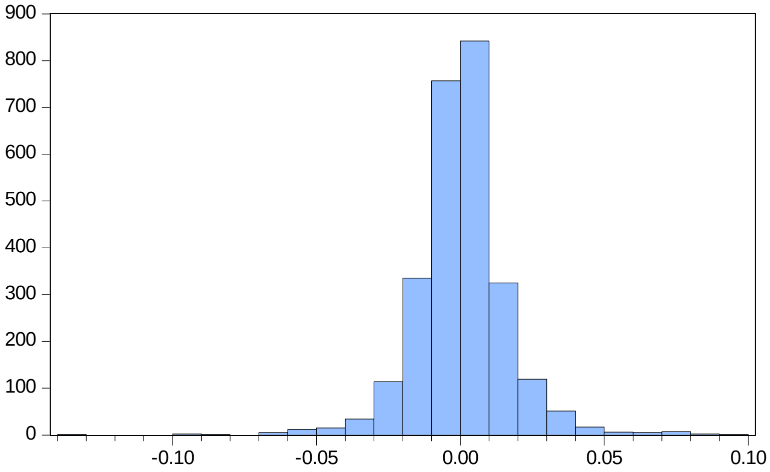
Series: SL__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2522

Mean	1.72e-05
Median	0.000000
Maximum	0.186564
Minimum	-0.189983
Std. Dev.	0.023146
Skewness	0.163734
Kurtosis	13.69834
Jarque-Bera	12038.54
Probability	0.000000



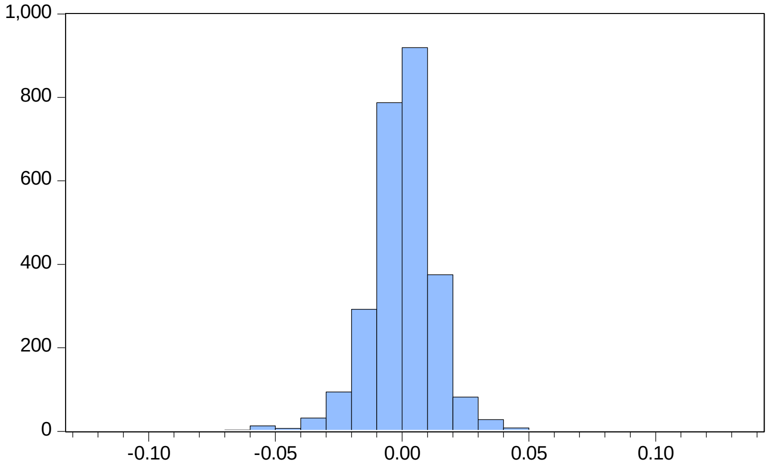
Series: SMIN_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	-0.000112
Median	0.000000
Maximum	0.109446
Minimum	-0.398657
Std. Dev.	0.018807
Skewness	-3.795753
Kurtosis	82.64109
Jarque-Bera	706970.2
Probability	0.000000



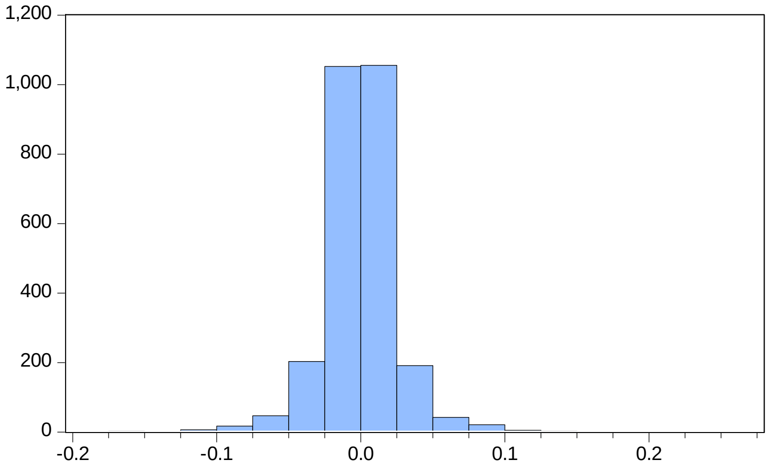
Series: SN__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000324
Median	0.000000
Maximum	0.091106
Minimum	-0.138999
Std. Dev.	0.016072
Skewness	-0.066750
Kurtosis	9.331737
Jarque-Bera	4430.341
Probability	0.000000



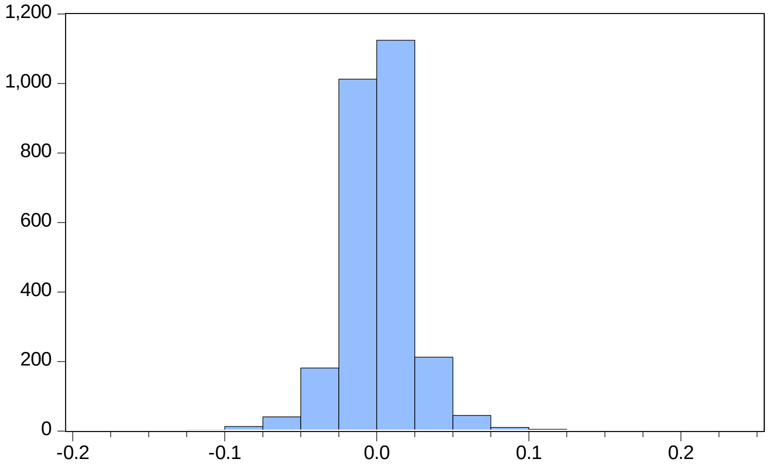
Series: SSE_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000158
Median	0.000000
Maximum	0.134709
Minimum	-0.129754
Std. Dev.	0.014009
Skewness	-0.374087
Kurtosis	12.38539
Jarque-Bera	9791.603
Probability	0.000000



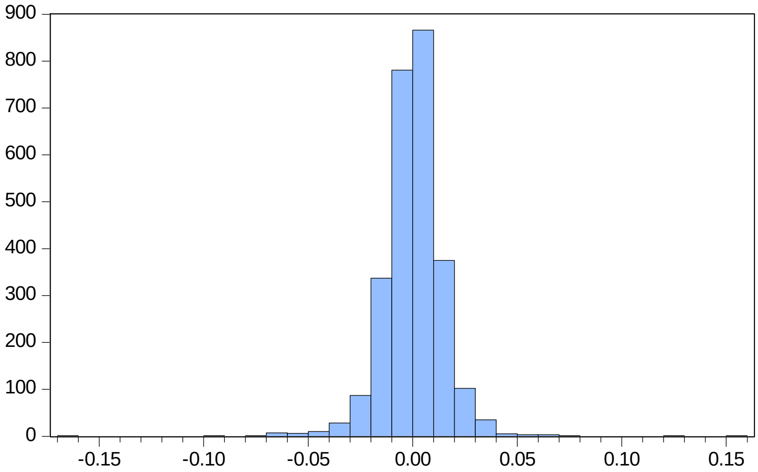
Series: STAN_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	-0.000236
Median	-0.000275
Maximum	0.262371
Minimum	-0.179470
Std. Dev.	0.026249
Skewness	0.316003
Kurtosis	13.46820
Jarque-Bera	12148.50
Probability	0.000000



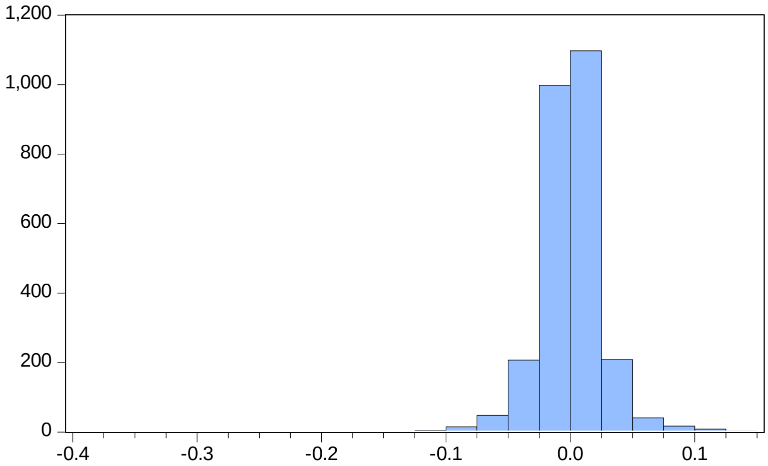
Series: STJ_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean	0.000405
Median	0.000633
Maximum	0.239404
Minimum	-0.176494
Std. Dev.	0.023707
Skewness	0.114643
Kurtosis	11.29187
Jarque-Bera	7600.377
Probability	0.000000



Series: SVT_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

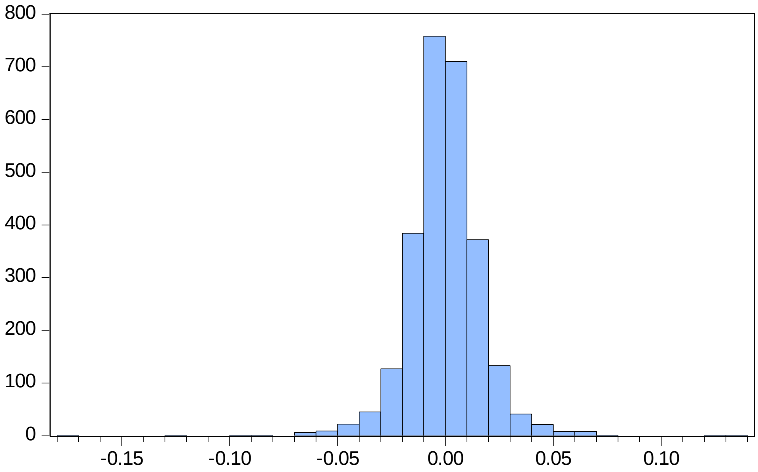
Mean	0.000227
Median	0.000000
Maximum	0.151713
Minimum	-0.160493
Std. Dev.	0.014511
Skewness	-0.145535
Kurtosis	18.01641
Jarque-Bera	24916.89
Probability	0.000000



```
Series: TPK_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean           0.000111
Median         0.000542
Maximum        0.144930
Minimum       -0.376017
Std. Dev.      0.026202
Skewness      -1.219669
Kurtosis       23.81613

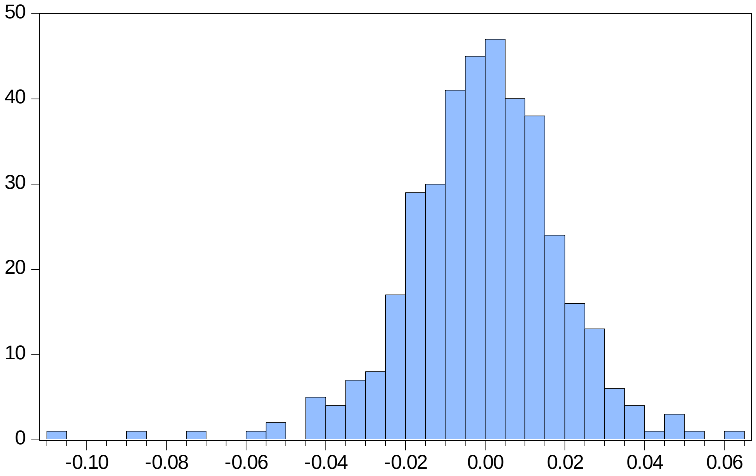
Jarque-Bera    48520.11
Probability    0.000000
```



```
Series: TSCO_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          -0.000234
Median        -0.000406
Maximum        0.139523
Minimum       -0.174199
Std. Dev.      0.016853
Skewness      -0.241710
Kurtosis       12.83034

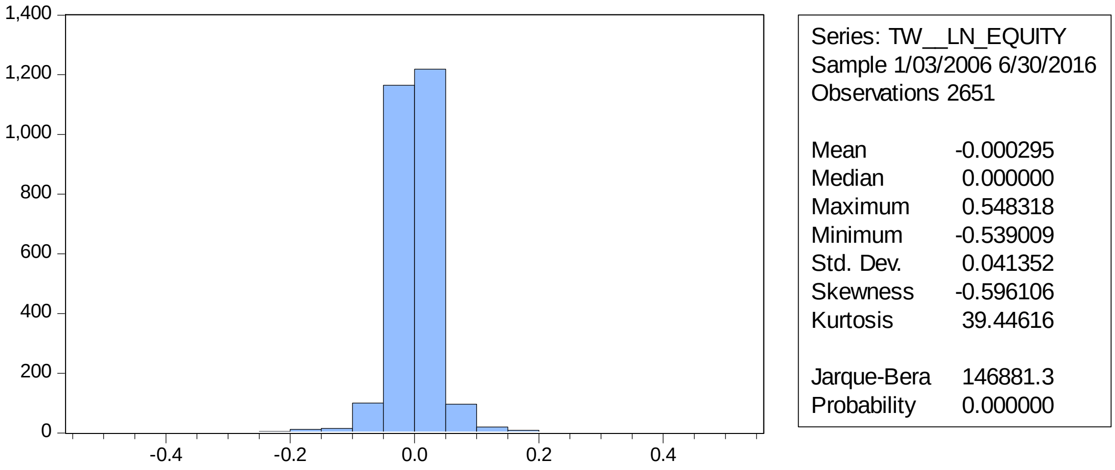
Jarque-Bera    10700.02
Probability    0.000000
```



```
Series: TUI_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 386

Mean          -0.000726
Median         0.000000
Maximum        0.063940
Minimum       -0.108978
Std. Dev.      0.019517
Skewness      -0.712387
Kurtosis       6.504693

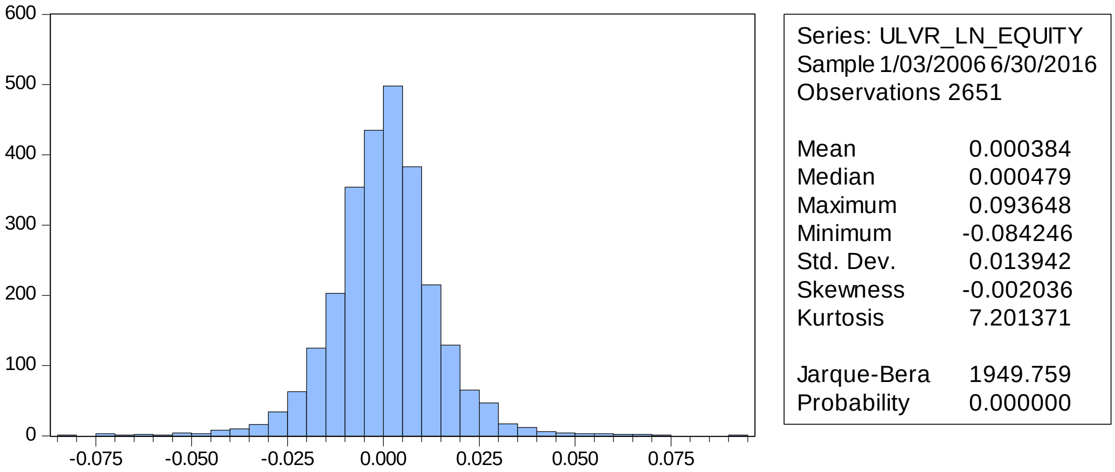
Jarque-Bera    230.1984
Probability    0.000000
```



```
Series: TW__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          -0.000295
Median         0.000000
Maximum        0.548318
Minimum       -0.539009
Std. Dev.      0.041352
Skewness      -0.596106
Kurtosis       39.44616

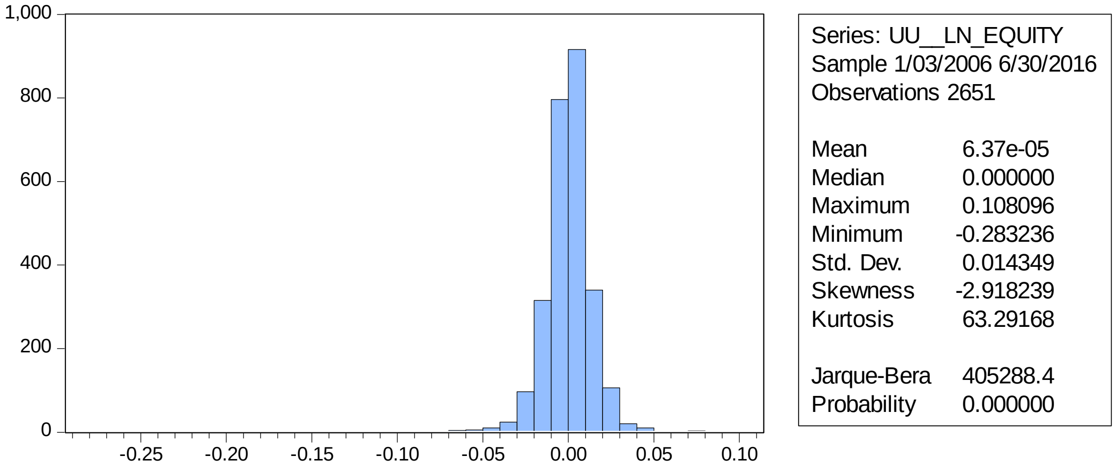
Jarque-Bera    146881.3
Probability    0.000000
```



```
Series: ULVR_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean           0.000384
Median         0.000479
Maximum        0.093648
Minimum       -0.084246
Std. Dev.      0.013942
Skewness      -0.002036
Kurtosis       7.201371

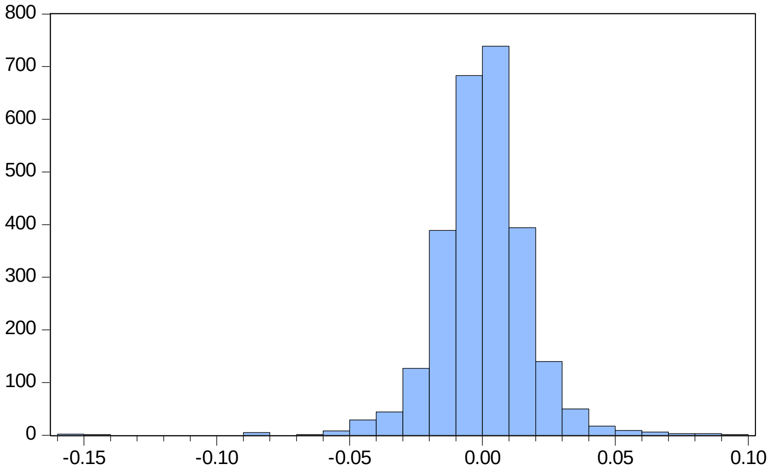
Jarque-Bera    1949.759
Probability    0.000000
```



```
Series: UU__LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean           6.37e-05
Median         0.000000
Maximum        0.108096
Minimum       -0.283236
Std. Dev.      0.014349
Skewness      -2.918239
Kurtosis       63.29168

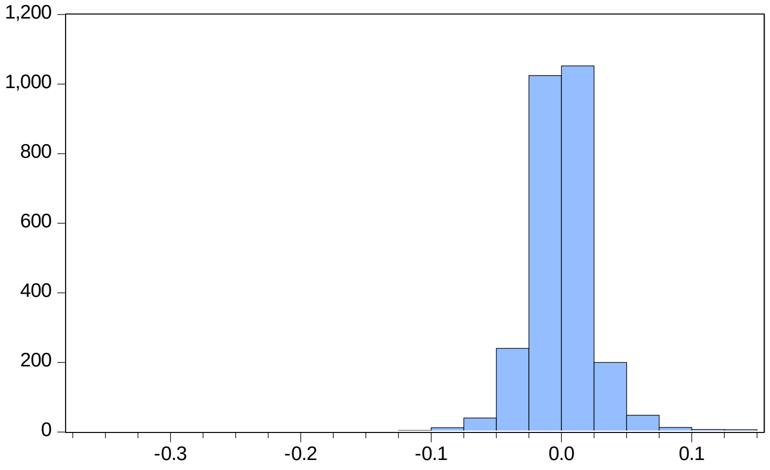
Jarque-Bera    405288.4
Probability    0.000000
```



```
Series: VOD_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean          8.68e-05
Median        0.000000
Maximum       0.090753
Minimum      -0.159013
Std. Dev.     0.017319
Skewness     -0.670940
Kurtosis      12.40163

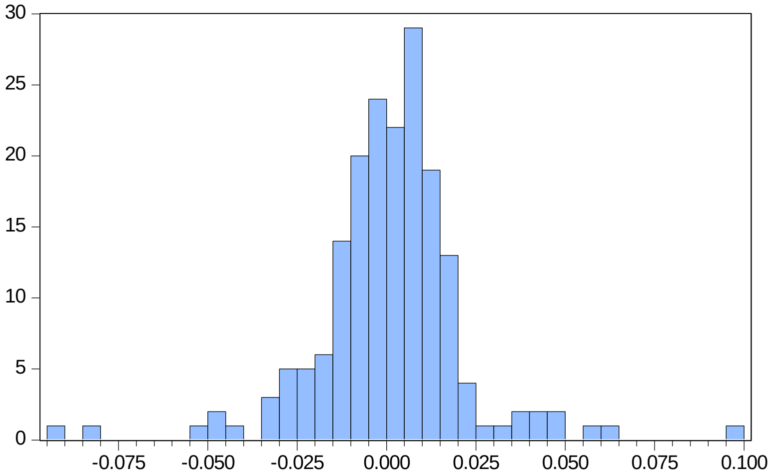
Jarque-Bera   9962.372
Probability   0.000000
```



```
Series: WOS_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean        -0.000129
Median       0.000000
Maximum      0.143045
Minimum     -0.352687
Std. Dev.    0.026318
Skewness    -0.969676
Kurtosis     21.07772

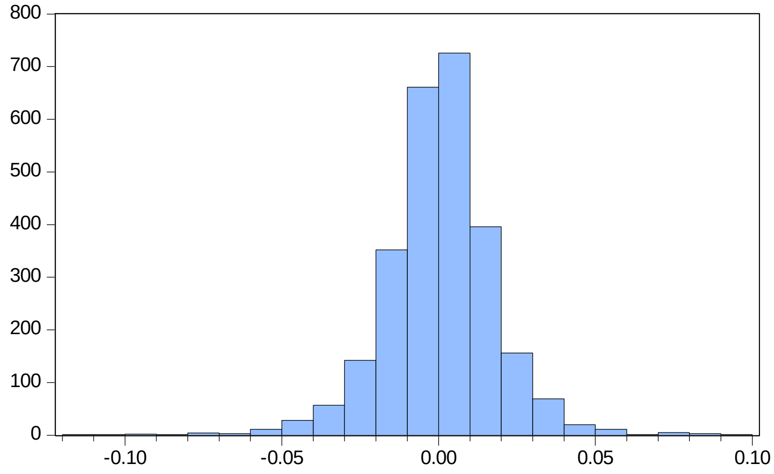
Jarque-Bera  36513.67
Probability  0.000000
```



```
Series: WPG_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 181

Mean          0.000685
Median        0.001029
Maximum       0.099091
Minimum      -0.090814
Std. Dev.     0.020971
Skewness     -0.129140
Kurtosis      8.572843

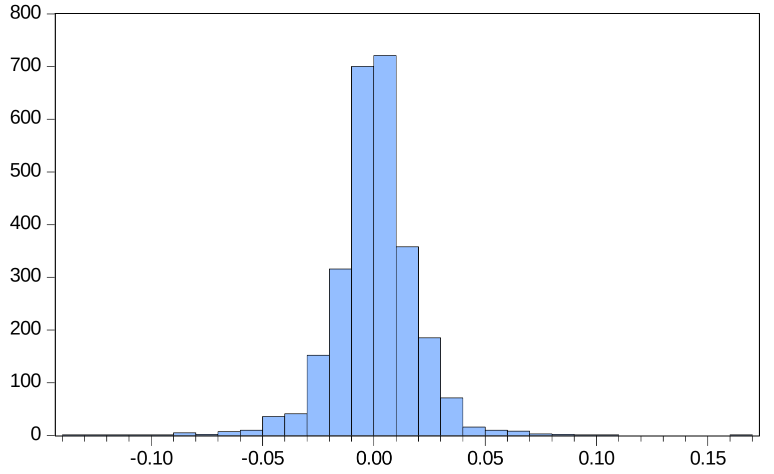
Jarque-Bera   234.7215
Probability   0.000000
```



```
Series: WPP_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean           0.000336
Median         0.000605
Maximum        0.096096
Minimum       -0.110917
Std. Dev.      0.017657
Skewness      -0.193240
Kurtosis       6.797106

Jarque-Bera    1609.088
Probability    0.000000
```



```
Series: WTB_LN_EQUITY
Sample 1/03/2006 6/30/2016
Observations 2651

Mean           0.000384
Median         0.000389
Maximum        0.165779
Minimum       -0.135336
Std. Dev.      0.018815
Skewness      -0.176928
Kurtosis       10.08863

Jarque-Bera    5564.222
Probability    0.000000
```

Appendix 3: Unit Roots test

In this appendix we run a unit root test (ADF) to first differences of stocks and index. In many cases, stocks and index seem to have unit roots in levels but not in first differences, thus the real struggle is to see their behavior in first differences rather than levels. If p-value is greater than 0.10, we accept the null hypothesis that the tested variable has a unit root. We choose to perform the test with Akaike Info Criterion and 27 maximum lags, as long as, we do this on daily data. The first table is for first differences and the second is for detrended residuals on first differences.

The results of the unit root test show that we must work this thesis with returns rather than prices, and taking into account the Jarque-Bera test on Appendix 2 we must use logarithmic returns. The results bellow are showing us no unit root problem in first differences, in any single case. In fact, our results are statistical important even at 1% level.

```
Null Hypothesis: D(UKX_INDEX) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=27)
======================================================================
                                              t-Statistic     Prob.*
======================================================================
Augmented Dickey-Fuller test statistic        -38.36229       0.0000
Test critical values:        1% level         -3.432626
                             5% level         -2.862431
                            10% level         -2.567289
======================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(UKX_INDEX,2)
Method: Least Squares
Date: 10/21/16   Time: 14:28
Sample (adjusted): 1/06/2006 6/30/2016
Included observations: 2649 after adjustments
======================================================================
      Variable          Coefficient   Std. Error   t-Statistic   Prob.
======================================================================
  D(UKX_INDEX(-1))       -1.077187     0.028079    -38.36229    0.0000
  D(UKX_INDEX(-1),2)      0.037858     0.019483     1.943098    0.0521
         C                0.323099     1.307762     0.247062    0.8049
======================================================================
R-squared                 0.519164   Mean dependent var        0.063296
Adjusted R-squared        0.518801   S.D. dependent var        97.02927
S.E. of regression        67.30776   Akaike info criterion     11.25756
Sum squared resid         11987265   Schwarz criterion         11.26422
Log likelihood           -14907.64   Hannan-Quinn criter.      11.25997
F-statistic               1428.460   Durbin-Watson stat        1.999409
Prob(F-statistic)         0.000000
======================================================================
```

Null Hypothesis: D(AAL_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 17 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.04511	0.0000
Test critical values:	1% level	-3.432641	
	5% level	-2.862438	
	10% level	-2.567293	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(AAL_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:30
Sample (adjusted): 1/30/2006 6/30/2016
Included observations: 2633 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(AAL_LN_EQUITY(-1))	-1.257252	0.096377	-13.04511	0.0000
D(AAL_LN_EQUITY(-1),2)	0.248755	0.093642	2.656449	0.0079
D(AAL_LN_EQUITY(-2),2)	0.187903	0.090840	2.068497	0.0387
D(AAL_LN_EQUITY(-3),2)	0.136321	0.087649	1.555299	0.1200
D(AAL_LN_EQUITY(-4),2)	0.139156	0.084159	1.653491	0.0984
D(AAL_LN_EQUITY(-5),2)	0.101319	0.080461	1.259233	0.2081
D(AAL_LN_EQUITY(-6),2)	0.085787	0.076840	1.116444	0.2643
D(AAL_LN_EQUITY(-7),2)	0.078372	0.073149	1.071393	0.2841
D(AAL_LN_EQUITY(-8),2)	0.074562	0.069314	1.075704	0.2822
D(AAL_LN_EQUITY(-9),2)	0.048223	0.065191	0.739724	0.4595
D(AAL_LN_EQUITY(-10),2)	0.056976	0.060971	0.934477	0.3501
D(AAL_LN_EQUITY(-11),2)	0.049129	0.056474	0.869934	0.3844
D(AAL_LN_EQUITY(-12),2)	0.030616	0.051651	0.592742	0.5534
D(AAL_LN_EQUITY(-13),2)	-0.014167	0.046458	-0.304938	0.7604
D(AAL_LN_EQUITY(-14),2)	-0.004013	0.041016	-0.097852	0.9221
D(AAL_LN_EQUITY(-15),2)	0.020644	0.034688	0.595150	0.5518
D(AAL_LN_EQUITY(-16),2)	0.067310	0.027693	2.430590	0.0151
D(AAL_LN_EQUITY(-17),2)	0.062653	0.019504	3.212331	0.0013
C	-0.719014	1.149616	-0.625438	0.5317

R-squared	0.510894	Mean dependent var	-0.014419
Adjusted R-squared	0.507526	S.D. dependent var	83.97383
S.E. of regression	58.92990	Akaike info criterion	10.99776
Sum squared resid	9077726.	Schwarz criterion	11.04017
Log likelihood	-14459.56	Hannan-Quinn criter.	11.01312
F-statistic	151.6912	Durbin-Watson stat	2.001438
Prob(F-statistic)	0.000000		

Null Hypothesis: D(ABF_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-38.36052	0.0000
Test critical values:	1% level	-3.432626	
	5% level	-2.862431	
	10% level	-2.567289	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ABF_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:31
Sample (adjusted): 1/06/2006 6/30/2016
Included observations: 2649 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ABF_LN_EQUITY(-1))	-1.075332	0.028032	-38.36052	0.0000
D(ABF_LN_EQUITY(-1),2)	0.040426	0.019498	2.073287	0.0382
C	0.753644	0.531139	1.418921	0.1560

R-squared	0.517144	Mean dependent var	0.021329
Adjusted R-squared	0.516779	S.D. dependent var	39.30142
S.E. of regression	27.32003	Akaike info criterion	9.454249
Sum squared resid	1974932.	Schwarz criterion	9.460911
Log likelihood	-12519.15	Hannan-Quinn criter.	9.456661
F-statistic	1416.947	Durbin-Watson stat	1.998687
Prob(F-statistic)	0.000000		

Null Hypothesis: D(ADM_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 9 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.29335	0.0000
Test critical values:	1% level	-3.432633	
	5% level	-2.862435	
	10% level	-2.567291	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ADM_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:31
Sample (adjusted): 1/18/2006 6/30/2016
Included observations: 2641 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ADM_LN_EQUITY(-1))	-1.203322	0.069583	-17.29335	0.0000
D(ADM_LN_EQUITY(-1),2)	0.191723	0.065306	2.935775	0.0034

D(ADM_LN_EQUITY(-2),2)	0.145006	0.061331	2.364313	0.0181
D(ADM_LN_EQUITY(-3),2)	0.087417	0.056879	1.536891	0.1244
D(ADM_LN_EQUITY(-4),2)	0.077444	0.052013	1.488928	0.1366
D(ADM_LN_EQUITY(-5),2)	0.016005	0.046713	0.342616	0.7319
D(ADM_LN_EQUITY(-6),2)	0.018339	0.041299	0.444058	0.6570
D(ADM_LN_EQUITY(-7),2)	0.026573	0.035079	0.757529	0.4488
D(ADM_LN_EQUITY(-8),2)	0.046631	0.028180	1.654747	0.0981
D(ADM_LN_EQUITY(-9),2)	-0.038915	0.019748	-1.970601	0.0489
C	0.690166	0.449241	1.536293	0.1246

R-squared	0.514734	Mean dependent var	0.027073
Adjusted R-squared	0.512889	S.D. dependent var	32.96008
S.E. of regression	23.00393	Akaike info criterion	9.113364
Sum squared resid	1391746.	Schwarz criterion	9.137850
Log likelihood	-12023.20	Hannan-Quinn criter.	9.122229
F-statistic	278.9712	Durbin-Watson stat	1.996378
Prob(F-statistic)	0.000000		

Null Hypothesis: D(AHT_LN_EQUITY) has a unit root

Exogenous: Constant

Lag Length: 26 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.552516	0.0000
Test critical values:	1% level	-3.432649	
	5% level	-2.862442	
	10% level	-2.567295	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(AHT_LN_EQUITY,2)

Method: Least Squares

Date: 10/21/16 Time: 14:31

Sample (adjusted): 2/10/2006 6/30/2016

Included observations: 2624 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(AHT_LN_EQUITY(-1))	-1.128489	0.118135	-9.552516	0.0000
D(AHT_LN_EQUITY(-1),2)	0.118464	0.116241	1.019127	0.3082
D(AHT_LN_EQUITY(-2),2)	0.011896	0.114287	0.104089	0.9171
D(AHT_LN_EQUITY(-3),2)	0.018248	0.112352	0.162415	0.8710
D(AHT_LN_EQUITY(-4),2)	-0.020209	0.110484	-0.182913	0.8549
D(AHT_LN_EQUITY(-5),2)	-0.022747	0.108512	-0.209628	0.8340
D(AHT_LN_EQUITY(-6),2)	0.002036	0.106318	0.019148	0.9847
D(AHT_LN_EQUITY(-7),2)	-0.034292	0.104051	-0.329574	0.7417
D(AHT_LN_EQUITY(-8),2)	-0.066782	0.101401	-0.658597	0.5102
D(AHT_LN_EQUITY(-9),2)	-0.067255	0.098608	-0.682048	0.4953
D(AHT_LN_EQUITY(-10),2)	-0.032137	0.095737	-0.335678	0.7371
D(AHT_LN_EQUITY(-11),2)	-0.092792	0.092426	-1.003961	0.3155
D(AHT_LN_EQUITY(-12),2)	-0.100387	0.088766	-1.130919	0.2582
D(AHT_LN_EQUITY(-13),2)	-0.133932	0.085076	-1.574267	0.1155
D(AHT_LN_EQUITY(-14),2)	-0.153688	0.081328	-1.889717	0.0589
D(AHT_LN_EQUITY(-15),2)	-0.175849	0.077597	-2.266193	0.0235
D(AHT_LN_EQUITY(-16),2)	-0.131716	0.073769	-1.785529	0.0743
D(AHT_LN_EQUITY(-17),2)	-0.069080	0.070181	-0.984313	0.3251
D(AHT_LN_EQUITY(-18),2)	-0.064366	0.066105	-0.973696	0.3303

```
 D(AHT_LN_EQUITY(-19),2)   -0.046965     0.061717    -0.760973      0.4467
 D(AHT_LN_EQUITY(-20),2)    0.023827     0.057258     0.416129      0.6773
 D(AHT_LN_EQUITY(-21),2)    0.027378     0.052845     0.518083      0.6044
 D(AHT_LN_EQUITY(-22),2)    0.072618     0.047749     1.520831      0.1284
 D(AHT_LN_EQUITY(-23),2)    0.097091     0.042043     2.309350      0.0210
 D(AHT_LN_EQUITY(-24),2)    0.077399     0.035946     2.153165      0.0314
 D(AHT_LN_EQUITY(-25),2)    0.054105     0.028407     1.904600      0.0569
 D(AHT_LN_EQUITY(-26),2)    0.052820     0.019982     2.643450      0.0083
            C               0.374025     0.223466     1.673748      0.0943
==========================================================================
R-squared                   0.523640    Mean dependent var         0.004281
Adjusted R-squared          0.518686    S.D. dependent var         16.27393
S.E. of regression          11.29034    Akaike info criterion      7.696385
Sum squared resid           330916.4    Schwarz criterion          7.759048
Log likelihood             -10069.66    Hannan-Quinn criter.       7.719078
F-statistic                 105.6911    Durbin-Watson stat         2.001133
Prob(F-statistic)           0.000000
==========================================================================
```

```
Null Hypothesis: D(ANTO_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                                 t-Statistic     Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic           -32.36964      0.0000
Test critical values:         1% level           -3.432627
                              5% level           -2.862432
                             10% level           -2.567290
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ANTO_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:32
Sample (adjusted): 1/09/2006 6/30/2016
Included observations: 2648 after adjustments
==========================================================================
        Variable           Coefficient   Std. Error   t-Statistic    Prob.
==========================================================================
  D(ANTO_LN_EQUITY(-1))    -1.121036     0.034632    -32.36964      0.0000
 D(ANTO_LN_EQUITY(-1),2)    0.085361     0.027939     3.055227      0.0023
 D(ANTO_LN_EQUITY(-2),2)    0.062333     0.019418     3.210004      0.0013
            C               0.034708     0.450458     0.077050      0.9386
==========================================================================
R-squared                   0.518832    Mean dependent var         0.009668
Adjusted R-squared          0.518286    S.D. dependent var         33.39784
S.E. of regression          23.17997    Akaike info criterion      9.125964
Sum squared resid           1420650.    Schwarz criterion          9.134848
Log likelihood             -12078.78    Hannan-Quinn criter.       9.129180
F-statistic                 950.3220    Durbin-Watson stat         2.001806
Prob(F-statistic)           0.000000
==========================================================================
```

Null Hypothesis: D(AV__LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=27)
======================================================================
                                              t-Statistic     Prob.*
======================================================================
Augmented Dickey-Fuller test statistic         -23.52755      0.0000
______________________________________________________________________
Test critical values:       1% level           -3.432630
                            5% level           -2.862433
                           10% level           -2.567290
======================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(AV__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:32
Sample (adjusted): 1/12/2006 6/30/2016
Included observations: 2645 after adjustments
======================================================================
        Variable           Coefficient    Std. Error    t-Statistic    Prob.
======================================================================
 D(AV__LN_EQUITY(-1))       -1.184440     0.050343     -23.52755     0.0000
D(AV__LN_EQUITY(-1),2)       0.174172     0.045460      3.831357     0.0001
D(AV__LN_EQUITY(-2),2)       0.159015     0.040217      3.953933     0.0001
D(AV__LN_EQUITY(-3),2)       0.089658     0.034337      2.611130     0.0091
D(AV__LN_EQUITY(-4),2)       0.079330     0.027957      2.837578     0.0046
D(AV__LN_EQUITY(-5),2)       0.058401     0.019619      2.976672     0.0029
           C                -0.146586     0.213671     -0.686036     0.4928
======================================================================
R-squared                    0.507817    Mean dependent var      -0.001399
Adjusted R-squared           0.506698    S.D. dependent var       15.63922
S.E. of regression           10.98428    Akaike info criterion    7.633451
Sum squared resid            318286.4    Schwarz criterion        7.649013
Log likelihood              -10088.24    Hannan-Quinn criter.     7.639084
F-statistic                  453.6325    Durbin-Watson stat       1.999291
Prob(F-statistic)            0.000000
======================================================================
```

Null Hypothesis: D(AZN_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 13 (Automatic - based on AIC, maxlag=27)
======================================================================
                                              t-Statistic     Prob.*
======================================================================
Augmented Dickey-Fuller test statistic         -16.58529      0.0000
______________________________________________________________________
Test critical values:       1% level           -3.432637
                            5% level           -2.862436
                           10% level           -2.567292
======================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(AZN_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:32
Sample (adjusted): 1/24/2006 6/30/2016
Included observations: 2637 after adjustments
======================================================================
```

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(AZN_LN_EQUITY(-1))	-1.307828	0.078855	-16.58529	0.0000
D(AZN_LN_EQUITY(-1),2)	0.300639	0.075405	3.986978	0.0001
D(AZN_LN_EQUITY(-2),2)	0.292637	0.072002	4.064314	0.0000
D(AZN_LN_EQUITY(-3),2)	0.284856	0.068403	4.164357	0.0000
D(AZN_LN_EQUITY(-4),2)	0.304463	0.064778	4.700068	0.0000
D(AZN_LN_EQUITY(-5),2)	0.261393	0.060948	4.288798	0.0000
D(AZN_LN_EQUITY(-6),2)	0.271040	0.056869	4.766013	0.0000
D(AZN_LN_EQUITY(-7),2)	0.254516	0.053041	4.798520	0.0000
D(AZN_LN_EQUITY(-8),2)	0.187200	0.049025	3.818463	0.0001
D(AZN_LN_EQUITY(-9),2)	0.174731	0.044435	3.932316	0.0001
D(AZN_LN_EQUITY(-10),2)	0.174679	0.039748	4.394685	0.0000
D(AZN_LN_EQUITY(-11),2)	0.144973	0.034245	4.233385	0.0000
D(AZN_LN_EQUITY(-12),2)	0.136384	0.027776	4.910215	0.0000
D(AZN_LN_EQUITY(-13),2)	0.092775	0.019534	4.749314	0.0000
C	0.807886	0.932749	0.866135	0.3865

R-squared	0.510258	Mean dependent var	0.042662
Adjusted R-squared	0.507643	S.D. dependent var	68.21580
S.E. of regression	47.86576	Akaike info criterion	10.58035
Sum squared resid	6007346.	Schwarz criterion	10.61378
Log likelihood	-13935.19	Hannan-Quinn criter.	10.59245
F-statistic	195.1314	Durbin-Watson stat	1.999869
Prob(F-statistic)	0.000000		

Null Hypothesis: D(BA__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-56.22466	0.0001
Test critical values:	1% level	-3.432625	
	5% level	-2.862431	
	10% level	-2.567289	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BA__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:33
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BA__LN_EQUITY(-1))	-1.089502	0.019378	-56.22466	0.0000
C	0.052415	0.125071	0.419084	0.6752

R-squared	0.544172	Mean dependent var	0.003491
Adjusted R-squared	0.544000	S.D. dependent var	9.534277
S.E. of regression	6.438284	Akaike info criterion	6.563156
Sum squared resid	109763.6	Schwarz criterion	6.567595
Log likelihood	-8694.181	Hannan-Quinn criter.	6.564763
F-statistic	3161.213	Durbin-Watson stat	2.000133
Prob(F-statistic)	0.000000		

Null Hypothesis: D(BAB_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-32.14306	0.0000
Test critical values:	1% level	-3.432627	
	5% level	-2.862432	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BAB_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:34
Sample (adjusted): 1/09/2006 6/30/2016
Included observations: 2648 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BAB_LN_EQUITY(-1))	-1.117454	0.034765	-32.14306	0.0000
D(BAB_LN_EQUITY(-1),2)	0.098183	0.027756	3.537313	0.0004
D(BAB_LN_EQUITY(-2),2)	0.033351	0.019481	1.711960	0.0870
C	0.292396	0.219214	1.333835	0.1824

R-squared	0.510545	Mean dependent var	-0.006408
Adjusted R-squared	0.509990	S.D. dependent var	16.10130
S.E. of regression	11.27103	Akaike info criterion	7.683858
Sum squared resid	335883.4	Schwarz criterion	7.692742
Log likelihood	-10169.43	Hannan-Quinn criter.	7.687074
F-statistic	919.3101	Durbin-Watson stat	2.000318
Prob(F-statistic)	0.000000		

Null Hypothesis: D(BARC_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-20.83847	0.0000
Test critical values:	1% level	-3.432632	
	5% level	-2.862434	
	10% level	-2.567291	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BARC_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:34
Sample (adjusted): 1/16/2006 6/30/2016
Included observations: 2643 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.

D(BARC_LN_EQUITY(-1))	-1.211973	0.058160	-20.83847	0.0000
D(BARC_LN_EQUITY(-1),2)	0.248081	0.053630	4.625808	0.0000
D(BARC_LN_EQUITY(-2),2)	0.185217	0.049214	3.763487	0.0002
D(BARC_LN_EQUITY(-3),2)	0.173111	0.044480	3.891924	0.0001
D(BARC_LN_EQUITY(-4),2)	0.132915	0.039307	3.381454	0.0007
D(BARC_LN_EQUITY(-5),2)	0.113639	0.033742	3.367850	0.0008
D(BARC_LN_EQUITY(-6),2)	0.089638	0.027171	3.299070	0.0010
D(BARC_LN_EQUITY(-7),2)	0.038016	0.019554	1.944145	0.0520
C	-0.190710	0.158646	-1.202108	0.2294

R-squared	0.485709	Mean dependent var	0.002799
Adjusted R-squared	0.484147	S.D. dependent var	11.33801
S.E. of regression	8.143282	Akaike info criterion	7.035663
Sum squared resid	174668.5	Schwarz criterion	7.055685
Log likelihood	-9288.629	Hannan-Quinn criter.	7.042911
F-statistic	310.9523	Durbin-Watson stat	1.998244
Prob(F-statistic)	0.000000		

Null Hypothesis: D(BATS_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-51.26925	0.0001
Test critical values:	1% level	-3.432625	
	5% level	-2.862431	
	10% level	-2.567289	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BATS_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:34
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BATS_LN_EQUITY(-1))	-0.999906	0.019503	-51.26925	0.0000
C	1.340635	0.651611	2.057416	0.0397

R-squared	0.498156	Mean dependent var	0.064151
Adjusted R-squared	0.497966	S.D. dependent var	47.30725
S.E. of regression	33.51924	Akaike info criterion	9.862871
Sum squared resid	2975133.	Schwarz criterion	9.867310
Log likelihood	-13066.30	Hannan-Quinn criter.	9.864478
F-statistic	2628.536	Durbin-Watson stat	1.992803
Prob(F-statistic)	0.000000		

Null Hypothesis: D(BDEV_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 26 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.294081	0.0000
Test critical values:	1% level	-3.432649	
	5% level	-2.862442	
	10% level	-2.567295	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BDEV_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:34
Sample (adjusted): 2/10/2006 6/30/2016
Included observations: 2624 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BDEV_LN_EQUITY(-1))	-0.876836	0.105718	-8.294081	0.0000
D(BDEV_LN_EQUITY(-1),2)	-0.046450	0.104588	-0.444130	0.6570
D(BDEV_LN_EQUITY(-2),2)	-0.090110	0.103329	-0.872069	0.3833
D(BDEV_LN_EQUITY(-3),2)	-0.077126	0.102173	-0.754859	0.4504
D(BDEV_LN_EQUITY(-4),2)	-0.158622	0.100770	-1.574107	0.1156
D(BDEV_LN_EQUITY(-5),2)	-0.189065	0.099030	-1.909169	0.0564
D(BDEV_LN_EQUITY(-6),2)	-0.214572	0.097210	-2.207302	0.0274
D(BDEV_LN_EQUITY(-7),2)	-0.194525	0.095355	-2.040015	0.0414
D(BDEV_LN_EQUITY(-8),2)	-0.235748	0.093246	-2.528243	0.0115
D(BDEV_LN_EQUITY(-9),2)	-0.211288	0.091040	-2.320841	0.0204
D(BDEV_LN_EQUITY(-10),2)	-0.188587	0.088561	-2.129460	0.0333
D(BDEV_LN_EQUITY(-11),2)	-0.151592	0.085789	-1.767042	0.0773
D(BDEV_LN_EQUITY(-12),2)	-0.197788	0.083124	-2.379444	0.0174
D(BDEV_LN_EQUITY(-13),2)	-0.153441	0.080438	-1.907572	0.0566
D(BDEV_LN_EQUITY(-14),2)	-0.134793	0.077556	-1.738009	0.0823
D(BDEV_LN_EQUITY(-15),2)	-0.132662	0.074242	-1.786875	0.0741
D(BDEV_LN_EQUITY(-16),2)	-0.183740	0.071010	-2.587530	0.0097
D(BDEV_LN_EQUITY(-17),2)	-0.137629	0.067477	-2.039637	0.0415
D(BDEV_LN_EQUITY(-18),2)	-0.078302	0.063659	-1.230021	0.2188
D(BDEV_LN_EQUITY(-19),2)	-0.054700	0.059482	-0.919618	0.3579
D(BDEV_LN_EQUITY(-20),2)	-0.019348	0.055452	-0.348916	0.7272
D(BDEV_LN_EQUITY(-21),2)	-0.012931	0.051040	-0.253358	0.8000
D(BDEV_LN_EQUITY(-22),2)	0.000941	0.046383	0.020283	0.9838
D(BDEV_LN_EQUITY(-23),2)	0.036861	0.041179	0.895138	0.3708
D(BDEV_LN_EQUITY(-24),2)	0.015708	0.036010	0.436226	0.6627
D(BDEV_LN_EQUITY(-25),2)	0.035446	0.029599	1.197539	0.2312
D(BDEV_LN_EQUITY(-26),2)	0.091905	0.021227	4.329543	0.0000
C	-0.110655	0.161982	-0.683129	0.4946

R-squared	0.483421	Mean dependent var	-0.007505
Adjusted R-squared	0.478049	S.D. dependent var	11.47933
S.E. of regression	8.293382	Akaike info criterion	7.079406
Sum squared resid	178553.4	Schwarz criterion	7.142070
Log likelihood	-9260.181	Hannan-Quinn criter.	7.102100
F-statistic	89.97672	Durbin-Watson stat	1.997636
Prob(F-statistic)	0.000000		

```
Null Hypothesis: D(BLND_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=27)
================================================================================
                                                        t-Statistic    Prob.*
================================================================================
Augmented Dickey-Fuller test statistic                   -23.25520     0.0000
--------------------------------------------------------------------------------
Test critical values:          1% level                  -3.432630
                               5% level                  -2.862433
                               10% level                 -2.567290
================================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BLND_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:35
Sample (adjusted): 1/12/2006 6/30/2016
Included observations: 2645 after adjustments
================================================================================
        Variable            Coefficient    Std. Error    t-Statistic     Prob.
================================================================================
  D(BLND_LN_EQUITY(-1))      -1.220633      0.052489     -23.25520      0.0000
 D(BLND_LN_EQUITY(-1),2)      0.180713      0.047350      3.816489      0.0001
 D(BLND_LN_EQUITY(-2),2)      0.138028      0.041851      3.298056      0.0010
 D(BLND_LN_EQUITY(-3),2)      0.106584      0.036066      2.955215      0.0032
 D(BLND_LN_EQUITY(-4),2)      0.064022      0.029128      2.197921      0.0280
 D(BLND_LN_EQUITY(-5),2)      0.037865      0.020031      1.890282      0.0588
            C                -0.122689      0.259787     -0.472268      0.6368
================================================================================
R-squared                     0.520087    Mean dependent var         -0.001372
Adjusted R-squared            0.518995    S.D. dependent var          19.26084
S.E. of regression            13.35827    Akaike info criterion       8.024791
Sum squared resid             470733.4    Schwarz criterion           8.040353
Log likelihood               -10605.79    Hannan-Quinn criter.        8.030425
F-statistic                   476.4707    Durbin-Watson stat          2.001072
Prob(F-statistic)             0.000000
================================================================================
```

```
Null Hypothesis: D(BLT_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)
================================================================================
                                                        t-Statistic    Prob.*
================================================================================
Augmented Dickey-Fuller test statistic                   -51.76886     0.0001
--------------------------------------------------------------------------------
Test critical values:          1% level                  -3.432625
                               5% level                  -2.862431
                               10% level                 -2.567289
================================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BLT_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:35
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments
================================================================================
```

```
        Variable            Coefficient     Std. Error    t-Statistic      Prob.

D(BLT_LN_EQUITY(-1))        -1.006156       0.019436     -51.76886       0.0000
            C                0.013715       0.690155       0.019872      0.9841

R-squared                    0.503004    Mean dependent var         0.009235
Adjusted R-squared           0.502817    S.D. dependent var         50.38617
S.E. of regression           35.52791    Akaike info criterion      9.979269
Sum squared resid            3342391.    Schwarz criterion          9.983708
Log likelihood              -13220.53    Hannan-Quinn criter.       9.980876
F-statistic                  2680.015    Durbin-Watson stat         1.999839
Prob(F-statistic)            0.000000
```

Null Hypothesis: D(BNZL_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)

```
                                                 t-Statistic      Prob.*

Augmented Dickey-Fuller test statistic           -51.33854       0.0001
Test critical values:         1% level           -3.432625
                              5% level           -2.862431
                              10% level          -2.567289
```

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BNZL_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:35
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments

```
        Variable            Coefficient     Std. Error    t-Statistic      Prob.

D(BNZL_LN_EQUITY(-1))       -1.002869       0.019534     -51.33854       0.0000
            C                0.628317       0.264055       2.379492      0.0174

R-squared                    0.498831    Mean dependent var         0.029245
Adjusted R-squared           0.498642    S.D. dependent var         19.17869
S.E. of regression           13.57979    Akaike info criterion      8.055797
Sum squared resid            488319.8    Schwarz criterion          8.060237
Log likelihood              -10671.93    Hannan-Quinn criter.       8.057404
F-statistic                  2635.645    Durbin-Watson stat         1.989268
Prob(F-statistic)            0.000000
```

Null Hypothesis: D(BP__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 9 (Automatic - based on AIC, maxlag=27)

```
                                                 t-Statistic      Prob.*

Augmented Dickey-Fuller test statistic           -15.13534       0.0000
Test critical values:         1% level           -3.432633
                              5% level           -2.862435
                              10% level          -2.567291
```

```
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BP__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:36
Sample (adjusted): 1/18/2006 6/30/2016
Included observations: 2641 after adjustments
==========================================================================
        Variable             Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
  D(BP__LN_EQUITY(-1))       -0.963941      0.063688     -15.13534     0.0000
 D(BP__LN_EQUITY(-1),2)      -0.065321      0.060404     -1.081400     0.2796
 D(BP__LN_EQUITY(-2),2)      -0.101903      0.056994     -1.787953     0.0739
 D(BP__LN_EQUITY(-3),2)      -0.125219      0.053672     -2.333029     0.0197
 D(BP__LN_EQUITY(-4),2)      -0.083532      0.049989     -1.671000     0.0948
 D(BP__LN_EQUITY(-5),2)      -0.050503      0.045858     -1.101303     0.2709
 D(BP__LN_EQUITY(-6),2)      -0.036822      0.040982     -0.898477     0.3690
 D(BP__LN_EQUITY(-7),2)      -0.013612      0.034962     -0.389352     0.6970
 D(BP__LN_EQUITY(-8),2)      -0.053385      0.028028     -1.904684     0.0569
 D(BP__LN_EQUITY(-9),2)      -0.064881      0.019489     -3.329071     0.0009
            C                -0.080731      0.158045     -0.510812     0.6095
==========================================================================
R-squared                     0.519075    Mean dependent var        0.006569
Adjusted R-squared            0.517246    S.D. dependent var        11.68072
S.E. of regression            8.115821    Akaike info criterion     7.029664
Sum squared resid             173229.0    Schwarz criterion         7.054150
Log likelihood               -9271.672    Hannan-Quinn criter.      7.038529
F-statistic                   283.8627    Durbin-Watson stat        1.997416
Prob(F-statistic)             0.000000
==========================================================================
```

Null Hypothesis: D(BRBY_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 24 (Automatic - based on AIC, maxlag=27)
============================================================================
                                                      t-Statistic    Prob.*
============================================================================
Augmented Dickey-Fuller test statistic                 -11.57444     0.0000
----------------------------------------------------------------------------
Test critical values:          1% level                -3.432647
                               5% level                -2.862441
                              10% level                -2.567294
============================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BRBY_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:36
Sample (adjusted): 2/08/2006 6/30/2016
Included observations: 2626 after adjustments
============================================================================
        Variable              Coefficient    Std. Error    t-Statistic    Prob.
============================================================================
  D(BRBY_LN_EQUITY(-1))       -1.279916      0.110581     -11.57444     0.0000
 D(BRBY_LN_EQUITY(-1),2)       0.314863      0.108015      2.914994     0.0036
 D(BRBY_LN_EQUITY(-2),2)       0.278636      0.105599      2.638625     0.0084
 D(BRBY_LN_EQUITY(-3),2)       0.220655      0.103094      2.140341     0.0324
 D(BRBY_LN_EQUITY(-4),2)       0.199796      0.100678      1.984511     0.0473
```

D(BRBY_LN_EQUITY(-5),2)	0.190535	0.098334	1.937626	0.0528
D(BRBY_LN_EQUITY(-6),2)	0.173706	0.095634	1.816360	0.0694
D(BRBY_LN_EQUITY(-7),2)	0.157440	0.092822	1.696147	0.0900
D(BRBY_LN_EQUITY(-8),2)	0.124815	0.090156	1.384433	0.1663
D(BRBY_LN_EQUITY(-9),2)	0.087681	0.087326	1.004062	0.3154
D(BRBY_LN_EQUITY(-10),2)	0.110674	0.084354	1.312017	0.1896
D(BRBY_LN_EQUITY(-11),2)	0.099690	0.081194	1.227811	0.2196
D(BRBY_LN_EQUITY(-12),2)	0.085603	0.077856	1.099501	0.2717
D(BRBY_LN_EQUITY(-13),2)	0.102316	0.074242	1.378141	0.1683
D(BRBY_LN_EQUITY(-14),2)	0.108461	0.070540	1.537570	0.1243
D(BRBY_LN_EQUITY(-15),2)	0.125636	0.066706	1.883428	0.0598
D(BRBY_LN_EQUITY(-16),2)	0.132659	0.062496	2.122677	0.0339
D(BRBY_LN_EQUITY(-17),2)	0.144922	0.058291	2.486172	0.0130
D(BRBY_LN_EQUITY(-18),2)	0.094949	0.054039	1.757052	0.0790
D(BRBY_LN_EQUITY(-19),2)	0.100947	0.049538	2.037753	0.0417
D(BRBY_LN_EQUITY(-20),2)	0.162527	0.044743	3.632484	0.0003
D(BRBY_LN_EQUITY(-21),2)	0.128296	0.039527	3.245752	0.0012
D(BRBY_LN_EQUITY(-22),2)	0.083659	0.033676	2.484224	0.0130
D(BRBY_LN_EQUITY(-23),2)	0.081519	0.027354	2.980127	0.0029
D(BRBY_LN_EQUITY(-24),2)	0.039822	0.019718	2.019596	0.0435
C	0.346987	0.428882	0.809050	0.4186

R-squared	0.492094	Mean dependent var	-0.000952
Adjusted R-squared	0.487210	S.D. dependent var	30.62746
S.E. of regression	21.93213	Akaike info criterion	9.023634
Sum squared resid	1250648.	Schwarz criterion	9.081785
Log likelihood	-11822.03	Hannan-Quinn criter.	9.044693
F-statistic	100.7621	Durbin-Watson stat	2.001111
Prob(F-statistic)	0.000000		

Null Hypothesis: D(BT_A_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-25.71752	0.0000
Test critical values:	1% level	-3.432629	
	5% level	-2.862433	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BT_A_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:36
Sample (adjusted): 1/11/2006 6/30/2016
Included observations: 2646 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BT_A_LN_EQUITY(-1))	-1.238951	0.048175	-25.71752	0.0000
D(BT_A_LN_EQUITY(-1),2)	0.179353	0.042413	4.228727	0.0000
D(BT_A_LN_EQUITY(-2),2)	0.093766	0.036530	2.566781	0.0103
D(BT_A_LN_EQUITY(-3),2)	0.103804	0.029045	3.573838	0.0004
D(BT_A_LN_EQUITY(-4),2)	0.043413	0.020153	2.154200	0.0313
C	0.087488	0.088633	0.987081	0.3237

```
R-squared                 0.533226   Mean dependent var      -0.000113
Adjusted R-squared        0.532342   S.D. dependent var       6.662360
S.E. of regression        4.556091   Akaike info criterion    5.873072
Sum squared resid         54801.03   Schwarz criterion        5.886407
Log likelihood           -7764.074   Hannan-Quinn criter.     5.877900
F-statistic               603.1678   Durbin-Watson stat       2.002032
Prob(F-statistic)         0.000000
```

Null Hypothesis: D(CCH_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 19 (Automatic - based on AIC, maxlag=20)

```
                                                t-Statistic    Prob.*

Augmented Dickey-Fuller test statistic           -6.558061     0.0000
Test critical values:          1% level          -3.438486
                               5% level          -2.865021
                              10% level          -2.568679
```

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CCH_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:37
Sample (adjusted): 2/01/2006 3/04/2009
Included observations: 782 after adjustments

```
         Variable            Coefficient    Std. Error    t-Statistic    Prob.

  D(CCH_LN_EQUITY(-1))        -1.136812     0.173346      -6.558061     0.0000
 D(CCH_LN_EQUITY(-1),2)        0.151030     0.167231       0.903126     0.3667
 D(CCH_LN_EQUITY(-2),2)        0.140281     0.161134       0.870586     0.3843
 D(CCH_LN_EQUITY(-3),2)        0.154712     0.155066       0.997715     0.3187
 D(CCH_LN_EQUITY(-4),2)        0.134625     0.149820       0.898581     0.3692
 D(CCH_LN_EQUITY(-5),2)        0.159458     0.143721       1.109498     0.2676
 D(CCH_LN_EQUITY(-6),2)        0.148676     0.138130       1.076343     0.2821
 D(CCH_LN_EQUITY(-7),2)        0.108242     0.131990       0.820077     0.4124
 D(CCH_LN_EQUITY(-8),2)        0.128012     0.125804       1.017554     0.3092
 D(CCH_LN_EQUITY(-9),2)        0.105070     0.119992       0.875641     0.3815
D(CCH_LN_EQUITY(-10),2)        0.113699     0.113796       0.999147     0.3180
D(CCH_LN_EQUITY(-11),2)        0.116964     0.107352       1.089536     0.2763
D(CCH_LN_EQUITY(-12),2)        0.044461     0.101033       0.440060     0.6600
D(CCH_LN_EQUITY(-13),2)        0.007270     0.094197       0.077176     0.9385
D(CCH_LN_EQUITY(-14),2)        0.039986     0.087433       0.457330     0.6476
D(CCH_LN_EQUITY(-15),2)       -0.019868     0.080051      -0.248188     0.8041
D(CCH_LN_EQUITY(-16),2)        0.056468     0.071506       0.789692     0.4300
D(CCH_LN_EQUITY(-17),2)       -0.034330     0.061795      -0.555537     0.5787
D(CCH_LN_EQUITY(-18),2)       -0.077492     0.050109      -1.546491     0.1224
D(CCH_LN_EQUITY(-19),2)       -0.111148     0.035152      -3.161930     0.0016
           C                  -0.373469     0.883690      -0.422624     0.6727

R-squared                 0.523294   Mean dependent var       0.083120
Adjusted R-squared        0.510765   S.D. dependent var       35.19544
S.E. of regression        24.61756   Akaike info criterion    9.271284
Sum squared resid         461184.4   Schwarz criterion        9.396474
Log likelihood           -3604.072   Hannan-Quinn criter.     9.319428
F-statistic               41.76856   Durbin-Watson stat       1.995639
Prob(F-statistic)         0.000000
```

Null Hypothesis: D(CCL_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-24.84578	0.0000
Test critical values:	1% level	-3.432628	
	5% level	-2.862432	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CCL_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:38
Sample (adjusted): 1/10/2006 6/30/2016
Included observations: 2647 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CCL_LN_EQUITY(-1))	-0.976274	0.039293	-24.84578	0.0000
D(CCL_LN_EQUITY(-1),2)	-0.006496	0.033845	-0.191923	0.8478
D(CCL_LN_EQUITY(-2),2)	-0.054112	0.027297	-1.982390	0.0475
D(CCL_LN_EQUITY(-3),2)	-0.049651	0.019505	-2.545566	0.0110
C	0.013224	0.874823	0.015116	0.9879

R-squared	0.494368	Mean dependent var	-0.016245
Adjusted R-squared	0.493603	S.D. dependent var	63.24863
S.E. of regression	45.00873	Akaike info criterion	10.45348
Sum squared resid	5352126.	Schwarz criterion	10.46459
Log likelihood	-13830.18	Hannan-Quinn criter.	10.45750
F-statistic	645.7869	Durbin-Watson stat	1.997370
Prob(F-statistic)	0.000000		

Null Hypothesis: D(CNA_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-25.92655	0.0000
Test critical values:	1% level	-3.432628	
	5% level	-2.862432	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CNA_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:38
Sample (adjusted): 1/10/2006 6/30/2016
Included observations: 2647 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CNA_LN_EQUITY(-1))	-1.098664	0.042376	-25.92655	0.0000
D(CNA_LN_EQUITY(-1),2)	0.012132	0.036011	0.336899	0.7362
D(CNA_LN_EQUITY(-2),2)	-0.004938	0.028826	-0.171299	0.8640
D(CNA_LN_EQUITY(-3),2)	-0.050376	0.019486	-2.585305	0.0098
C	0.000778	0.085334	0.009117	0.9927

R-squared	0.545493	Mean dependent var	0.003354
Adjusted R-squared	0.544805	S.D. dependent var	6.507269
S.E. of regression	4.390335	Akaike info criterion	5.798575
Sum squared resid	50924.67	Schwarz criterion	5.809685
Log likelihood	-7669.415	Hannan-Quinn criter.	5.802597
F-statistic	792.7219	Durbin-Watson stat	1.995035
Prob(F-statistic)	0.000000		

Null Hypothesis: D(CPG_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 10 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.77046	0.0000
Test critical values:	1% level	-3.432634	
	5% level	-2.862435	
	10% level	-2.567291	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CPG_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:38
Sample (adjusted): 1/19/2006 6/30/2016
Included observations: 2640 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CPG_LN_EQUITY(-1))	-1.292459	0.072731	-17.77046	0.0000
D(CPG_LN_EQUITY(-1),2)	0.267864	0.068866	3.889664	0.0001
D(CPG_LN_EQUITY(-2),2)	0.248156	0.064844	3.826985	0.0001
D(CPG_LN_EQUITY(-3),2)	0.232117	0.060660	3.826509	0.0001
D(CPG_LN_EQUITY(-4),2)	0.211297	0.056257	3.755912	0.0002
D(CPG_LN_EQUITY(-5),2)	0.157659	0.051597	3.055572	0.0023
D(CPG_LN_EQUITY(-6),2)	0.165085	0.046296	3.565843	0.0004
D(CPG_LN_EQUITY(-7),2)	0.140791	0.040940	3.438928	0.0006
D(CPG_LN_EQUITY(-8),2)	0.133632	0.035120	3.804959	0.0001
D(CPG_LN_EQUITY(-9),2)	0.107428	0.028393	3.783580	0.0002
D(CPG_LN_EQUITY(-10),2)	0.063928	0.019799	3.228845	0.0013
C	0.564724	0.181475	3.111852	0.0019

R-squared	0.514833	Mean dependent var	0.004794
Adjusted R-squared	0.512802	S.D. dependent var	13.18033
S.E. of regression	9.199812	Akaike info criterion	7.280778
Sum squared resid	222424.8	Schwarz criterion	7.307499
Log likelihood	-9598.627	Hannan-Quinn criter.	7.290452
F-statistic	253.5174	Durbin-Watson stat	1.999464
Prob(F-statistic)	0.000000		

Null Hypothesis: D(CPI_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 23 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.49712	0.0000
Test critical values:	1% level	-3.432647	
	5% level	-2.862440	
	10% level	-2.567294	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CPI_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:39
Sample (adjusted): 2/07/2006 6/30/2016
Included observations: 2627 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CPI_LN_EQUITY(-1))	-1.334976	0.116114	-11.49712	0.0000
D(CPI_LN_EQUITY(-1),2)	0.316776	0.113625	2.787915	0.0053
D(CPI_LN_EQUITY(-2),2)	0.280125	0.111209	2.518907	0.0118
D(CPI_LN_EQUITY(-3),2)	0.245161	0.108983	2.249540	0.0246
D(CPI_LN_EQUITY(-4),2)	0.196352	0.106526	1.843229	0.0654
D(CPI_LN_EQUITY(-5),2)	0.140934	0.103717	1.358834	0.1743
D(CPI_LN_EQUITY(-6),2)	0.121154	0.100581	1.204546	0.2285
D(CPI_LN_EQUITY(-7),2)	0.122754	0.097402	1.260286	0.2077
D(CPI_LN_EQUITY(-8),2)	0.126344	0.094113	1.342462	0.1796
D(CPI_LN_EQUITY(-9),2)	0.102213	0.090748	1.126346	0.2601
D(CPI_LN_EQUITY(-10),2)	0.103091	0.087203	1.182189	0.2372
D(CPI_LN_EQUITY(-11),2)	0.086287	0.083700	1.030907	0.3027
D(CPI_LN_EQUITY(-12),2)	0.090465	0.079923	1.131901	0.2578
D(CPI_LN_EQUITY(-13),2)	0.101060	0.075881	1.331822	0.1830
D(CPI_LN_EQUITY(-14),2)	0.052170	0.071768	0.726919	0.4673
D(CPI_LN_EQUITY(-15),2)	0.059031	0.067466	0.874973	0.3817
D(CPI_LN_EQUITY(-16),2)	0.060552	0.063172	0.958516	0.3379
D(CPI_LN_EQUITY(-17),2)	0.065171	0.058565	1.112812	0.2659
D(CPI_LN_EQUITY(-18),2)	0.061600	0.053627	1.148667	0.2508
D(CPI_LN_EQUITY(-19),2)	0.117581	0.048363	2.431196	0.0151
D(CPI_LN_EQUITY(-20),2)	0.157864	0.042814	3.687166	0.0002
D(CPI_LN_EQUITY(-21),2)	0.123939	0.036793	3.368535	0.0008
D(CPI_LN_EQUITY(-22),2)	0.089572	0.029756	3.010251	0.0026
D(CPI_LN_EQUITY(-23),2)	0.065610	0.020591	3.186424	0.0015
C	0.271227	0.240772	1.126489	0.2601

R-squared	0.515435	Mean dependent var	0.008571
Adjusted R-squared	0.510966	S.D. dependent var	17.54351
S.E. of regression	12.26835	Akaike info criterion	7.861393
Sum squared resid	391633.2	Schwarz criterion	7.917290
Log likelihood	-10300.94	Hannan-Quinn criter.	7.881635
F-statistic	115.3236	Durbin-Watson stat	1.998401
Prob(F-statistic)	0.000000		

```
Null Hypothesis: D(CRH_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 8 (Automatic - based on AIC, maxlag=27)

                                                  t-Statistic    Prob.*

Augmented Dickey-Fuller test statistic            -19.80401     0.0000
Test critical values:        1% level             -3.432633
                             5% level             -2.862434
                             10% level            -2.567291

*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CRH_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:39
Sample (adjusted): 1/17/2006 6/30/2016
Included observations: 2642 after adjustments

        Variable           Coefficient   Std. Error   t-Statistic    Prob.

  D(CRH_LN_EQUITY(-1))     -1.330355     0.067176     -19.80401     0.0000
 D(CRH_LN_EQUITY(-1),2)     0.321196     0.062510      5.138304     0.0000
 D(CRH_LN_EQUITY(-2),2)     0.240907     0.057928      4.158751     0.0000
 D(CRH_LN_EQUITY(-3),2)     0.179231     0.052824      3.393015     0.0007
 D(CRH_LN_EQUITY(-4),2)     0.149101     0.047404      3.145284     0.0017
 D(CRH_LN_EQUITY(-5),2)     0.122308     0.041505      2.946841     0.0032
 D(CRH_LN_EQUITY(-6),2)     0.091407     0.034963      2.614397     0.0090
 D(CRH_LN_EQUITY(-7),2)     0.087445     0.027798      3.145745     0.0017
 D(CRH_LN_EQUITY(-8),2)     0.029111     0.019608      1.484600     0.1378
            C               0.275347     0.680667      0.404526     0.6859

R-squared                   0.507206   Mean dependent var        0.018555
Adjusted R-squared          0.505521   S.D. dependent var        49.74649
S.E. of regression          34.98134   Akaike info criterion     9.951285
Sum squared resid           3220763.   Schwarz criterion         9.973538
Log likelihood             -13135.65   Hannan-Quinn criter.      9.959341
F-statistic                 300.9969   Durbin-Watson stat        1.997032
Prob(F-statistic)           0.000000


Null Hypothesis: D(DC__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=23)

                                                  t-Statistic    Prob.*

Augmented Dickey-Fuller test statistic            -21.68112     0.0000
Test critical values:        1% level             -3.434288
                             5% level             -2.863166
                             10% level            -2.567684

*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DC__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:40
```

Sample (adjusted): 1/10/2006 4/04/2012
Included observations: 1578 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(DC__LN_EQUITY(-1))	-1.077820	0.049712	-21.68112	0.0000
D(DC__LN_EQUITY(-1),2)	0.122709	0.042934	2.858065	0.0043
D(DC__LN_EQUITY(-2),2)	0.075694	0.034840	2.172605	0.0300
D(DC__LN_EQUITY(-3),2)	0.086768	0.025401	3.415867	0.0007
C	0.112807	0.191255	0.589823	0.5554

R-squared	0.482869	Mean dependent var	-0.013752
Adjusted R-squared	0.481554	S.D. dependent var	10.54569
S.E. of regression	7.593232	Akaike info criterion	6.895555
Sum squared resid	90694.74	Schwarz criterion	6.912551
Log likelihood	-5435.593	Hannan-Quinn criter.	6.901871
F-statistic	367.1963	Durbin-Watson stat	1.995590
Prob(F-statistic)	0.000000		

Null Hypothesis: D(DC__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-21.68112	0.0000
Test critical values:	1% level	-3.434288	
	5% level	-2.863166	
	10% level	-2.567684	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DC__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:40
Sample (adjusted): 1/10/2006 4/04/2012
Included observations: 1578 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(DC__LN_EQUITY(-1))	-1.077820	0.049712	-21.68112	0.0000
D(DC__LN_EQUITY(-1),2)	0.122709	0.042934	2.858065	0.0043
D(DC__LN_EQUITY(-2),2)	0.075694	0.034840	2.172605	0.0300
D(DC__LN_EQUITY(-3),2)	0.086768	0.025401	3.415867	0.0007
C	0.112807	0.191255	0.589823	0.5554

R-squared	0.482869	Mean dependent var	-0.013752
Adjusted R-squared	0.481554	S.D. dependent var	10.54569
S.E. of regression	7.593232	Akaike info criterion	6.895555
Sum squared resid	90694.74	Schwarz criterion	6.912551
Log likelihood	-5435.593	Hannan-Quinn criter.	6.901871
F-statistic	367.1963	Durbin-Watson stat	1.995590
Prob(F-statistic)	0.000000		

Null Hypothesis: D(DGE_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 27 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.30596	0.0000
Test critical values:	1% level	-3.432650	
	5% level	-2.862442	
	10% level	-2.567295	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DGE_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:41
Sample (adjusted): 2/13/2006 6/30/2016
Included observations: 2623 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(DGE_LN_EQUITY(-1))	-1.526451	0.135013	-11.30596	0.0000
D(DGE_LN_EQUITY(-1),2)	0.453502	0.132224	3.429796	0.0006
D(DGE_LN_EQUITY(-2),2)	0.418932	0.129388	3.237795	0.0012
D(DGE_LN_EQUITY(-3),2)	0.423874	0.126435	3.352515	0.0008
D(DGE_LN_EQUITY(-4),2)	0.429729	0.123291	3.485487	0.0005
D(DGE_LN_EQUITY(-5),2)	0.420103	0.120226	3.494284	0.0005
D(DGE_LN_EQUITY(-6),2)	0.410920	0.117128	3.508289	0.0005
D(DGE_LN_EQUITY(-7),2)	0.373717	0.113924	3.280419	0.0011
D(DGE_LN_EQUITY(-8),2)	0.382787	0.110624	3.460256	0.0005
D(DGE_LN_EQUITY(-9),2)	0.362560	0.107344	3.377569	0.0007
D(DGE_LN_EQUITY(-10),2)	0.326932	0.103803	3.149549	0.0017
D(DGE_LN_EQUITY(-11),2)	0.254111	0.100330	2.532747	0.0114
D(DGE_LN_EQUITY(-12),2)	0.228878	0.096782	2.364874	0.0181
D(DGE_LN_EQUITY(-13),2)	0.188455	0.092861	2.029429	0.0425
D(DGE_LN_EQUITY(-14),2)	0.163974	0.088753	1.847538	0.0648
D(DGE_LN_EQUITY(-15),2)	0.159140	0.084539	1.882432	0.0599
D(DGE_LN_EQUITY(-16),2)	0.195040	0.080315	2.428434	0.0152
D(DGE_LN_EQUITY(-17),2)	0.174000	0.075997	2.289579	0.0221
D(DGE_LN_EQUITY(-18),2)	0.133966	0.071871	1.863964	0.0624
D(DGE_LN_EQUITY(-19),2)	0.159033	0.067697	2.349183	0.0189
D(DGE_LN_EQUITY(-20),2)	0.135952	0.063398	2.144427	0.0321
D(DGE_LN_EQUITY(-21),2)	0.123948	0.058739	2.110139	0.0349
D(DGE_LN_EQUITY(-22),2)	0.125471	0.054044	2.321628	0.0203
D(DGE_LN_EQUITY(-23),2)	0.114812	0.049005	2.342879	0.0192
D(DGE_LN_EQUITY(-24),2)	0.080427	0.043462	1.850523	0.0644
D(DGE_LN_EQUITY(-25),2)	0.105179	0.037063	2.837856	0.0046
D(DGE_LN_EQUITY(-26),2)	0.103822	0.029409	3.530314	0.0004
D(DGE_LN_EQUITY(-27),2)	0.062774	0.019916	3.151991	0.0016
C	0.671902	0.339200	1.980839	0.0477

R-squared	0.540626	Mean dependent var	0.035646
Adjusted R-squared	0.535667	S.D. dependent var	25.19475
S.E. of regression	17.16820	Akaike info criterion	8.534989
Sum squared resid	764573.8	Schwarz criterion	8.599911
Log likelihood	-11164.64	Hannan-Quinn criter.	8.558501
F-statistic	109.0290	Durbin-Watson stat	1.987706
Prob(F-statistic)	0.000000		

```
Null Hypothesis: D(DLG_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=21)
======================================================================
                                             t-Statistic     Prob.*
======================================================================
Augmented Dickey-Fuller test statistic       -13.22944      0.0000
Test critical values:       1% level          -3.437137
                            5% level          -2.864425
                            10% level         -2.568359
======================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLG_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:41
Sample (adjusted): 1/13/2006 9/21/2009
Included observations: 933 after adjustments
======================================================================
        Variable           Coefficient   Std. Error   t-Statistic   Prob.
======================================================================
  D(DLG_LN_EQUITY(-1))      -1.107753    0.083734    -13.22944    0.0000
 D(DLG_LN_EQUITY(-1),2)      0.193713    0.076965     2.516916    0.0120
 D(DLG_LN_EQUITY(-2),2)      0.165996    0.069996     2.371511    0.0179
 D(DLG_LN_EQUITY(-3),2)      0.186763    0.062868     2.970720    0.0030
 D(DLG_LN_EQUITY(-4),2)      0.133489    0.055476     2.406224    0.0163
 D(DLG_LN_EQUITY(-5),2)      0.114025    0.046006     2.478496    0.0134
 D(DLG_LN_EQUITY(-6),2)      0.098562    0.033532     2.939392    0.0034
           C                 0.163139    0.131958     1.236291    0.2167
======================================================================
R-squared                 0.464951   Mean dependent var      -0.001666
Adjusted R-squared        0.460902   S.D. dependent var       5.460618
S.E. of regression        4.009367   Akaike info criterion    5.623681
Sum squared resid         14869.40   Schwarz criterion        5.665168
Log likelihood           -2615.447   Hannan-Quinn criter.     5.639502
F-statistic               114.8303   Durbin-Watson stat       2.006511
Prob(F-statistic)         0.000000
======================================================================
```

```
Null Hypothesis: D(EXPN_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=26)
======================================================================
                                             t-Statistic     Prob.*
======================================================================
Augmented Dickey-Fuller test statistic       -30.07439      0.0000
Test critical values:       1% level          -3.432819
                            5% level          -2.862517
                            10% level         -2.567335
======================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EXPN_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:42
```

Sample (adjusted): 1/09/2006 9/24/2015
Included observations: 2455 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EXPN_LN_EQUITY(-1))	-1.071949	0.035643	-30.07439	0.0000
D(EXPN_LN_EQUITY(-1),2)	0.063341	0.028894	2.192191	0.0285
D(EXPN_LN_EQUITY(-2),2)	0.047110	0.020287	2.322166	0.0203
C	0.363271	0.256150	1.418194	0.1563

R-squared	0.503241	Mean dependent var	0.023422
Adjusted R-squared	0.502633	S.D. dependent var	17.97969
S.E. of regression	12.68004	Akaike info criterion	7.919563
Sum squared resid	394080.1	Schwarz criterion	7.929023
Log likelihood	-9717.264	Hannan-Quinn criter.	7.923001
F-statistic	827.6619	Durbin-Watson stat	1.993840
Prob(F-statistic)	0.000000		

Null Hypothesis: D(EZJ_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 19 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.732161	0.0000
Test critical values:	1% level	-3.432643	
	5% level	-2.862439	
	10% level	-2.567293	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EZJ_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:43
Sample (adjusted): 2/01/2006 6/30/2016
Included observations: 2631 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EZJ_LN_EQUITY(-1))	-1.074125	0.110369	-9.732161	0.0000
D(EZJ_LN_EQUITY(-1),2)	0.126728	0.108081	1.172523	0.2411
D(EZJ_LN_EQUITY(-2),2)	0.004612	0.105573	0.043686	0.9652
D(EZJ_LN_EQUITY(-3),2)	0.003017	0.102682	0.029384	0.9766
D(EZJ_LN_EQUITY(-4),2)	-0.051298	0.099187	-0.517187	0.6051
D(EZJ_LN_EQUITY(-5),2)	-0.049610	0.095381	-0.520127	0.6030
D(EZJ_LN_EQUITY(-6),2)	-0.090224	0.091371	-0.987446	0.3235
D(EZJ_LN_EQUITY(-7),2)	-0.116452	0.087412	-1.332220	0.1829
D(EZJ_LN_EQUITY(-8),2)	-0.119949	0.083114	-1.443190	0.1491
D(EZJ_LN_EQUITY(-9),2)	-0.139942	0.078803	-1.775837	0.0759
D(EZJ_LN_EQUITY(-10),2)	-0.155017	0.074397	-2.083632	0.0373
D(EZJ_LN_EQUITY(-11),2)	-0.146810	0.069960	-2.098494	0.0360
D(EZJ_LN_EQUITY(-12),2)	-0.163959	0.065510	-2.502799	0.0124
D(EZJ_LN_EQUITY(-13),2)	-0.133495	0.060749	-2.197494	0.0281
D(EZJ_LN_EQUITY(-14),2)	-0.175454	0.055766	-3.146248	0.0017
D(EZJ_LN_EQUITY(-15),2)	-0.165859	0.050572	-3.279658	0.0011
D(EZJ_LN_EQUITY(-16),2)	-0.177952	0.044336	-4.013714	0.0001
D(EZJ_LN_EQUITY(-17),2)	-0.179952	0.037614	-4.784173	0.0000
D(EZJ_LN_EQUITY(-18),2)	-0.097394	0.029631	-3.286866	0.0010

```
D(EZJ_LN_EQUITY(-19),2)   -0.059968    0.020994    -2.856471    0.0043
          C                0.267933    0.398385     0.672549    0.5013
==========================================================================

R-squared                  0.490520    Mean dependent var          0.003870
Adjusted R-squared         0.486616    S.D. dependent var          28.36118
S.E. of regression         20.32101    Akaike info criterion       8.869137
Sum squared resid          1077782.    Schwarz criterion           8.916031
Log likelihood            -11646.35    Hannan-Quinn criter.        8.886118
F-statistic                125.6437    Durbin-Watson stat          2.000853
Prob(F-statistic)          0.000000
==========================================================================
```

```
Null Hypothesis: D(FRES_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=25)
==========================================================================
                                                   t-Statistic    Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic              -45.21563    0.0001
--------------------------------------------------------------------------
Test critical values:          1% level             -3.433331
                               5% level             -2.862743
                              10% level             -2.567457
==========================================================================

*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(FRES_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:43
Sample (adjusted): 1/05/2006 2/24/2014
Included observations: 2057 after adjustments
==========================================================================
        Variable          Coefficient   Std. Error   t-Statistic    Prob.
==========================================================================
 D(FRES_LN_EQUITY(-1))     -0.997912    0.022070    -45.21563    0.0000
          C                 0.545379    0.686166     0.794821    0.4268
==========================================================================
R-squared                  0.498714    Mean dependent var          0.044725
Adjusted R-squared         0.498470    S.D. dependent var          43.93808
S.E. of regression         31.11643    Akaike info criterion       9.714321
Sum squared resid          1989717.    Schwarz criterion           9.719794
Log likelihood            -9989.179    Hannan-Quinn criter.        9.716327
F-statistic                2044.453    Durbin-Watson stat          1.998040
Prob(F-statistic)          0.000000
==========================================================================
```

```
Null Hypothesis: D(GKN_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                                   t-Statistic    Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic              -24.98539    0.0000
--------------------------------------------------------------------------
Test critical values:          1% level             -3.432629
                               5% level             -2.862433
                              10% level             -2.567290
==========================================================================

*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GKN_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:43
Sample (adjusted): 1/11/2006 6/30/2016
Included observations: 2646 after adjustments
==============================================================================
         Variable          Coefficient   Std. Error   t-Statistic     Prob.
==============================================================================
   D(GKN_LN_EQUITY(-1))     -1.109006     0.044386    -24.98539      0.0000
  D(GKN_LN_EQUITY(-1),2)     0.142058     0.039235     3.620690      0.0003
  D(GKN_LN_EQUITY(-2),2)     0.081622     0.033719     2.420690      0.0156
  D(GKN_LN_EQUITY(-3),2)     0.066483     0.027226     2.441861      0.0147
  D(GKN_LN_EQUITY(-4),2)     0.035194     0.019573     1.798112      0.0723
             C               0.032095     0.091957     0.349023      0.7271
==============================================================================
R-squared                    0.486201   Mean dependent var          0.003198
Adjusted R-squared           0.485228   S.D. dependent var          6.592263
S.E. of regression           4.729793   Akaike info criterion       5.947905
Sum squared resid            59059.29   Schwarz criterion           5.961240
Log likelihood              -7863.078   Hannan-Quinn criter.        5.952732
F-statistic                  499.6386   Durbin-Watson stat          1.999928
Prob(F-statistic)            0.000000
==============================================================================
```

Null Hypothesis: D(GLEN_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=22)
==============================================================================
                                                    t-Statistic    Prob.*
==============================================================================
Augmented Dickey-Fuller test statistic              -23.06062     0.0000
------------------------------------------------------------------------------
Test critical values:          1% level             -3.435204
                               5% level             -2.863571
                              10% level             -2.567901
==============================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GLEN_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:43
Sample (adjusted): 1/09/2006 2/14/2011
Included observations: 1291 after adjustments
==============================================================================
         Variable          Coefficient   Std. Error   t-Statistic     Prob.
==============================================================================
   D(GLEN_LN_EQUITY(-1))    -1.117771     0.048471    -23.06062      0.0000
  D(GLEN_LN_EQUITY(-1),2)    0.148248     0.038576     3.843050      0.0001
  D(GLEN_LN_EQUITY(-2),2)    0.058248     0.027828     2.093190      0.0365
             C              -0.313664     0.209870    -1.494564      0.1353
==============================================================================
R-squared                    0.489873   Mean dependent var          0.012470
Adjusted R-squared           0.488684   S.D. dependent var          10.52051
S.E. of regression           7.522832   Akaike info criterion       6.876856
Sum squared resid            72835.20   Schwarz criterion           6.892853
Log likelihood              -4435.011   Hannan-Quinn criter.        6.882860
F-statistic                  411.9678   Durbin-Watson stat          1.999001
Prob(F-statistic)            0.000000
```

```
Null Hypothesis: D(GSK_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                              t-Statistic    Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic        -52.77588      0.0001
--------------------------------------------------------------------------
Test critical values:      1% level           -3.432625
                           5% level           -2.862431
                           10% level          -2.567289
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GSK_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:44
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments
==========================================================================
      Variable           Coefficient    Std. Error   t-Statistic   Prob.
==========================================================================
 D(GSK_LN_EQUITY(-1))     -1.026113     0.019443     -52.77588     0.0000
         C                 0.046869     0.330662      0.141743     0.8873
==========================================================================
R-squared                 0.512634   Mean dependent var          0.006792
Adjusted R-squared        0.512450   S.D. dependent var          24.37794
S.E. of regression        17.02183   Akaike info criterion       8.507625
Sum squared resid         767239.0   Schwarz criterion           8.512065
Log likelihood           -11270.60   Hannan-Quinn criter.        8.509232
F-statistic               2785.293   Durbin-Watson stat          1.999041
Prob(F-statistic)         0.000000
==========================================================================
```

```
Null Hypothesis: D(HIK_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 27 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                              t-Statistic    Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic        -9.369731      0.0000
--------------------------------------------------------------------------
Test critical values:      1% level           -3.432650
                           5% level           -2.862442
                           10% level          -2.567295
==========================================================================
*MacKinnon (1996) one-sided p-values.
```

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(HIK_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:45
Sample (adjusted): 2/13/2006 6/30/2016
Included observations: 2623 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HIK_LN_EQUITY(-1))	-0.960908	0.102554	-9.369731	0.0000
D(HIK_LN_EQUITY(-1),2)	-0.024191	0.100958	-0.239610	0.8107
D(HIK_LN_EQUITY(-2),2)	0.021428	0.099459	0.215450	0.8294
D(HIK_LN_EQUITY(-3),2)	0.007130	0.097739	0.072950	0.9419
D(HIK_LN_EQUITY(-4),2)	-0.039839	0.095851	-0.415640	0.6777
D(HIK_LN_EQUITY(-5),2)	-0.025913	0.093720	-0.276490	0.7822
D(HIK_LN_EQUITY(-6),2)	0.007004	0.091682	0.076395	0.9391
D(HIK_LN_EQUITY(-7),2)	0.027302	0.089527	0.304953	0.7604
D(HIK_LN_EQUITY(-8),2)	-0.026606	0.087418	-0.304351	0.7609
D(HIK_LN_EQUITY(-9),2)	-0.041895	0.085055	-0.492564	0.6224
D(HIK_LN_EQUITY(-10),2)	-0.018182	0.082782	-0.219635	0.8262
D(HIK_LN_EQUITY(-11),2)	-0.055047	0.080616	-0.682839	0.4948
D(HIK_LN_EQUITY(-12),2)	-0.027976	0.078585	-0.356001	0.7219
D(HIK_LN_EQUITY(-13),2)	-0.008390	0.076293	-0.109977	0.9124
D(HIK_LN_EQUITY(-14),2)	-0.004732	0.073842	-0.064089	0.9489
D(HIK_LN_EQUITY(-15),2)	0.008667	0.071290	0.121571	0.9032
D(HIK_LN_EQUITY(-16),2)	0.040757	0.068523	0.594793	0.5520
D(HIK_LN_EQUITY(-17),2)	0.002578	0.065460	0.039390	0.9686
D(HIK_LN_EQUITY(-18),2)	-0.037808	0.062448	-0.605427	0.5449
D(HIK_LN_EQUITY(-19),2)	-0.069720	0.059064	-1.180419	0.2379
D(HIK_LN_EQUITY(-20),2)	-0.014408	0.055563	-0.259311	0.7954
D(HIK_LN_EQUITY(-21),2)	-0.031569	0.052168	-0.605152	0.5451
D(HIK_LN_EQUITY(-22),2)	-0.018251	0.048388	-0.377179	0.7061
D(HIK_LN_EQUITY(-23),2)	-0.052438	0.044036	-1.190798	0.2338
D(HIK_LN_EQUITY(-24),2)	-0.000773	0.039062	-0.019797	0.9842
D(HIK_LN_EQUITY(-25),2)	0.031595	0.033900	0.932001	0.3514
D(HIK_LN_EQUITY(-26),2)	0.087029	0.028070	3.100464	0.0020
D(HIK_LN_EQUITY(-27),2)	0.047510	0.019962	2.380060	0.0174
C	0.746246	0.422488	1.766311	0.0775

R-squared	0.508719	Mean dependent var	0.019920
Adjusted R-squared	0.503416	S.D. dependent var	30.25644
S.E. of regression	21.32132	Akaike info criterion	8.968287
Sum squared resid	1179230.	Schwarz criterion	9.033209
Log likelihood	-11732.91	Hannan-Quinn criter.	8.991799
F-statistic	95.93122	Durbin-Watson stat	1.996428
Prob(F-statistic)	0.000000		

Null Hypothesis: D(HL__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 22 (Automatic - based on AIC, maxlag=26)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.697681	0.0000
Test critical values:	1% level	-3.433016	
	5% level	-2.862604	
	10% level	-2.567382	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(HL__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 14:45
Sample (adjusted): 2/06/2006 2/19/2015
Included observations: 2285 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HL__LN_EQUITY(-1))	-1.055086	0.108798	-9.697681	0.0000
D(HL__LN_EQUITY(-1),2)	0.090584	0.106708	0.848898	0.3960
D(HL__LN_EQUITY(-2),2)	0.025965	0.104407	0.248690	0.8036
D(HL__LN_EQUITY(-3),2)	0.036536	0.102242	0.357349	0.7209
D(HL__LN_EQUITY(-4),2)	-0.034676	0.099682	-0.347871	0.7280
D(HL__LN_EQUITY(-5),2)	-0.016636	0.096826	-0.171809	0.8636
D(HL__LN_EQUITY(-6),2)	-0.031899	0.093886	-0.339760	0.7341
D(HL__LN_EQUITY(-7),2)	0.010320	0.090601	0.113910	0.9093
D(HL__LN_EQUITY(-8),2)	0.033233	0.087309	0.380634	0.7035
D(HL__LN_EQUITY(-9),2)	0.010045	0.083727	0.119968	0.9045
D(HL__LN_EQUITY(-10),2)	-0.006596	0.080598	-0.081836	0.9348
D(HL__LN_EQUITY(-11),2)	0.019031	0.077108	0.246806	0.8051
D(HL__LN_EQUITY(-12),2)	-0.040539	0.073831	-0.549079	0.5830
D(HL__LN_EQUITY(-13),2)	-0.017542	0.070216	-0.249829	0.8027
D(HL__LN_EQUITY(-14),2)	-0.120779	0.066665	-1.811735	0.0702
D(HL__LN_EQUITY(-15),2)	-0.094784	0.063283	-1.497790	0.1343
D(HL__LN_EQUITY(-16),2)	-0.113778	0.059572	-1.909919	0.0563
D(HL__LN_EQUITY(-17),2)	-0.057206	0.055373	-1.033089	0.3017
D(HL__LN_EQUITY(-18),2)	-0.057848	0.050906	-1.136351	0.2559
D(HL__LN_EQUITY(-19),2)	-0.038166	0.045432	-0.840056	0.4010
D(HL__LN_EQUITY(-20),2)	-0.007802	0.039607	-0.196976	0.8439
D(HL__LN_EQUITY(-21),2)	-0.012787	0.032145	-0.397800	0.6908
D(HL__LN_EQUITY(-22),2)	0.046585	0.022596	2.061689	0.0394
C	0.470884	0.356756	1.319904	0.1870

R-squared	0.505210	Mean dependent var	0.007987
Adjusted R-squared	0.500177	S.D. dependent var	23.87132
S.E. of regression	16.87658	Akaike info criterion	8.500179
Sum squared resid	643976.0	Schwarz criterion	8.560406
Log likelihood	-9687.455	Hannan-Quinn criter.	8.522144
F-statistic	100.3746	Durbin-Watson stat	2.002343
Prob(F-statistic)	0.000000		

Null Hypothesis: D(HMSO_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-50.25421	0.0001
Test critical values:	1% level	-3.432625	
	5% level	-2.862431	
	10% level	-2.567289	

*MacKinnon (1996) one-sided p-values.

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(HMSO_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:45
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments
==============================================================================
        Variable           Coefficient   Std. Error    t-Statistic     Prob.
==============================================================================
 D(HMSO_LN_EQUITY(-1))      -0.976849     0.019438     -50.25421      0.0000
           C                -0.059490     0.215665     -0.275843      0.7827
==============================================================================
R-squared                    0.488159   Mean dependent var           0.004730
Adjusted R-squared           0.487966   S.D. dependent var           15.51479
S.E. of regression           11.10185   Akaike info criterion        7.652855
Sum squared resid            326368.8   Schwarz criterion            7.657294
Log likelihood              -10138.03   Hannan-Quinn criter.         7.654462
F-statistic                  2525.486   Durbin-Watson stat           1.998262
Prob(F-statistic)            0.000000
==============================================================================
```

```
Null Hypothesis: D(HSBA_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 15 (Automatic - based on AIC, maxlag=27)
================================================================================
                                                        t-Statistic     Prob.*
================================================================================
Augmented Dickey-Fuller test statistic                  -13.61053      0.0000
--------------------------------------------------------------------------------
Test critical values:         1% level                  -3.432639
                              5% level                  -2.862437
                             10% level                  -2.567292
================================================================================
*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(HSBA_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 14:46
Sample (adjusted): 1/26/2006 6/30/2016
Included observations: 2635 after adjustments
================================================================================
         Variable            Coefficient   Std. Error    t-Statistic     Prob.
================================================================================
  D(HSBA_LN_EQUITY(-1))       -1.233787     0.090649     -13.61053      0.0000
 D(HSBA_LN_EQUITY(-1),2)       0.201117     0.087180      2.306907      0.0211
 D(HSBA_LN_EQUITY(-2),2)       0.164423     0.083790      1.962307      0.0498
 D(HSBA_LN_EQUITY(-3),2)       0.129936     0.080484      1.614429      0.1066
 D(HSBA_LN_EQUITY(-4),2)       0.097934     0.077019      1.271560      0.2036
 D(HSBA_LN_EQUITY(-5),2)       0.079939     0.073184      1.092295      0.2748
 D(HSBA_LN_EQUITY(-6),2)       0.029141     0.069446      0.419616      0.6748
 D(HSBA_LN_EQUITY(-7),2)       0.051451     0.065480      0.785753      0.4321
 D(HSBA_LN_EQUITY(-8),2)       0.076808     0.061453      1.249873      0.2115
 D(HSBA_LN_EQUITY(-9),2)       0.051524     0.056952      0.904680      0.3657
D(HSBA_LN_EQUITY(-10),2)       0.051600     0.051864      0.994905      0.3199
D(HSBA_LN_EQUITY(-11),2)       0.004347     0.046717      0.093059      0.9259
D(HSBA_LN_EQUITY(-12),2)       0.034127     0.041101      0.830313      0.4064
D(HSBA_LN_EQUITY(-13),2)       0.032109     0.034996      0.917512      0.3590
D(HSBA_LN_EQUITY(-14),2)      -0.013105     0.028074     -0.466805      0.6407
D(HSBA_LN_EQUITY(-15),2)      -0.057538     0.019504     -2.949993      0.0032
            C                 -0.163980     0.207667     -0.789631      0.4298
```

```
R-squared                 0.524448    Mean dependent var       0.003337
Adjusted R-squared        0.521542    S.D. dependent var       15.37935
S.E. of regression        10.63801    Akaike info criterion    7.573174
Sum squared resid         296271.6    Schwarz criterion        7.611088
Log likelihood           -9960.657    Hannan-Quinn criter.     7.586902
F-statistic               180.4488    Durbin-Watson stat       2.000799
Prob(F-statistic)         0.000000
```

Null Hypothesis: D(IAG_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=27)

                                                  t-Statistic    Prob.*

Augmented Dickey-Fuller test statistic             -38.81527     0.0000
Test critical values:          1% level            -3.432627
                               5% level            -2.862432
                              10% level            -2.567290

*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(IAG_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:18
Sample (adjusted): 1/06/2006 6/29/2016
Included observations: 2648 after adjustments

        Variable          Coefficient    Std. Error    t-Statistic    Prob.

   D(IAG_LN_EQUITY(-1))    -1.051095     0.027079     -38.81527     0.0000
 D(IAG_LN_EQUITY(-1),2)     0.078073     0.019391      4.026338     0.0001
           C                0.013626     0.155364      0.087701     0.9301

R-squared                 0.490450    Mean dependent var       0.005174
Adjusted R-squared        0.490065    S.D. dependent var       11.19572
S.E. of regression        7.994833    Akaike info criterion    6.996600
Sum squared resid         169061.4    Schwarz criterion        7.003264
Log likelihood           -9260.499    Hannan-Quinn criter.     6.999012
F-statistic               1272.928    Durbin-Watson stat       1.999983
Prob(F-statistic)         0.000000
```

Null Hypothesis: D(IHG_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)

                                                  t-Statistic    Prob.*

Augmented Dickey-Fuller test statistic             -52.18771     0.0001
Test critical values:          1% level            -3.432625
                               5% level            -2.862431
                              10% level            -2.567289

*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(IHG_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:19
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments
==============================================================================
       Variable          Coefficient    Std. Error    t-Statistic      Prob.
==============================================================================
 D(IHG_LN_EQUITY(-1))     -1.014185      0.019433     -52.18771       0.0000
           C               0.437566      0.716515      0.610687       0.5415
==============================================================================
R-squared                  0.507033   Mean dependent var             0.009531
Adjusted R-squared         0.506847   S.D. dependent var             52.52053
S.E. of regression         36.88247   Akaike info criterion          10.05410
Sum squared resid          3602118.   Schwarz criterion              10.05854
Log likelihood            -13319.69   Hannan-Quinn criter.           10.05571
F-statistic                2723.557   Durbin-Watson stat             2.000037
Prob(F-statistic)          0.000000
==============================================================================
```

Null Hypothesis: D(III_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)
==============================================================================
                                                     t-Statistic     Prob.*
==============================================================================
Augmented Dickey-Fuller test statistic               -51.42119      0.0001
------------------------------------------------------------------------------
Test critical values:        1% level                -3.432625
                             5% level                -2.862431
                            10% level                -2.567289
==============================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(III_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:19
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments
==============================================================================
       Variable          Coefficient    Std. Error    t-Statistic      Prob.
==============================================================================
  D(III_LN_EQUITY(-1))    -1.003170      0.019509     -51.42119       0.0000
           C              -0.080552      0.181763     -0.443172       0.6577
==============================================================================
R-squared                  0.499635   Mean dependent var             0.013449
Adjusted R-squared         0.499446   S.D. dependent var             13.22455
S.E. of regression         9.356345   Akaike info criterion          7.310741
Sum squared resid          231809.1   Schwarz criterion              7.315181
Log likelihood            -9684.732   Hannan-Quinn criter.           7.312348
F-statistic                2644.139   Durbin-Watson stat             1.992336
Prob(F-statistic)          0.000000
==============================================================================
```

```
Null Hypothesis: D(IMB_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 8 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                                    t-Statistic   Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic              -18.95192     0.0000
Test critical values:       1% level                -3.432633
                            5% level                -2.862434
                           10% level                -2.567291
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(IMB_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:19
Sample (adjusted): 1/17/2006 6/30/2016
Included observations: 2642 after adjustments
==========================================================================
        Variable            Coefficient   Std. Error   t-Statistic   Prob.
==========================================================================
 D(IMB_LN_EQUITY(-1))        -1.241747    0.065521     -18.95192    0.0000
D(IMB_LN_EQUITY(-1),2)        0.225612    0.061393      3.674855    0.0002
D(IMB_LN_EQUITY(-2),2)        0.171348    0.056779      3.017803    0.0026
D(IMB_LN_EQUITY(-3),2)        0.136349    0.051938      2.625227    0.0087
D(IMB_LN_EQUITY(-4),2)        0.138665    0.047044      2.947589    0.0032
D(IMB_LN_EQUITY(-5),2)        0.138551    0.041594      3.331058    0.0009
D(IMB_LN_EQUITY(-6),2)        0.084699    0.035303      2.399196    0.0165
D(IMB_LN_EQUITY(-7),2)        0.055340    0.028165      1.964878    0.0495
D(IMB_LN_EQUITY(-8),2)        0.064536    0.019657      3.283157    0.0010
           C                  1.183239    0.618549      1.912926    0.0559
==========================================================================
R-squared                     0.510004   Mean dependent var       0.053425
Adjusted R-squared            0.508329   S.D. dependent var       45.16122
S.E. of regression            31.66671   Akaike info criterion    9.752187
Sum squared resid             2639318.   Schwarz criterion        9.774440
Log likelihood               -12872.64   Hannan-Quinn criter.     9.760243
F-statistic                   304.3864   Durbin-Watson stat       1.992959
Prob(F-statistic)             0.000000
==========================================================================
```

```
Null Hypothesis: D(INF_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                                    t-Statistic   Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic              -52.24329     0.0001
Test critical values:       1% level                -3.432625
                            5% level                -2.862431
                           10% level                -2.567289
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INF_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:19
```

```
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments
==========================================================================
        Variable            Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
 D(INF_LN_EQUITY(-1))        -1.019405      0.019513     -52.24329     0.0000
          C                   0.136151      0.148284      0.918176     0.3586
==========================================================================
R-squared                     0.507565   Mean dependent var         0.012578
Adjusted R-squared            0.507379   S.D. dependent var         10.87441
S.E. of regression            7.632415   Akaike info criterion      6.903440
Sum squared resid             154255.9   Schwarz criterion          6.907880
Log likelihood               -9145.058   Hannan-Quinn criter.       6.905047
F-statistic                   2729.361   Durbin-Watson stat         1.991132
Prob(F-statistic)             0.000000
==========================================================================
```

```
Null Hypothesis: D(INTU_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                                   t-Statistic    Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic             -20.11980      0.0000
--------------------------------------------------------------------------
Test critical values:          1% level            -3.432632
                               5% level            -2.862434
                              10% level            -2.567291
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INTU_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:20
Sample (adjusted): 1/16/2006 6/30/2016
Included observations: 2643 after adjustments
==========================================================================
        Variable            Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
  D(INTU_LN_EQUITY(-1))      -1.210530      0.060166     -20.11980     0.0000
D(INTU_LN_EQUITY(-1),2)       0.160573      0.055914      2.871762     0.0041
D(INTU_LN_EQUITY(-2),2)       0.170515      0.051002      3.343296     0.0008
D(INTU_LN_EQUITY(-3),2)       0.134884      0.045946      2.935712     0.0034
D(INTU_LN_EQUITY(-4),2)       0.107877      0.040722      2.649121     0.0081
D(INTU_LN_EQUITY(-5),2)       0.056829      0.034968      1.625179     0.1042
D(INTU_LN_EQUITY(-6),2)       0.021433      0.028438      0.753658     0.4511
D(INTU_LN_EQUITY(-7),2)       0.050659      0.019562      2.589663     0.0097
          C                  -0.165751      0.178523     -0.928457     0.3533
==========================================================================
R-squared                     0.529192   Mean dependent var         0.005922
Adjusted R-squared            0.527762   S.D. dependent var         13.34106
S.E. of regression            9.167920   Akaike info criterion      7.272697
Sum squared resid             221389.7   Schwarz criterion          7.292719
Log likelihood               -9601.870   Hannan-Quinn criter.       7.279946
F-statistic                   370.0792   Durbin-Watson stat         1.999176
Prob(F-statistic)             0.000000
==========================================================================
```

```
Null Hypothesis: D(ITRK_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=27)
=========================================================================
                                                  t-Statistic    Prob.*
=========================================================================
Augmented Dickey-Fuller test statistic             -27.73373     0.0000
-------------------------------------------------------------------------
Test critical values:        1% level              -3.432628
                             5% level              -2.862432
                             10% level             -2.567290
=========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ITRK_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:20
Sample (adjusted): 1/10/2006 6/30/2016
Included observations: 2647 after adjustments
=========================================================================
        Variable           Coefficient   Std. Error   t-Statistic   Prob.
=========================================================================
  D(ITRK_LN_EQUITY(-1))     -1.117393    0.040290     -27.73373    0.0000
 D(ITRK_LN_EQUITY(-1),2)     0.099366    0.034442      2.884984    0.0039
 D(ITRK_LN_EQUITY(-2),2)     0.106451    0.028053      3.794688    0.0002
 D(ITRK_LN_EQUITY(-3),2)     0.047914    0.019646      2.438900    0.0148
            C                1.164160    0.597369      1.948814    0.0514
=========================================================================
R-squared                    0.508613   Mean dependent var       0.056479
Adjusted R-squared           0.507869   S.D. dependent var       43.71953
S.E. of regression           30.67015   Akaike info criterion    9.686344
Sum squared resid            2485219.   Schwarz criterion        9.697453
Log likelihood              -12814.88   Hannan-Quinn criter.     9.690365
F-statistic                  683.6540   Durbin-Watson stat       1.992908
Prob(F-statistic)            0.000000
=========================================================================


Null Hypothesis: D(ITV_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 19 (Automatic - based on AIC, maxlag=27)
=========================================================================
                                                  t-Statistic    Prob.*
=========================================================================
Augmented Dickey-Fuller test statistic             -10.45888     0.0000
-------------------------------------------------------------------------
Test critical values:        1% level              -3.432643
                             5% level              -2.862439
                             10% level             -2.567293
=========================================================================
*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ITV_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:20
Sample (adjusted): 2/01/2006 6/30/2016
Included observations: 2631 after adjustments
=============================================================================
        Variable            Coefficient    Std. Error    t-Statistic    Prob.
=============================================================================
   D(ITV_LN_EQUITY(-1))      -1.126975      0.107753     -10.45888     0.0000
  D(ITV_LN_EQUITY(-1),2)      0.146484      0.105238      1.391934     0.1641
  D(ITV_LN_EQUITY(-2),2)      0.087412      0.102918      0.849341     0.3958
  D(ITV_LN_EQUITY(-3),2)      0.061606      0.100395      0.613637     0.5395
  D(ITV_LN_EQUITY(-4),2)     -0.012214      0.097346     -0.125474     0.9002
  D(ITV_LN_EQUITY(-5),2)     -0.073407      0.093666     -0.783713     0.4333
  D(ITV_LN_EQUITY(-6),2)     -0.073660      0.089924     -0.819137     0.4128
  D(ITV_LN_EQUITY(-7),2)     -0.146611      0.086343     -1.698003     0.0896
  D(ITV_LN_EQUITY(-8),2)     -0.160471      0.082477     -1.945648     0.0518
  D(ITV_LN_EQUITY(-9),2)     -0.154001      0.078299     -1.966846     0.0493
 D(ITV_LN_EQUITY(-10),2)     -0.162860      0.073850     -2.205284     0.0275
 D(ITV_LN_EQUITY(-11),2)     -0.158200      0.069255     -2.284297     0.0224
 D(ITV_LN_EQUITY(-12),2)     -0.132966      0.064376     -2.065462     0.0390
 D(ITV_LN_EQUITY(-13),2)     -0.109503      0.059324     -1.845846     0.0650
 D(ITV_LN_EQUITY(-14),2)     -0.149953      0.054456     -2.753670     0.0059
 D(ITV_LN_EQUITY(-15),2)     -0.159049      0.049055     -3.242294     0.0012
 D(ITV_LN_EQUITY(-16),2)     -0.136944      0.043405     -3.155004     0.0016
 D(ITV_LN_EQUITY(-17),2)     -0.109463      0.037610     -2.910514     0.0036
 D(ITV_LN_EQUITY(-18),2)     -0.043224      0.030695     -1.408209     0.1592
 D(ITV_LN_EQUITY(-19),2)     -0.062139      0.021442     -2.897986     0.0038
            C                 0.030499      0.048688      0.626403     0.5311
=============================================================================
R-squared                     0.500657    Mean dependent var          0.000855
Adjusted R-squared            0.496830    S.D. dependent var          3.510540
S.E. of regression            2.490182    Akaike info criterion       4.670539
Sum squared resid             16184.63    Schwarz criterion           4.717433
Log likelihood               -6123.094    Hannan-Quinn criter.        4.687519
F-statistic                   130.8432    Durbin-Watson stat          2.001784
Prob(F-statistic)             0.000000
=============================================================================
```

```
Null Hypothesis: D(JMAT_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)
=============================================================================
                                                  t-Statistic     Prob.*
=============================================================================
Augmented Dickey-Fuller test statistic             -53.66092      0.0001
-----------------------------------------------------------------------------
Test critical values:          1% level            -3.432625
                               5% level            -2.862431
                              10% level            -2.567289
=============================================================================
*MacKinnon (1996) one-sided p-values.
```

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(JMAT_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:20
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(JMAT_LN_EQUITY(-1))	-1.041908	0.019417	-53.66092	0.0000
C	0.463063	0.786910	0.588458	0.5563

R-squared	0.520940	Mean dependent var	-0.006498
Adjusted R-squared	0.520759	S.D. dependent var	58.51188
S.E. of regression	40.50614	Akaike info criterion	10.24154
Sum squared resid	4344700.	Schwarz criterion	10.24598
Log likelihood	-13568.04	Hannan-Quinn criter.	10.24315
F-statistic	2879.494	Durbin-Watson stat	1.997694
Prob(F-statistic)	0.000000		

Null Hypothesis: D(KGF_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-27.90130	0.0000
Test critical values:	1% level	-3.432628	
	5% level	-2.862432	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(KGF_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:21
Sample (adjusted): 1/10/2006 6/30/2016
Included observations: 2647 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(KGF_LN_EQUITY(-1))	-1.118928	0.040103	-27.90130	0.0000
D(KGF_LN_EQUITY(-1),2)	0.108966	0.034338	3.173352	0.0015
D(KGF_LN_EQUITY(-2),2)	0.067026	0.027708	2.419018	0.0156
D(KGF_LN_EQUITY(-3),2)	0.048867	0.019575	2.496377	0.0126
C	0.037992	0.089092	0.426435	0.6698

R-squared	0.506077	Mean dependent var	-0.000756
Adjusted R-squared	0.505329	S.D. dependent var	6.516374
S.E. of regression	4.583152	Akaike info criterion	5.884538
Sum squared resid	55495.95	Schwarz criterion	5.895647
Log likelihood	-7783.186	Hannan-Quinn criter.	5.888559
F-statistic	676.7524	Durbin-Watson stat	2.000905
Prob(F-statistic)	0.000000		

```
Null Hypothesis: D(LAND_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=27)
=====================================================================
                                              t-Statistic   Prob.*
=====================================================================
Augmented Dickey-Fuller test statistic         -23.64281    0.0000
Test critical values:        1% level          -3.432630
                             5% level          -2.862433
                            10% level          -2.567290
=====================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LAND_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:21
Sample (adjusted): 1/12/2006 6/30/2016
Included observations: 2645 after adjustments
=====================================================================
        Variable            Coefficient   Std. Error   t-Statistic   Prob.
=====================================================================
  D(LAND_LN_EQUITY(-1))      -1.171402     0.049546    -23.64281    0.0000
 D(LAND_LN_EQUITY(-1),2)      0.184132     0.044605     4.128086    0.0000
 D(LAND_LN_EQUITY(-2),2)      0.164089     0.039172     4.188901    0.0000
 D(LAND_LN_EQUITY(-3),2)      0.153251     0.034197     4.481405    0.0000
 D(LAND_LN_EQUITY(-4),2)      0.057831     0.028142     2.054992    0.0400
 D(LAND_LN_EQUITY(-5),2)      0.051073     0.019907     2.565563    0.0104
            C                -0.180947     0.377750    -0.479011    0.6320
=====================================================================
R-squared                     0.498602   Mean dependent var      0.006427
Adjusted R-squared            0.497462   S.D. dependent var      27.39899
S.E. of regression            19.42313   Akaike info criterion   8.773449
Sum squared resid             995206.3   Schwarz criterion       8.789012
Log likelihood               -11595.89   Hannan-Quinn criter.    8.779083
F-statistic                   437.2151   Durbin-Watson stat      1.999159
Prob(F-statistic)             0.000000
=====================================================================
```

```
Null Hypothesis: D(LGEN_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=27)
=====================================================================
                                              t-Statistic   Prob.*
=====================================================================
Augmented Dickey-Fuller test statistic         -25.01115    0.0000
Test critical values:        1% level          -3.432629
                             5% level          -2.862433
                            10% level          -2.567290
=====================================================================
*MacKinnon (1996) one-sided p-values.
```

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LGEN_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:21
Sample (adjusted): 1/11/2006 6/30/2016
Included observations: 2646 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGEN_LN_EQUITY(-1))	-1.127431	0.045077	-25.01115	0.0000
D(LGEN_LN_EQUITY(-1),2)	0.149598	0.039994	3.740509	0.0002
D(LGEN_LN_EQUITY(-2),2)	0.093450	0.034913	2.676649	0.0075
D(LGEN_LN_EQUITY(-3),2)	0.094088	0.029017	3.242554	0.0012
D(LGEN_LN_EQUITY(-4),2)	0.051546	0.020854	2.471764	0.0135
C	0.028378	0.057757	0.491325	0.6232

R-squared	0.492255	Mean dependent var	0.001323
Adjusted R-squared	0.491293	S.D. dependent var	4.164587
S.E. of regression	2.970338	Akaike info criterion	5.017494
Sum squared resid	23292.48	Schwarz criterion	5.030829
Log likelihood	-6632.144	Hannan-Quinn criter.	5.022321
F-statistic	511.8912	Durbin-Watson stat	1.997707
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LLOY_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 27 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.293861	0.0000
Test critical values:	1% level	-3.432650	
	5% level	-2.862442	
	10% level	-2.567295	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LLOY_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:22
Sample (adjusted): 2/13/2006 6/30/2016
Included observations: 2623 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LLOY_LN_EQUITY(-1))	-1.009756	0.121747	-8.293861	0.0000
D(LLOY_LN_EQUITY(-1),2)	-0.001729	0.119889	-0.014420	0.9885
D(LLOY_LN_EQUITY(-2),2)	-0.052731	0.118175	-0.446210	0.6555
D(LLOY_LN_EQUITY(-3),2)	-0.065004	0.116368	-0.558604	0.5765
D(LLOY_LN_EQUITY(-4),2)	-0.071675	0.114387	-0.626603	0.5310
D(LLOY_LN_EQUITY(-5),2)	-0.112881	0.112224	-1.005854	0.3146
D(LLOY_LN_EQUITY(-6),2)	-0.153208	0.109867	-1.394478	0.1633
D(LLOY_LN_EQUITY(-7),2)	-0.191932	0.107449	-1.786258	0.0742
D(LLOY_LN_EQUITY(-8),2)	-0.255293	0.104848	-2.434896	0.0150
D(LLOY_LN_EQUITY(-9),2)	-0.284059	0.102165	-2.780406	0.0055
D(LLOY_LN_EQUITY(-10),2)	-0.284875	0.099194	-2.871907	0.0041
D(LLOY_LN_EQUITY(-11),2)	-0.271065	0.095613	-2.835029	0.0046
D(LLOY_LN_EQUITY(-12),2)	-0.289685	0.091716	-3.158484	0.0016

D(LLOY_LN_EQUITY(-13),2)	-0.273984	0.087916	-3.116419	0.0019
D(LLOY_LN_EQUITY(-14),2)	-0.319590	0.084207	-3.795283	0.0002
D(LLOY_LN_EQUITY(-15),2)	-0.371988	0.080659	-4.611891	0.0000
D(LLOY_LN_EQUITY(-16),2)	-0.408585	0.076922	-5.311688	0.0000
D(LLOY_LN_EQUITY(-17),2)	-0.379904	0.073210	-5.189260	0.0000
D(LLOY_LN_EQUITY(-18),2)	-0.281603	0.069137	-4.073146	0.0000
D(LLOY_LN_EQUITY(-19),2)	-0.231966	0.064633	-3.588984	0.0003
D(LLOY_LN_EQUITY(-20),2)	-0.219573	0.059923	-3.664239	0.0003
D(LLOY_LN_EQUITY(-21),2)	-0.174776	0.055352	-3.157564	0.0016
D(LLOY_LN_EQUITY(-22),2)	-0.174080	0.050655	-3.436559	0.0006
D(LLOY_LN_EQUITY(-23),2)	-0.135642	0.045823	-2.960167	0.0031
D(LLOY_LN_EQUITY(-24),2)	-0.099429	0.040706	-2.442602	0.0146
D(LLOY_LN_EQUITY(-25),2)	-0.064491	0.034857	-1.850152	0.0644
D(LLOY_LN_EQUITY(-26),2)	-0.034123	0.027913	-1.222468	0.2216
D(LLOY_LN_EQUITY(-27),2)	-0.072254	0.019544	-3.696949	0.0002
C	-0.086032	0.055732	-1.543685	0.1228

R-squared	0.519034	Mean dependent var	-0.000557
Adjusted R-squared	0.513842	S.D. dependent var	4.043746
S.E. of regression	2.819503	Akaike info criterion	4.921993
Sum squared resid	20621.25	Schwarz criterion	4.986914
Log likelihood	-6426.193	Hannan-Quinn criter.	4.945505
F-statistic	99.97534	Durbin-Watson stat	2.003387
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LSE_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 26 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.12344	0.0000
Test critical values:	1% level	-3.432649	
	5% level	-2.862442	
	10% level	-2.567295	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LSE_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:22
Sample (adjusted): 2/10/2006 6/30/2016
Included observations: 2624 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LSE_LN_EQUITY(-1))	-1.144018	0.113007	-10.12344	0.0000
D(LSE_LN_EQUITY(-1),2)	0.120232	0.111054	1.082642	0.2791
D(LSE_LN_EQUITY(-2),2)	0.131177	0.108860	1.205010	0.2283
D(LSE_LN_EQUITY(-3),2)	0.167324	0.106751	1.567433	0.1171
D(LSE_LN_EQUITY(-4),2)	0.102149	0.104611	0.976468	0.3289
D(LSE_LN_EQUITY(-5),2)	0.051453	0.102453	0.502211	0.6156
D(LSE_LN_EQUITY(-6),2)	0.034257	0.099866	0.343033	0.7316
D(LSE_LN_EQUITY(-7),2)	0.051634	0.097189	0.531279	0.5953
D(LSE_LN_EQUITY(-8),2)	0.054561	0.094351	0.578276	0.5631
D(LSE_LN_EQUITY(-9),2)	0.059108	0.091663	0.644843	0.5191
D(LSE_LN_EQUITY(-10),2)	0.056058	0.089027	0.629675	0.5290
D(LSE_LN_EQUITY(-11),2)	0.022389	0.086154	0.259872	0.7950

D(LSE_LN_EQUITY(-12),2)	0.015419	0.082977	0.185825	0.8526
D(LSE_LN_EQUITY(-13),2)	-0.014738	0.079707	-0.184903	0.8533
D(LSE_LN_EQUITY(-14),2)	-0.038045	0.076413	-0.497887	0.6186
D(LSE_LN_EQUITY(-15),2)	-0.044715	0.073110	-0.611611	0.5408
D(LSE_LN_EQUITY(-16),2)	-0.011425	0.069632	-0.164082	0.8697
D(LSE_LN_EQUITY(-17),2)	0.016687	0.066187	0.252115	0.8010
D(LSE_LN_EQUITY(-18),2)	0.000194	0.062601	0.003095	0.9975
D(LSE_LN_EQUITY(-19),2)	-0.039093	0.058791	-0.664947	0.5061
D(LSE_LN_EQUITY(-20),2)	-0.018522	0.054733	-0.338404	0.7351
D(LSE_LN_EQUITY(-21),2)	-0.016650	0.050310	-0.330940	0.7407
D(LSE_LN_EQUITY(-22),2)	0.054341	0.045674	1.189751	0.2343
D(LSE_LN_EQUITY(-23),2)	0.032183	0.040827	0.788269	0.4306
D(LSE_LN_EQUITY(-24),2)	0.019067	0.035881	0.531402	0.5952
D(LSE_LN_EQUITY(-25),2)	0.010207	0.029473	0.346336	0.7291
D(LSE_LN_EQUITY(-26),2)	0.068994	0.020392	3.383461	0.0007
C	0.736286	0.574583	1.281427	0.2002

R-squared	0.526229	Mean dependent var	0.008825
Adjusted R-squared	0.521302	S.D. dependent var	42.13217
S.E. of regression	29.15042	Akaike info criterion	9.593429
Sum squared resid	2205943.	Schwarz criterion	9.656092
Log likelihood	-12558.58	Hannan-Quinn criter.	9.616123
F-statistic	106.7941	Durbin-Watson stat	2.000297
Prob(F-statistic)	0.000000		

Null Hypothesis: D(MCRO_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-37.57804	0.0000
Test critical values:	1% level	-3.432626	
	5% level	-2.862431	
	10% level	-2.567289	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(MCRO_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:22
Sample (adjusted): 1/06/2006 6/30/2016
Included observations: 2649 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(MCRO_LN_EQUITY(-1))	-1.041342	0.027711	-37.57804	0.0000
D(MCRO_LN_EQUITY(-1),2)	0.032616	0.019494	1.673131	0.0944
C	0.563820	0.305156	1.847648	0.0648

R-squared	0.503481	Mean dependent var	0.020692
Adjusted R-squared	0.503106	S.D. dependent var	22.25641
S.E. of regression	15.68870	Akaike info criterion	8.344890
Sum squared resid	651274.1	Schwarz criterion	8.351552
Log likelihood	-11049.81	Hannan-Quinn criter.	8.347302
F-statistic	1341.552	Durbin-Watson stat	1.995322
Prob(F-statistic)	0.000000		

```
Null Hypothesis: D(MDC_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=19)
==========================================================================
                                                t-Statistic      Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic          -28.51158       0.0000
--------------------------------------------------------------------------
Test critical values:        1% level            -3.438672
                             5% level            -2.865103
                             10% level           -2.568722
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(MDC_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:22
Sample (adjusted): 1/05/2006 1/13/2009
Included observations: 765 after adjustments
==========================================================================
       Variable          Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
 D(MDC_LN_EQUITY(-1))     -1.031812     0.036189      -28.51158     0.0000
           C               0.700905     0.801976       0.873973     0.3824
==========================================================================
R-squared                  0.515835   Mean dependent var          0.014379
Adjusted R-squared         0.515201   S.D. dependent var          31.84308
S.E. of regression         22.17155   Akaike info criterion       9.038108
Sum squared resid          375073.7   Schwarz criterion           9.050238
Log likelihood            -3455.076   Hannan-Quinn criter.        9.042778
F-statistic                812.9102   Durbin-Watson stat          1.997635
Prob(F-statistic)          0.000000
==========================================================================
```

```
Null Hypothesis: D(MERL_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=19)
==========================================================================
                                                t-Statistic      Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic          -11.30131       0.0000
--------------------------------------------------------------------------
Test critical values:        1% level            -3.440029
                             5% level            -2.865702
                             10% level           -2.569044
==========================================================================
*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(MERL_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:23
Sample (adjusted): 1/13/2006 8/21/2008
Included observations: 660 after adjustments
==============================================================================
        Variable             Coefficient    Std. Error    t-Statistic    Prob.
==============================================================================
 D(MERL_LN_EQUITY(-1))        -1.218929      0.107857     -11.30131     0.0000
D(MERL_LN_EQUITY(-1),2)        0.220607      0.098931      2.229900     0.0261
D(MERL_LN_EQUITY(-2),2)        0.167965      0.089190      1.883235     0.0601
D(MERL_LN_EQUITY(-3),2)        0.194371      0.079569      2.442782     0.0148
D(MERL_LN_EQUITY(-4),2)        0.156907      0.069257      2.265580     0.0238
D(MERL_LN_EQUITY(-5),2)        0.111152      0.055698      1.995621     0.0464
D(MERL_LN_EQUITY(-6),2)        0.110579      0.038735      2.854763     0.0044
           C                   0.174319      0.212493      0.820348     0.4123
==============================================================================
R-squared                      0.508191   Mean dependent var         0.016667
Adjusted R-squared             0.502911   S.D. dependent var         7.727055
S.E. of regression             5.447924   Akaike info criterion      6.240393
Sum squared resid              19351.28   Schwarz criterion          6.294845
Log likelihood                -2051.330   Hannan-Quinn criter.       6.261499
F-statistic                    96.24553   Durbin-Watson stat         1.984382
Prob(F-statistic)              0.000000
==============================================================================
```

Null Hypothesis: D(MKS_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)
==============================================================================
                                                  t-Statistic      Prob.*
==============================================================================
Augmented Dickey-Fuller test statistic            -50.48919       0.0001
Test critical values:        1% level             -3.432625
                             5% level             -2.862431
                             10% level            -2.567289
==============================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(MKS_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:23
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments
==============================================================================
        Variable             Coefficient    Std. Error    t-Statistic    Prob.
==============================================================================
  D(MKS_LN_EQUITY(-1))        -0.980979      0.019429     -50.48919     0.0000
           C                  -0.066930      0.150433     -0.444915     0.6564
==============================================================================
R-squared                      0.490491   Mean dependent var        -7.55E-05
Adjusted R-squared             0.490298   S.D. dependent var         10.84656
S.E. of regression             7.743727   Akaike info criterion      6.932398
Sum squared resid              158788.2   Schwarz criterion          6.936837
Log likelihood                -9183.427   Hannan-Quinn criter.       6.934005
F-statistic                    2549.159   Durbin-Watson stat         1.999427
Prob(F-statistic)              0.000000
==============================================================================
```

Null Hypothesis: D(MNDI_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 26 (Automatic - based on AIC, maxlag=26)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.312048	0.0000
Test critical values:	1% level	-3.433064	
	5% level	-2.862625	
	10% level	-2.567393	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(MNDI_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:23
Sample (adjusted): 2/10/2006 1/02/2015
Included observations: 2247 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(MNDI_LN_EQUITY(-1))	-1.062009	0.114047	-9.312048	0.0000
D(MNDI_LN_EQUITY(-1),2)	0.080327	0.111976	0.717356	0.4732
D(MNDI_LN_EQUITY(-2),2)	0.059362	0.109884	0.540227	0.5891
D(MNDI_LN_EQUITY(-3),2)	0.088776	0.107618	0.824917	0.4095
D(MNDI_LN_EQUITY(-4),2)	0.082580	0.105576	0.782183	0.4342
D(MNDI_LN_EQUITY(-5),2)	0.060956	0.103380	0.589630	0.5555
D(MNDI_LN_EQUITY(-6),2)	0.022786	0.101089	0.225402	0.8217
D(MNDI_LN_EQUITY(-7),2)	0.052678	0.098704	0.533695	0.5936
D(MNDI_LN_EQUITY(-8),2)	0.085781	0.096127	0.892365	0.3723
D(MNDI_LN_EQUITY(-9),2)	0.082870	0.093567	0.885672	0.3759
D(MNDI_LN_EQUITY(-10),2)	0.051266	0.090694	0.565260	0.5720
D(MNDI_LN_EQUITY(-11),2)	0.031178	0.087403	0.356719	0.7213
D(MNDI_LN_EQUITY(-12),2)	0.033280	0.083856	0.396867	0.6915
D(MNDI_LN_EQUITY(-13),2)	-0.005762	0.080496	-0.071575	0.9429
D(MNDI_LN_EQUITY(-14),2)	-0.050771	0.077201	-0.657653	0.5108
D(MNDI_LN_EQUITY(-15),2)	-0.108209	0.073966	-1.462950	0.1436
D(MNDI_LN_EQUITY(-16),2)	-0.085865	0.070564	-1.216842	0.2238
D(MNDI_LN_EQUITY(-17),2)	-0.028737	0.067163	-0.427874	0.6688
D(MNDI_LN_EQUITY(-18),2)	0.023322	0.063801	0.365549	0.7147
D(MNDI_LN_EQUITY(-19),2)	0.012603	0.060304	0.208991	0.8345
D(MNDI_LN_EQUITY(-20),2)	0.040162	0.056374	0.712425	0.4763
D(MNDI_LN_EQUITY(-21),2)	0.044616	0.051945	0.858917	0.3905
D(MNDI_LN_EQUITY(-22),2)	0.053506	0.047471	1.127135	0.2598
D(MNDI_LN_EQUITY(-23),2)	0.074762	0.042677	1.751835	0.0799
D(MNDI_LN_EQUITY(-24),2)	0.008760	0.037281	0.234973	0.8143
D(MNDI_LN_EQUITY(-25),2)	0.044976	0.030327	1.483022	0.1382
D(MNDI_LN_EQUITY(-26),2)	0.045915	0.021542	2.131404	0.0332
C	0.431807	0.311470	1.386352	0.1658

R-squared	0.502796	Mean dependent var	0.018580
Adjusted R-squared	0.496746	S.D. dependent var	20.60647
S.E. of regression	14.61831	Akaike info criterion	8.214809
Sum squared resid	474189.1	Schwarz criterion	8.286054
Log likelihood	-9201.338	Hannan-Quinn criter.	8.240815
F-statistic	83.10947	Durbin-Watson stat	1.995705
Prob(F-statistic)	0.000000		

Null Hypothesis: D(MRW_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-32.04951	0.0000
Test critical values:	1% level	-3.432627	
	5% level	-2.862432	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(MRW_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:23
Sample (adjusted): 1/09/2006 6/30/2016
Included observations: 2648 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(MRW_LN_EQUITY(-1))	-1.121234	0.034984	-32.04951	0.0000
D(MRW_LN_EQUITY(-1),2)	0.066087	0.028256	2.338911	0.0194
D(MRW_LN_EQUITY(-2),2)	0.054839	0.019431	2.822177	0.0048
C	-0.004005	0.075866	-0.052787	0.9579

R-squared	0.528445	Mean dependent var	0.001265
Adjusted R-squared	0.527910	S.D. dependent var	5.681883
S.E. of regression	3.903954	Akaike info criterion	5.563366
Sum squared resid	40296.82	Schwarz criterion	5.572251
Log likelihood	-7361.897	Hannan-Quinn criter.	5.566582
F-statistic	987.6609	Durbin-Watson stat	1.998603
Prob(F-statistic)	0.000000		

Null Hypothesis: D(NG__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 9 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.58599	0.0000
Test critical values:	1% level	-3.432633	
	5% level	-2.862435	
	10% level	-2.567291	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(NG__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:24
Sample (adjusted): 1/18/2006 6/30/2016
Included observations: 2641 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(NG__LN_EQUITY(-1))	-1.266655	0.072026	-17.58599	0.0000
D(NG__LN_EQUITY(-1),2)	0.225061	0.068056	3.306996	0.0010
D(NG__LN_EQUITY(-2),2)	0.161577	0.063749	2.534570	0.0113
D(NG__LN_EQUITY(-3),2)	0.124411	0.058847	2.114149	0.0346
D(NG__LN_EQUITY(-4),2)	0.141148	0.053775	2.624807	0.0087
D(NG__LN_EQUITY(-5),2)	0.113306	0.048520	2.335221	0.0196
D(NG__LN_EQUITY(-6),2)	0.082297	0.042914	1.917718	0.0553
D(NG__LN_EQUITY(-7),2)	0.048301	0.036240	1.332795	0.1827
D(NG__LN_EQUITY(-8),2)	0.066648	0.028624	2.328420	0.0200
D(NG__LN_EQUITY(-9),2)	0.050478	0.019679	2.565095	0.0104
C	0.273388	0.171988	1.589575	0.1121

R-squared	0.522369	Mean dependent var	0.011039
Adjusted R-squared	0.520553	S.D. dependent var	12.72655
S.E. of regression	8.812130	Akaike info criterion	7.194292
Sum squared resid	204229.0	Schwarz criterion	7.218778
Log likelihood	-9489.062	Hannan-Quinn criter.	7.203157
F-statistic	287.6348	Durbin-Watson stat	1.991191
Prob(F-statistic)	0.000000		

Null Hypothesis: D(NXT_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-28.12709	0.0000
Test critical values:	1% level	-3.432628	
	5% level	-2.862432	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(NXT_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:24
Sample (adjusted): 1/10/2006 6/30/2016
Included observations: 2647 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(NXT_LN_EQUITY(-1))	-1.151692	0.040946	-28.12709	0.0000
D(NXT_LN_EQUITY(-1),2)	0.127373	0.035080	3.630898	0.0003
D(NXT_LN_EQUITY(-2),2)	0.062746	0.028020	2.239319	0.0252
D(NXT_LN_EQUITY(-3),2)	0.057287	0.019787	2.895238	0.0038
C	1.412085	1.146355	1.231804	0.2181

R-squared	0.514603	Mean dependent var	0.017000
Adjusted R-squared	0.513868	S.D. dependent var	84.51691

S.E. of regression	58.92784	Akaike info criterion	10.99239
Sum squared resid	9174319.	Schwarz criterion	11.00350
Log likelihood	-14543.43	Hannan-Quinn criter.	10.99641
F-statistic	700.2428	Durbin-Watson stat	1.998366
Prob(F-statistic)	0.000000		

Null Hypothesis: D(OML_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-53.71795	0.0001
Test critical values:	1% level	-3.432625	
	5% level	-2.862431	
	10% level	-2.567289	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(OML_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:26
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(OML_LN_EQUITY(-1))	-1.043727	0.019430	-53.71795	0.0000
C	0.002526	0.067002	0.037705	0.9699

R-squared	0.521470	Mean dependent var	0.001547
Adjusted R-squared	0.521290	S.D. dependent var	4.985070
S.E. of regression	3.449115	Akaike info criterion	5.314867
Sum squared resid	31501.65	Schwarz criterion	5.319306
Log likelihood	-7040.199	Hannan-Quinn criter.	5.316474
F-statistic	2885.619	Durbin-Watson stat	1.999647
Prob(F-statistic)	0.000000		

Null Hypothesis: D(PFG_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 26 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.152278	0.0000
Test critical values:	1% level	-3.432649	
	5% level	-2.862442	
	10% level	-2.567295	

*MacKinnon (1996) one-sided p-values.

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PFG_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:26
Sample (adjusted): 2/10/2006 6/30/2016
Included observations: 2624 after adjustments
=========================================================================
         Variable            Coefficient   Std. Error   t-Statistic   Prob.
=========================================================================
   D(PFG_LN_EQUITY(-1))       -1.062098     0.116047     -9.152278    0.0000
  D(PFG_LN_EQUITY(-1),2)       0.110618     0.114416      0.966798    0.3337
  D(PFG_LN_EQUITY(-2),2)       0.065676     0.112580      0.583373    0.5597
  D(PFG_LN_EQUITY(-3),2)       0.101320     0.110711      0.915177    0.3602
  D(PFG_LN_EQUITY(-4),2)       0.024096     0.108515      0.222054    0.8243
  D(PFG_LN_EQUITY(-5),2)      -0.061552     0.106112     -0.580068    0.5619
  D(PFG_LN_EQUITY(-6),2)      -0.083331     0.103275     -0.806882    0.4198
  D(PFG_LN_EQUITY(-7),2)      -0.063771     0.100537     -0.634301    0.5259
  D(PFG_LN_EQUITY(-8),2)      -0.049112     0.097903     -0.501637    0.6160
  D(PFG_LN_EQUITY(-9),2)      -0.048179     0.095438     -0.504824    0.6137
 D(PFG_LN_EQUITY(-10),2)      -0.020352     0.092905     -0.219063    0.8266
 D(PFG_LN_EQUITY(-11),2)      -0.037109     0.090204     -0.411394    0.6808
 D(PFG_LN_EQUITY(-12),2)      -0.035075     0.087367     -0.401465    0.6881
 D(PFG_LN_EQUITY(-13),2)      -0.007936     0.084271     -0.094177    0.9250
 D(PFG_LN_EQUITY(-14),2)      -0.024204     0.081062     -0.298591    0.7653
 D(PFG_LN_EQUITY(-15),2)      -0.007157     0.077510     -0.092332    0.9264
 D(PFG_LN_EQUITY(-16),2)       0.013234     0.073809      0.179294    0.8577
 D(PFG_LN_EQUITY(-17),2)       0.043154     0.070104      0.615565    0.5382
 D(PFG_LN_EQUITY(-18),2)       0.050959     0.066171      0.770108    0.4413
 D(PFG_LN_EQUITY(-19),2)       0.002113     0.062190      0.033970    0.9729
 D(PFG_LN_EQUITY(-20),2)      -0.020760     0.057858     -0.358806    0.7198
 D(PFG_LN_EQUITY(-21),2)      -0.037350     0.052949     -0.705400    0.4806
 D(PFG_LN_EQUITY(-22),2)       0.025338     0.047776      0.530363    0.5959
 D(PFG_LN_EQUITY(-23),2)      -0.027664     0.042577     -0.649737    0.5159
 D(PFG_LN_EQUITY(-24),2)      -0.032014     0.037342     -0.857326    0.3913
 D(PFG_LN_EQUITY(-25),2)       0.023887     0.030731      0.777272    0.4371
 D(PFG_LN_EQUITY(-26),2)       0.082555     0.021739      3.797484    0.0001
            C                  0.654235     0.527837      1.239464    0.2153
=========================================================================
R-squared                      0.496968    Mean dependent var     -0.007011
Adjusted R-squared             0.491736    S.D. dependent var      37.36437
S.E. of regression             26.63803    Akaike info criterion   9.413171
Sum squared resid              1842082.    Schwarz criterion       9.475834
Log likelihood                -12322.08    Hannan-Quinn criter.    9.435864
F-statistic                    94.98919    Durbin-Watson stat      1.998481
Prob(F-statistic)              0.000000
=========================================================================
```

Null Hypothesis: D(POLY_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=22)
=====================================================================
                                              t-Statistic     Prob.*
=====================================================================
Augmented Dickey-Fuller test statistic         -33.19391     0.0000
---------------------------------------------------------------------
Test critical values:        1% level          -3.435687
                             5% level          -2.863784
                             10% level         -2.568015
=====================================================================

*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(POLY_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:27
Sample (adjusted): 1/05/2006 9/01/2010
Included observations: 1178 after adjustments
==========================================================================
         Variable           Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
D(POLY_LN_EQUITY(-1))       -0.968885     0.029189     -33.19391     0.0000
            C                0.105327     0.520391      0.202400     0.8396
==========================================================================
R-squared                    0.483720   Mean dependent var         0.028014
Adjusted R-squared           0.483281   S.D. dependent var         24.84684
S.E. of regression           17.86068   Akaike info criterion      8.604777
Sum squared resid            375148.8   Schwarz criterion          8.613388
Log likelihood              -5066.214   Hannan-Quinn criter.       8.608024
F-statistic                  1101.836   Durbin-Watson stat         1.990426
Prob(F-statistic)            0.000000
==========================================================================
```

Null Hypothesis: D(PPB_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 19 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                                  t-Statistic     Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic            -11.52985      0.0000
--------------------------------------------------------------------------
Test critical values:          1% level           -3.432643
                               5% level           -2.862439
                              10% level           -2.567293
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PPB_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:27
Sample (adjusted): 2/01/2006 6/30/2016
Included observations: 2631 after adjustments
==========================================================================
         Variable            Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
  D(PPB_LN_EQUITY(-1))       -1.102846     0.095651     -11.52985     0.0000
 D(PPB_LN_EQUITY(-1),2)       0.199681     0.092860      2.150329     0.0316
 D(PPB_LN_EQUITY(-2),2)       0.262431     0.090145      2.911211     0.0036
 D(PPB_LN_EQUITY(-3),2)       0.264254     0.087105      3.033743     0.0024
 D(PPB_LN_EQUITY(-4),2)       0.199766     0.083680      2.387263     0.0170
 D(PPB_LN_EQUITY(-5),2)       0.160421     0.080302      1.997718     0.0459
 D(PPB_LN_EQUITY(-6),2)       0.142148     0.076496      1.858244     0.0632
 D(PPB_LN_EQUITY(-7),2)       0.104540     0.072606      1.439828     0.1500
 D(PPB_LN_EQUITY(-8),2)       0.070064     0.068595      1.021422     0.3071
 D(PPB_LN_EQUITY(-9),2)       0.049926     0.064800      0.770467     0.4411
D(PPB_LN_EQUITY(-10),2)       0.006397     0.060867      0.105101     0.9163
D(PPB_LN_EQUITY(-11),2)       0.001184     0.056953      0.020781     0.9834
D(PPB_LN_EQUITY(-12),2)      -0.054117     0.052958     -1.021884     0.3069
D(PPB_LN_EQUITY(-13),2)      -0.064844     0.048921     -1.325481     0.1851
D(PPB_LN_EQUITY(-14),2)      -0.089822     0.044919     -1.999666     0.0456
D(PPB_LN_EQUITY(-15),2)      -0.064601     0.040734     -1.585920     0.1129
D(PPB_LN_EQUITY(-16),2)      -0.108688     0.036343     -2.990606     0.0028
```

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D(PPB_LN_EQUITY(-17),2)    -0.100540     0.032152    -3.127067     0.0018
D(PPB_LN_EQUITY(-18),2)    -0.043608     0.027110    -1.608570     0.1078
D(PPB_LN_EQUITY(-19),2)    -0.065624     0.020142    -3.258076     0.0011
           C                2.991241     1.513305     1.976627     0.0482
==========================================================================
R-squared                   0.460946    Mean dependent var        -0.018184
Adjusted R-squared          0.456815    S.D. dependent var         103.3728
S.E. of regression          76.18689    Akaike info criterion      11.51221
Sum squared resid           15149593    Schwarz criterion          11.55910
Log likelihood             -15123.31    Hannan-Quinn criter.       11.52919
F-statistic                 111.5908    Durbin-Watson stat         2.000692
Prob(F-statistic)           0.000000
==========================================================================
```

Null Hypothesis: D(PRU_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                                 t-Statistic    Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic            -25.37841     0.0000
--------------------------------------------------------------------------
Test critical values:          1% level           -3.432629
                               5% level           -2.862433
                              10% level           -2.567290
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PRU_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:28
Sample (adjusted): 1/11/2006 6/30/2016
Included observations: 2646 after adjustments
==========================================================================
        Variable           Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
  D(PRU_LN_EQUITY(-1))      -1.185266     0.046704     -25.37841     0.0000
D(PRU_LN_EQUITY(-1),2)       0.161224     0.041334      3.900473     0.0001
D(PRU_LN_EQUITY(-2),2)       0.077411     0.035547      2.177679     0.0295
D(PRU_LN_EQUITY(-3),2)       0.082608     0.028531      2.895387     0.0038
D(PRU_LN_EQUITY(-4),2)       0.053108     0.019916      2.666561     0.0077
           C                 0.311015     0.352610      0.882036     0.3778
==========================================================================
R-squared                    0.516055    Mean dependent var        0.005102
Adjusted R-squared           0.515139    S.D. dependent var        26.03406
S.E. of regression           18.12803    Akaike info criterion     8.635061
Sum squared resid            867571.6    Schwarz criterion         8.648396
Log likelihood              -11418.19    Hannan-Quinn criter.      8.639889
F-statistic                  563.0333    Durbin-Watson stat        2.000719
Prob(F-statistic)            0.000000
==========================================================================
```

```
Null Hypothesis: D(PSN_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 26 (Automatic - based on AIC, maxlag=27)
==============================================================================
                                                   t-Statistic     Prob.*
==============================================================================
Augmented Dickey-Fuller test statistic              -9.028991      0.0000
------------------------------------------------------------------------------
Test critical values:        1% level              -3.432649
                             5% level              -2.862442
                             10% level             -2.567295
==============================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PSN_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:28
Sample (adjusted): 2/10/2006 6/30/2016
Included observations: 2624 after adjustments
==============================================================================
          Variable              Coefficient   Std. Error   t-Statistic   Prob.
==============================================================================
    D(PSN_LN_EQUITY(-1))         -1.234551     0.136732    -9.028991     0.0000
   D(PSN_LN_EQUITY(-1),2)         0.302115     0.134906     2.239448     0.0252
   D(PSN_LN_EQUITY(-2),2)         0.243143     0.133010     1.828008     0.0677
   D(PSN_LN_EQUITY(-3),2)         0.226500     0.130978     1.729300     0.0839
   D(PSN_LN_EQUITY(-4),2)         0.135709     0.128754     1.054021     0.2920
   D(PSN_LN_EQUITY(-5),2)         0.065164     0.125734     0.518267     0.6043
   D(PSN_LN_EQUITY(-6),2)         0.071545     0.122555     0.583781     0.5594
   D(PSN_LN_EQUITY(-7),2)         0.054464     0.119384     0.456212     0.6483
   D(PSN_LN_EQUITY(-8),2)         0.043948     0.115853     0.379340     0.7045
   D(PSN_LN_EQUITY(-9),2)         0.011826     0.112299     0.105305     0.9161
  D(PSN_LN_EQUITY(-10),2)         0.021003     0.108607     0.193390     0.8467
  D(PSN_LN_EQUITY(-11),2)        -0.000561     0.104527    -0.005363     0.9957
  D(PSN_LN_EQUITY(-12),2)        -0.063694     0.100470    -0.633954     0.5262
  D(PSN_LN_EQUITY(-13),2)        -0.043330     0.096277    -0.450055     0.6527
  D(PSN_LN_EQUITY(-14),2)        -0.030791     0.091841    -0.335264     0.7375
  D(PSN_LN_EQUITY(-15),2)        -0.033045     0.086981    -0.379909     0.7040
  D(PSN_LN_EQUITY(-16),2)        -0.080020     0.082243    -0.972961     0.3307
  D(PSN_LN_EQUITY(-17),2)        -0.019469     0.077465    -0.251324     0.8016
  D(PSN_LN_EQUITY(-18),2)         0.010988     0.072496     0.151569     0.8795
  D(PSN_LN_EQUITY(-19),2)         0.014466     0.067588     0.214036     0.8305
  D(PSN_LN_EQUITY(-20),2)         0.054864     0.062604     0.876368     0.3809
  D(PSN_LN_EQUITY(-21),2)         0.054421     0.057449     0.947305     0.3436
  D(PSN_LN_EQUITY(-22),2)         0.054446     0.051728     1.052544     0.2926
  D(PSN_LN_EQUITY(-23),2)         0.050325     0.045602     1.103585     0.2699
  D(PSN_LN_EQUITY(-24),2)        -0.002902     0.039414    -0.073631     0.9413
  D(PSN_LN_EQUITY(-25),2)         0.036630     0.031884     1.148824     0.2507
  D(PSN_LN_EQUITY(-26),2)         0.102024     0.022488     4.536844     0.0000
             C                    0.059815     0.481087     0.124332     0.9011
==============================================================================
R-squared                   0.489808    Mean dependent var        -0.012957
Adjusted R-squared          0.484501    S.D. dependent var         34.21440
S.E. of regression          24.56534    Akaike info criterion      9.251164
Sum squared resid           1566572.    Schwarz criterion          9.313827
Log likelihood             -12109.53    Hannan-Quinn criter.       9.273857
F-statistic                 92.30650    Durbin-Watson stat         1.996946
Prob(F-statistic)           0.000000
==============================================================================
```

```
Null Hypothesis: D(PSON_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)
===========================================================================
                                                  t-Statistic     Prob.*
===========================================================================
Augmented Dickey-Fuller test statistic            -51.47686      0.0001
---------------------------------------------------------------------------
Test critical values:          1% level           -3.432625
                               5% level           -2.862431
                               10% level          -2.567289
===========================================================================

*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PSON_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:28
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments
===========================================================================
       Variable            Coefficient    Std. Error    t-Statistic    Prob.
===========================================================================
 D(PSON_LN_EQUITY(-1))      -1.000373      0.019433     -51.47686     0.0000
           C                 0.101358      0.286650      0.353596     0.7237
===========================================================================
R-squared                    0.500176    Mean dependent var          0.000377
Adjusted R-squared           0.499987    S.D. dependent var          20.86770
S.E. of regression           14.75587    Akaike info criterion       8.221914
Sum squared resid            576564.5    Schwarz criterion           8.226353
Log likelihood              -10892.04    Hannan-Quinn criter.        8.223521
F-statistic                  2649.867    Durbin-Watson stat          1.999438
Prob(F-statistic)            0.000000
===========================================================================


Null Hypothesis: D(RB__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 11 (Automatic - based on AIC, maxlag=27)
===========================================================================
                                                  t-Statistic     Prob.*
===========================================================================
Augmented Dickey-Fuller test statistic            -16.24534      0.0000
---------------------------------------------------------------------------
Test critical values:          1% level           -3.432635
                               5% level           -2.862435
                               10% level          -2.567292
===========================================================================

*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RB__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:29
Sample (adjusted): 1/20/2006 6/30/2016
Included observations: 2639 after adjustments
===========================================================================
       Variable            Coefficient    Std. Error    t-Statistic    Prob.
===========================================================================
  D(RB__LN_EQUITY(-1))      -1.339370      0.082446     -16.24534     0.0000
 D(RB__LN_EQUITY(-1),2)      0.259454      0.078634      3.299523     0.0010
 D(RB__LN_EQUITY(-2),2)      0.196571      0.074461      2.639911     0.0083
```

D(RB__LN_EQUITY(-3),2)	0.191251	0.069810	2.739605	0.0062
D(RB__LN_EQUITY(-4),2)	0.186289	0.064957	2.867873	0.0042
D(RB__LN_EQUITY(-5),2)	0.182394	0.059874	3.046301	0.0023
D(RB__LN_EQUITY(-6),2)	0.172669	0.055015	3.138560	0.0017
D(RB__LN_EQUITY(-7),2)	0.099437	0.049794	1.996950	0.0459
D(RB__LN_EQUITY(-8),2)	0.084002	0.043937	1.911885	0.0560
D(RB__LN_EQUITY(-9),2)	0.059122	0.037235	1.587808	0.1125
D(RB__LN_EQUITY(-10),2)	0.072878	0.029254	2.491217	0.0128
D(RB__LN_EQUITY(-11),2)	0.055350	0.019740	2.803961	0.0051
C	2.806179	0.964894	2.908277	0.0037

R-squared	0.540727	Mean dependent var	0.075536
Adjusted R-squared	0.538628	S.D. dependent var	72.01318
S.E. of regression	48.91449	Akaike info criterion	10.62294
Sum squared resid	6283039.	Schwarz criterion	10.65189
Log likelihood	-14003.97	Hannan-Quinn criter.	10.63342
F-statistic	257.6443	Durbin-Watson stat	1.993539
Prob(F-statistic)	0.000000		

Null Hypothesis: D(RBS_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 18 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.05061	0.0000
Test critical values:	1% level	-3.432642	
	5% level	-2.862438	
	10% level	-2.567293	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RBS_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:29
Sample (adjusted): 1/31/2006 6/30/2016
Included observations: 2632 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RBS_LN_EQUITY(-1))	-1.014979	0.091848	-11.05061	0.0000
D(RBS_LN_EQUITY(-1),2)	0.092576	0.089486	1.034528	0.3010
D(RBS_LN_EQUITY(-2),2)	0.008289	0.086805	0.095495	0.9239
D(RBS_LN_EQUITY(-3),2)	0.034979	0.083966	0.416586	0.6770
D(RBS_LN_EQUITY(-4),2)	-0.015731	0.080978	-0.194265	0.8460
D(RBS_LN_EQUITY(-5),2)	-0.029062	0.077811	-0.373501	0.7088
D(RBS_LN_EQUITY(-6),2)	-0.079768	0.074701	-1.067837	0.2857
D(RBS_LN_EQUITY(-7),2)	-0.086687	0.071072	-1.219698	0.2227
D(RBS_LN_EQUITY(-8),2)	-0.116886	0.067722	-1.725955	0.0845
D(RBS_LN_EQUITY(-9),2)	-0.096870	0.064118	-1.510804	0.1310
D(RBS_LN_EQUITY(-10),2)	-0.106711	0.060351	-1.768171	0.0771
D(RBS_LN_EQUITY(-11),2)	-0.090478	0.056205	-1.609788	0.1076
D(RBS_LN_EQUITY(-12),2)	-0.164739	0.051960	-3.170487	0.0015
D(RBS_LN_EQUITY(-13),2)	-0.098942	0.047485	-2.083648	0.0373
D(RBS_LN_EQUITY(-14),2)	-0.130523	0.042927	-3.040601	0.0024
D(RBS_LN_EQUITY(-15),2)	-0.117388	0.038002	-3.088966	0.0020
D(RBS_LN_EQUITY(-16),2)	-0.108109	0.032902	-3.285843	0.0010
D(RBS_LN_EQUITY(-17),2)	-0.098253	0.026485	-3.709720	0.0002

D(RBS_LN_EQUITY(-18),2)	-0.043731	0.019480	-2.244937	0.0249
C	-1.798083	0.924516	-1.944892	0.0519

R-squared	0.479738	Mean dependent var	0.002035
Adjusted R-squared	0.475953	S.D. dependent var	64.47617
S.E. of regression	46.67500	Akaike info criterion	10.53186
Sum squared resid	5690387.	Schwarz criterion	10.57651
Log likelihood	-13839.93	Hannan-Quinn criter.	10.54803
F-statistic	126.7654	Durbin-Watson stat	1.999208
Prob(F-statistic)	0.000000		

Null Hypothesis: D(RDSA_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-15.56688	0.0000
Test critical values:	1% level	-3.432636	
	5% level	-2.862436	
	10% level	-2.567292	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RDSA_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:29
Sample (adjusted): 1/23/2006 6/30/2016
Included observations: 2638 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RDSA_LN_EQUITY(-1))	-1.163668	0.074753	-15.56688	0.0000
D(RDSA_LN_EQUITY(-1),2)	0.157732	0.071655	2.201267	0.0278
D(RDSA_LN_EQUITY(-2),2)	0.137278	0.068411	2.006679	0.0449
D(RDSA_LN_EQUITY(-3),2)	0.111147	0.065047	1.708725	0.0876
D(RDSA_LN_EQUITY(-4),2)	0.157226	0.061116	2.572565	0.0101
D(RDSA_LN_EQUITY(-5),2)	0.138006	0.057222	2.411760	0.0159
D(RDSA_LN_EQUITY(-6),2)	0.112219	0.053385	2.102086	0.0356
D(RDSA_LN_EQUITY(-7),2)	0.119087	0.049175	2.421694	0.0155
D(RDSA_LN_EQUITY(-8),2)	0.072661	0.044818	1.621242	0.1051
D(RDSA_LN_EQUITY(-9),2)	0.037593	0.040152	0.936279	0.3492
D(RDSA_LN_EQUITY(-10),2)	0.087003	0.034344	2.533237	0.0114
D(RDSA_LN_EQUITY(-11),2)	0.074142	0.027787	2.668236	0.0077
D(RDSA_LN_EQUITY(-12),2)	0.065582	0.019551	3.354398	0.0008
C	0.079902	0.565670	0.141253	0.8877

R-squared	0.510898	Mean dependent var	0.015732
Adjusted R-squared	0.508474	S.D. dependent var	41.44038
S.E. of regression	29.05339	Akaike info criterion	9.581440
Sum squared resid	2214917.	Schwarz criterion	9.612634
Log likelihood	-12623.92	Hannan-Quinn criter.	9.592734
F-statistic	210.8407	Durbin-Watson stat	2.001711
Prob(F-statistic)	0.000000		

```
Null Hypothesis: D(RDSB_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic - based on AIC, maxlag=27)
======================================================================
                                              t-Statistic    Prob.*
======================================================================
Augmented Dickey-Fuller test statistic         -15.64010     0.0000
Test critical values:         1% level          -3.432636
                              5% level          -2.862436
                              10% level         -2.567292
======================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RDSB_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:30
Sample (adjusted): 1/23/2006 6/30/2016
Included observations: 2638 after adjustments
======================================================================
         Variable            Coefficient  Std. Error  t-Statistic   Prob.
======================================================================
  D(RDSB_LN_EQUITY(-1))       -1.162772    0.074346   -15.64010    0.0000
 D(RDSB_LN_EQUITY(-1),2)       0.152887    0.071220    2.146686    0.0319
 D(RDSB_LN_EQUITY(-2),2)       0.137231    0.067979    2.018723    0.0436
 D(RDSB_LN_EQUITY(-3),2)       0.117559    0.064623    1.819160    0.0690
 D(RDSB_LN_EQUITY(-4),2)       0.156177    0.060767    2.570085    0.0102
 D(RDSB_LN_EQUITY(-5),2)       0.136174    0.056943    2.391419    0.0169
 D(RDSB_LN_EQUITY(-6),2)       0.119548    0.053190    2.247589    0.0247
 D(RDSB_LN_EQUITY(-7),2)       0.129175    0.049063    2.632860    0.0085
 D(RDSB_LN_EQUITY(-8),2)       0.082102    0.044721    1.835878    0.0665
 D(RDSB_LN_EQUITY(-9),2)       0.049015    0.040070    1.223225    0.2214
D(RDSB_LN_EQUITY(-10),2)       0.089440    0.034370    2.602271    0.0093
D(RDSB_LN_EQUITY(-11),2)       0.076744    0.027846    2.756057    0.0059
D(RDSB_LN_EQUITY(-12),2)       0.062437    0.019568    3.190728    0.0014
            C                  0.047691    0.592060    0.080551    0.9358
======================================================================
R-squared                      0.511170    Mean dependent var     0.015353
Adjusted R-squared             0.508749    S.D. dependent var     43.38547
S.E. of regression             30.40859    Akaike info criterion  9.672620
Sum squared resid              2426366.    Schwarz criterion      9.703814
Log likelihood                -12744.19    Hannan-Quinn criter.   9.683914
F-statistic                    211.0710    Durbin-Watson stat     2.001636
Prob(F-statistic)              0.000000
======================================================================
```

```
Null Hypothesis: D(REL_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=27)
======================================================================
                                              t-Statistic    Prob.*
======================================================================
Augmented Dickey-Fuller test statistic         -21.64351     0.0000
Test critical values:         1% level          -3.432630
                              5% level          -2.862433
                              10% level         -2.567290
======================================================================
*MacKinnon (1996) one-sided p-values.
```

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(REL_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:30
Sample (adjusted): 1/12/2006 6/30/2016
Included observations: 2645 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(REL_LN_EQUITY(-1))	-1.096367	0.050656	-21.64351	0.0000
D(REL_LN_EQUITY(-1),2)	0.061932	0.046128	1.342609	0.1795
D(REL_LN_EQUITY(-2),2)	0.024860	0.041361	0.601038	0.5479
D(REL_LN_EQUITY(-3),2)	0.030071	0.035458	0.848096	0.3965
D(REL_LN_EQUITY(-4),2)	0.075425	0.028376	2.658091	0.0079
D(REL_LN_EQUITY(-5),2)	0.029213	0.019637	1.487628	0.1370
C	0.303716	0.196970	1.541937	0.1232

R-squared	0.519565	Mean dependent var	0.005958
Adjusted R-squared	0.518472	S.D. dependent var	14.56944
S.E. of regression	10.11006	Akaike info criterion	7.467581
Sum squared resid	269638.5	Schwarz criterion	7.483144
Log likelihood	-9868.876	Hannan-Quinn criter.	7.473215
F-statistic	475.4764	Durbin-Watson stat	1.996669
Prob(F-statistic)	0.000000		

Null Hypothesis: D(RIO_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-37.38712	0.0000
Test critical values:	1% level	-3.432626	
	5% level	-2.862431	
	10% level	-2.567289	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RIO_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:30
Sample (adjusted): 1/06/2006 6/30/2016
Included observations: 2649 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RIO_LN_EQUITY(-1))	-1.020585	0.027298	-37.38712	0.0000
D(RIO_LN_EQUITY(-1),2)	0.034720	0.019434	1.786566	0.0741
C	0.038101	1.616845	0.023565	0.9812

R-squared	0.493735	Mean dependent var	0.050462
Adjusted R-squared	0.493353	S.D. dependent var	116.9113
S.E. of regression	83.21646	Akaike info criterion	11.68190
Sum squared resid	18323493	Schwarz criterion	11.68856
Log likelihood	-15469.68	Hannan-Quinn criter.	11.68431
F-statistic	1290.258	Durbin-Watson stat	2.000426
Prob(F-statistic)	0.000000		

Null Hypothesis: D(RMG_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=19)
===============================================================================
                                                    t-Statistic     Prob.*
===============================================================================
Augmented Dickey-Fuller test statistic              -20.42437      0.0000
-------------------------------------------------------------------------------
Test critical values:           1% level            -3.439668
                                5% level            -2.865542
                                10% level           -2.568958
===============================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RMG_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:30
Sample (adjusted): 1/06/2006 9/19/2008
Included observations: 685 after adjustments
===============================================================================
        Variable            Coefficient   Std. Error   t-Statistic     Prob.
===============================================================================
 D(RMG_LN_EQUITY(-1))        -1.000537     0.048987    -20.42437      0.0000
D(RMG_LN_EQUITY(-1),2)        0.023132     0.033271     0.695275      0.4871
           C                  0.041566     0.318392     0.130551      0.8962
===============================================================================
R-squared                     0.491833   Mean dependent var          -0.037956
Adjusted R-squared            0.490343   S.D. dependent var           11.66893
S.E. of regression            8.330479   Akaike info criterion        7.082089
Sum squared resid             47328.67   Schwarz criterion            7.101926
Log likelihood               -2422.615   Hannan-Quinn criter.         7.089765
F-statistic                   330.0392   Durbin-Watson stat           2.005491
Prob(F-statistic)             0.000000
===============================================================================
```

Null Hypothesis: D(RR__LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)
===============================================================================
                                                    t-Statistic     Prob.*
===============================================================================
Augmented Dickey-Fuller test statistic              -51.54656      0.0001
-------------------------------------------------------------------------------
Test critical values:           1% level            -3.432625
                                5% level            -2.862431
                                10% level           -2.567289
===============================================================================
*MacKinnon (1996) one-sided p-values.
```

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RR__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:31
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RR__LN_EQUITY(-1))	-1.001706	0.019433	-51.54656	0.0000
C	0.102061	0.243363	0.419376	0.6750

R-squared	0.500853	Mean dependent var	0.000000
Adjusted R-squared	0.500664	S.D. dependent var	17.72827
S.E. of regression	12.52745	Akaike info criterion	7.894475
Sum squared resid	415568.9	Schwarz criterion	7.898915
Log likelihood	-10458.18	Hannan-Quinn criter.	7.896082
F-statistic	2657.048	Durbin-Watson stat	1.999856
Prob(F-statistic)	0.000000		

Null Hypothesis: D(RRS_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 22 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.35183	0.0000
Test critical values:	1% level	-3.432646	
	5% level	-2.862440	
	10% level	-2.567294	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RRS_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:31
Sample (adjusted): 2/06/2006 6/30/2016
Included observations: 2628 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RRS_LN_EQUITY(-1))	-0.991375	0.095768	-10.35183	0.0000
D(RRS_LN_EQUITY(-1),2)	-0.031702	0.093831	-0.337867	0.7355
D(RRS_LN_EQUITY(-2),2)	-0.055710	0.091886	-0.606294	0.5444
D(RRS_LN_EQUITY(-3),2)	-0.033317	0.090127	-0.369671	0.7117
D(RRS_LN_EQUITY(-4),2)	-0.017605	0.087941	-0.200189	0.8413
D(RRS_LN_EQUITY(-5),2)	-0.006324	0.085469	-0.073989	0.9410
D(RRS_LN_EQUITY(-6),2)	0.007446	0.083090	0.089609	0.9286
D(RRS_LN_EQUITY(-7),2)	0.038430	0.080735	0.476005	0.6341
D(RRS_LN_EQUITY(-8),2)	0.036307	0.078098	0.464891	0.6420
D(RRS_LN_EQUITY(-9),2)	0.052943	0.075656	0.699779	0.4841
D(RRS_LN_EQUITY(-10),2)	0.052447	0.073013	0.718327	0.4726
D(RRS_LN_EQUITY(-11),2)	0.039738	0.070400	0.564457	0.5725
D(RRS_LN_EQUITY(-12),2)	0.054172	0.067620	0.801124	0.4231
D(RRS_LN_EQUITY(-13),2)	0.027580	0.064857	0.425238	0.6707
D(RRS_LN_EQUITY(-14),2)	0.064992	0.061951	1.049077	0.2942
D(RRS_LN_EQUITY(-15),2)	0.028105	0.058771	0.478205	0.6325
D(RRS_LN_EQUITY(-16),2)	0.085509	0.055351	1.544840	0.1225

D(RRS_LN_EQUITY(-17),2)	0.068780	0.051454	1.336724	0.1814
D(RRS_LN_EQUITY(-18),2)	0.038373	0.047126	0.814267	0.4156
D(RRS_LN_EQUITY(-19),2)	0.059843	0.042138	1.420145	0.1557
D(RRS_LN_EQUITY(-20),2)	0.104106	0.036299	2.868008	0.0042
D(RRS_LN_EQUITY(-21),2)	0.054004	0.029233	1.847334	0.0648
D(RRS_LN_EQUITY(-22),2)	0.037626	0.020211	1.861687	0.0628
C	2.786780	2.159302	1.290593	0.1970

R-squared	0.521514	Mean dependent var	0.135464
Adjusted R-squared	0.517287	S.D. dependent var	158.5996
S.E. of regression	110.1911	Akaike info criterion	12.25140
Sum squared resid	31617946	Schwarz criterion	12.30504
Log likelihood	-16074.34	Hannan-Quinn criter.	12.27082
F-statistic	123.3984	Durbin-Watson stat	1.997970
Prob(F-statistic)	0.000000		

Null Hypothesis: D(RSA_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 22 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.91852	0.0000
Test critical values:	1% level	-3.432646	
	5% level	-2.862440	
	10% level	-2.567294	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RSA_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:31
Sample (adjusted): 2/06/2006 6/30/2016
Included observations: 2628 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RSA_LN_EQUITY(-1))	-1.354925	0.124094	-10.91852	0.0000
D(RSA_LN_EQUITY(-1),2)	0.274321	0.121154	2.264227	0.0236
D(RSA_LN_EQUITY(-2),2)	0.241714	0.117987	2.048651	0.0406
D(RSA_LN_EQUITY(-3),2)	0.161116	0.114728	1.404331	0.1603
D(RSA_LN_EQUITY(-4),2)	0.167636	0.111153	1.508157	0.1316
D(RSA_LN_EQUITY(-5),2)	0.110725	0.107583	1.029212	0.3035
D(RSA_LN_EQUITY(-6),2)	0.089979	0.104024	0.864990	0.3871
D(RSA_LN_EQUITY(-7),2)	0.008545	0.100077	0.085382	0.9320
D(RSA_LN_EQUITY(-8),2)	0.037374	0.095652	0.390732	0.6960
D(RSA_LN_EQUITY(-9),2)	0.068719	0.091325	0.752466	0.4518
D(RSA_LN_EQUITY(-10),2)	0.086544	0.087111	0.993490	0.3206
D(RSA_LN_EQUITY(-11),2)	0.046979	0.082851	0.567031	0.5707
D(RSA_LN_EQUITY(-12),2)	-0.015338	0.078760	-0.194739	0.8456
D(RSA_LN_EQUITY(-13),2)	-0.043760	0.074712	-0.585708	0.5581
D(RSA_LN_EQUITY(-14),2)	-0.094211	0.070319	-1.339770	0.1804
D(RSA_LN_EQUITY(-15),2)	-0.143829	0.065425	-2.198377	0.0280
D(RSA_LN_EQUITY(-16),2)	-0.094122	0.059935	-1.570388	0.1164
D(RSA_LN_EQUITY(-17),2)	-0.048626	0.054622	-0.890227	0.3734
D(RSA_LN_EQUITY(-18),2)	-0.080912	0.048929	-1.653667	0.0983
D(RSA_LN_EQUITY(-19),2)	-0.105420	0.043099	-2.445979	0.0145
D(RSA_LN_EQUITY(-20),2)	-0.073543	0.036252	-2.028689	0.0426

D(RSA_LN_EQUITY(-21),2)	-0.077596	0.028909	-2.684154	0.0073
D(RSA_LN_EQUITY(-22),2)	-0.060229	0.019592	-3.074082	0.0021
C	-0.034010	0.201465	-0.168811	0.8660

R-squared	0.554479	Mean dependent var	0.009787
Adjusted R-squared	0.550544	S.D. dependent var	15.40271
S.E. of regression	10.32621	Akaike info criterion	7.516337
Sum squared resid	277665.9	Schwarz criterion	7.569981
Log likelihood	-9852.467	Hannan-Quinn criter.	7.535763
F-statistic	140.9063	Durbin-Watson stat	1.999960
Prob(F-statistic)	0.000000		

Null Hypothesis: D(SAB_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.69629	0.0000
Test critical values:	1% level	-3.432631	
	5% level	-2.862433	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SAB_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:31
Sample (adjusted): 1/13/2006 6/30/2016
Included observations: 2644 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(SAB_LN_EQUITY(-1))	-1.081527	0.054910	-19.69629	0.0000
D(SAB_LN_EQUITY(-1),2)	0.047153	0.050290	0.937621	0.3485
D(SAB_LN_EQUITY(-2),2)	0.027723	0.045552	0.608608	0.5428
D(SAB_LN_EQUITY(-3),2)	0.033919	0.040299	0.841681	0.4000
D(SAB_LN_EQUITY(-4),2)	-0.007830	0.034746	-0.225358	0.8217
D(SAB_LN_EQUITY(-5),2)	-0.012671	0.028021	-0.452186	0.6512
D(SAB_LN_EQUITY(-6),2)	-0.052619	0.019456	-2.704587	0.0069
C	1.327203	0.683425	1.941987	0.0522

R-squared	0.521031	Mean dependent var	0.015129
Adjusted R-squared	0.519759	S.D. dependent var	50.47185
S.E. of regression	34.97670	Akaike info criterion	9.950263
Sum squared resid	3224803.	Schwarz criterion	9.968054
Log likelihood	-13146.25	Hannan-Quinn criter.	9.956703
F-statistic	409.6408	Durbin-Watson stat	1.998135
Prob(F-statistic)	0.000000		

Null Hypothesis: D(SBRY_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*

Augmented Dickey-Fuller test statistic		-22.56677	0.0000
Test critical values:	1% level	-3.432629	
	5% level	-2.862433	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SBRY_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:32
Sample (adjusted): 1/11/2006 6/30/2016
Included observations: 2646 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(SBRY_LN_EQUITY(-1))	-1.028991	0.045598	-22.56677	0.0000
D(SBRY_LN_EQUITY(-1),2)	-0.019474	0.040445	-0.481491	0.6302
D(SBRY_LN_EQUITY(-2),2)	-0.010181	0.034731	-0.293144	0.7694
D(SBRY_LN_EQUITY(-3),2)	-0.037672	0.028248	-1.333629	0.1824
D(SBRY_LN_EQUITY(-4),2)	-0.053730	0.019487	-2.757218	0.0059
C	-0.035551	0.119701	-0.296999	0.7665

R-squared	0.526703	Mean dependent var	0.000472
Adjusted R-squared	0.525807	S.D. dependent var	8.940781
S.E. of regression	6.156773	Akaike info criterion	6.475247
Sum squared resid	100071.4	Schwarz criterion	6.488583
Log likelihood	-8560.752	Hannan-Quinn criter.	6.480075
F-statistic	587.5790	Durbin-Watson stat	1.998746
Prob(F-statistic)	0.000000		

Null Hypothesis: D(SDR_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-25.40589	0.0000
Test critical values:	1% level	-3.432629	
	5% level	-2.862433	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SDR_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:33
Sample (adjusted): 1/11/2006 6/30/2016
Included observations: 2646 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(SDR_LN_EQUITY(-1))	-1.150510	0.045285	-25.40589	0.0000
D(SDR_LN_EQUITY(-1),2)	0.165379	0.040214	4.112491	0.0000
D(SDR_LN_EQUITY(-2),2)	0.107877	0.034822	3.097949	0.0020
D(SDR_LN_EQUITY(-3),2)	0.091495	0.028547	3.205094	0.0014
D(SDR_LN_EQUITY(-4),2)	0.058928	0.020221	2.914197	0.0036

```
                C                   0.596350     0.672254     0.887089      0.3751
==================================================================================

R-squared                           0.494876   Mean dependent var         0.041572
Adjusted R-squared                  0.493919   S.D. dependent var         48.58033
S.E. of regression                  34.55975   Akaike info criterion      9.925521
Sum squared resid                   3153153.   Schwarz criterion          9.938857
Log likelihood                     -13125.46   Hannan-Quinn criter.       9.930349
F-statistic                         517.2869   Durbin-Watson stat         1.997110
Prob(F-statistic)                   0.000000
==================================================================================
```

Null Hypothesis: D(SGE_LN_EQUITY) has a unit root

```
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=27)
==================================================================================
                                                         t-Statistic     Prob.*
==================================================================================

Augmented Dickey-Fuller test statistic                    -20.12107      0.0000
----------------------------------------------------------------------------------
Test critical values:           1% level                  -3.432631
                                5% level                  -2.862433
                               10% level                  -2.567290
==================================================================================

*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SGE_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:33
Sample (adjusted): 1/13/2006 6/30/2016
Included observations: 2644 after adjustments
==================================================================================
           Variable               Coefficient   Std. Error   t-Statistic    Prob.
==================================================================================

   D(SGE_LN_EQUITY(-1))            -1.126674     0.055995    -20.12107      0.0000
  D(SGE_LN_EQUITY(-1),2)            0.070175     0.051773     1.355429      0.1754
  D(SGE_LN_EQUITY(-2),2)            0.066128     0.046698     1.416070      0.1569
  D(SGE_LN_EQUITY(-3),2)            0.057217     0.041560     1.376735      0.1687
  D(SGE_LN_EQUITY(-4),2)            0.020396     0.035969     0.567048      0.5707
  D(SGE_LN_EQUITY(-5),2)           -0.018326     0.029197    -0.627658      0.5303
  D(SGE_LN_EQUITY(-6),2)            0.030068     0.019982     1.504758      0.1325
                C                   0.157909     0.101033     1.562940      0.1182
==================================================================================

R-squared                           0.531357   Mean dependent var         0.004669
Adjusted R-squared                  0.530112   S.D. dependent var         7.559373
S.E. of regression                  5.181826   Akaike info criterion      6.131213
Sum squared resid                   70780.09   Schwarz criterion          6.149005
Log likelihood                     -8097.464   Hannan-Quinn criter.       6.137654
F-statistic                         426.9639   Durbin-Watson stat         1.998201
Prob(F-statistic)                   0.000000
==================================================================================
```

Null Hypothesis: D(SHP_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 26 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.32289	0.0000
Test critical values:	1% level	-3.432649	
	5% level	-2.862442	
	10% level	-2.567295	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SHP_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:33
Sample (adjusted): 2/10/2006 6/30/2016
Included observations: 2624 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(SHP_LN_EQUITY(-1))	-1.082484	0.104862	-10.32289	0.0000
D(SHP_LN_EQUITY(-1),2)	0.128180	0.102908	1.245577	0.2130
D(SHP_LN_EQUITY(-2),2)	0.099951	0.100771	0.991861	0.3214
D(SHP_LN_EQUITY(-3),2)	0.142151	0.098527	1.442761	0.1492
D(SHP_LN_EQUITY(-4),2)	0.088447	0.096498	0.916570	0.3595
D(SHP_LN_EQUITY(-5),2)	0.097203	0.094356	1.030169	0.3030
D(SHP_LN_EQUITY(-6),2)	0.157760	0.092217	1.710749	0.0872
D(SHP_LN_EQUITY(-7),2)	0.178870	0.090129	1.984591	0.0473
D(SHP_LN_EQUITY(-8),2)	0.132565	0.087977	1.506816	0.1320
D(SHP_LN_EQUITY(-9),2)	0.083310	0.085627	0.972939	0.3307
D(SHP_LN_EQUITY(-10),2)	0.053160	0.083169	0.639181	0.5228
D(SHP_LN_EQUITY(-11),2)	0.069349	0.080420	0.862341	0.3886
D(SHP_LN_EQUITY(-12),2)	0.032704	0.077372	0.422681	0.6726
D(SHP_LN_EQUITY(-13),2)	-0.004301	0.074202	-0.057968	0.9538
D(SHP_LN_EQUITY(-14),2)	-0.035017	0.071036	-0.492956	0.6221
D(SHP_LN_EQUITY(-15),2)	-0.042013	0.067903	-0.618720	0.5362
D(SHP_LN_EQUITY(-16),2)	-0.002747	0.064818	-0.042382	0.9662
D(SHP_LN_EQUITY(-17),2)	0.037330	0.061433	0.607660	0.5435
D(SHP_LN_EQUITY(-18),2)	0.038496	0.058050	0.663145	0.5073
D(SHP_LN_EQUITY(-19),2)	0.067806	0.054794	1.237472	0.2160
D(SHP_LN_EQUITY(-20),2)	0.076222	0.051657	1.475526	0.1402
D(SHP_LN_EQUITY(-21),2)	0.063481	0.048147	1.318483	0.1875
D(SHP_LN_EQUITY(-22),2)	0.049161	0.043798	1.122456	0.2618
D(SHP_LN_EQUITY(-23),2)	0.060217	0.038889	1.548409	0.1216
D(SHP_LN_EQUITY(-24),2)	0.003342	0.033930	0.098493	0.9215
D(SHP_LN_EQUITY(-25),2)	0.016725	0.027554	0.606973	0.5439
D(SHP_LN_EQUITY(-26),2)	0.056317	0.019813	2.842474	0.0045
C	1.519782	1.010003	1.504730	0.1325

R-squared	0.493897	Mean dependent var	0.061547
Adjusted R-squared	0.488633	S.D. dependent var	71.70202
S.E. of regression	51.27407	Akaike info criterion	10.72286
Sum squared resid	6824963.	Schwarz criterion	10.78552
Log likelihood	-14040.39	Hannan-Quinn criter.	10.74555
F-statistic	93.82915	Durbin-Watson stat	1.995724
Prob(F-statistic)	0.000000		

Null Hypothesis: D(SKY_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-21.75121	0.0000
Test critical values:	1% level	-3.432631	
	5% level	-2.862433	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SKY_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:33
Sample (adjusted): 1/13/2006 6/30/2016
Included observations: 2644 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(SKY_LN_EQUITY(-1))	-1.168881	0.053739	-21.75121	0.0000
D(SKY_LN_EQUITY(-1),2)	0.145662	0.049299	2.954655	0.0032
D(SKY_LN_EQUITY(-2),2)	0.128491	0.044791	2.868646	0.0042
D(SKY_LN_EQUITY(-3),2)	0.118885	0.040130	2.962504	0.0031
D(SKY_LN_EQUITY(-4),2)	0.130020	0.034654	3.751937	0.0002
D(SKY_LN_EQUITY(-5),2)	0.098101	0.028159	3.483770	0.0005
D(SKY_LN_EQUITY(-6),2)	0.058827	0.019659	2.992372	0.0028
C	0.147655	0.205843	0.717318	0.4732

R-squared	0.512983	Mean dependent var	-0.001513
Adjusted R-squared	0.511689	S.D. dependent var	15.13794
S.E. of regression	10.57828	Akaike info criterion	7.558503
Sum squared resid	294968.2	Schwarz criterion	7.576295
Log likelihood	-9984.341	Hannan-Quinn criter.	7.564944
F-statistic	396.6485	Durbin-Watson stat	1.998719
Prob(F-statistic)	0.000000		

Null Hypothesis: D(SL__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 15 (Automatic - based on AIC, maxlag=26)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.49197	0.0000
Test critical values:	1% level	-3.432766	
	5% level	-2.862493	
	10% level	-2.567322	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SL__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:34
Sample (adjusted): 1/26/2006 12/23/2015
Included observations: 2506 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(SL__LN_EQUITY(-1))	-1.314638	0.097439	-13.49197	0.0000
D(SL__LN_EQUITY(-1),2)	0.323498	0.093598	3.456258	0.0006
D(SL__LN_EQUITY(-2),2)	0.241453	0.089847	2.687378	0.0072
D(SL__LN_EQUITY(-3),2)	0.195459	0.086023	2.272168	0.0232
D(SL__LN_EQUITY(-4),2)	0.197991	0.081967	2.415482	0.0158
D(SL__LN_EQUITY(-5),2)	0.128715	0.077552	1.659718	0.0971
D(SL__LN_EQUITY(-6),2)	0.104240	0.073166	1.424714	0.1544
D(SL__LN_EQUITY(-7),2)	0.060172	0.068659	0.876391	0.3809
D(SL__LN_EQUITY(-8),2)	0.062726	0.063936	0.981078	0.3266
D(SL__LN_EQUITY(-9),2)	0.053357	0.058854	0.906593	0.3647
D(SL__LN_EQUITY(-10),2)	0.036439	0.053709	0.678440	0.4976
D(SL__LN_EQUITY(-11),2)	-0.010862	0.048241	-0.225165	0.8219
D(SL__LN_EQUITY(-12),2)	-0.000698	0.042732	-0.016328	0.9870
D(SL__LN_EQUITY(-13),2)	-0.009719	0.036193	-0.268525	0.7883
D(SL__LN_EQUITY(-14),2)	-0.040013	0.028805	-1.389085	0.1649
D(SL__LN_EQUITY(-15),2)	-0.076347	0.020310	-3.759085	0.0002
C	-0.004925	0.142969	-0.034446	0.9725

R-squared	0.507872	Mean dependent var	0.001747
Adjusted R-squared	0.504708	S.D. dependent var	10.16938
S.E. of regression	7.156903	Akaike info criterion	6.780792
Sum squared resid	127489.7	Schwarz criterion	6.820317
Log likelihood	-8479.333	Hannan-Quinn criter.	6.795140
F-statistic	160.5390	Durbin-Watson stat	1.998775
Prob(F-statistic)	0.000000		

Null Hypothesis: D(SMIN_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-38.39356	0.0000
Test critical values:	1% level	-3.432626	
	5% level	-2.862431	
	10% level	-2.567289	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SMIN_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:34
Sample (adjusted): 1/06/2006 6/30/2016
Included observations: 2649 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(SMIN_LN_EQUITY(-1))	-1.069256	0.027850	-38.39356	0.0000
D(SMIN_LN_EQUITY(-1),2)	0.043503	0.019446	2.237067	0.0254
C	-0.152380	0.418120	-0.364441	0.7156

R-squared	0.512677	Mean dependent var	0.022839
Adjusted R-squared	0.512308	S.D. dependent var	30.81349
S.E. of regression	21.51858	Akaike info criterion	8.976842
Sum squared resid	1225228.	Schwarz criterion	8.983504

```
Log likelihood              -11886.83   Hannan-Quinn criter.      8.979254
F-statistic                  1391.830   Durbin-Watson stat        1.999222
Prob(F-statistic)            0.000000
==========================================================================
```

```
Null Hypothesis: D(SN__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=27)
======================================================================
                                              t-Statistic    Prob.*
======================================================================
Augmented Dickey-Fuller test statistic         -52.81322     0.0001
----------------------------------------------------------------------
Test critical values:       1% level           -3.432625
                            5% level           -2.862431
                           10% level           -2.567289
======================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SN__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:34
Sample (adjusted): 1/05/2006 6/30/2016
Included observations: 2650 after adjustments
======================================================================
        Variable         Coefficient    Std. Error   t-Statistic   Prob.
======================================================================
 D(SN__LN_EQUITY(-1))     -1.027338      0.019452    -52.81322    0.0000
           C               0.279093      0.218543     1.277063    0.2017
======================================================================
R-squared                  0.512988   Mean dependent var      0.008302
Adjusted R-squared         0.512804   S.D. dependent var      16.11343
S.E. of regression         11.24708   Akaike info criterion   7.678848
Sum squared resid          334963.5   Schwarz criterion       7.683288
Log likelihood            -10172.47   Hannan-Quinn criter.    7.680455
F-statistic                2789.236   Durbin-Watson stat      1.997019
Prob(F-statistic)          0.000000
======================================================================
```

```
Null Hypothesis: D(SSE_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on AIC, maxlag=27)
======================================================================
                                              t-Statistic    Prob.*
======================================================================
Augmented Dickey-Fuller test statistic         -19.32170     0.0000
----------------------------------------------------------------------
Test critical values:       1% level           -3.432632
                            5% level           -2.862434
                           10% level           -2.567291
======================================================================
*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SSE_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:34
Sample (adjusted): 1/16/2006 6/30/2016
Included observations: 2643 after adjustments
==============================================================================
        Variable           Coefficient    Std. Error    t-Statistic    Prob.
==============================================================================
  D(SSE_LN_EQUITY(-1))      -1.232567      0.063792     -19.32170     0.0000
 D(SSE_LN_EQUITY(-1),2)      0.160173      0.058943      2.717405     0.0066
 D(SSE_LN_EQUITY(-2),2)      0.122058      0.053924      2.263531     0.0237
 D(SSE_LN_EQUITY(-3),2)      0.098458      0.048657      2.023490     0.0431
 D(SSE_LN_EQUITY(-4),2)      0.048362      0.042954      1.125899     0.2603
 D(SSE_LN_EQUITY(-5),2)      0.018272      0.036686      0.498047     0.6185
 D(SSE_LN_EQUITY(-6),2)     -0.009057      0.029235     -0.309799     0.7567
 D(SSE_LN_EQUITY(-7),2)     -0.043773      0.019812     -2.209385     0.0272
           C                 0.232382      0.361399      0.643007     0.5203
==============================================================================
R-squared                    0.535939    Mean dependent var          0.027053
Adjusted R-squared           0.534530    S.D. dependent var          27.21945
S.E. of regression           18.57057    Akaike info criterion       8.684433
Sum squared resid            908377.5    Schwarz criterion           8.704455
Log likelihood              -11467.48    Hannan-Quinn criter.        8.691681
F-statistic                  380.2476    Durbin-Watson stat          1.994982
Prob(F-statistic)            0.000000
==============================================================================
```

```
Null Hypothesis: D(STAN_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=27)
==============================================================================
                                                   t-Statistic     Prob.*
==============================================================================
Augmented Dickey-Fuller test statistic              -23.59927      0.0000
Test critical values:          1% level             -3.432630
                               5% level             -2.862433
                               10% level            -2.567290
==============================================================================
*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(STAN_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:35
Sample (adjusted): 1/12/2006 6/30/2016
Included observations: 2645 after adjustments
==============================================================================
        Variable           Coefficient    Std. Error    t-Statistic    Prob.
==============================================================================
  D(STAN_LN_EQUITY(-1))     -1.232920      0.052244     -23.59927     0.0000
 D(STAN_LN_EQUITY(-1),2)     0.194340      0.047229      4.114795     0.0000
 D(STAN_LN_EQUITY(-2),2)     0.128313      0.041654      3.080456     0.0021
 D(STAN_LN_EQUITY(-3),2)     0.087817      0.035282      2.489012     0.0129
 D(STAN_LN_EQUITY(-4),2)     0.073070      0.028019      2.607897     0.0092
 D(STAN_LN_EQUITY(-5),2)     0.062407      0.019433      3.211418     0.0013
           C                -0.226615      0.539014     -0.420426     0.6742
==============================================================================
R-squared                    0.521118    Mean dependent var          0.000635
Adjusted R-squared           0.520028    S.D. dependent var          40.00651
```

S.E. of regression	27.71651	Akaike info criterion	9.484576
Sum squared resid	2026524.	Schwarz criterion	9.500139
Log likelihood	-12536.35	Hannan-Quinn criter.	9.490210
F-statistic	478.4431	Durbin-Watson stat	2.001954
Prob(F-statistic)	0.000000		

Null Hypothesis: D(STJ_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 26 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.11939	0.0000
Test critical values:	1% level	-3.432649	
	5% level	-2.862442	
	10% level	-2.567295	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(STJ_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:35
Sample (adjusted): 2/10/2006 6/30/2016
Included observations: 2624 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(STJ_LN_EQUITY(-1))	-1.294833	0.127956	-10.11939	0.0000
D(STJ_LN_EQUITY(-1),2)	0.297932	0.125742	2.369389	0.0179
D(STJ_LN_EQUITY(-2),2)	0.272028	0.123531	2.202098	0.0277
D(STJ_LN_EQUITY(-3),2)	0.238739	0.121233	1.969256	0.0490
D(STJ_LN_EQUITY(-4),2)	0.186091	0.118836	1.565956	0.1175
D(STJ_LN_EQUITY(-5),2)	0.146527	0.116302	1.259880	0.2078
D(STJ_LN_EQUITY(-6),2)	0.113833	0.113402	1.003799	0.3156
D(STJ_LN_EQUITY(-7),2)	0.054908	0.110485	0.496975	0.6192
D(STJ_LN_EQUITY(-8),2)	0.056075	0.107149	0.523335	0.6008
D(STJ_LN_EQUITY(-9),2)	0.035145	0.103815	0.338534	0.7350
D(STJ_LN_EQUITY(-10),2)	0.023358	0.100429	0.232580	0.8161
D(STJ_LN_EQUITY(-11),2)	0.012349	0.097033	0.127264	0.8987
D(STJ_LN_EQUITY(-12),2)	0.001666	0.093323	0.017852	0.9858
D(STJ_LN_EQUITY(-13),2)	-0.010748	0.089496	-0.120099	0.9044
D(STJ_LN_EQUITY(-14),2)	-0.021097	0.085534	-0.246647	0.8052
D(STJ_LN_EQUITY(-15),2)	-0.029376	0.081386	-0.360945	0.7182
D(STJ_LN_EQUITY(-16),2)	-0.001356	0.077016	-0.017603	0.9860
D(STJ_LN_EQUITY(-17),2)	-0.021649	0.072469	-0.298731	0.7652
D(STJ_LN_EQUITY(-18),2)	-0.012724	0.067792	-0.187687	0.8511
D(STJ_LN_EQUITY(-19),2)	-0.025315	0.063042	-0.401553	0.6880
D(STJ_LN_EQUITY(-20),2)	0.040613	0.058017	0.700020	0.4840
D(STJ_LN_EQUITY(-21),2)	0.039943	0.053120	0.751945	0.4522
D(STJ_LN_EQUITY(-22),2)	0.087345	0.048110	1.815531	0.0696
D(STJ_LN_EQUITY(-23),2)	0.034524	0.042707	0.808379	0.4189
D(STJ_LN_EQUITY(-24),2)	0.014364	0.036785	0.390481	0.6962
D(STJ_LN_EQUITY(-25),2)	0.057891	0.030015	1.928727	0.0539
D(STJ_LN_EQUITY(-26),2)	0.057182	0.021008	2.721845	0.0065
C	0.246824	0.203778	1.211244	0.2259

R-squared	0.509798	Mean dependent var	-0.001334
Adjusted R-squared	0.504700	S.D. dependent var	14.68492

```
S.E. of regression      10.33489   Akaike info criterion     7.519541
Sum squared resid       277278.5   Schwarz criterion         7.582204
Log likelihood         -9837.638   Hannan-Quinn criter.      7.542235
F-statistic             99.99188   Durbin-Watson stat        1.999821
Prob(F-statistic)       0.000000
=====================================================================
```

```
Null Hypothesis: D(SVT_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=27)
=====================================================================
                                             t-Statistic    Prob.*
=====================================================================
Augmented Dickey-Fuller test statistic        -37.61807    0.0000
---------------------------------------------------------------------
Test critical values:        1% level         -3.432626
                             5% level         -2.862431
                            10% level         -2.567289
=====================================================================
*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SVT_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:35
Sample (adjusted): 1/06/2006 6/30/2016
Included observations: 2649 after adjustments
=====================================================================
        Variable          Coefficient  Std. Error  t-Statistic  Prob.
=====================================================================
  D(SVT_LN_EQUITY(-1))     -1.038816    0.027615    -37.61807   0.0000
 D(SVT_LN_EQUITY(-1),2)     0.036589    0.019496     1.876786   0.0607
           C                0.440648    0.429683     1.025520   0.3052
=====================================================================
R-squared               0.501157   Mean dependent var        0.032471
Adjusted R-squared      0.500780   S.D. dependent var        31.29060
S.E. of regression      22.10854   Akaike info criterion     9.030937
Sum squared resid       1293332.   Schwarz criterion         9.037598
Log likelihood         -11958.48   Hannan-Quinn criter.      9.033348
F-statistic             1329.135   Durbin-Watson stat        1.997409
Prob(F-statistic)       0.000000
=====================================================================
```

```
Null Hypothesis: D(TPK_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 10 (Automatic - based on AIC, maxlag=27)
=====================================================================
                                             t-Statistic    Prob.*
=====================================================================
Augmented Dickey-Fuller test statistic        -14.83734    0.0000
---------------------------------------------------------------------
Test critical values:        1% level         -3.432634
                             5% level         -2.862435
                            10% level         -2.567291
=====================================================================
*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TPK_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:36
Sample (adjusted): 1/19/2006 6/30/2016
Included observations: 2640 after adjustments
==========================================================================
          Variable            Coefficient   Std. Error   t-Statistic   Prob.
==========================================================================
   D(TPK_LN_EQUITY(-1))        -1.077551     0.072624    -14.83734    0.0000
  D(TPK_LN_EQUITY(-1),2)        0.111757     0.069177     1.615507    0.1063
  D(TPK_LN_EQUITY(-2),2)        0.041077     0.065398     0.628103    0.5300
  D(TPK_LN_EQUITY(-3),2)        0.033041     0.061572     0.536623    0.5916
  D(TPK_LN_EQUITY(-4),2)        0.006232     0.057103     0.109143    0.9131
  D(TPK_LN_EQUITY(-5),2)       -0.045828     0.052571    -0.871740    0.3834
  D(TPK_LN_EQUITY(-6),2)       -0.046524     0.047596    -0.977470    0.3284
  D(TPK_LN_EQUITY(-7),2)       -0.077732     0.042292    -1.837978    0.0662
  D(TPK_LN_EQUITY(-8),2)       -0.078213     0.036420    -2.147508    0.0318
  D(TPK_LN_EQUITY(-9),2)       -0.096282     0.029342    -3.281342    0.0010
 D(TPK_LN_EQUITY(-10),2)       -0.053910     0.020692    -2.605406    0.0092
             C                  0.131025     0.466253     0.281017    0.7787
==========================================================================
R-squared                       0.488957   Mean dependent var    -0.004532
Adjusted R-squared              0.486818   S.D. dependent var     33.42047
S.E. of regression              23.94132   Akaike info criterion  9.193624
Sum squared resid               1506335.   Schwarz criterion      9.220345
Log likelihood                 -12123.58   Hannan-Quinn criter.   9.203298
F-statistic                     228.5843   Durbin-Watson stat     1.996898
Prob(F-statistic)               0.000000
==========================================================================


Null Hypothesis: D(TSCO_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                                  t-Statistic    Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic             -25.45253     0.0000
--------------------------------------------------------------------------
Test critical values:          1% level            -3.432629
                               5% level            -2.862433
                              10% level            -2.567290
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TSCO_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:37
Sample (adjusted): 1/11/2006 6/30/2016
Included observations: 2646 after adjustments
==========================================================================
          Variable            Coefficient   Std. Error   t-Statistic   Prob.
==========================================================================
   D(TSCO_LN_EQUITY(-1))       -1.195341     0.046964    -25.45253    0.0000
 D(TSCO_LN_EQUITY(-1),2)        0.169947     0.041402     4.104762    0.0000
 D(TSCO_LN_EQUITY(-2),2)        0.115182     0.034877     3.302541    0.0010
 D(TSCO_LN_EQUITY(-3),2)        0.036930     0.027910     1.323175    0.1859
 D(TSCO_LN_EQUITY(-4),2)        0.040069     0.019475     2.057453    0.0397
             C                 -0.066755     0.105839    -0.630723    0.5283
==========================================================================
```

```
R-squared                0.515276   Mean dependent var       0.001398
Adjusted R-squared       0.514358   S.D. dependent var       7.809534
S.E. of regression       5.442307   Akaike info criterion    6.228548
Sum squared resid        78193.39   Schwarz criterion        6.241883
Log likelihood          -8234.369   Hannan-Quinn criter.     6.233376
F-statistic              561.2807   Durbin-Watson stat       1.998637
Prob(F-statistic)        0.000000
=====================================================================
```

```
Null Hypothesis: D(TUI_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=16)
=====================================================================
                                              t-Statistic    Prob.*
=====================================================================
Augmented Dickey-Fuller test statistic         -10.40896    0.0000
---------------------------------------------------------------------
Test critical values:        1% level          -3.447304
                             5% level          -2.868908
                            10% level          -2.570761
=====================================================================
*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TUI_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:37
Sample (adjusted): 1/11/2006 7/13/2007
Included observations: 381 after adjustments
=====================================================================
        Variable           Coefficient   Std. Error   t-Statistic   Prob.
=====================================================================
  D(TUI_LN_EQUITY(-1))      -1.273909     0.122386    -10.40896    0.0000
 D(TUI_LN_EQUITY(-1),2)      0.303408     0.107696     2.817274    0.0051
 D(TUI_LN_EQUITY(-2),2)      0.223993     0.091956     2.435871    0.0153
 D(TUI_LN_EQUITY(-3),2)      0.191386     0.075237     2.543792    0.0114
 D(TUI_LN_EQUITY(-4),2)      0.110590     0.054115     2.043621    0.0417
           C                -0.726599     1.093354    -0.664560    0.5067
=====================================================================
R-squared                0.492388   Mean dependent var       0.018373
Adjusted R-squared       0.485620   S.D. dependent var       29.70955
S.E. of regression       21.30778   Akaike info criterion    8.971644
Sum squared resid        170258.1   Schwarz criterion        9.033736
Log likelihood          -1703.098   Hannan-Quinn criter.     8.996280
F-statistic              72.75066   Durbin-Watson stat       2.012103
Prob(F-statistic)        0.000000
=====================================================================
```

```
Null Hypothesis: D(TW__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 26 (Automatic - based on AIC, maxlag=27)
=====================================================================
                                              t-Statistic    Prob.*
=====================================================================
Augmented Dickey-Fuller test statistic         -8.429695    0.0000
---------------------------------------------------------------------
Test critical values:        1% level          -3.432649
                             5% level          -2.862442
                            10% level          -2.567295
=====================================================================
*MacKinnon (1996) one-sided p-values.
```

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TW__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:37
Sample (adjusted): 2/10/2006 6/30/2016
Included observations: 2624 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(TW__LN_EQUITY(-1))	-0.809157	0.095989	-8.429695	0.0000
D(TW__LN_EQUITY(-1),2)	-0.102840	0.094930	-1.083321	0.2788
D(TW__LN_EQUITY(-2),2)	-0.127499	0.093665	-1.361227	0.1736
D(TW__LN_EQUITY(-3),2)	-0.109866	0.092412	-1.188875	0.2346
D(TW__LN_EQUITY(-4),2)	-0.162761	0.090998	-1.788623	0.0738
D(TW__LN_EQUITY(-5),2)	-0.153356	0.089332	-1.716692	0.0862
D(TW__LN_EQUITY(-6),2)	-0.194776	0.087812	-2.218102	0.0266
D(TW__LN_EQUITY(-7),2)	-0.154586	0.086150	-1.794379	0.0729
D(TW__LN_EQUITY(-8),2)	-0.169128	0.084066	-2.011855	0.0443
D(TW__LN_EQUITY(-9),2)	-0.156496	0.082029	-1.907808	0.0565
D(TW__LN_EQUITY(-10),2)	-0.157527	0.079877	-1.972114	0.0487
D(TW__LN_EQUITY(-11),2)	-0.115676	0.077407	-1.494391	0.1352
D(TW__LN_EQUITY(-12),2)	-0.126282	0.075123	-1.680992	0.0929
D(TW__LN_EQUITY(-13),2)	-0.111702	0.072763	-1.535143	0.1249
D(TW__LN_EQUITY(-14),2)	-0.116027	0.070356	-1.649148	0.0992
D(TW__LN_EQUITY(-15),2)	-0.118512	0.067743	-1.749444	0.0803
D(TW__LN_EQUITY(-16),2)	-0.161680	0.065051	-2.485447	0.0130
D(TW__LN_EQUITY(-17),2)	-0.095544	0.061992	-1.541226	0.1234
D(TW__LN_EQUITY(-18),2)	-0.074466	0.058777	-1.266919	0.2053
D(TW__LN_EQUITY(-19),2)	-0.097717	0.055313	-1.766607	0.0774
D(TW__LN_EQUITY(-20),2)	-0.027144	0.051843	-0.523573	0.6006
D(TW__LN_EQUITY(-21),2)	0.019953	0.047884	0.416691	0.6769
D(TW__LN_EQUITY(-22),2)	-0.027802	0.043963	-0.632401	0.5272
D(TW__LN_EQUITY(-23),2)	-0.022244	0.039305	-0.565938	0.5715
D(TW__LN_EQUITY(-24),2)	-0.027116	0.034482	-0.786383	0.4317
D(TW__LN_EQUITY(-25),2)	-0.011591	0.028464	-0.407198	0.6839
D(TW__LN_EQUITY(-26),2)	0.062977	0.020758	3.033845	0.0024
C	-0.060706	0.068066	-0.891876	0.3725

R-squared	0.477944	Mean dependent var	-0.002398
Adjusted R-squared	0.472514	S.D. dependent var	4.790913
S.E. of regression	3.479556	Akaike info criterion	5.342300
Sum squared resid	31430.57	Schwarz criterion	5.404963
Log likelihood	-6981.097	Hannan-Quinn criter.	5.364994
F-statistic	88.02378	Durbin-Watson stat	1.995984
Prob(F-statistic)	0.000000		

Null Hypothesis: D(ULVR_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-37.91796	0.0000
Test critical values:	1% level	-3.432626	
	5% level	-2.862431	
	10% level	-2.567289	

*MacKinnon (1996) one-sided p-values.

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ULVR_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:37
Sample (adjusted): 1/06/2006 6/30/2016
Included observations: 2649 after adjustments
==========================================================================
        Variable            Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
  D(ULVR_LN_EQUITY(-1))      -1.068511      0.028180     -37.91796     0.0000
D(ULVR_LN_EQUITY(-1),2)       0.032267      0.019551      1.650447     0.0990
           C                  0.924961      0.524642      1.763033     0.0780
==========================================================================
R-squared                     0.515815   Mean dependent var          0.049306
Adjusted R-squared            0.515449   S.D. dependent var          38.75533
S.E. of regression            26.97747   Akaike info criterion       9.429013
Sum squared resid             1925716.   Schwarz criterion           9.435674
Log likelihood               -12485.73   Hannan-Quinn criter.        9.431424
F-statistic                   1409.427   Durbin-Watson stat          1.990656
Prob(F-statistic)             0.000000
==========================================================================
```

```
Null Hypothesis: D(UU__LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=27)
==========================================================================
                                                   t-Statistic    Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic              -22.77511     0.0000
--------------------------------------------------------------------------
Test critical values:         1% level              -3.432630
                              5% level              -2.862433
                              10% level             -2.567290
==========================================================================
*MacKinnon (1996) one-sided p-values.
```

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(UU__LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:37
Sample (adjusted): 1/12/2006 6/30/2016
Included observations: 2645 after adjustments
==========================================================================
        Variable            Coefficient    Std. Error    t-Statistic    Prob.
==========================================================================
  D(UU__LN_EQUITY(-1))       -1.119232      0.049143     -22.77511     0.0000
 D(UU__LN_EQUITY(-1),2)       0.120677      0.044740      2.697311     0.0070
 D(UU__LN_EQUITY(-2),2)       0.093483      0.039947      2.340211     0.0193
 D(UU__LN_EQUITY(-3),2)       0.079688      0.034298      2.323357     0.0202
 D(UU__LN_EQUITY(-4),2)       0.090235      0.027690      3.258765     0.0011
 D(UU__LN_EQUITY(-5),2)       0.072207      0.019526      3.698059     0.0002
           C                  0.073686      0.210267      0.350441     0.7260
==========================================================================
R-squared                     0.501718   Mean dependent var          0.009519
Adjusted R-squared            0.500585   S.D. dependent var          15.30149
S.E. of regression            10.81346   Akaike info criterion       7.602103
Sum squared resid             308463.8   Schwarz criterion           7.617666
Log likelihood               -10046.78   Hannan-Quinn criter.        7.607737
F-statistic                   442.6987   Durbin-Watson stat          1.998392
```

```
Prob(F-statistic)              0.000000
```

Null Hypothesis: D(VOD_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=27)

```
                                                    t-Statistic     Prob.*

Augmented Dickey-Fuller test statistic              -23.54606       0.0000
Test critical values:          1% level             -3.432630
                               5% level             -2.862433
                               10% level            -2.567290
```

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(VOD_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:38
Sample (adjusted): 1/12/2006 6/30/2016
Included observations: 2645 after adjustments

```
         Variable            Coefficient    Std. Error     t-Statistic      Prob.

  D(VOD_LN_EQUITY(-1))        -1.274840      0.054142      -23.54606       0.0000
 D(VOD_LN_EQUITY(-1),2)        0.202815      0.048763       4.159236       0.0000
 D(VOD_LN_EQUITY(-2),2)        0.139795      0.042786       3.267348       0.0011
 D(VOD_LN_EQUITY(-3),2)        0.090290      0.036117       2.499941       0.0125
 D(VOD_LN_EQUITY(-4),2)        0.058598      0.028587       2.049831       0.0405
 D(VOD_LN_EQUITY(-5),2)        0.037072      0.019513       1.899891       0.0576
            C                  0.018925      0.065178       0.290365       0.7716

R-squared                      0.535065    Mean dependent var           0.001640
Adjusted R-squared             0.534008    S.D. dependent var           4.910217
S.E. of regression             3.351892    Akaike info criterion        5.259570
Sum squared resid              29638.40    Schwarz criterion            5.275132
Log likelihood                -6948.781    Hannan-Quinn criter.         5.265204
F-statistic                    505.9858    Durbin-Watson stat           1.999568
Prob(F-statistic)              0.000000
```

Null Hypothesis: D(WOS_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=27)

```
                                                    t-Statistic     Prob.*

Augmented Dickey-Fuller test statistic              -22.38703       0.0000
Test critical values:          1% level             -3.432630
                               5% level             -2.862433
                               10% level            -2.567290
```

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(WOS_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:38
Sample (adjusted): 1/12/2006 6/30/2016
Included observations: 2645 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(WOS_LN_EQUITY(-1))	-1.111382	0.049644	-22.38703	0.0000
D(WOS_LN_EQUITY(-1),2)	0.066222	0.045157	1.466489	0.1426
D(WOS_LN_EQUITY(-2),2)	0.055110	0.040178	1.371630	0.1703
D(WOS_LN_EQUITY(-3),2)	0.079318	0.034865	2.275003	0.0230
D(WOS_LN_EQUITY(-4),2)	0.047713	0.028210	1.691366	0.0909
D(WOS_LN_EQUITY(-5),2)	0.043013	0.019494	2.206458	0.0274
C	-0.794430	1.254746	-0.633140	0.5267

R-squared	0.525041	Mean dependent var	-0.042220
Adjusted R-squared	0.523961	S.D. dependent var	93.49461
S.E. of regression	64.50717	Akaike info criterion	11.17407
Sum squared resid	10977181	Schwarz criterion	11.18964
Log likelihood	-14770.71	Hannan-Quinn criter.	11.17971
F-statistic	486.0270	Durbin-Watson stat	2.000356
Prob(F-statistic)	0.000000		

Null Hypothesis: D(WPG_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.725751	0.0000
Test critical values:	1% level	-3.468072	
	5% level	-2.878015	
	10% level	-2.575632	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(WPG_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:38
Sample (adjusted): 1/13/2006 9/20/2006
Included observations: 174 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(WPG_LN_EQUITY(-1))	-1.765502	0.228522	-7.725751	0.0000
D(WPG_LN_EQUITY(-1),2)	0.858342	0.200320	4.284859	0.0000
D(WPG_LN_EQUITY(-2),2)	0.701758	0.174385	4.024189	0.0001
D(WPG_LN_EQUITY(-3),2)	0.690656	0.151789	4.550112	0.0000
D(WPG_LN_EQUITY(-4),2)	0.425535	0.137385	3.097395	0.0023
D(WPG_LN_EQUITY(-5),2)	0.208827	0.111161	1.878605	0.0621
D(WPG_LN_EQUITY(-6),2)	0.179140	0.077429	2.313605	0.0219
C	0.179525	0.397032	0.452167	0.6517

R-squared	0.515318	Mean dependent var	0.043966
Adjusted R-squared	0.494880	S.D. dependent var	7.350414
S.E. of regression	5.224072	Akaike info criterion	6.189318

Sum squared resid	4530.295	Schwarz criterion	6.334562
Log likelihood	-530.4707	Hannan-Quinn criter.	6.248238
F-statistic	25.21325	Durbin-Watson stat	1.952563
Prob(F-statistic)	0.000000		

Null Hypothesis: D(WPP_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-24.40672	0.0000
Test critical values:	1% level	-3.432629	
	5% level	-2.862433	
	10% level	-2.567290	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(WPP_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16 Time: 15:38
Sample (adjusted): 1/11/2006 6/30/2016
Included observations: 2646 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(WPP_LN_EQUITY(-1))	-1.129454	0.046276	-24.40672	0.0000
D(WPP_LN_EQUITY(-1),2)	0.079043	0.041125	1.922014	0.0547
D(WPP_LN_EQUITY(-2),2)	0.031548	0.035529	0.887962	0.3746
D(WPP_LN_EQUITY(-3),2)	0.059502	0.028478	2.089396	0.0368
D(WPP_LN_EQUITY(-4),2)	0.031709	0.019643	1.614297	0.1066
C	0.391839	0.267683	1.463818	0.1434

R-squared	0.527105	Mean dependent var	-0.001512
Adjusted R-squared	0.526209	S.D. dependent var	19.96984
S.E. of regression	13.74574	Akaike info criterion	8.081600
Sum squared resid	498815.7	Schwarz criterion	8.094935
Log likelihood	-10685.96	Hannan-Quinn criter.	8.086427
F-statistic	588.5259	Durbin-Watson stat	2.001604
Prob(F-statistic)	0.000000		

Null Hypothesis: D(WTB_LN_EQUITY) has a unit root
Exogenous: Constant
Lag Length: 20 (Automatic - based on AIC, maxlag=27)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.43988	0.0000
Test critical values:	1% level	-3.432644	
	5% level	-2.862439	
	10% level	-2.567294	

*MacKinnon (1996) one-sided p-values.

```
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(WTB_LN_EQUITY,2)
Method: Least Squares
Date: 10/21/16   Time: 15:39
Sample (adjusted): 2/02/2006 6/30/2016
Included observations: 2630 after adjustments
===========================================================================
        Variable            Coefficient   Std. Error   t-Statistic   Prob.
===========================================================================
   D(WTB_LN_EQUITY(-1))      -1.037406     0.099370    -10.43988    0.0000
  D(WTB_LN_EQUITY(-1),2)      0.119979     0.097022     1.236622    0.2163
  D(WTB_LN_EQUITY(-2),2)      0.042773     0.094499     0.452633    0.6509
  D(WTB_LN_EQUITY(-3),2)      0.075667     0.091956     0.822857    0.4107
  D(WTB_LN_EQUITY(-4),2)      0.014454     0.088977     0.162451    0.8710
  D(WTB_LN_EQUITY(-5),2)     -0.007299     0.085915    -0.084954    0.9323
  D(WTB_LN_EQUITY(-6),2)     -0.042333     0.082767    -0.511474    0.6091
  D(WTB_LN_EQUITY(-7),2)     -0.062845     0.079554    -0.789970    0.4296
  D(WTB_LN_EQUITY(-8),2)     -0.046072     0.076119    -0.605265    0.5451
  D(WTB_LN_EQUITY(-9),2)     -0.037600     0.072841    -0.516184    0.6058
 D(WTB_LN_EQUITY(-10),2)     -0.007472     0.069261    -0.107889    0.9141
 D(WTB_LN_EQUITY(-11),2)     -0.076823     0.065943    -1.164999    0.2441
 D(WTB_LN_EQUITY(-12),2)     -0.036444     0.062269    -0.585267    0.5584
 D(WTB_LN_EQUITY(-13),2)     -0.083778     0.058313    -1.436686    0.1509
 D(WTB_LN_EQUITY(-14),2)     -0.062584     0.054051    -1.157877    0.2470
 D(WTB_LN_EQUITY(-15),2)     -0.075334     0.049632    -1.517853    0.1292
 D(WTB_LN_EQUITY(-16),2)     -0.075667     0.045070    -1.678895    0.0933
 D(WTB_LN_EQUITY(-17),2)     -0.106591     0.039933    -2.669225    0.0076
 D(WTB_LN_EQUITY(-18),2)     -0.083819     0.034765    -2.411061    0.0160
 D(WTB_LN_EQUITY(-19),2)     -0.104234     0.028110    -3.708057    0.0002
 D(WTB_LN_EQUITY(-20),2)     -0.041564     0.020499    -2.027644    0.0427
            C                 0.825884     0.786295     1.050349    0.2937
===========================================================================
R-squared                     0.476439   Mean dependent var      -0.033273
Adjusted R-squared            0.472224   S.D. dependent var       55.04547
S.E. of regression            39.98955   Akaike info criterion    10.22344
Sum squared resid             4170620.   Schwarz criterion        10.27259
Log likelihood               -13421.83   Hannan-Quinn criter.     10.24124
F-statistic                   113.0132   Durbin-Watson stat       1.999211
Prob(F-statistic)             0.000000
===========================================================================
```

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Tables

18. Table 5.11.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (2 periods-5 years- Sub period B (2011-2016)-daily data)

19. Table 5.12.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (2 periods-5 years- Sub period A (2006-2010)-weekly data)

20. Table 5.13.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (2 periods-5 years- Sub period B (2011-2016)-weekly data)

21. Table 5.14.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (2 periods-5 years- Sub period A (2006-2010)-monthly data)

22. Table 5.15.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (2 periods-5 years- Sub period B (2011-2016)-weekly data)

23. Table 5.16.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years- Sub period A (2006-2008)-daily data)

24. Table 5.17.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years- Sub period B (2008-2010)-daily data)

25. Table 5.18.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years- Sub period C (2011-2012)-daily data)

26. Table 5.19.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years- Sub period D (2013-2014)-daily data)

27. Table 5.20.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years- Sub period E (2015-2016)-daily data)

28. Table 5.21.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years- Sub period A (2006-2008)-weekly data)

29. Table 5.22.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years- Sub period B (2008-2010)-weekly data)

30. Table 5.23.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years- Sub period C (2011-2012)-weekly data)

31. Table 5.24.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years- Sub period D (2013-2014)-weekly data)

32. Table 5.25.: Weights of the efficient portfolio Q $E(R_p)=E(R_q)$ (5 periods-2 years- Sub period E (2015-2016)-weekly data)

Figures

36. Figure 5.13.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years- Sub period D (2013-2014)-daily data)

37. Figure 5.14.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years- Sub period E (2015-2016)-daily data)

38. Figure 5.15.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years- Sub period A (2006-2008)-weekly data)

39. Figure 5.16.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years- Sub period B (2008-2010)-weekly data)

40. Figure 5.17.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years- Sub period C (2011-2012)-weekly data)

41. Figure 5.18.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years- Sub period D (2013-2014)-weekly data)

42. Figure 5.19.: Efficient frontier and FTSE 100 Index Portfolio (5 periods-2 years- Sub period E (2015-2016)-weekly data)

43. Figure 5.20.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year- Sub period A (2006)-daily data)

44. Figure 5.21.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year- Sub period B (2007)-daily data)

45. Figure 5.22.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year- Sub period C (2008)-daily data)

46. Figure 5.23.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year- Sub period D (2009)-daily data)

47. Figure 5.24.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year- Sub period E (2010)-daily data)

48. Figure 5.25.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year- Sub period F (2011)-daily data)

49. Figure 5.26.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year- Sub period G (2012)-daily data)

50. Figure 5.27.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year- Sub period H (2013)-daily data)

51. Figure 5.28.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year- Sub period I (2014)-daily data)

52. Figure 5.29.: Efficient frontier and FTSE 100 Index Portfolio (10 periods-1 year- Sub period J (2015-2016)-daily data)