UNIVERSITY OF PIRAEUS

DEPARTMENT OF BANKING & FINANCIAL MANAGEMENT

MASTER OF SCIENCE (M.Sc.) IN BANKING & FINANCIAL MANAGEMENT

THESIS

Empirical Assessment of the Three-Dimensional Model Between Expected Return and Betas & Comparison to Multi-Factor Asset Pricing Models

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A thesis submitted in fulfillment of the requirements for the degree of Master of Science in Banking & Financial Management

Piraeus, Greece **April 2019**

I would like to dedicate this thesis to my loving parents Isidoros and Vasiliki and to my beloved grandmother Androniki…

Declaration

I hereby declare that the work in this thesis was carried out in accordance with the requirements of the University's regulations and Code of Practice for Masters Degree Programs, and that the contents of this thesis are original and have not been submitted in whole or in part for consideration for any other degree or qualification in this, or any other university. This thesis is the author's own work and contains nothing which is the outcome of the work of others, except where specific reference is made in the text. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the thesis are those of the author.

Gerasimos Lazarou

April 2019

Acknowledgments

I would like to express my deepest respect, appreciation, and gratitude to Professor George Diacogiannis, for his meaningful advice, endless encouragement and invaluable guidance throughout the whole thesis-writing period.

I would like to thank my supervisor, Associate Professor Nikolaos Kourogenis, as well as, the other two members of my evaluation committee, Professor Emmanouil Tsiritakis and Assistant Professor Dimitrios Kyriazis who accepted to be the examiners of this thesis.

I would like to express my honest gratitude to all the Professors of the Department of Banking & Financial Management for the knowledge and the support they offered me throughout the whole period of the Master's Degree.

I wish to thank the Administrative Staff of the Department of Banking & Financial Management for their incredible assistance in offering me helpful advice and answering all my questions.

Last but not least, I would like to thank my loving parents for their constant support, motivation, and faith in my abilities.

Abstract

The purpose of this thesis is to prove the inefficiency of the FTSE 100 Index. In order to test it, we used the 3D Model of Dr. George Diacogiannis. We took daily, weekly and monthly data for the FTSE 100 Index and for every constituent of the Index, for an 8-year period starting from 2010 up to 2018. The data were downloaded from the Thomson Reuters Datastream database from the Department of Banking & Financial Management of the University of Piraeus. Our results indicate that the FTSE 100 Index is an inefficient portfolio and this result was proven schematically by creating the Efficient Frontier following Roll's Methodology (1977) and statistically by using the methodology of George E.P. Box.

Keywords: *FTSE 100 Index, Efficient Frontier, Portfolio Management, CAPM, Asset Pricing, Mean-Standard Deviation Space, Roll, Diacogiannis, Feldman, Minimum Variance Portfolios.*

Περίληψη

Ο σκοπός αυτής της διπλωματικής εργασίας είναι να αποδείξει την μη αποδοτικότητα του δείκτη FTSE 100. Για να εξεταστεί αυτή η υπόθεση, χρησιμοποιήσαμε το Τρισδιάστατο Υπόδειγμα του Γ. Διακογιάννη. Λάβαμε ημερήσια, εβδομαδιαία και μηνιαία δεδομένα, τόσο για τον δείκτη όσο και για κάθε μετοχή που απαρτίζει τον δείκτη, για μία περίοδο οκτώ -8- ετών, ξεκινώντας από το 2010 και καταλήγοντας στο 2018. Τα δεδομένα ελήφθησαν από την Βάση Δεδομένων Thomson Reuters Datastream, από το Τμήμα Χρηματοοικονομικής & Τραπεζικής Διοικητικής του Πανεπιστημίου Πειραιώς. Τα αποτελέσματα μας έδειξαν πως ο δείκτης FTSE 100 δεν είναι αποδοτικό χαρτοφυλάκιο και αυτό το αποτέλεσμα αποδείχθηκε σχηματικά, κατασκευάζοντας το Αποδοτικό Σύνορο βάσει της μεθοδολογίας του Roll (1977), αλλά και στατιστικά, ακολουθώντας τη μεθοδολογία του George E. P. Box.

Λέξεις Κλειδιά: *FTSE 100 Index, Αποδοτικό Σύνορο, Θεωρία Χαρτοφυλακίου, CAPM, Αποτίμηση Περιουσιακών Στοιχείων, Χώρος Αναμενόμενης Απόδοσης και Τυπικής Απόκλισης, Roll, Διακογιάννης, Feldman, Χαρτοφυλάκια Ελαχίστου Κινδύνου.*

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“The essence of portfolio management is the management of risks, not the management of returns. Well-managed portfolios start with this precept.”

Benjamin Graham

Chapter 1

Portfolio Theory

Nowadays, everyone owns assets. Based on the assets we own, we can create different types of portfolios with different values. When we buy something, even with the smallest value, we become investors at that exact moment. We invest our money in purchasing something that it will satisfy our needs or that it will provide us an income at some moment in the future. We invest based on the **Expected Value** that we will gain, and we do it only when this value is positive, otherwise, we would just lose money. But, as Benjamin Graham informs us, it is important first to calculate the risks attached to an investment, and then measure the returns. By calculating the risks, you measure the uncertain part of the equation, and therefore you can be almost certain that you minimized the losses.

The creation of a portfolio is a constant battle between our needs and desires. In everything we do, we always try to balance what we want to possess with what we need. It is not an easy process because balancing means that we need to sacrifice a portion of both. Balancing means finding the equilibrium. At this point, someone would stop and ask: “Why do we have to balance everything? Why don’t we maximize our investments’ returns by maximizing the amount of money we invest?” Well, the answer is obvious; because we don’t have unlimited access to money. We have unlimited desires and needs but a strictly limited amount of money to invest. That is the most significant reason that leads us to allocate our income accordingly to find the most efficient (meaning with the highest return and the lowest risk involved) equilibrium and that is the reason why portfolio theory was born.

In this chapter, our goal is to analyze the modern portfolio theory and all its aspects. First, we will explain the categories of different financial securities and the markets in which these securities trade. Secondly, we will discuss the fundamental hypotheses that lie behind the modern portfolio theory and we will introduce the Markowitz's theory. Furthermore, we will examine important models that are based on the existing bibliography, such as the Capital Market Line -CML and the Capital Asset Pricing Model -CAPM. Along the way, we will introduce the meanings of the rational investor, the Efficient Market Hypothesis (EMH) and in the last part of this chapter, we will present the most popular portfolio performance measures that are based on the CML and the CAPM.

1.1 FINANCIAL SECURITIES & FINANCIAL MARKETS

In this paragraph, we will introduce all the existent categories of financial securities and the markets that these securities trade in. First of all, it is important to understand what is a security. "*A security is a fungible, negotiable financial instrument that holds some type of monetary value. It represents an ownership position in a publicly-traded corporation (via stock), a creditor relationship with a governmental body or a corporation (represented by owning that entity's bond), or rights to ownership represented by an option.*"[1] We can now categorize the different marketable financial securities into two broad categories: The **equity** securities and the **debt** securities.

The former category represents the securities that offer to their holders an ownership position in an entity (e.g. a publicly-traded company, a trust, a partnership). The holder of such securities has no obligation to regular payments but has the advantage of increasing his/her capital gains by either accumulating the dividend payments that the

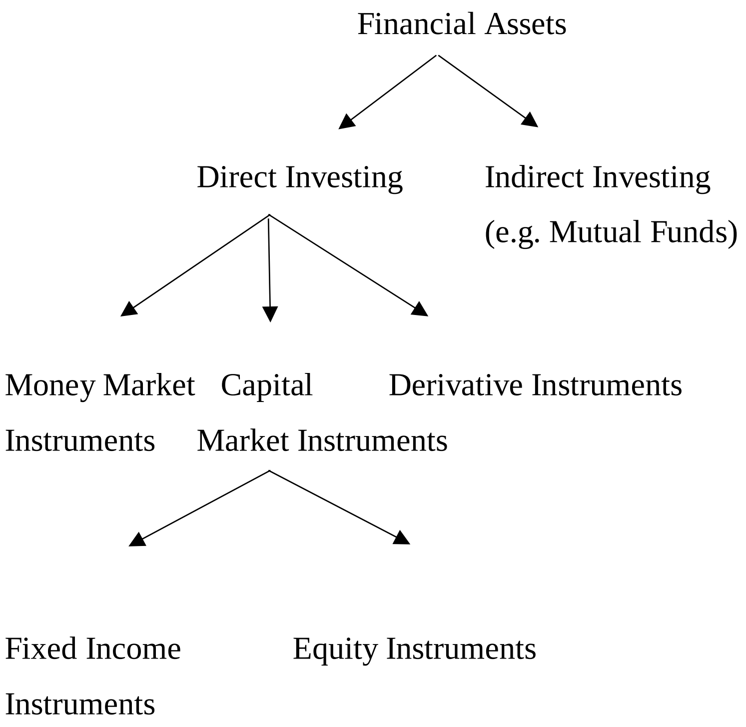
[1] Investopedia, Security, https://www.investopedia.com/terms/s/security.asp .

entity makes or by selling these equity securities at the Stock Exchange Market when their price is higher than what it was when the holder bought them. Finally, this type of securities entitles their holders to some kind of control of the company, usually by voting rights.

On the other hand, the latter category represents the securities that make fixed or floating payments to their holders and that at the end of their life the present value of the face value of the initial loan is also compensated. The regular payments depend on the initial value of the loan, the interest rate and the maturity of the loan. Usually, when a payment is made, it is composed by the interest payment and the principal payment as well. These financial instruments are Corporate and Government Bonds, Certificates of Deposit (CDs), Treasury Notes and Bonds, Municipal Bonds, Collateralized Debt Obligations (CDOs) and Collateralized Mortgage Obligations (CMOs). Finally, this kind of securities can be secured with collateral or unsecured (meaning the non-asset-backed securities).

Before we start explaining all the different financial assets and financial markets, we pose a diagram to map the possible investment routes that a potential investor can choose:

Diagram 1.1.a – Financial Assets Map



Source: Brown, J., Stephen, Elton, J., Edwin, Goetzmann, N., William, Gruber, J., Martin, 2014, "*Modern Portfolio Theory and Investment Analysis*", 9th Edition, Wiley & Sons Inc., New Jersey, USA, Part 1, "*Introduction*", Chapter 2, "*Financial Securities*", Page 12.

As we can see in the above diagram, we have two types of investing; the **direct** investing and the **indirect** investing. By **direct** we mean that each investor can purchase a certain number of financial securities directly from the company itself. On the other hand, when we refer to the word **indirect**, we simply mean that an investor will buy a certain number of shares of a mutual fund and he/she will not contact the company at all. In this form of investment, the investor will gain or lose money based on the performance of the portfolio of the mutual fund, meaning that the shares that he/she bought from the fund, can correspond to many different investments that the mutual fund has made and not just to one entity. Because direct investing is the most common practice nowadays in terms of higher returns, we will analyze the sub-categories of direct investing first.

Direct investing can be separated into three -3- different tiers; the **money market** instruments, the **capital market** instruments, and the **derivative** instruments. Depending on the type of investor (meaning if he/she is risk-averse or risk-lover), each category offers the right assets. Each of the above three categories is "*classified by the time horizon of the investment.*"[2] Based on this statement, if an investment has a time horizon smaller than a year then it is a **money market investment**. If the time horizon is more than a year, then it is a **capital market investment**. Last but not least, the **derivative instruments** are those investments in financial products whose price derives from the price movement of their underlying asset. For instance, a futures contract is a binding agreement to buy or sell an asset at a specified price in the future for a specified time. The price of this contract is derived from its underlying asset price movement, which underlying asset can be one of the following:

1. Stocks
2. Bonds
3. Gold
4. Silver
5. Copper
6. Oil
7. Foreign Currency
8. Cryptocurrencies
9. Other Investment Commodities
10. Other Consumption Commodities

1.1.1 Money Market Instruments

We will start our analysis with the **money market instruments**. These "*are short-term debt instruments sold by governments, financial institutions, and corporations. They have maturities at the time of issuance one year or less and the minimum transaction*

[2] Brown, J., Stephen, Elton, J., Edwin, Goetzmann, N., William, Gruber, J., Martin, 2014, "*Modern Portfolio Theory and Investment Analysis*", 9th Edition, Wiley & Sons Inc., New Jersey, USA, Part 1, "*Introduction*", Chapter 2, "*Financial Securities*", Page 12.

size is $100,000."[3] The different sub-categories of this kind of financial products are the following[4]:

"

- *Treasury Bills*
- *Repurchase Agreements (Repos)*
- *LIBOR*
- *Negotiable Certificate of Deposit*
- *Banker's Acceptances*
- *Commercial Paper*
- *Eurodollar*

"

Now, we will analyze each type of money market securities.

Treasury Bills: "*US Treasury Bills are the least risky and the most marketable of all money market instruments. They represent a short-term IOU* (meaning an abbreviation in phonetic terms of the phrase "I owe you", and it represents a document that acknowledges the amount of debt that is owed to someone) *of the US Federal Government. Treasury Bills (T-bills) are sold in minimum denominations of $10,000.*"[5] The mechanism that this risk-free investment product works is the following: "*T-bills are sold at a discount from face value (meaning the cash payment the investor will receive at maturity) and pay no explicit interest payments. The difference between the purchase price and the face value constitutes the return the investor receives.*"[6]

Repurchase Agreements (Repos): "*A repurchase agreement (repo) is an agreement between a borrower and a lender to sell and repurchase a government security. A borrower, usually a government securities dealer, will institute the repo by contracting to sell securities to a lender at a particular price and simultaneously contracting to buy back the securities at a future date at a specified price. The difference between the two*

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[3] Brown, J., Stephen, Elton, J., Edwin, Goetzmann, N., William, Gruber, J., Martin, 2014, "*Modern Portfolio Theory and Investment Analysis*", 9th Edition, Wiley & Sons Inc., New Jersey, USA, Part 1, "*Introduction*", Chapter 2, "*Financial Securities*", Page 12.

[4] ″

[5] Brown, J., Stephen, Elton, J., Edwin, Goetzmann, N., William, Gruber, J., Martin, 2014, "*Modern Portfolio Theory and Investment Analysis*", 9th Edition, Wiley & Sons Inc., New Jersey, USA, Part 1, "*Introduction*", Chapter 2, "*Financial Securities*", Page 13.

[6] ″

prices represents the return to the lender. A repo is a short-term collateralized loan for which the amount of required collateral depends on the risk of the collateral. Finally, the maturity of a repo is very short-term (less than 14 days)."[7] A reverse repo is exactly the reverse transaction from the side of the lender who buys the securities and at a later date at a specified price he/she sells back to the dealer the amount of the securities.

LIBOR: "*LIBOR is a benchmark that some of the world's leading banks charge each other for short-term loans. It stands for Intercontinental Exchange London Interbank Offered Rate and it is based on five -5- currencies: the US dollar (USD), the Euro (EUR), the British Pound Sterling (GBP), the Japanese yen (JPY) and the Swiss franc (CHF). It serves seven -7- different maturities: overnight, one week and 1, 2, 3, 6, 12 months. Finally, the most commonly quoted rate is the* ***three-month US dollar rate****.*"[8]

Negotiable Certificate of Deposit (CD)[9]: "*A CD is a time deposit with a bank that restricts holders from withdrawing funds on demand. Specifically, it is a savings certificate with a fixed maturity date, specified fixed interest rate and can be issued in any denomination aside from minimum investment requirements. It is usually issued by commercial banks and it is backed by the Federal Deposit Insurance Corporation (FDIC) in the USA. It is issued electronically and may automatically renew upon the maturity of the original CD.*"

Banker's Acceptance[10]: "*A Banker's Acceptance is a contract by a bank to pay a specific sum of money on a particular date. It is a short-term debt instrument issued by a company and guaranteed by a commercial bank. It sells at rates that depend on the credit rating of the bank that backs them. A Banker's Acceptance is similar to a T-bill because it is traded at a discount from face value on the secondary market.*"

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[7] Brown, J., Stephen, Elton, J., Edwin, Goetzmann, N., William, Gruber, J., Martin, 2014, "*Modern Portfolio Theory and Investment Analysis*", 9th Edition, Wiley & Sons Inc., New Jersey, USA, Part 1, "*Introduction*", Chapter 2, "*Financial Securities*", Page 13.
[8] Investopedia, LIBOR, https://www.investopedia.com/terms/l/libor.asp .
[9] Brown, J., Stephen, Elton, J., Edwin, Goetzmann, N., William, Gruber, J., Martin, 2014, "*Modern Portfolio Theory and Investment Analysis*", 9th Edition, Wiley & Sons Inc., New Jersey, USA, Part 1, "*Introduction*", Chapter 2, "*Financial Securities*", Page 13. --- Investopedia, Certificate of Deposit, https://www.investopedia.com/terms/c/certificateofdeposit.asp .
[10] The same 1st source as above. --- Investopedia, Banker's Acceptance, https://www.investopedia.com/terms/b/bankersacceptance.asp .

Commercial Paper[11]: "*Commercial Paper is an unsecured, short-term debt instrument issued by a well-known corporation, typically for the financing of accounts receivable, inventories and meeting short-term liabilities. It is usually issued at a discount from face value and reflects prevailing market interest rates. Finally, it matures in around 270 days and it is backed by any form of collateral.*"

Eurodollar[12]: "*It refers to US dollar-denominated deposits at foreign banks or at the overseas branches of American banks. Because these deposits are located outside the United States of America, are not subject to regulation by the Federal Reserve Board and therefore banks that hold them are not supposed to maintain additional reserves.*"

1.1.2 Capital Market Instruments

Capital Market Instruments can be sub-categorized into two different pillars: The **Fixed Income Securities** and the **Equity Securities**.

1.1.2.1 Fixed Income Securities

The **Fixed Income Securities (FIS)** are "*investments that provide returns in the form of fixed periodic payments (that are known at the beginning of the contract) and the eventual return of principal at maturity.*"[13] Actually, they are selected by investors who want to enjoy a greater financial security because they offer a regular and stable income and also lower risk than other investments due to the stability of the payments. Generally, these investments can be used if someone wants to reduce his/her overall

[11] Brown, J., Stephen, Elton, J., Edwin, Goetzmann, N., William, Gruber, J., Martin, 2014, "*Modern Portfolio Theory and Investment Analysis*", 9th Edition, Wiley & Sons Inc., New Jersey, USA, Part 1, "*Introduction*", Chapter 2, "*Financial Securities*", Page 14. --- Investopedia, Commercial Paper, https://www.investopedia.com/terms/c/commercialpaper.asp .
[12] Investopedia, Eurodollar, https://www.investopedia.com/terms/e/eurodollar.asp .
[13]″, Fixed Income Security, https://www.investopedia.com/terms/f/fixed-incomesecurity.asp

portfolio risk exposure. The types of financial products that shape this category of capital market instruments are the following:

- Corporate Bonds
- Government Bonds
- Treasury Notes
- Federal Agency Securities
- Municipal Bonds

As we can see from the above categorization all the fixed income instruments are bonds or belong in the wide variety of financial assets that behave like bonds. They will be either backed by the collateral of the corporation that issues them or by the government itself.

At this moment, we believe it is time to introduce the calculation of the **present value of a Bond**. Let's suppose that we own a bond with **face value = F**, **maturity = T**, **coupon rate = C** and **rate of return = r**. Then, the mathematical equation that calculates the present value of this bond is the following:

$$P = C * [\sum_{t=1}^{T} (\frac{1}{(1+r)^t})] + \frac{F}{(1+r)^T} \qquad \mathbf{(1.1)}$$

Now we will use numbers in order to clarify our example and make it more understandable:

<u>Example 1.1</u>

The previous bond has the following characteristics:

- **Face Value = $1,000**
- **Coupon Rate = 10%** (meaning Coupon = $10 (0.10*1,000))
- **Interest Rate = 8%**
- **Time to Maturity = 3 years** (each coupon payment is made every year, meaning 3 total coupon payments)

Then the **present value** of this bond is calculated as follows:

$$P = 10 * \left[\frac{1}{(1.08)} + \frac{1}{(1.08)^2} + \frac{1}{(1.08)^3}\right] + \frac{1000}{(1.08)^3}$$
$$= 10 * (0.9259 + 1.7833 + 2.5771) + 793.8322 = \$846.6952$$

1.1.2.2 Equity Instruments

On the other hand, the **Equity Instruments** tend to be riskier but also offering greater returns. This category of capital market instruments is much more volatile than the fixed income securities because it bears the risk of default of each issuer as well. One type of equity instruments is **stocks**. These are split into two categories: The **common** stocks and the **preferred** stocks. The differences in the rights that derive from common and preferred stocks can be explained as follows:

- Holders of common stocks are described as the owners of the company because this type of stocks offers voting rights, whereas preferred stocks don't.
- The preferred stocks receive their dividend payments before the common stocks.
- The amount of dividend per stock is usually higher and stable in time for the preferred stocks, something that is not happening for the common ones.
- In case of bankruptcy, after holders of debt claims are paid, the holders of preferred stocks will be compensated first and then the holders of common stocks.

Now, we will analyze the **present value** of a **common stock**. We denote with $\mathbf{P_0}$ the **present value** (meaning today in Year 0), with $\mathbf{D_1, D_2, D_3, \ldots D_n}$ the **dividends** of each consecutive year after Year 0 up to the Year n. We suppose that the company pays the dividend once every year. Moreover, we need the **final value** in Year n of our stock, which we denote with $\mathbf{P_n}$. Finally, we denote with **r** the **rate of return** and to simplify things, we suppose that the rate of return remains constant for every year (something that in real life may not be true). Then, the present value of our hypothetical stock will be the following:

$$P_0 = \frac{D_1}{(1+r)} + \frac{D_2}{(1+r)^2} + \frac{D_3}{(1+r)^3} + \cdots + \frac{D_n}{(1+r)^n} + \frac{P_n}{(1+r)^n} \qquad \mathbf{(1.2)}$$

In numbers, the above equation gives the following result:

<u>Example 1.2</u>

Let's suppose a common stock that its current life is three -3- years and that P_3 = $25, D_1 = 0.5$, D_2 = $0.7, D_3 = $1.0 and r = 5%. Then, its present value will be:

$$P_0 = \frac{0.5}{(1.05)} + \frac{0.7}{(1.05)^2} + \frac{1}{(1.05)^3} + \frac{25}{(1.05)^3}$$
$$= 0.4762 + 0.6349 + 0.8638 + 21.5960 = \$23.5709$$

This means that the stock can be purchased today for $23.5709. That is the price everyone can see in the stock market price table today.

Finally, except the stocks, another type of equity instruments that we can use is the **Asset-Backed Securities**. In general terms, "*an asset-backed security is a contractual claim on a pool of securities-typically loans. These include home mortgages, commercial mortgages, automobile loans, student loans and credit card debt. Collectively referred to as* ***Collateralized Debt Obligations (CDOs)****, they are usually structured so that there are several classes, known as tranches, with different maturities and different levels of risk.*"[14]

[14] Brown, J., Stephen, Elton, J., Edwin, Goetzmann, N., William, Gruber, J., Martin, 2014, "*Modern Portfolio Theory and Investment Analysis*", 9th Edition, Wiley & Sons Inc., New Jersey, USA, Part 1, "*Introduction*", Chapter 2, "*Financial Securities*", Page 16.

1.1.3 Derivative Instruments

Last but not least, in the Direct Investing category, another possible investment route for an investor is the **Derivatives Market**. The **Derivative Instruments** are those financial products that their price derives from the price movements of their underlying asset (as we discussed earlier). Because of the leverage these products create, they are considered to be extremely volatile. In fact, in many cases, the investor is not supposed to exchange money for the contract that he/she agrees on. But, even in the cases where some money will be required, the position that he/she takes has a value of many times more than the actual money that has been exchanged.

They are basically categorized as follows:

- Forwards
- Futures
- Options
- Swaps

We will now begin to analyze each separate category and provide examples in cases that we believe it is necessary.

1.1.3.1 Forwards/Futures Contracts

"*A forward/future contract is an agreement to buy or sell an asset at a certain future time for a certain price.*"[15] In this type of contract, we have two parties. The **buyer** of the contract and the **seller** of the contract. The buyer of the contract "*... agrees to buy the underlying asset on a certain specified future date for a specified price*"[16] and he/she is the one who has taken a **long position** and the seller "*... agrees to sell the asset on the same date for the same price*"[17] and he/she is the one who has taken a **short**

[15] Hull, C., John, 2012, "*Options, Futures and Other Derivatives*", 8th Edition, Prentice Hall, Pearson Education Inc., Boston, MA, USA, Chapter 1, "*Introduction*", Pages 5 & 7.
[16] ″
[17] ″

position. They are generally being used for hedging strategies and not so much for speculation or arbitrage. Specifically, they are most valuable in hedging risks that derive from foreign currency price fluctuations. At this point, it is important to mention that **in a forward/future contract nothing is exchanged when the contract is signed**.

Example 1.3:

Investor A contacts Investor B and they agreed that Investor A will buy 1 kg of gold at $ 40,000 in exactly six -6- months time. Today's price of 1 kg of gold is $ 39,936.37. After the period of the six months, Investor A has two options: He will either buy the 1 kg of gold or he will pay or receive the difference of the price that he agreed on with the price that the 1 kg of gold is valued on the day of the maturity. The former (meaning the actual acquisition of gold) is called **Physical Delivery** while the latter (meaning the difference between the delivery price and the price on the maturity) is called **Cash Settlement**.

In order to clarify our example we summarize the following:

- **Underlying Asset:** It is the asset that underlies the above deal, meaning the 1 kg of Gold.
- **Delivery Price:** The fixed price at which the transaction will be executed, meaning $ 40,000 (which is the price that Investor A and Investor B agreed on). It is denoted by **K**.
- **Maturity Date:** The future time at which the contract ends. It is denoted by **T**.
- **Spot Price:** It is the price that the 1 kg of Gold is valued today, meaning the $ 39,936.37. It is denoted by **S(t)**.
- **Forward/Future Price:** It is the market price that will be agreed upon today for delivery of the asset on a specified maturity date. When the contract between Investor A and Investor B is signed, the Future Price becomes the Delivery Price. It is denoted by **F(t, T)**.
- **Contract Size:** It is the amount of the asset that will be delivered or that it will be used for the cash settlement. In our example is the 1kg of Gold.

Because as we said at the beginning of this paragraph, a forward/future contract does not require any money exchange on the day that it is signed, it means that at maturity, its payoff equals its profit/loss result. Being said that, Investor's A payoff will be the following:

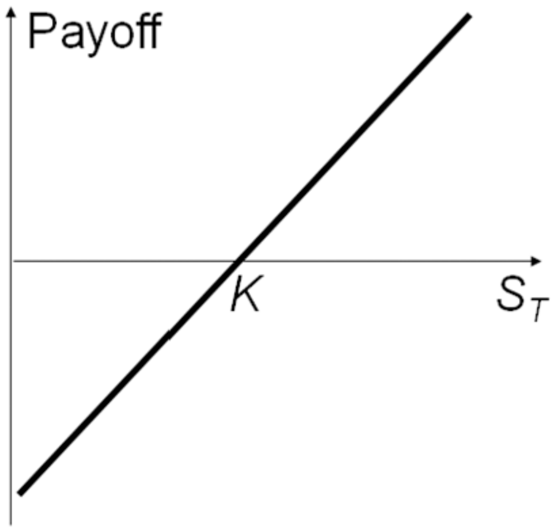
Payoff of Long Position = S(t) – K

By contrast, the payoff of Investor B will be the following:

Payoff of Short Position = K – S(t)

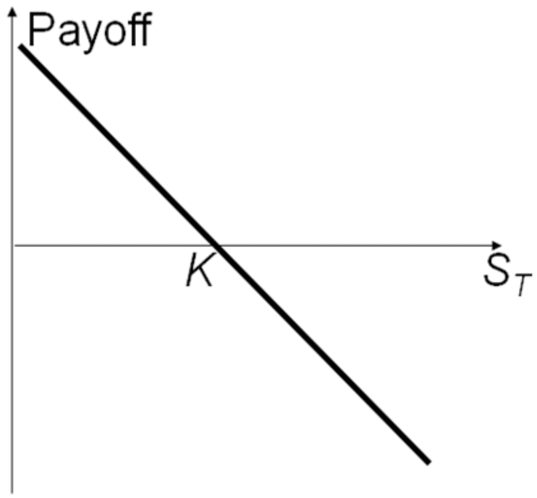
The diagrams of each of the above payoffs are the following:

<u>Diagram 1.1.3.1.a – Long Position Payoff</u>



<u>Source</u>: Hull, C., John, 2012, "*Options, Futures and Other Derivatives*", 8th Edition, Prentice Hall, Pearson Education Inc., Boston, MA, USA, Chapter 1, "*Introduction*", Page 6.

Diagram 1.1.3.1.b – Short Position Payoff



Source: Hull, C., John, 2012, "*Options, Futures and Other Derivatives*", 8th Edition, Prentice Hall, Pearson Education Inc., Boston, MA, USA, Chapter 1, "*Introduction*", Page 6.

Now, it is the time to summarize the differences between forwards and futures contracts. The general mechanism, under which, these products are being used is explained in the previous pages and it's the same for both of them. But they differ in the following terms:

Table 1.1.3.1.a – Forwards/Futures Differences

Forward Contracts	Future Contracts
Traded in Over-the-Counter (OTC) Markets	Traded in Organized Exchanged Markets
Contracts are negotiable	Contracts are standardized
Settlement at the maturity	Daily Settlement via the use of a Margin Account
Private Agreement, meaning that the price is not publicly available	Prices are being daily posted. It is the marking-to-market mechanism
Delivery usually occurs	Delivery rarely occurs
Fixed delivery date	Not specified delivery date

1.1.3.2 Options

Another type of derivative instrument is the **Option**. An Option is separated into two categories: The **Call Option** and the **Put Option**. The **Call Option** "*... gives the holder the right to buy the underlying asset by a certain date for a certain price.*"[18] On the opposite side, the **Put Option** "*... gives the holder the right to sell the underlying asset by a certain date for a certain price.*"[19] Furthermore, the Options are separated into **American** and **European**. A holder of an **American** Option has the freedom to exercise his option whenever he wishes to up until the maturity date. On the other hand, a holder of a **European** Option is not allowed to exercise the option at any time before its maturity date. In order to clarify the basic terminology of Options, we summarize the following:

- **Strike/Exercise Price:** It is the price of the Option contract. It is denoted by **K**.
- **Spot Price:** The price of the underlying asset today. It is denoted by **S(t)**.
- **Expiration/Maturity Date:** It is the date on which the life of the Option ends. It is denoted by **T**.
- **Option Class:** It is the set of all Call or Put Options of the **same underlying asset**.
- **Option Series:** All Call or Put Options of a given class with the **same strike price** and the **same maturity date**.

Every holder of an Option can take any of the four -4- following positions:

- **Long** a **Call** Option
- **Short** a **Call** Option
- **Long** a **Put** Option
- **Short** a **Put** Option

By definition, in the Options Derivative vocabulary, a **long position** on an Option means that the holder has the right to buy the derivative at a specified price on a fixed

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[18] Hull, C., John, 2012, "*Options, Futures and Other Derivatives*", 8th Edition, Prentice Hall, Pearson Education Inc., Boston, MA, USA, Chapter 1, "*Introduction*", Page 7.
[19] ″

future date. On the opposite side, a **short position** on an Option means that the holder has the right to sell the derivative at a specified price on a fixed future date.

At this moment, we should make clear that in the Option terminology, when we say that the holder has the right to exercise the Option, we simply mean that he/she has a **right** and **not the obligation** to buy or sell the derivative. That is one of the main differences between Options and Forwards/Futures contracts. An Option contract offers you the right to exercise it or not up until its maturity date instead of a Forward/Future contract which is an obligation to abide by the rules of the contract.

On the other hand, the only obligation that does exist in the Option contract is the **obligation** of the party that has taken the **opposite side** on the contract. For instance, if Investor A purchases a **Call Option** from Investor B, then, Investor A has the right to buy the underlying asset. Investor B though is obligated to sell to Investor A the underlying asset if the former exercises his right. Investor A has only rights and Investor B only obligations.

Also, another basic difference between Options and Forwards/Futures is the fact that in an Options contract, the holder of the Option has to pay the Option's premium (which is the price of acquiring the Option today). That is totally different from the Forwards/Futures since there, none of the two parties of the transaction is obligated to exchange money today. Let's make an example in order to help the reader fully grasp the content of Options contracts.

<u>Example 1.4</u>:

Suppose that Investor A buys today from Investor B a European Call Option (meaning a **Long Position on a European Call Option**) on a stock (underlying asset) with the following rules:

- In three -3- months (meaning 60 trading days), the Investor A has the right to buy from Investor B the stock for $10 (that is our **strike price**).
- In order for Investor A to acquire this right, he pays Investor B today, $4 (which is the **Option's premium**).

Now, after the three -3- months have passed, one of the following may happen:

1. The stock's price is **higher than $10** meaning that it is profitable for Investor A to exercise the Option and buy the stock for $10. It is profitable because he will purchase something worth more than $10 for $10. So his profit is the difference between the spot price of the stock today and the strike price of $10. His payoff can be described as follows:

Payoff of Long Call Option = max{S(t) – K, 0}

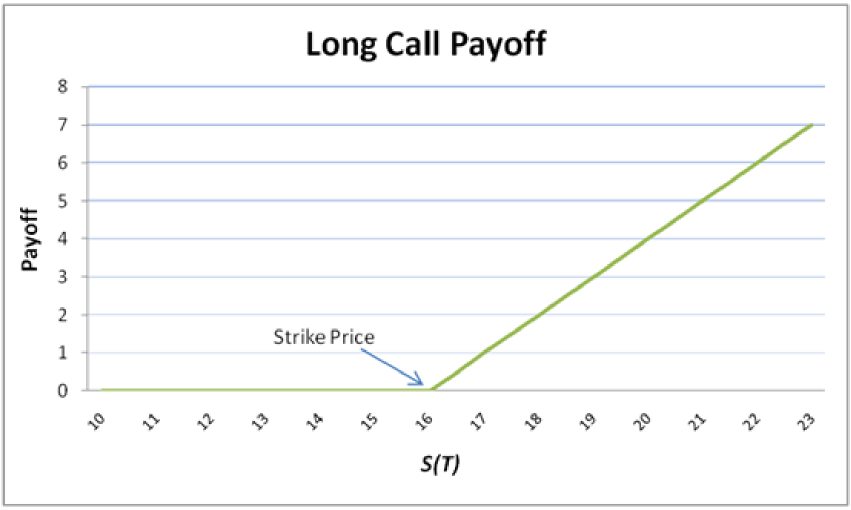
Investor A will gain the maximum of the difference between the spot price of the underlying asset today (meaning S(t)) and the strike price of the Option (meaning K). By contrast, Investor B is obligated to sell to Investor A the stock for $10.

2. The stock's price is **lower than $10** meaning that Investor A will **not exercise** the Option and that is denoted by **0** in the above Payoff.

The example that we described above is called **Plain Vanilla Call Option** and it's the simplest way of describing how Options actually work.

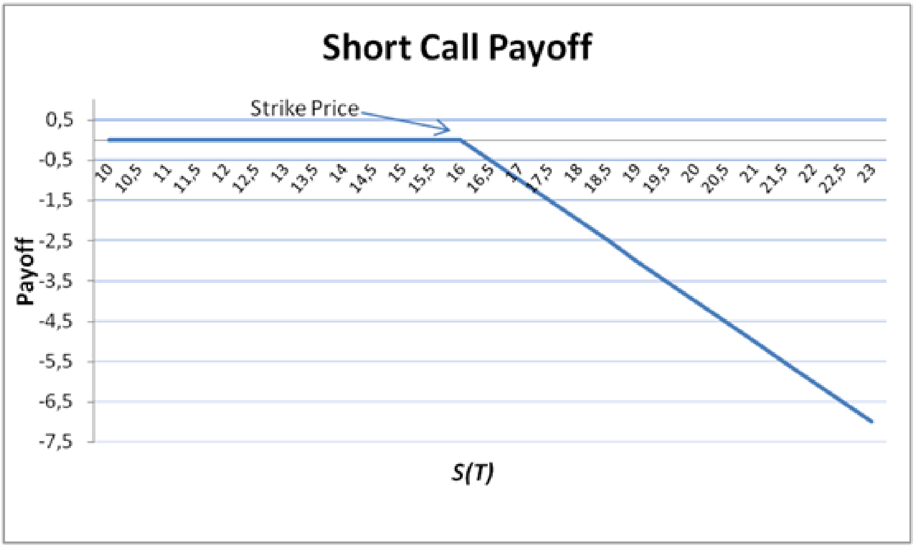
Last but not least, we should mention that the majority of Options contracts are settled in **cash** and not in **physical delivery**. Also, because we would like to visualize each Options position, we set underneath, the four -4- payoff diagrams, one for each position:

Diagram 1.1.3.2.a – Long Call Payoff



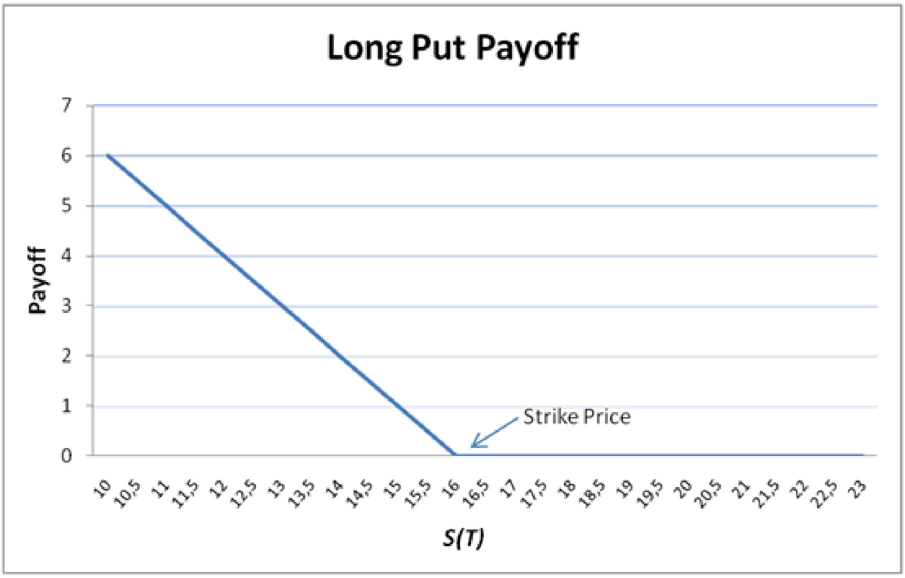
Source: Anthropelos, Michail, University of Piraeus, Department of Banking & Financial Management, Spring, 2018, "*Financial Derivatives Course*", Section 2, "*Introduction to Options*", Page 18.

Diagram 1.1.3.2.b – Short Call Payoff



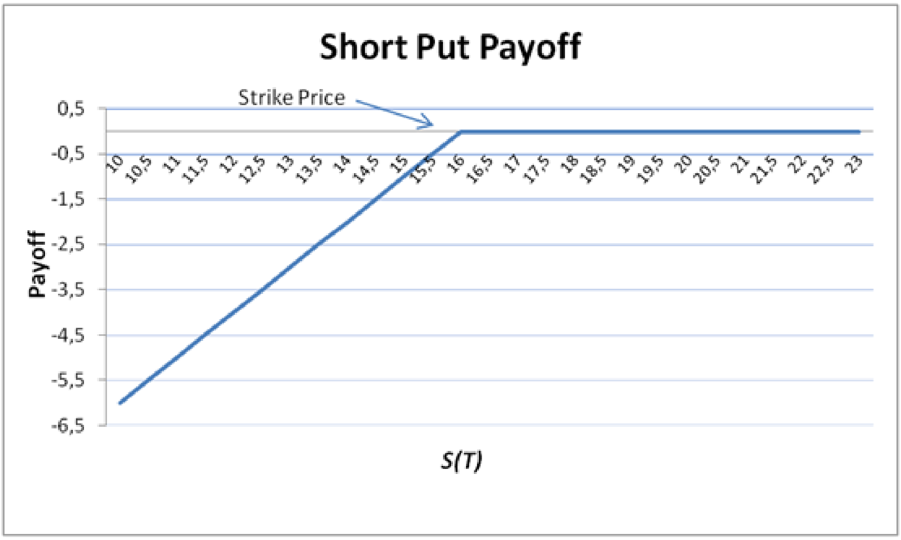
Source: Anthropelos, Michail, University of Piraeus, Department of Banking & Financial Management, Spring, 2018, "*Financial Derivatives Course*", Section 2, "*Introduction to Options*", Page 18.

Diagram 1.1.3.2.c – Long Put Payoff



Source: Anthropelos, Michail, University of Piraeus, Department of Banking & Financial Management, Spring, 2018, "*Financial Derivatives Course*", Section 2, "*Introduction to Options*", Page 19.

Diagram 1.1.3.2.d – Short Put Option



Source: Anthropelos, Michail, University of Piraeus, Department of Banking & Financial Management, Spring, 2018, "*Financial Derivatives Course*", Section 2, "*Introduction to Options*", Page 19.

1.1.3.3 Swaps

The last type of Derivative Instruments that we will discuss in this thesis are the Swaps. "*A Swap is an Over-the-Counter agreement between two companies to exchange cash flows in the future. The agreement defines the dates when the cash flows are to be paid and the way in which they are to be calculated. Usually, the calculation of the cash flows involves the future value of an interest rate, an exchange rate, or another market variable*."[20] The two most popular types of Swap contracts are the following:

- **Interest Rate Swaps**

[20] Hull, C., John, 2012, "*Options, Futures and Other Derivatives*", 8th Edition, Prentice Hall, Pearson Education Inc., Boston, MA, USA, Chapter 7, "*Swaps*", Page 148.

- **Currency Swaps**

We will briefly discuss next each of the above two categories.

Interest Rate Swap: An Interest Rate Swap (IRS) is an agreement between two entities where the one entity will make cash flow payments of interest equal to a predetermined fixed rate while the other will make cash flow payments of interest equal to a floating rate. Both of these transactions will happen for the same period of time and each payment will be calculated based on the same notional value of principal.

<u>Example 1.5</u>:

Company A wants to convert its floating liabilities to fixed ones and Company B wants to convert its fixed liabilities to floating ones. Therefore, they agree to sign a Swap contract. **Company A** will be paying **fixed rate payments** while **Company B** will be paying **floating rate payments**. Both of the payments will be exchanged simultaneously and will be calculated on the notional principal that they both agreed on. The terms of this contract, in hypothetical numbers, are the following:

- **Notional Principal:** $ 100,000,000
- **Fixed Rate:** 8%
- **Fixed Payment for Company A:** $ 8,000,000 (8% * 100,000,000)
- **Floating Rate:** LIBOR
- **Floating Payment:** LIBOR * 100,000,000
- **Initiation Date:** It is the date that the Swap contract commences. In our example, this date is: 09/01/2018
- **Reset Period:** It is the period between the cash flows. In our example, this will be happening every year.
- **Tenor:** It is the life of the Swap. Here we set a life of 5 years.

It is important to note that the notional principal is **never exchanged in the Swap contract**. We simply agree on a notional principal in order to calculate easily the payments of each counterparty. Furthermore, the **swap rate** is the **fixed rate** and **it is never changed throughout the life of the Swap**.

Currency Swap: It is the "*... exchange of principal and interest in one currency for principal and interest in another currency.*"[21] By contrast, **a currency swap involves the payment of interest and principal**, whereas an IRS required only the exchange of interest payments. In this occasion, the principal is specified in each of the two currencies and it has to be almost equal in value, using the exchange rate, on the Swap's initiation date. Also, **the principal is exchanged at the beginning and the end of the Swap's life**. The next example will clear things up:

Example 1.6:

We again have two entities, Company C and Company D that agree on signing a Currency Swap contract. Company C is a European manufacturer in the Eurozone and therefore its home currency is the Euro (€) and Company D is an American manufacturer and therefore its home currency is the dollar ($). They both agreed that the Currency Swap will be a **fixed-for-fixed currency swap** meaning that the interest payments that will be exchanged will all be fixed and not floating. The terms of the contract are the following:

- **Notional Principal:** € 8,500,000 and $ 10,000,000 (€/$ = 0.85)
- **Fixed Rate:** 8.9% in € and 11.2% in $
- **Fixed Payment in €:** $ 850,000 (0.085* $ 10,000,000)
- **Fixed Payment in $:** € 952,000 (0.112* € 8,500,000)
- **Initiation Date:** 07/10/2018
- **Reset Period:** 1 Year
- **Tenor:** 5 Years

Generally, the currency swaps are being used for hedging foreign exchange rate fluctuations, but, on some occasions, they can also be used for speculation.

[21] Hull, C., John, 2012, "*Options, Futures and Other Derivatives*", 8th Edition, Prentice Hall, Pearson Education Inc., Boston, MA, USA, Chapter 7, "*Swaps*", Page 165.

1.1.4 Indirect Investing

In today's financial markets many investors feel the need to invest in a **mutual fund** in order to lower their portfolio risk. **Mutual Funds**[22] are "*... investment vehicles made of a pool of money collected from many investors for the purpose of investing in securities such as stocks, bonds, money market instruments and other assets. They are operated by professional money managers, who allocate the fund's investments and attempt to produce capital gains or income for the fund's investors*." The mutual funds are separated into the following two categories:

Open-end Funds[23]**:** "*Open-end fund shares are purchased and sold directly from and to the mutual fund. They are purchased and sold at the value of the net assets standing behind each share, where the net asset value is determined once a day at a stated time.*"

Close-end Funds[24]**:** "*Closed-end Funds differ from Open-end Funds in that they initially sell a predetermined number of shares in the fund. They then take the proceeds (minus costs) from the sale of fund shares and invest in stocks and bonds. Shares in the fund are then traded on an exchange. The assets of the Closed-end Fund are stocks and bonds.*" Usually, the shares of a Closed-end Fund sell at a discount from net asset value (meaning the actual market value of stocks and bonds that the fund has invested in).

Another type of an indirect investment is an **Exchange-Traded Fund (ETF)**[25]**:** "*An ETF, is a marketable security that tracks an index, a commodity, bonds, or a basket of assets like an index fund. Unlike mutual funds, an ETF trades like a common stock on a stock exchange. They experience price changes throughout the day and they are bought and sold. They also have higher liquidity and lower fees than mutual fund shares.*" It is another investment instrument that owns the underlying assets of the fund and offers shares to the investors, which shares are the proof of indirect ownership of the stocks, bonds and/or commodities that the ETF has invested in. Last but not least,

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[22] Investopedia, Mutual Fund, https://www.investopedia.com/terms/m/mutualfund.asp .
[23] Brown, J., Stephen, Elton, J., Edwin, Goetzmann, N., William, Gruber, J., Martin, 2014, "*Modern Portfolio Theory and Investment Analysis*", 9th Edition, Wiley & Sons Inc., New Jersey, USA, Part 1, "*Introduction*", Chapter 2, "*Financial Securities*", Page 18.
[24] ", Pages 18-19.
[25] Investopedia, Exchange-Traded Fund (ETF), https://www.investopedia.com/terms/e/etf.asp .

ETF shares trade publicly on the Stock Exchange like every other regulated investment instrument.

Investing indirectly certainly can prove less stressful because the asset allocation and the creation of the fund's portfolio is a responsibility of the money manager, but, on the other hand, if the manager is not a trustworthy person, or at least, a person who has a valuable name in the mutual fund market, then it can prove devastating and extremely unprofitable for those who chose to put their money into the fund. That is why many analysts and portfolio managers advise the potential investors to always do a background check of the people in charge of corporations, funds, and banks.

1.2 FUNDAMENTALS OF PORTFOLIO THEORY

Since, in the previous paragraph (Paragraph 1.1) we analyzed the existing financial securities that a potential investor can choose from, in order to construct his portfolio, it is now time to pass to the core aspects of the portfolio theory. We will start by explaining the theory that H. Markowitz suggested and the model that he produced. Then we will continue with explaining the calculation of expected return and risk for individual investments, as well as, for portfolios. Thirdly, we will introduce the mechanisms of efficient frontier and optimal portfolio selection. Last but not least, our analysis will cover the topics of Single-Index Model, the Capital Market Line (CML) and the Capital Asset Pricing Model (CAPM) and their computations.

1.2.1 Markowitz's Theory

Harry Markowitz was an American economist who in 1952 published a paper under the title "*Portfolio Selection*", which was meant to be the fundamental source of the theory of the upcoming book that he published in 1959. This is the paper that gave him the Nobel Prize in Economics. The model that he invented and the theory that he introduced became the bases on which the **Modern Portfolio Theory (MPT)** or Mean-Variance

Analysis was structured. Specifically, MPT is "*... a theory on how risk-averse investors can construct portfolios to optimize or maximize expected return based on a given level of market risk, emphasizing that risk is an inherent part of higher reward. According to the theory, it is possible to construct an efficient frontier of optimal portfolios offering the maximum possible expected return for a given level of risk*"[26].

In the world of H. Markowitz, we can base our analysis on the expected return and the risk of the investment. Specifically, the risk is measured by the variance[27] of the returns. That is the **1st assumption** of the model, meaning that the author assumes that **the risk can be calculated only by knowing the moment of variance** and not any **higher moments** like the ones of **skewness and kurtosis**. Based on this simplification we **informally assume** that the **expected return of a financial security (e.g. stock) follows the Normal Distribution**.

The four -4- hypotheses of this model that H. Markowitz introduced are the following:

1. Investors **assess every stock** by each **expected return and the risk** of that return. The **risk is measured** with the statistical tool of **variance**.
2. Between two -2- stocks that offer the **same expected return**, the investor **chooses the one with the lowest risk**.
3. Between two -2- stocks that offer the **same level of risk**, the investor **chooses the one with the highest expected return**.
4. **All investors are rational**, meaning that each of them should try to **minimize the risk** and **maximize the expected return simultaneously**.
5. The model assumes that **there does not exist a risk-free asset**, meaning that every financial security, instrument or asset accumulates a certain level of risk.

Based on what we have written so far, about this theory, we can utterly conclude that the assumption of normality and the one of rationality are the most important ones. Specifically, a **rational investor** is someone who acts in his most optimal level of benefit or utility. It's that investor who tries to maximize wealth and minimize all the financial risks. Nowadays, the word investor does not necessarily describe the rational investor that used to. Because of the last financial crisis, the existence of behavioral

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[26] Investopedia, Modern Portfolio Theory (MPT), https://www.investopedia.com/terms/m/modernportfoliotheory.asp .
[27] We will see later on in this chapter, the definition of variance and its statistical calculation.

finance has become indispensable in order to explain why investors do not always act rationally and are controlled by fear, anxiety and the behavior of others. In our thesis, however, when we refer to investors, we will always mean the rational ones.

1.2.2 Realized Return & Expected Return

In this subparagraph, we will present the concepts of realized return and expected return. Specifically, in portfolio management, we care most for the expected return on our investments because it is a critical point of choice whether we will proceed with each investment or not. But, before we start elaborating more on each separate return, it would be valuable to present the three -3- different definitions of the word "return" that we can derive from an asset. These are the following:

1. **Expected Return[28]:** "*It is the expected profit or loss an investor anticipates on an investment that has known or expected rates of return.*"
2. **Realized Return[29]:** "*It is the return that is actually earned over a given time period.*"
3. **Required Return[30]:** "*It is the minimum return that an investor will accept for an investment or project that compensates them for a given level of risk.*"

[28] Investopedia, Expected Return, https://www.investopedia.com/terms/e/expectedreturn.asp .
[29] Nasdaq, Realized Return Definition, https://www.nasdaq.com/investing/glossary/r/realized-return .
[30] Investopedia, Required Rate of Return (RRR), https://www.investopedia.com/terms/r/requiredrateofreturn.asp .

1.2.2.1 Realized Return

In individual investments, as well as, in portfolio management, when we want to assess the performance of our portfolio, we use the financial return as a measure of success. The term **financial return**[31] means "*the money made or lost on an investment. A return can be expressed nominally as the change in dollar value of an investment over time. A return can be expressed as a percentage derived from the ratio of profit to investment.*" If we own a financial security (e.g. stock), the realized return is denoted with R and calculated as follows:

$$R = \frac{Final\ Stock\ Price - Initial\ Stock\ Price}{Initial\ Stock\ Price} + \frac{Final\ Year's\ Dividend}{Initial\ Stock\ Price} \quad (\mathbf{1.3})$$

If we denote with $\mathbf{P_f}$ the **Final Stock Price**, with $\mathbf{P_i}$ the **Initial Stock Price** and with $\mathbf{D_f}$ the **Final Year's Dividend**, then the above equation becomes the following:

$$R = \frac{P_f - P_i}{P_i} + \frac{D_f}{P_i} \quad (\mathbf{1.4})$$

Using numbers we get the following result:

<u>Example 1.7</u>

Let's suppose that a stock has a life of one -1- year. Today (meaning the initial stock price) has a price of $10. In one year's time, the price will be $12 (it is the final stock price). In one year, the dividend will be $0.25 per share. If we buy the stock today and we sell it after one year, the return that we will gain is the following:

$$R = \frac{12 - 10}{10} + \frac{0.25}{10} = 0.2 + 0.025 = 0.225\ or\ 22.5\%$$

[31] Investopedia, Financial Return, https://www.investopedia.com/terms/r/return.asp .

By following the above strategy of holding the stock only for 1 year, we gained a profit of 22.5%. This is the traditional way of calculating the financial return of an investment instrument and it is called the **arithmetic return**. Nowadays though, almost everyone uses the **logarithmic return**. The most important reasons that support this decision are the following:

1. **Log-normality:** In research, it is shown that stocks tend to be log-normally distributed. If we use the term log(1+r) in our calculations, then we can safely suppose that our returns will be normally distributed, something that can make our calculations a lot simpler.
2. **Time-additivity:** By using logarithmic returns, we suppose that the trading of financial instruments (e.g. stocks) is constant through time, meaning that we have a continuous stochastic process. In that sense, if we have an ordered sequence of n trades, the return that we get is the **compounding return** which is the following:

$$(1 + r_1)(1 + r_2)(1 + r_3) \dots (1 + r_n) = \prod_i (1 + r_i)^n \quad \mathbf{(1.5)}$$

The problem that arises here is that a compounding return will **not follow a normal distribution**, as Probability Theory supports. So, in order to fix this issue, we use log-normal returns and the return that we get is the sum of these returns, meaning:

$$\sum_i \log(1 + r_i) = \log(1 + r_1) + \log(1 + r_2) + \log(1 + r_3) + \cdots + \log(1 + r_n) \quad \mathbf{(1.6)}$$

The above returns are normally distributed as we mentioned in number 1 and, in theory, we know that when we have a sum of normally distributed data, then the result of the summation will also follow a normal distribution.

3. **Incorporation of Continuous Trading:** When we use the logarithmic return instead of the arithmetic return we encompass the continuous compounding of the stock. By contrast, when we use the arithmetic return we suppose that the stock

was compounded only as many times as we calculated its return. For instance, in the previous arithmetic example (Example 1.7) we take into account one compounding period, a year. In real life though, the compounding for that year was continuous and it did not happen once for the whole period. That is why using a logarithmic return can prove a tool that can bring us closer to reality and provide effective results.

After the analysis of the Logarithmic Return, it is now time to express in a mathematical way its form:

$$R = log\left(\frac{P_f + D_f}{P_i}\right) \quad \mathbf{(1.7)}$$

Where: P_f = Final Stock Price, P_i = Initial Stock Price and D_f = Final Year's Dividend.

<u>Example 1.8</u>

Consider the data from Example 1.7. The **logarithmic return** will be the following:

$$R_{log} = \log\left(\frac{12.25}{10}\right) = 0.08814 \; or \; 8.814\%$$

We can notice that the arithmetic and the logarithmic returns are not the same. That happens because of the continuous compounding that is incorporated into the logarithmic return. In fact, when we use logarithmic returns, we always come across this type of difference.

1.2.2.2 Expected Return

As we saw in the previous subparagraph (subparagraph 1.2.2.1) the realized arithmetic return of the stock in Example 1.7 was 22.5% and the realized logarithmic return of the stock in Example 1.8 was 8.814%. On the other hand, in portfolio theory and generally in every investment that we make, we cannot wait until the time passes and the returns become realized because that strategy is completely risky in the sense that if the outcome is not beneficial for us, we will lose all of our invested capital. Therefore, before we make any investment decision, we have to calculate the projected return based on the information that we now have and the risk that we are willing to take. That is the reason to use the **expected return** of an asset, which is nothing more than the calculation of the **average return** of the asset in the different time periods.

In mathematical terms, the **Expected Return of an Asset** is the following:

$$E(R_i) = \frac{1}{T}\sum_{i=1}^{T} R_{it} \qquad \mathbf{(1.8)}$$

Where,

- $E(R_i)$ = Expected Return of the Asset
- T = The overall time period
- R_{it} = The realized return of every time period before maturity

Example 1.9

Let's assume that we invested in a stock for six -6- months. The realized returns of our stock are the following:

Month	Realized Return
1	0.03
2	0.04
3	0.07
4	0.04
5	0.05
6	0.10

Then, the **expected return** of that stock is calculated as follows:

$$E(R_i) = \frac{(0.03 + 0.04 + 0.07 + 0.04 + 0.05 + 0.10)}{6} = \frac{0.33}{6} = 0.055 \; or \; 5.50\%$$

The expected return that we calculated is the return that we anticipate for one asset. In a portfolio, however, we have an abundance of assets. Therefore, it is important to find a different way to calculate the expected return there. That can be done by using the **value weights** of each particular asset. An **asset's value weight** is the proportion of the capital invested in the portfolio to buy that particular asset. This definition can be expressed as follows:

$$Weight\ (w_i) of\ Asset\ i = \frac{Capital\ invested\ to\ purchase\ the\ asset}{Total\ Capital\ invested\ in\ the\ whole\ portfolio} \quad (\mathbf{1.9})$$

Where,

$$Capital\ invested\ to\ purchase\ the\ asset = Number\ of\ Assets * Asset\ Price \quad (\mathbf{1.10})$$

And,

$$Total\ Capital\ invested\ in\ the\ whole\ portfolio = Sum\ of\ Invested\ Capital\ in\ each\ Asset \quad (\mathbf{1.11})$$

The mathematical way to derive the **Expected Return** of a **Portfolio of Assets** is the following:

$$E(R_p) = \sum_{i=1}^{N} w_i E(R_i) \quad (\mathbf{1.12})$$

Where,

- $E(R_p)$ = Expected Return of the Portfolio
- W_i = The value weight of each asset
- $E(R_i)$ = The Expected Return of each asset
- N = The total number of assets in the portfolio

Example 1.10

Let's assume that we have created a portfolio that is worth of $ 1,000 with the following securities:

Security	Weight	Capital Invested	Expected Return
Stocks	40%	$400 (0.40*1,000)	0.08
Bonds	25%	$250 (0.25*1,000)	0.005
Mutual Fund	10%	$100 (0.10*1,000)	0.0125
Cryptocurrency	25%	$250 (0.25*1,000)	0.125

Then the **Expected Return** of our Portfolio will be the following:

$$E(R_p) = [(40\% * 0.08) + (25\% * 0.005) + (10\% * 0.0125) + (25\% * 0.125)] = 0.06575 \text{ or } 6.575\%$$

1.2.3 Risk/Volatility for Individual Investments

Now that we have measured the expected return on our investments, it is fundamental to calculate the potential risk that we will face with those investments. Again, the analysis will start with the hypothesis that we invest in one asset and then we will present the risk measurement of a portfolio of securities.

Risk or Financial Risk is "*... the possibility that shareholders will lose money when they invest in a company that has debt if the company's cash flow proves inadequate to meet its financial obligations. Financial Risk also refers to the possibility of a corporation or government defaulting on its bonds, which would cause those bondholders to lose money.*"[32] But, we also refer to the word "Volatility". **Volatility** is "*a statistical measure of the dispersion of returns for a given security or market index. Volatility can either be measured by using the standard deviation (s.d.) or variance between returns from that same security or market index. Commonly, the* ***higher the volatility****, the* ***riskier the security****.*"[33]

Now that we have explained both of the above terms, it is time to introduce the mathematical expression of volatility in corporate finance and portfolio theory. If we assume that we have invested our money in one sole asset, then the calculation of its risk will be the volatility of its realized returns. This volatility can be calculated by using the **variance** of the returns. The **variance** measures the squared distance of the realized returns of the asset from the average return or the expected return (as we saw earlier) and is divided by the quantity (T-1). It is denoted by $\boldsymbol{\sigma^2}$ or **Var** and the mathematical expression is the following:

$$Var(R_i) = \frac{1}{T-1}\sum_{t=1}^{T}(R_{it} - E(R_{it}))^2 \quad \mathbf{(1.13)}$$

Where,

- **Var (R_i)** = The variance of the realized returns
- **T-1** = The overall time period minus one -1- time period. We subtract one period because we use the average return in our calculations and we lost one degree of freedom. Moreover, we have data from a specific sample and not from the whole population. Specifically, the term (T-1) equals the average of the standard deviations of all the samples in the population. Therefore, using (T-1) instead of (T) makes the calculations unbiased.

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[32] Investopedia, Financial Risk, https://www.investopedia.com/terms/f/financialrisk.asp .
[33] ″, Volatility, https://www.investopedia.com/terms/v/volatility.asp .

- **R_i** = The realized returns of the asset in each specific period
- **$E(R_i)$** = The expected return of that asset

There is also another mathematical expression for the computation of Variance and that is the following:

$$Var(R_i) = E(R_{it}^2) - \left(E(R_{it})\right)^2 \quad (\mathbf{1.14})$$

The above expression is mostly used in statistics. In this thesis, however, we will make use of the **equation 1.13** and the equivalent one for portfolios.

<u>Example 1.11</u>

Using the data of Example 1.9 we see that the **variance** of the realized returns is the following:

$$Var\ (R_i) = \frac{1}{6-1} * [(0.03-0.055)^2 + (0.04-0.055)^2 + (0.07-0.055)^2 + (0.04-0.055)^2 + (0.05-0.055)^2 + (0.10-0.055)^2] = \cdots = 0.00056$$

Furthermore, as the definition of volatility mentions, we can use as well, the **standard deviation** (denoted by **σ)** of the realized returns, which is the square root of the variance, meaning:

$$\sigma(R_i) = \sqrt{Var(R_i)} \quad (\mathbf{1.15})$$

In our example, the **standard deviation** of the realized returns of the stock is the following:

$$\sigma(R_i) = \sqrt{0.00056} = 0.02363 \; or \; 2.363\%$$

If we want to find a measure that can inform us of the risk of our portfolio related to the expected return that this specific portfolio offers, then we can make use of a statistical measure called **Coefficient of Variation (CV)**. CV is highly used in portfolio management and represents the ratio of the standard deviation to the mean (expected return). It represents the risk per unit of expected return. It assumes that the data follow a Normal Distribution and it is calculated as follows:

$$CV(R_i) = \frac{\sigma(R_i)}{E(R_i)} \quad (\mathbf{1.16})$$

In the previous example (Example 1.11), the CV is the following:

$$CV(R_i) = \frac{0.02363}{0.055} = 0.429 \; or \; 42.9\%$$

As we said in paragraph 1.2.1, according to H. Markowitz, we should minimize the risk of the investment and maximize our expected return. Based on this assumption, when we calculate the Coefficient of Variation (CV), **we will always search for the lowest CV** of all the potential investments, meaning that **the lower the CV**, **the lower risk we accumulate per every unit of expected return**.

Before we start introducing the equivalent measures that can be used to calculate the risk of a portfolio, it is important to analyze what happens when we have two or more financial instruments that affect each other's price movements. Then it will not be completely right to only calculate the variance of each asset's returns, but, we will have to use a statistical tool called **Covariance**. **Covariance** is "… *a measure of the directional relationship between the returns on two risky assets. A positive covariance means that asset returns move together while a negative covariance means that asset returns move inversely*."[34] It is denoted by **Cov (R_i, R_j)** and the statistical expression of covariance is the following:

$$Cov(R_i, R_j) = \frac{1}{T-1} * \sum_{t=1}^{T} \left[\left(R_{it} - E(R_{it})\right) * \left(R_{jt} - E(R_{jt})\right) \right] \quad (\mathbf{1.17})$$

Example 1.12

Let's assume that we want to calculate the covariance among two stocks, Stock A and Stock B. Then, in the following table we can see the realized returns of each stock for a time period of 3 months:

Month	Stock A Realized Returns	Stock B Realized Returns
1	0.01	-0.015
2	0.03	0.02
3	0.05	0.025
Expected Return	**0.03**	**0.01**

Then, based on the **equation 1.16** the covariance among the two stocks is the following:

$$Cov(A, B) = \frac{[(0.01 - 0.03) * (-0.015 - 0.01) + \cdots + (0.05 - 0.03) * (0.025 - 0.01)]}{3-1}$$
$$= \frac{0.0005 + 0 + 0.0003}{2} = 0.0004$$

[34] Investopedia, Covariance, https://www.investopedia.com/terms/c/covariance.asp .

Since the above covariance is **positive** then we can conclude that the returns of the two stocks move together. Nevertheless, because the calculated covariance is almost zero (0), then we can also say that the effect of the positive covariance is not that significant for the time period that we examined.

If we have more than two assets to analyze (something that always happens in a portfolio of assets) we can use a matrix instead. This matrix is called the **Variance-Covariance Matrix** and it is highly used in Portfolio Management. It is actually a table, on which, on the main diagonal the variances of each separate asset appear. Above and underneath the diagonal, we find the covariances of the different assets. A theoretical (without numbers) example is shown below. We assume that the portfolio is created with five -5- different assets (1, 2, 3, 4, 5). Then, the matrix will be the next table:

Table 1.2.3.a – Variance-Covariance Matrix of 5 Financial Assets

	Asset 1	**Asset 2**	**Asset 3**	**Asset 4**	**Asset 5**
Asset 1	**Var(1,1)**	Cov(1,2)	Cov(1,3)	Cov(1,4)	Cov(1,5)
Asset 2	Cov(2,1)	**Var(2,2)**	Cov(2,3)	Cov(2,4)	Cov(2,5)
Asset 3	Cov(3,1)	Cov(3,2)	**Var(3,3)**	Cov(3,4)	Cov(3,5)
Asset 4	Cov(4,1)	Cov(4,2)	Cov(4,3)	**Var(4,4)**	Cov(4,5)
Asset 5	Cov(5,1)	Cov(5,2)	Cov(5,3)	Cov(5,4)	**Var(5,5)**

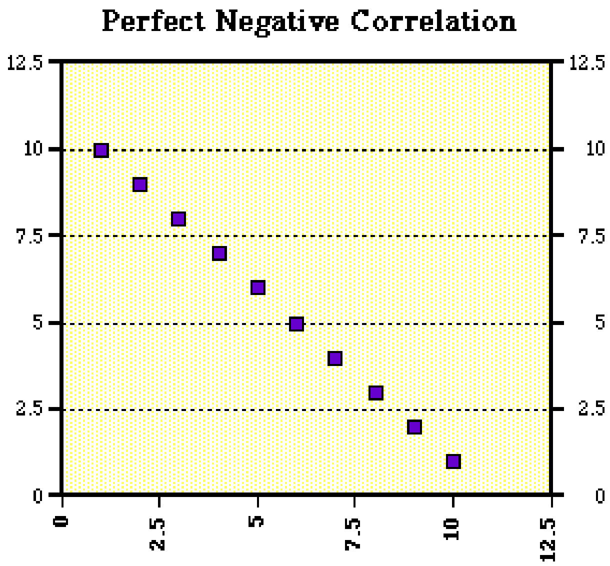
Nevertheless, calculating the covariance does not remove completely the bias of our computations. This happens because the covariance as a measure of the correlation among different assets has a major disadvantage. It shows us the direction of the movement of the returns of each asset but **it does not show the strength of the relationship between the returns**. To address this issue, we also use the **Correlation Coefficient (Corr(R_i, R_j))**. The correlation coefficient shows how powerful is the relationship between the returns of two different assets. Its mathematical expression is the following:

$$Corr(R_i, R_j) = \frac{Cov(R_{it}, R_{jt})}{\sigma(R_{it}) * \sigma(R_{jt})} \quad \mathbf{(1.18)}$$

The correlation coefficient can take values in the range [-1.0, 1.0]. In this numerical range, we can introduce (theoretically) the following five -5- cases:

1. **Corr(R_i, R_j) = -1.0, Perfect Negative Correlation** (Theoretical Case): It means that the returns move in opposite directions and when one increases the other decreases. Geometrically, it means that all the pairs of the returns are found on the same straight trend line which has a negative slope. The following diagram describes the case:

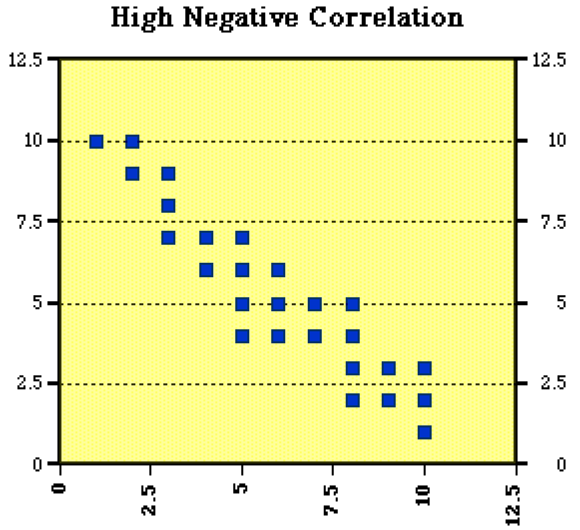
Diagram 1.2.3.a – Perfect Negative Correlation



Source: University of Illinois at Urbana-Champaign, College of Education, Office for Mathematics, Science & Technology Education, Chicago, USA. Link: http://mste.illinois.edu/courses/ci330ms/youtsey/scatterinfo.html

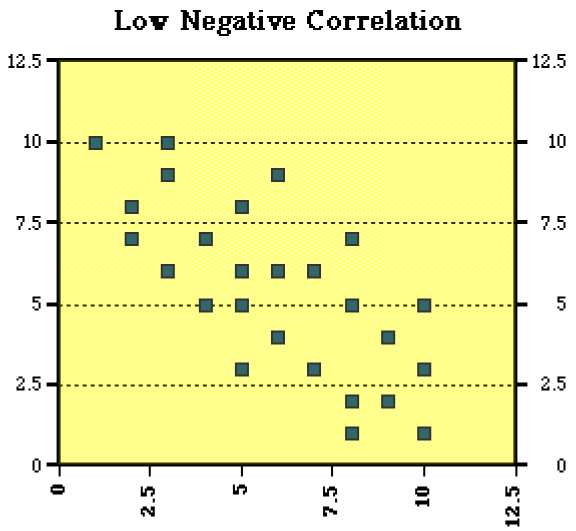
2. **-1.0 < Corr(R_i, R_j) < 0.0, Negative Correlation:** It is the case when we have a negative relationship between the returns but not a strong form of that negativity as in the previous case. Geometrically, the pairs of the returns move around the trend line which has a negative slope. We can either observe a **high negative correlation** when the correlation coefficient is close to -1.0, or we can observe a **low negative correlation** when the correlation coefficient is close to 0.0. The following diagrams describe these two cases:

Diagram 1.2.3.b – High Negative Correlation



Source: University of Illinois at Urbana-Champaign, College of Education, Office for Mathematics, Science & Technology Education, Chicago, USA. Link: http://mste.illinois.edu/courses/ci330ms/youtsey/scatterinfo.html

Diagram 1.2.3.c – Low Negative Correlation

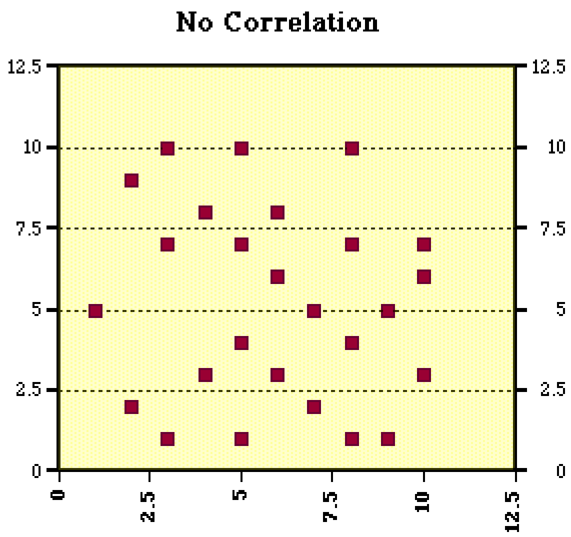


Source: University of Illinois at Urbana-Champaign, College of Education, Office for Mathematics, Science & Technology Education, Chicago, USA. Link: http://mste.illinois.edu/courses/ci330ms/youtsey/scatterinfo.html

3. **Corr(R_i, R_j) = 0.0, Zero Correlation:** It happens when the returns of each asset do not show a linear relationship. Every return is linearly independent of the others. Geometrically, the returns of the assets do not follow a certain path or a specific

trend line and they do not form a certain geometric shape (e.g. a line). The following diagram describes exactly that:

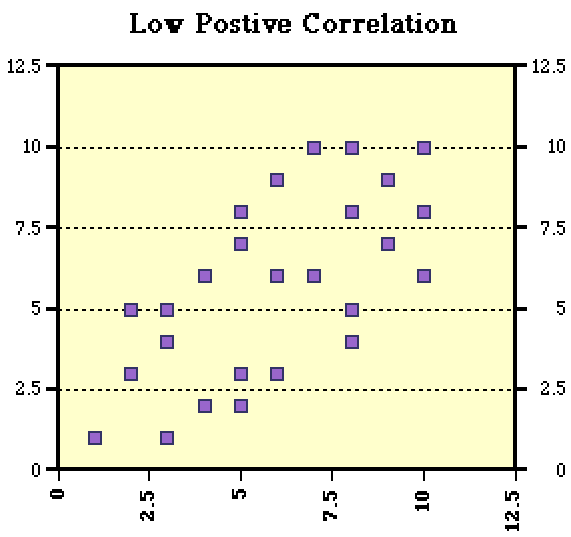
Diagram 1.2.3.d – Zero Correlation



Source: University of Illinois at Urbana-Champaign, College of Education, Office for Mathematics, Science & Technology Education, Chicago, USA. Link: http://mste.illinois.edu/courses/ci330ms/youtsey/scatterinfo.html

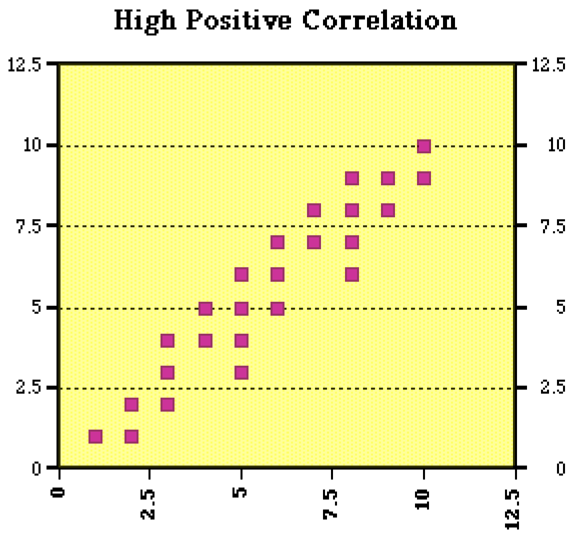
4. **0.0 < Corr(R_i, R_j) < 1.0, Positive Correlation:** It is the case when we have a positive relationship between the returns but not a perfect form of positive correlation. Geometrically, the pairs of the returns move around the trend line which has a positive slope. We can either observe a **low positive correlation** when the correlation coefficient is close to 0.0, or we can observe a **high positive correlation** when the correlation coefficient is close to 1.0. The following diagrams describe these two cases:

Diagram 1.2.3.e – Low Positive Correlation



Source: University of Illinois at Urbana-Champaign, College of Education, Office for Mathematics, Science & Technology Education, Chicago, USA. Link: http://mste.illinois.edu/courses/ci330ms/youtsey/scatterinfo.html

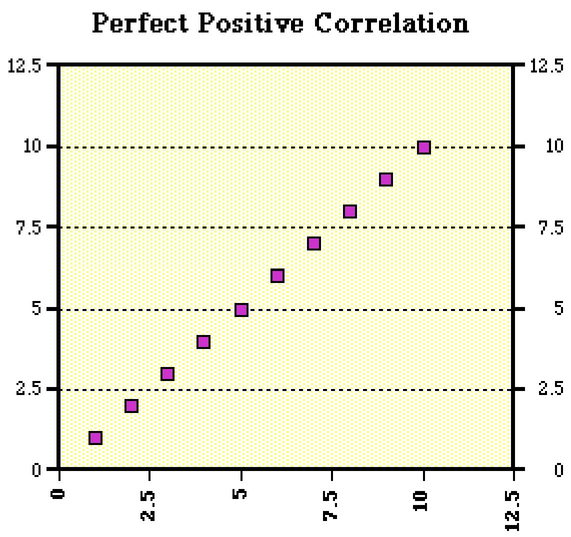
Diagram 1.2.3.f – High Positive Correlation



Source: University of Illinois at Urbana-Champaign, College of Education, Office for Mathematics, Science & Technology Education, Chicago, USA. Link: http://mste.illinois.edu/courses/ci330ms/youtsey/scatterinfo.html

5. **Corr(R_i, R_j) = 1.0, Perfect Positive Correlation** (Theoretical Case): It means that the returns move together and in the same direction and when one increases the other increases too. Geometrically, it means that all the pairs of the returns are found on the same straight trend line which has a positive slope. The following diagram describes the phenomenon:

Diagram 1.2.3.g – Perfect Positive Correlation



Source: University of Illinois at Urbana-Champaign, College of Education, Office for Mathematics, Science & Technology Education, Chicago, USA. Link: http://mste.illinois.edu/courses/ci330ms/youtsey/scatterinfo.html

In general, when we find two financial assets (e.g. two stocks) that have a **perfect positive** or a **perfect negative** correlation, then we can be sure that these two assets are **substitutes**. A general rule that a potential investor can establish when considering assets to construct his/her portfolio is that he/she should choose assets with returns that show a **low positive** or a **low negative** correlation. It is important to understand that we **do not want assets with returns of zero correlation** because then it will be extremely difficult for us to identify and project the expected returns of them, and as a result, we will be exposed to significant amounts of risk. Finally, as a rule of thumb, if two assets offer a correlation coefficient of less or equal to 0.5, then the investor is safe because this correlation coefficient is considered to be low.

Example 1.13

Consider the data of Example 2.12. The calculated variance and standard deviation of each of the two assets are shown below:

$$Var(A) = \frac{[(0.01 - 0.03)^2 + (0.03 - 0.03)^2 + (0.05 - 0.03)^2]}{3 - 1} = \frac{0.0008}{2}$$
$$= 0.0004$$

$$\sigma(A) = \sqrt{Var(A)} = \sqrt{0.0004} = 0.02 \; or \; 20\%$$

$$Var(B) = \frac{[(-0.015 - 0.01)^2 + (0.02 - 0.01)^2 + (0.025 - 0.01)^2}{3 - 1} = \frac{0.00095}{2}$$
$$= 0.000475$$

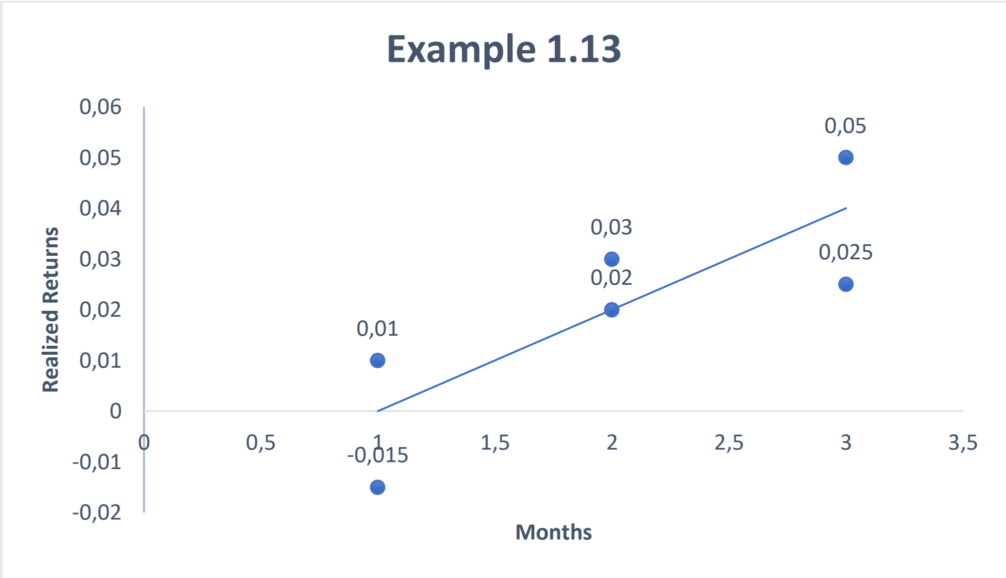
$$\sigma(B) = \sqrt{Var(B)} = \sqrt{0.000475} = 0.0218 \; or \; 21.8\%$$

Based on the above results we can now compute the Correlation Coefficient:

$$Corr(A, B) = \frac{0.0004}{0.02 * 0.0218} = 0.9174 \; or \; 91.74\%$$

Based on the theory we described in the previous pages, the result of 91.74% is a **high positive correlation**, meaning that the returns of the assets A and B move together and around the positive trend line. The following diagram describes geometrically what we have just proved with numbers:

Diagram 1.2.3.h – Example 2.13



As we mentioned in the case of Covariance, if we have more than two assets and we want to calculate all the correlation coefficients that exist between them, then we can construct a **Correlation Coefficient Matrix**. It is a table as the one of covariance and on the main diagonal appear the correlation coefficients that each asset has with itself, meaning that every correlation coefficient in every cell on the diagonal is equal to 1.0. In this case, as well, above and underneath the main diagonal we find the correlation coefficients of the different assets. If we assume again five -5- assets, then the Correlation Coefficient Matrix is the following:

Table 1.2.3.b – Correlation Coefficient Matrix of 5 Financial Assets

	Asset 1	Asset 2	Asset 3	Asset 4	Asset 5
Asset 1	**Corr(1,1)=1**	Corr(1,2)	Corr(1,3)	Corr(1,4)	Corr(1,5)
Asset 2	Corr(2,1)	**Corr(2,2)=1**	Corr(2,3)	Corr(2,4)	Corr(2,5)
Asset 3	Corr(3,1)	Corr(3,2)	**Corr(3,3)=1**	Corr(3,4)	Corr(3,5)
Asset 4	Corr(4,1)	Corr(4,2)	Corr(4,3)	**Corr(4,4)=1**	Corr(4,5)
Asset 5	Corr(5,1)	Corr(5,2)	Corr(5,3)	Corr(5,4)	**Corr(5,5)=1**

Now that we have described what tools we need in order to calculate the risk involved in individual investments of one or more assets, we will introduce the tools that the portfolio theory suggests. As we will see, these are the same equations, but some of them will be slightly changed.

1.2.4 Portfolio Risk/Volatility

The portfolio risk is computed with the statistical measure of **Portfolio Variance**. Specifically, the **equation 1.13** for a portfolio of more than one assets becomes the following:

For $i \neq j$,

$$Var(R_p) = \sum_{i=1}^{N} w_i^2 * Var(R_{it}) + \sum_{i=1}^{N}\sum_{j=1}^{N} w_i * w_j * Cov(R_{it}, R_{jt}) \quad (\mathbf{1.19})$$

Where,

- **Var(R_p)** = The portfolio variance
- **w_i, w_j =** The weights of each asset
- **Var(R_{it}) =** The variance of each separate asset
- **Cov(R_{it}, R_{jt})** = Covariance of the assets. Also, **Cov(R_{it}, R_{jt}) = Corr(R_{it}, R_{jt})*σ(R_i)*σ(R_j)**

Moreover, the **Standard Deviation** of the portfolio is denoted with **σ** and is calculated as follows:

$$\sigma(R_p) = \sqrt{Var(R_p)} \quad (\mathbf{1.20})$$

Last but not least, if we want to measure the risk per unit of the expected return of our portfolio we can deploy the **Coefficient of Variation (CV)** and assume for one more time, that our data are following the Normal Distribution function. The CV is calculated as follows:

$$CV_p = \frac{\sigma(R_p)}{E(R_p)} \quad \mathbf{(1.21)}$$

In this case, as well, **we will always search for the lowest CV** of all the potential investments, meaning that **the lower the CV**, **the lower risk we accumulate per every unit of expected return**, based on the Markowitz's Theory.

<u>Example 1.14</u>

Let's assume that we want to construct two different portfolios (Portfolio A and Portfolio B) based on two -2- separate stocks. The next table shows the realized returns of the two stocks and their expected returns, for a time period of six -6- months:

Months	Realized Returns of Stock 1	Realized Returns of Stock 2
1	0.03	0.05
2	0.025	0.02
3	0.024	0.03
4	0.04	0.06
5	0.06	-0.02
6	0.065	0.09
Expected Return	**0.0407 or 4.07%**	**0.0383 or 3.83%**

Let's assume, as well, that the two -2- portfolios that we aim to construct will weight each stock as follows:

	The weight of Stock 1	The weight of Stock 2
Portfolio A	60%	40%
Portfolio B	40%	60%

We will calculate each stock's variance and standard deviation and the covariance between them. We denote with **Var(R_1)** and **Var (R_2)**, the **variance of each stock**, with **σ(R_1)** and **σ(R_2)**, the **standard deviation** and with **Cov(R_1, R_2)** the **covariance** between Stock 1 and Stock 2. The results are the following:

$$Var(R_1) = \frac{[(0.03 - 0.047)^2 + (0.025 - 0.047)^2 + \cdots + (0.065 - 0.047)^2]}{6 - 1}$$
$$= 0.0002672$$

$$Var(R_2) = \frac{[(0.05 - 0.0383)^2 + (0.02 - 0.0383)^2 + \cdots + (0.09 - 0.0383)^2]}{6 - 1}$$
$$= 0.001181$$

$$\sigma(R_1) = \sqrt{Var(1)} = \sqrt{0.0002672} = 0.016347 \; or \; 1.6347$$

$$\sigma(R_2) = \sqrt{Var(2)} = \sqrt{0.001181} = 0.034359 \; or \; 3.4359\%$$

$$Cov(R_1, R_2)$$
$$= \frac{[(0.03 - 0.047) * (0.05 - 0.0383) + \cdots + (0.065 - 0.047) * (0.09 - 0.0383)]}{6 - 1}$$
$$= 0.00007$$

Based on the above calculations, now, we can measure the following:

- The **Expected Return** (denoted with **E(R_A) for Portfolio A** and **E(R_B) for Portfolio B**)
- The **variance** (denoted with **Var(R_A) for Portfolio A** and **Var(R_B) for Portfolio B**)
- The **standard deviation** (denoted with **σ(R_A) for Portfolio A** and **σ(R_B) for Portfolio B**)
- The **Coefficient of Variation** (denoted with **CV_A for Portfolio A** and **CV_B for Portfolio B**).

Next, we show the results of each separate calculation:

$$E(R_A) = [(0.6 * 0.0407) + (0.4 * 0.0383)] = 0.0397 \ or \ 3.97\%$$

$$E(R_B) = [(0.4 * 0.0407) + (0.6 * 0.0383)] = 0.0393 \ or \ 3.93\%$$

$$Var(R_A) = (0.6)^2 * (0.016347)^2 + (0.4)^2 * (0.034359)^2 + 2 * 0.6 * 0.4 * 0.00007 = 0.00032$$

$$Var(R_B) = (0.4)^2 * (0.016347)^2 + (0.6)^2 * (0.034359)^2 + 2 * 0.4 * 0.6 * 0.00007 = 0.00050$$

$$\sigma(R_A) = \sqrt{Var(R_A)} = \sqrt{0.00032} = 0.01789 \ or \ 1.789\%$$

$$\sigma(R_B) = \sqrt{Var(R_B)} = \sqrt{0.00050} = 0.02236 \ or \ 2.236\%$$

$$CV_A = \frac{\sigma(R_A)}{E(R_A)} = \frac{0.01789}{0.0397} = 0.4506 \ or \ 45.06\%$$

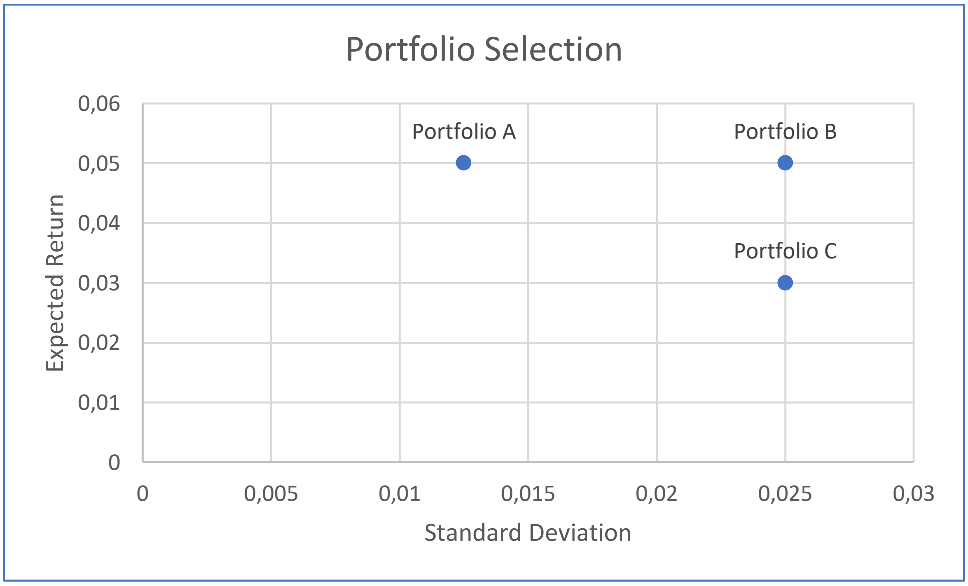
$$CV_B = \frac{\sigma(R_B)}{E(R_B)} = \frac{0.02236}{0.0393} = 0.5689 \; or \; 56.89\%$$

Based on the Markowitz's Theory and the results of the CVs, we can conclude that **Portfolio A offers a lower CV and therefore a lower amount of risk than Portfolio B**. So, we choose to construct Portfolio A and not Portfolio B.

1.2.5 Efficient Frontier & Optimal Portfolio Selection

In this paragraph, we will continue the Markowitz's Theory that we introduced in paragraph 1.2.1 in order to construct the efficient frontier and to find the optimal portfolio in terms of efficiency, as described by H. Markowitz. Firstly though, we will start our analysis based on a very simple and understandable diagram:

Diagram 1.2.5.a – Portfolio Selection



In the above diagram we can notice three -3- different portfolios, Portfolio A, Portfolio B and Portfolio C. Let's compare the portfolios two by two, meaning that we will compare portfolios A and B first, then B and C and finally A and C. Portfolios A and B offer the exact same expected return which is equal to 0.05 or 5%, but **Portfolio A offers a risk of 0.0125 whereas, Portfolio B offers a risk of 0.025**. Recalling the hypothesis 2 of the theory that H. Markowitz introduced in 1952, in this situation we would choose **Portfolio A** because it offers a **lower level of risk involved than Portfolio B.**

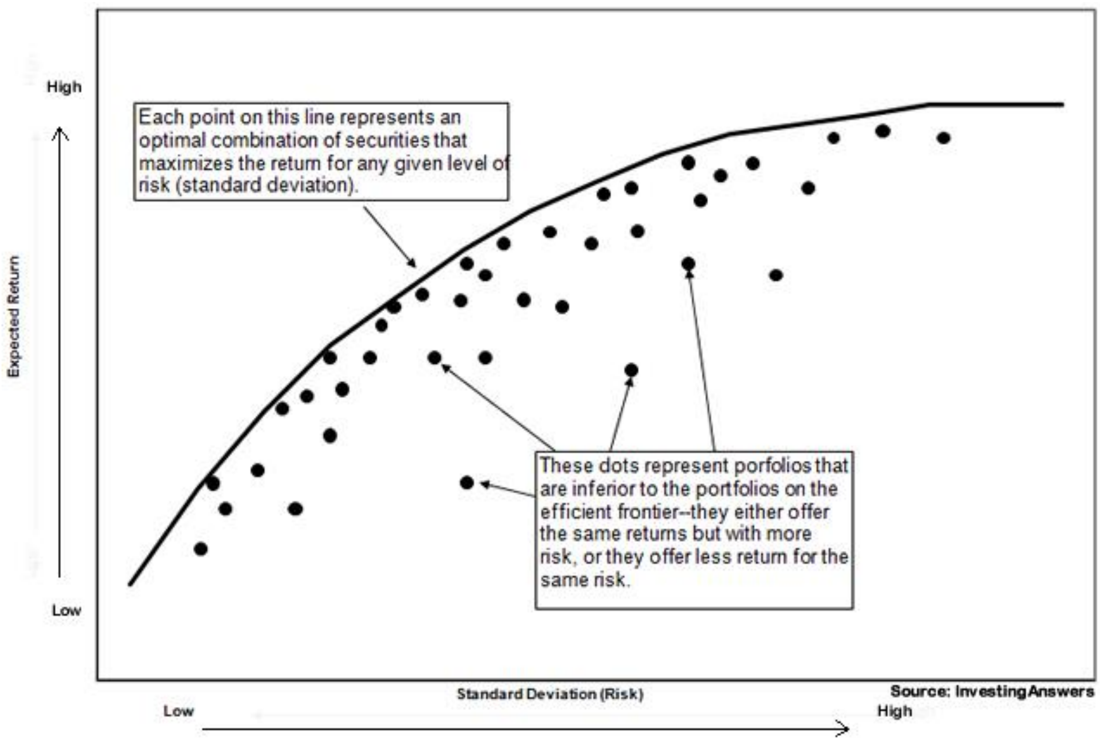
On the other hand, when we compare portfolios B and C, we notice that these offer the exact same risk (or standard deviation equal to 0.025), but **Portfolio B offers a higher return (0.05) than Portfolio C (0.03)**, and that is the reason to choose **Portfolio B** (hypothesis 3 of Markowitz's Theory). Furthermore, the comparison of Portfolio A to Portfolio C gives the conclusion that, by far, **Portfolio A is a better choice than Portfolio C**. It offers **a higher return (0.05 rather than 0.03) and lower risk involved (0.0125 rather than 0.025)**. Last but not least, if we want to test all the three -3- existing portfolios, we would again conclude that **Portfolio A outperforms Portfolios B and C**, in terms of H. Markowitz's Theory.

The previous theoretical example was the first step to understand how portfolio selection works, based on the theory of Markowitz. But, the question that arises is the following: Are we certain that Portfolio A is the most efficient portfolio there is? The answer is No, we do not know that. Let's remind what Markowitz suggests as an **Efficient Portfolio**. It is the portfolio with the **highest expected return and the lowest possible risk involved, simultaneously**. This definition exposes the fundamental problem of controlling risk. In order to do so, Markowitz assumes that we have to **minimize the term** $\sigma^2(R_p)$ based on the three following -3- conditions that he posed:

1. **A Certain Expected Return**, meaning $E(R_p) = k\%$, where k is a number
2. $\sum_{i=1}^{n} w_i = 1$, meaning that **the sum of all the weights of the assets in a portfolio is equal to one**
3. $w_i \geq 0, \forall i$, meaning that **all the weights have to be greater than zero, for every i**

If we have to choose to invest in a portfolio of assets, but our potential choices are unlimited (meaning that we can choose among a great variety of existing portfolios) then we should choose a portfolio that lies close to the **Efficient Frontier**. The **Efficient Frontier** is a modern portfolio theory tool that shows investors the best possible return they can expect from their portfolio, given the level of volatility they are willing to accept. Basically, it is a set of optimal portfolios (meaning portfolios with the lowest risk and the highest expected return based on that risk). Graphically, an efficient frontier is the following:

Diagram 1.2.5.b – Efficient Frontier



Source: Efficient Frontier, Investing Answers, http://www.investinganswers.com/financial-dictionary/investing/efficient-frontier-1010.

As we notice, the efficient frontier is constructed with portfolios having an **optimal level of balance between expected return and risk**. Every portfolio on the black line is an **Optimal Portfolio**, meaning **a portfolio with the most efficient risk-return**

tradeoff, whereas, every portfolio that can be found underneath the black line is not an optimal one and underperforms in terms of return and/or risk. The first point (meaning the first portfolio) that lies on the curve of the efficient frontier and is situated at the left-bottom side of the curve is the portfolio with the lowest level of risk and is called a **Spherical Portfolio**. Also, every portfolio above the black line is impossible to be reached.

We stated before that the efficient frontier gives investors the chance to optimize their financial returns **based on the level of risk they are willing to accept**. In Markowitz's world, an investor is always supposed to be risk-averse and rational. Based on this assumption, every investor would choose a portfolio somewhere in the middle of the curve. But, as it turns out, that is not the case. Imagine a 25-year-old investor and an 85-year-old investor. The first one is agile, young, enthusiastic, fearless of losing money and willing to accept more risk because he aims for a higher return.

On the other hand, the 85-year-old investor is someone who has lived his life, is cautious, very responsible and not willing to take that much risk. Therefore, a logical assumption is that these two types of investors will not land on the same point on the efficient frontier. Actually, that is the case. Based on the characteristics of the 25-year-old, he will probably move to a higher level of return, meaning that he will choose a portfolio on the upper-right end of the curve. By contrast, the 85-year-old will choose a risk-return pair on the lower-left side of the curve. What is important is to always remember that whatever your risk tolerance is, you should always choose a combination of assets (a portfolio) as close as possible to the efficient frontier.

Before we end this paragraph, it is important to mention some of the limitations of the Markowitz's Theory. First of all, Markowitz assumes that all investors are rational, a theory that nowadays tends to become abolished, specifically after the world financial crisis. Furthermore, the notion of normality in the data might not represent 100% the existing reality, because we keep finding asset returns deviating from the mean more than two -2- or three -3- standard deviations. Also, the hypothesis that investors have unlimited access to borrowing and lending is quite outdated, especially when the majority of investors today, are people that invest a certain and very fixed amount of money and many of them might experience capital controls, as well. Last but not least, the assumption that market prices cannot be influenced by anyone is quite false because large institutional investors and corporations have been accused in the past for manipulating market prices, especially in the developed financial markets.

1.2.6 The Single-Index Model (SIM) For Individual Investments

We have now reached a point where we should start analyzing Asset Pricing Models and the first one we will introduce is the **Single-Index Model (SIM)** which is a return production model of stocks and portfolios. According to this model, the returns of a security can be represented as a linear relationship with one economic variable relevant to this specific security. We assume that there is only one -1- macroeconomic factor that causes the **systematic risk** affecting all security returns and this factor can be represented by the rate of return on a market index. Basically, the return of a security (e.g. stock) is a simple linear function of the returns of a stock market index. In mathematical terms the model is the following:

$$R_i = a_i + \beta_i * R_m + e_i \quad \mathbf{(1.22)}$$

Where,

- **R_i** = It is the return of the security (e.g. stock).
- **a_i** = It represents the abnormal returns of the security and it is a constant.
- **β_i** = It represents the beta of the security. The **beta measures the volatility of a security in relation to a stock market index**. It can be expressed as a **sensitivity coefficient**, meaning that it can show **how sensitive are the returns of the security to the movements of the index returns**. It is calculated as follows:

$$\beta_i = \frac{Cov(R_i, R_m)}{Var(R_m)} \quad \mathbf{(1.23)}$$

- **R_m** = It represents the returns of the stock market index.
- **e_i** = It represents the statistical standard error and it is a part of the unsystematic risk of the security.

Macroeconomic events, such as interest rates or the cost of labor, causes the systematic risk that affects the returns of all stocks, and the **firm-specific events** are the **unexpected microeconomic events** that affect the returns of specific firms, such as the death of key people or the lowering of the firm's credit rating, that would affect the firm, but would have a negligible effect on the economy.

If we want to transform the previous model into an **Empirical Single-Index Model**, then, we will have to use the notion of time and the model becomes the following one:

$$R_{it} = a_i + \beta_i * R_{mt} + e_{it} \quad \mathbf{(1.24)}$$

Also, in order to use the **Empirical Single-Index Model** we assume the following five -5- hypotheses:

1. $E(e_{it}) = 0$
2. $Cov(R_{mt}, e_{it}) = 0$
3. $\sigma^2(e_{it})$ → It must remain constant through time. This phenomenon means that our **standard errors must be homoscedastic**
4. $Cov(e_{it}, e_{i(t-1)}) = 0$, meaning that **the standard errors will present zero autocorrelation**
5. The terms (a_i) and (β_i) must remain constant through time

Based on Equation 1.24, the **overall return** of a security is split into two -2- parts; the **Non-Systematic Return** and the **Systematic Return**.

Non-Systematic Return = a_{it} + e_{it} , It is the return due to firm-specific factors and can be controlled by the firm.

Systematic Return = β_i*R_{mt} , It is the return due to the index performance. This return cannot be controlled by the firm.

In general, we use this model to calculate **Expected Returns** and the **Variance (Risk)** of the returns of the security that we examine. The equation 1.24 becomes then, the following:

$$E(R_{it}) = a_i + \beta_i * E(R_{mt}) \quad \mathbf{(1.25)}$$

In terms of **Expected Return**, we can again separate it into **Non-Systematic Return** and **Systematic Return**.

Non-Systematic Return = a_i

Systematic Return = β_i*E(R_{mt})

The above equation (**equation 1.25**) calculates the **Expected Return** of the security. It is written without the term E(e_{it}) because hypothesis 1 informs us that E(e_{it}) = 0. The **variance of the return** is calculated as follows:

$$Var(R_{it}) = (\beta_i^2 * Var(R_{mt})) + Var(e_{it}) \quad \mathbf{(1.26)}$$

Again, the **overall risk** of the security is split into two -2- categories; the **Systematic Risk** and the **Non-Systematic Risk**.

Systematic Risk = β_i^2*Var(R_{mt})

Non-Systematic Risk = Var(e_{it})

<u>Mathematical Proof of the Beta (β_i)</u>

Because in this paragraph, we introduced a different measure of risk, which is the **beta**, and in order not to confuse the reader, it would be wise to show the **mathematical proof** of the **beta (β_i)**:

$$
\begin{aligned}
Cov(R_i, R_m) &= Cov(a_i + \beta_i * R_m + e_i, R_m) \\
&= Cov\big((a_i, R_m) + \beta_i * (R_m, R_m) + (e_i, R_m)\big) \\
&= Cov(a_i, R_m) + \beta_i * Cov(R_m, R_m) + Cov(e_i, R_m) \\
&= \beta_\iota * Cov(R_m, R_m)
\end{aligned}
$$

Because **Cov(a_i, R_m) = 0**, due to the fact that **a_i is a variable** and **Cov(e_i, R_m) = 0 from hypothesis 2**. Furthermore, **Cov(R_m, R_m) = Var(R_m)**.

So, we have the following:

$$Cov(R_i, R_m) = \beta_i * Var(R_m) \Leftrightarrow \beta_i = \frac{Cov(R_i, R_m)}{Var(R_m)}$$

The numerator shows the risk of the security **i** inside the stock market index **m** and the denominator shows the overall risk of the market. Therefore, the beta is a measure of risk that depends on the risk of the market (**m**). So, **it is not** an **absolute measure of risk** as it is the variance. **The beta is a relevant measure of risk**. Moreover, the beta can take prices in the region (-∞, +∞), with number 1 being its landmark.

- If **β < 1** → The security or the portfolio is characterized as **defensive**, meaning that it underperforms in comparison with the market.
- If **β > 1** → The security or the portfolio is characterized as **offensive**, meaning that it overperforms in comparison with the market.

As you can imagine, we use an informal rule that suggests that the market returns (meaning the returns of the stock market indices) offer a beta equal to one -1. Specifically, if we expect that **market returns will rise**, then we **should choose offensive assets** to build our portfolio **because these will offer greater profits than the market (β > 1)**. On the other hand, if we expect that **market returns will fall**, then we **should choose defensive assets** to build our portfolio **because these will fall less than the market (β < 1)**.

<u>Example 1.15</u>

In the table underneath, you can find the monthly realized returns of two stocks; Stock 1 and Stock 2, the monthly realized returns of a Stock Market Index and each category's expected return. We want to use the **Empirical Single-Index Model** and calculate the **Non-Systematic** and the **Overall Risk** of each stock.

Months	Stock 1 – Realized Returns	Stock 2 – Realized Returns	Index – Realized Returns
1	0.10	0.08	0.092
2	0.03	0.03	0.03
3	0.09	0.01	0.058
4	0.08	0.08	0.08
5	0.06	0.03	0.048
6	0.12	0.07	0.10
Expected Return	**0.08 or 8%**	**0.05 or 5%**	**0.068 or 6.8%**

We will start by calculating the important measures that can help us find the results of the beta and the alpha of Stock 1 and then we will measure the requested risks for this stock. The same process will give us the required results for Stock 2, as well.

$$Var(R_{mt}) = \frac{[(0.092 - 0.068)^2 + (0.03 - 0.068)^2 + \cdots + (0.10 - 0.068)^2]}{6 - 1}$$

$$= 0.0007368$$

$$Cov(R_{1t}, R_{mt}) = \frac{[(0.10 - 0.08) * (0.092 - 0.068) + \cdots + (0.12 - 0.08) * (0.10 - 0.068)]}{6 - 1}$$

$$= 0.000792$$

So,

$$\beta_1 = \frac{Cov(R_{1t}, R_{mt})}{Var(R_{mt})} = \frac{0.000792}{0.0007368} = 1.08 > 1$$

It means that **Stock 1** is an **Offensive Stock**.

Then, we calculate the term (a_1):

$$a_1 = E(R_{1t}) - \beta_1 * E(R_{mt}) = 0.08 - (1.08 * 0.068) = 0.00656$$

Now, we can calculate the standard errors of Stock 1:

$$e_{11} = R_{11} - a_1 - (\beta_1 * R_{m1}) = 0.10 - 0.00656 - (1.08 * 0.092) = -0.00592$$

$$e_{12} = R_{12} - a_1 - (\beta_1 * R_{m2}) = 0.03 - 0.00656 - (1.08 * 0.03) = -0.00896$$

Where,

- **R_{11} =** It is the **Realized Return of Stock 1 in month 1**
- **R_{12} =** ″ ″ ″ ″ **2**
- **R_{m1} =** It is the **Realized Return of the Index in month 1**
- **R_{m2} =** ″ ″ ″ ″ **2**

Based on the above logic, the results of the remaining four -4- standard errors are the following:

$$e_{13} = 0.0208$$

$$e_{14} = -0.01296$$

$$e_{15} = 0.0016$$

$$e_{16} = 0.00544$$

Now, as we assumed in hypothesis 1, E(e_{it}) = 0, meaning that the $\sum_{t=1}^{6} e_{it} = 0$. In order to calculate the **non-systematic risk** and the **overall risk** of **Stock 1** we will square the result of each standard error. Then, we construct the following table:

Squared Standard Errors	Results
e_{11}^2	0.000035
e_{12}^2	0.0000803
e_{13}^2	0.000433
e_{14}^2	0.000168
e_{15}^2	0.00000256
e_{16}^2	0.0000296
Sum of Squared Standard Errors $\sum_{t=1}^{6} e_{1t}^2$	**0.000748**

Finally, after all these calculations, we are ready to find the result of the **non-systematic risk** and of the **overall risk** of **Stock 1**.

Non-Systematic Risk:

$$Var(e_{it}) = \frac{\sum_{t=1}^{6} e_{1t}^2}{6-1} = \frac{0.000748}{5} = 0.0001496 \text{ } or \text{ } 0.01496\%$$

Overall Risk:

$$Var(R_{1t}) = \left(\beta_1^2 * Var(R_{mt})\right) + Var(e_{it}) = (1.08^2 * 0.0007368) + 0.0001496$$
$$= 0.00100 \text{ } or \text{ } 0.1\%$$

Now, we will follow the same path to calculate the **non-systematic risk** and the **overall risk** of **Stock 2**.

$$Cov(R_{2t}, R_{mt})$$
$$= \frac{[(0.08 - 0.05) * (0.092 - 0.068) + \cdots + (0.07 - 0.05) * (0.10 - 0.068)]}{6 - 1}$$
$$= 0.00066$$

So,

$$\beta_2 = \frac{Cov(R_{2t}, R_{mt})}{Var(R_{mt})} = \frac{0.00066}{0.0007368} = 0.8958 < 1$$

It means that **Stock 2** is a **Defensive Stock**.

Then, we calculate the term (a_2):

$$a_2 = E(R_{2t}) - \left(\beta_2 * E(R_{mt})\right) = 0.05 - (0.8958 * 0.068) = -0.011$$

Now we can continue with the standard errors of Stock 2,

$$e_{21} = R_{21} - a_2 - (\beta_2 * R_{m1}) = 0.08 - (-0.011) - (0.8958 * 0.092) = 0.00912$$

$$e_{22} = R_{22} - a_2 - (\beta_2 * R_{m2}) = 0.03 - (-0.011) - (0.8958 * 0.03) = 0.0143$$

Based on the same logic, as in Stock 1, the following four -4- standard errors are:

$$e_{23} = -0.031$$

$$e_{24} = 0.0198$$

$$e_{25} = -0.801$$

$$e_{26} = -0.008$$

The square result of each standard error is presented in the following table:

Squared Standard Errors	Results
e_{21}^2	0.0000832
e_{22}^2	0.000205
e_{23}^2	0.000961
e_{24}^2	0.000392
e_{25}^2	0.6416
e_{26}^2	0.000064
Sum of Squared Standard Errors $\sum_{t=1}^{6} e_{2t}^2$	**0.6433**

So, the **Non-Systematic Risk** is the following:

$$Var(e_{2t}) = \frac{\sum_{t=1}^{6} e_{2t}^2}{6-1} = \frac{0.6433}{5} = 0.129 \text{ or } 12.9\%$$

Overall Risk:

$$Var(R_{2t}) = \left(\beta_2^2 * Var(R_{mt})\right) + Var(e_{2t}) = (0.8958^2 * 0.0007368) + 0.129$$
$$= 0.1296 \text{ or } 12.96\%$$

Based on the overall risk results for Stock 1 and Stock 2, we can conclude that **Stock 2** is way **more risky** than **Stock 1**.

1.2.7 The Single-Index Model (SIM) For Portfolios

In the case of **portfolios** the SIM does not change radically and the **five -5- hypotheses** that we introduced in the previous paragraph, **remain the same**, but, we have to take into account the importance of **Diversification** and in order to do so, we have to use the statistical tool of **R^2 or Coefficient of Determination**.

First of all, **Diversification**[35] is "… *a risk management technique that mixes a wide variety of investments within a portfolio. The rationale behind this technique contends that a portfolio constructed of different kind of investments will, on average, yield higher returns and pose a lower risk than any individual investment found within a portfolio.*" Generally, it is an old and very famous technique that investors tend to use when they want to maximize their portfolio returns. Specifically, it has been shown that if we want to fully diversify our portfolios and hedge our risk exposure, we have to possess 35 to 48 financial assets (e.g. stocks). The table underneath explains how research in diversification evolved:

Date	Correct Diversification
Up to the year 1975	15-18 financial assets
1975-1995	20-28 financial assets
1995-2019	35-48 financial assets

Because of the globalization and the facilitation of money moving around the world, nowadays, many investors diversify their portfolios with international assets (meaning that they invest in financial or real assets in other countries with different currencies than their home currency). On the one hand, this strategy might increase the foreign exchange risk but on the other hand, it reduces all other risks involved with the assets that we invest in. This happens because of the negative correlations that affect the financial assets among different countries. As a final remark on the subject of diversification, we can comment that an internationally diversified portfolio can offer a higher expected return with lower risk.

Before we continue further on the subject of diversification, let's first present the mathematical equations of the SIM for Portfolios. The **Empirical SIM for Portfolios** is the following:

$$R_{pt} = a_p + (\beta_p * R_{mt}) + e_{pt} \quad \mathbf{(1.27)}$$

[35] Investopedia, Diversification, https://www.investopedia.com/terms/d/diversification.asp .

Where,

- **R_{pt} =** The realized return of our portfolio.
- **a_p =** The alpha of our portfolio, meaning the abnormal returns of the portfolio. It is a constant.
- **β_p =** It is the beta of the portfolio. The **beta measures the volatility of a portfolio in relation to a stock market index**. Its equation is the following:

$$\beta_p = \frac{Cov(R_{pt}, R_{mt})}{Var(R_{mt})} = \sum_{i=1}^{N} w_i * \beta_i \quad \mathbf{(1.28)}$$

Where,

- **w_i** = The **weight of each portfolio's asset**.
- **β_i** = The **individual beta of each asset**.

- **R_{mt}** = It represents the returns of the stock market index.
- **e_{pt}** = It represents the statistical standard error and it is a part of the unsystematic risk of the portfolio.

Now, the same model is converted into the following one when we are using it to estimate the **Expected Return** of the **Portfolio**:

$$E(R_{pt}) = a_p + \beta_p * E(R_{mt}) \quad \mathbf{(1.29)}$$

Where,

- **$E(R_{pt})$ =** It is the expected return of the portfolio.
- **$E(R_{mt})$ =** It is the expected return of the market.

The **Overall Risk** of the **Portfolio** or the **Portfolio Variance** is computed as follows:

$$Var(R_{pt}) = (\beta_p^2 * Var(R_{mt})) + Var(e_{pt}) \quad \mathbf{(1.30)}$$

Where the **overall risk** of the portfolio is split into two -2- categories; the **Systematic Risk** and the **Non-Systematic Risk**.

Systematic Risk = β_p^2*Var(R_{mt})

Non-Systematic Risk = Var(e_{pt})

Now that we have introduced all the above terms and equations we can continue on describing the importance of diversification. It is crucial to understand that the non-systematic risk due to firm-specific factors of a portfolio can be reduced to zero by diversification. The proof of this assumption is presented underneath:

Mathematical Proof of Zero Non-Systematic Risk:

Let's assume that a **portfolio (p)** is constructed with **(N) number of shares** and **equal weights (x_i)**, meaning $x_i = \frac{1}{N}$. Also, from Hypothesis 2 (previous paragraph) we assume Cov(e_{pt}, $e_{p(t-1)}$) = 0. Then,

$$Var(R_{pt}) = (\beta_p^2 * Var(R_{mt})) + Var(e_{pt}) = (\beta_p^2 * Var(R_{mt})) + \sum_{i=1}^{N} x_i^2 * Var(e_{pt})$$

$$= (\beta_p^2 * Var(R_{mt})) + \sum_{i=1}^{N} \frac{1}{N^2} * Var(e_{pt})$$

$$= (\beta_p^2 * Var(R_{mt})) + (\frac{1}{N} * \sum_{i=1}^{N} \frac{1}{N} * Var(e_{pt}))$$

$$= (\beta_p^2 * Var(R_{mt})) + (\frac{1}{N} * \overline{Var(e_{pt})})$$

Where, $\overline{Var(e_{pt})}$ = Mean Variance. If N →∞ then $\left(\frac{1}{N} * \overline{Var(e_{pt})}\right) = 0$ and that means that we have **eliminated the non-systematic** or **unsystematic risk**.

After the thorough analysis on the subject of Diversification, it is time to analyze the statistical tool that provides information on how well or not diversified is our portfolio. This measure is called **Coefficient of Determination** and is denoted by $\mathbf{R^2}$. It is used to analyze how differences in one variable can be explained by a difference in a second variable. It is also similar to the **Correlation Coefficient**, it is expressed in percentage terms and it shows the percentage of a security's realized return volatility that can be explained by the volatility of the realized return of a stock market index.

The R^2 can take prices in the region [0,1]. Specifically,

- If $R^2 = 0$ that means that **there is no linear relationship between the returns of the portfolio and the stock market index**.
- If $R^2 = 1$ then it means that **the returns of the portfolio have a perfect linear relationship with the ones of the stock market index**. It also means that the portfolio has **zero non-systematic risk**.

Furthermore, there are **three -3- methods of calculation** for R^2 and are as follows:

1. R^2 is the **Correlation Coefficient squared**, meaning:

$$R^2 = Corr(R_{pt}, R_{mt})^2 = \left(\frac{Cov(R_{pt}, R_{mt})}{\sigma(R_{pt}) * \sigma(R_{mt})}\right)^2 \quad \mathbf{(1.31)}$$

2. Using the **Portfolio Variance** mathematical expression:

$$Var(R_{pt}) = (\beta_p^2 * Var(R_{mt})) + Var(e_{pt}) \Leftrightarrow \frac{Var(R_{pt})}{Var(R_{pt})}$$
$$= \frac{(\boldsymbol{\beta_p^2} * \boldsymbol{Var}(\boldsymbol{R_{mt}}))}{\boldsymbol{Var}(\boldsymbol{R_{pt}})} + \frac{Var(e_{pt})}{Var(R_{pt})} \Leftrightarrow 1 = \boldsymbol{R^2} + \frac{Var(e_{pt})}{Var(R_{pt})}$$

Meaning that,

$$R^2 = \frac{(\beta_p^2 * Var(R_{mt}))}{Var(R_{pt})} \quad \mathbf{(1.32)}$$

3. Again using the **Portfolio Variance** equation:

$$R^2 = 1 - \frac{Var(e_{pt})}{Var(R_{pt})} \quad \mathbf{(1.33)}$$

The **Equation 1.32** shows the **contribution of the Systematic Risk** to the **Overall Risk of the Portfolio**. On the other hand, the following expression,

$$\frac{Var(e_{pt})}{Var(R_{pt})}$$

is the **contribution of the Non-Systematic Risk** to the **Overall Risk of the Portfolio**.

Last but not least, because we mentioned earlier that R^2 can provide information on how well is diversified our portfolio, as a general rule we can say that when the R^2 offers **a high percentage number (e.g. > 40%)** then we can conclude that **our portfolio is well diversified**. Otherwise, we might lack diversification which can increase the levels of risk exposure.

1.2.8 Capital Market Theory (CMT)

The **Capital Market Theory (CMT)** is based upon the theory that Markowitz developed but has a key difference with the one of H. Markowitz. The difference is that it **does take into account risk-free investments**. As we saw in the previous paragraphs, Markowitz presumes that there are **no risk-free assets** and therefore **no risk-free investments**. Well, the CMT abolishes this way of thinking and assumes that an **investment in Treasury Bills** is a **risk-free investment**. Basically, this theory tries to capture the contemporary investor who will construct a portfolio with **at least one -1- risk-free investment**. The CMT searches answers for the next three -3- questions:

1. What is the relationship between the Expected Return and Risk for Efficient Portfolios?
2. What is the relationship between the Expected Return and Risk for Stocks and Portfolios (irrespective of their efficiency)?
3. Which is the most appropriate measure of risk for Stocks and Portfolios?

The **hypotheses** that the **CMT** is developed on, are the following:

a. **Investors follow the rules of H. Markowitz's Theory**.
b. There is **at least one financial asset** that investors can lend money to or borrow money from. This asset is **risk-free**.
c. All investors have the **same investment horizon**.
d. **The market is perfect**.
e. There are **no taxes**.
f. There is **no inflation**.
g. **Information does not cost anything**.
h. Any investor can **buy or sell any amount of securities**.
i. There are **no transaction costs**.

All the above assumptions, however, offer a secret and informal meaning. They quietly accept the case of **balance in the market**, meaning that **every single time the price of a stock is unique**. This sentence is supported by the **Efficient Market Hypothesis (EMH)** which is an "… *investment theory whereby share prices reflect all information. According to the EMH, stocks always trade at their fair value on stock exchanges, making it impossible for investors to either purchase undervalued stocks or sell stocks for inflated prices. As such, it should be impossible to outperform the overall market through expert stock selection or market timing, and the only way an investor can possibly obtain higher returns is by purchasing riskier investments*"[36].

Based on the above assumptions, the CMT provides two -2- Asset Pricing Models; the **Capital Market Line (CML) Model** and the **Capital Asset Pricing Model (CAPM)**.

1.2.8.1 Capital Market Line (CML) Model

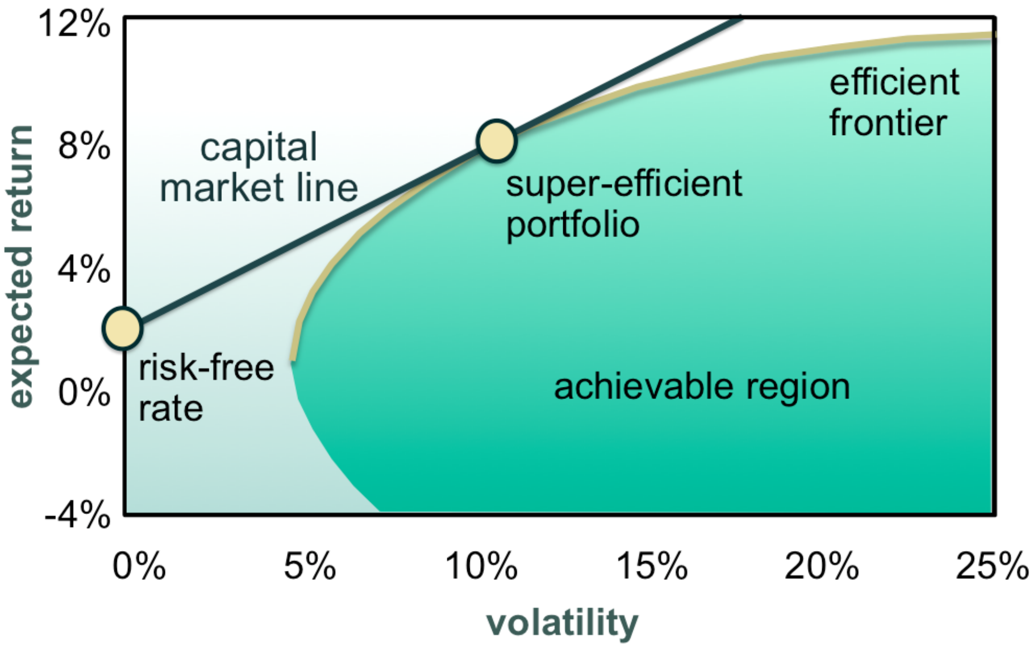
The first of the two asset pricing models that we are going to examine is the **Capital Market Line (CML), Model**. Specifically, James Tobin in 1958 thought of using the term **leverage** in portfolio theory. Tobin suggested that the portfolio construction can be a two-step process. The **first step** for each potential investor is to **find the efficient frontier of risky assets**. Then, **the second and final step** is to **find the optimum fraction to invest** in the efficient portfolio of risky assets and the risk-free asset. This is called **Tobin's Separation Theorem** and it is then that leverage can be deployed. Based on the risk profile of each investor, he/she can buy or sell units of the risk-free asset and calibrate his/her portfolio risk-return tradeoff, according to his/her preferences.

Basically, the CML is a model based on the assumptions of Markowitz's Theory but the efficient frontier of the optimal portfolios it is not a curve but a straight line that intersects with the y-axis (meaning that it starts from the y-axis) and is tangent to the

[36] Investopedia, Efficient Market Hypothesis – EMH, https://www.investopedia.com/terms/e/efficientmarkethypothesis.asp .

Markowitz's efficient frontier (meaning the curve). The following graph will clarify the previous theory:

Diagram 1.2.8.1.a – Capital Market Line (CML)



Source: Glyn Holton Risk Management Coach, Capital Market Line (CML), June 5, 2013, https://www.glynholton.com/notes/capital_market_line/

In the above diagram, we can notice that the CML starts from the y-axis or the **Expected Return axis** and the point is the **risk-free rate investment** (meaning Treasury Bills), which is about 2%. As hypothesis 2 of the Capital Market Theory mentions, there is at least one financial asset that is a risk-free investment. Then, the line continues to climb and becomes tangent with Markowitz's efficient frontier at the **super-efficient portfolio** or the **market portfolio** as it is called. The rationale behind this theory is that if investors combine a risk-free investment with a portfolio of risky investments on Markowitz's efficient frontier, then, they would achieve risk-return tradeoffs that will be superior to the ones of the efficient frontier. Actually, **every portfolio that falls on the CML is superior (in risk-return terms) than any portfolio of Markowitz's efficient frontier**. The **CML** is the **new efficient frontier**.

It is now time to analyze the algebra behind the theory. Let's assume that we own a portfolio (S) that is located on the CML and somewhere in between the risk-free point (F) and the super-efficient portfolio (M). The slope of Portfolio S will be the same with the slope of Portfolio M because both portfolios are on the same line (CML):

$$\frac{E(R_S) - r_F}{\sigma_S} = \frac{E(R_M) - r_F}{\sigma_M}$$

Then, the **Expected Return of S** will be computed as follows:

$$E(R_S) = r_F + \left[\frac{(E(R_M) - r_F)}{\sigma_M} * \sigma_S\right] \quad \mathbf{(1.34)}$$

Where,

- **$E(R_S)$ =** Expected Return of Portfolio S.
- **r_F =** The return of the risk-free asset.
- **$E(R_M)$ =** The Expected Return of the Market Portfolio or Super-Efficient Portfolio.
- **σ_M =** It is the standard deviation of the Market Portfolio.
- **σ_S =** It is the standard deviation of the Portfolio S.

The above equation can be characterized as follows:

1. It is a **linear relationship**.
2. It has a **positive slope**.
3. It shows a **relationship between Expected Return and Risk for Efficient Portfolios**.

Based on number 3 above, we have already answered the first -1st- question of Capital Market Theory, meaning that we proved a linear relationship between the Expected Return and Risk for Efficient Portfolios. Furthermore, the term,

$$\left[\frac{(E(R_M) - r_F)}{\sigma_M} * \sigma_S\right]$$

is the **risk premium** which shows the **Additional Return** that the investor demands in order to invest in Portfolio S and accept its risk.

If we want to calculate the Realized Return of Portfolio S we can use the **weights** of the money we invest in the portfolio and the risk-free asset:

$$R_S = (w_F * r_F) + (w_M * R_m) \quad \mathbf{(1.35)}$$

Where,

- **R_S** = The Realized Return of Portfolio S.
- **w_F, w_M** = The weights of the money invested in the Risk-Free Investment (F) and the Market Portfolio (M).
- **R_M** = The Realized Return of Portfolio M.

Then, the **Expected Return** of **Portfolio S** is calculated as follows:

$$E(R_S) = (w_F * E(r_F)) + (w_M * E(R_M)) = (w_F * r_F) + (w_M * E(R_M)) \quad \mathbf{(1.36)}$$

Where,

- **$E(R_S)$** = Expected Return of Portfolio S.
- **w_F, w_M** = The weights of the money invested in the Risk-Free Investment (F) and the Market Portfolio (M).
- **$E(r_F)$ = r_F** = The expected return of the risk-free asset. It is the same with the realized return because it is stable over time.
- **$E(R_M)$** = The Expected Return of the Market Portfolio or Super-Efficient Portfolio.

Also,

$$w_F + w_M = 1$$

Based on **Equation 1.35** we can now continue on estimating the **variance (risk)** of our portfolio:

$$\begin{aligned} Var(R_S) = Var\big((w_F * r_F) + (w_M * R_m)\big) \\ = Var(w_F * r_F) + Var(w_M * R_m) + \big(2 * w_F * w_M * Cov(r_F, R_m)\big) \\ = Var(w_M * R_m) = w_M^2 * Var(R_M) \quad \mathbf{(1.37)} \end{aligned}$$

Where,

- **Var(R_S) =** The variance of Portfolio S.
- **Var(r_F) =** The variance of the Risk-Free Asset, which is equal to zero because it is a constant. Also, that is why the terms $Var(w_F * r_F)$ and $\big(2 * w_F * w_M * Cov(r_F, R_m)\big)$ are eliminated from equation 2.37.
- **Var(R_M) =** The variance of Portfolio M.

The **Standard Deviation** of the **Portfolio S** is simply the term:

$$\sigma_S = \sqrt{Var(R_S)} = \sqrt{w_M^2 * Var(R_M)} = w_M * \sigma_M \quad \mathbf{(1.38)}$$

Where,

- **σ_S =** It is the standard deviation of Portfolio S.
- **σ_M** = It represents the standard deviation of Portfolio M.

Last but not least, we should mention that the **CML works only for Efficient Portfolios**, meaning that **Portfolio S and Portfolio M must be efficient**. Now, we will provide a numerical example that will help the reader understand the concept of the CML Model.

<u>Example 1.16</u>

In the following tables, we can see the monthly realized returns of a stock market index (M) and a portfolio (Q). It is also given the expected return of the risk-free asset (r_F) and the standard deviation of the market's portfolio (Portfolio M). We assume that a CML already exists and connects the risk-free asset with the Portfolio M. Does the Portfolio Q fall on the CML?

Month	Portfolio Q	Portfolio M – Stock Market Index
1	0.0560	0.092
2	0.0250	0.030
3	0.0390	0.058
4	0.0500	0.080
5	0.0340	0.048
6	0.0600	0.0100

Expected Return of r_F	0.02
Standard Deviation of M	**0.02716**

Firstly, we calculate the **Expected Return** of the **Portfolio Q** and **Portfolio M**, meaning:

$$E(R_Q) = \frac{(0.0560 + 0.0250 + \cdots + 0.0600)}{6} = 0.044 \text{ } or \text{ } 4.4\%$$

$$E(R_M) = \frac{(0.092 + 0.030 + \cdots + 0.0100)}{6} = 0.068 \; or \; 6.8\%$$

Secondly, we will estimate the **Variance** and the **Standard Deviation** of **Portfolio Q**, meaning:

$$Var(R_Q) = \frac{[(0.0560 - 0.044)^2 + (0.0250 - 0.044)^2 + \cdots + (0.0600 - 0.044)^2]}{6 - 1}$$
$$= 0.0001844$$

$$\sigma_Q = \sqrt{Var(R_Q)} = \sqrt{0.0001844} = 0.01358 \; or \; 1.358\%$$

Based on the CML Model, it must be:

$$E(R_Q) = r_f + (E(R_M) - r_F) * \frac{\sigma_Q}{\sigma_M} = 0.02 + (0.068 - 0.02) * \frac{0.01358}{0.02716}$$
$$= 0.044 \; or \; 4.4\%$$

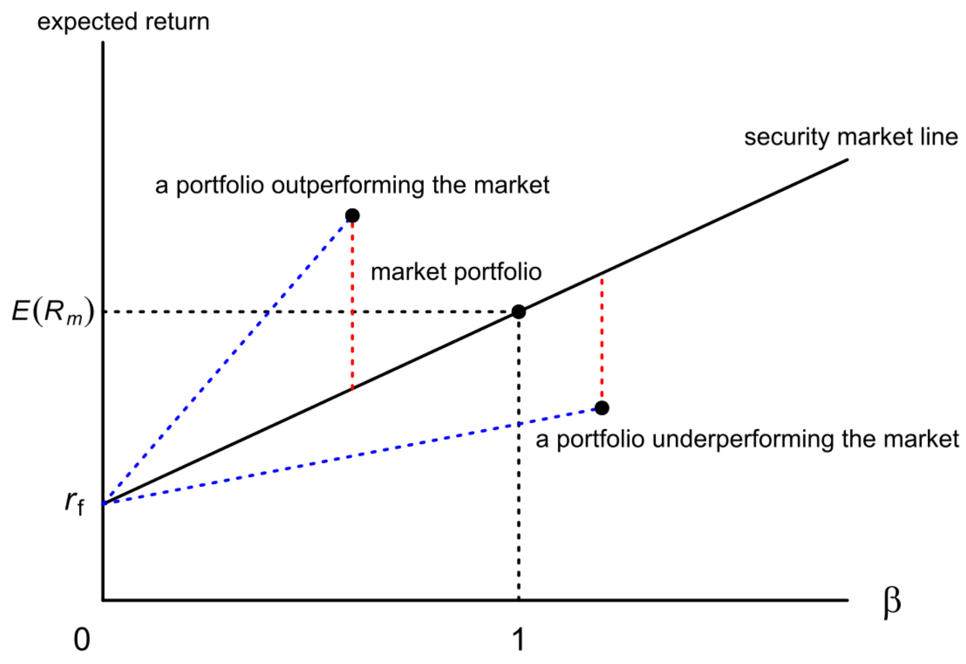
Since the **Expected Return** that we calculated using the CML Model is the same with the **Expected Return** that we computed with the **Average Equation**, then, the **Portfolio Q falls on the CML and it is an Efficient Portfolio**.

1.2.8.2 Capital Asset Pricing Model (CAPM)

The second and last Asset Pricing Model that we are going to examine and is a development of the Capital Market Theory is the **Capital Asset Pricing Model (CAPM)**. The CAPM is a generalization of the CML Model, meaning that the Portfolio S can now be efficient or not, or even a stock. William Sharpe was the first who developed and introduced the CAPM in 1964 and because of his work, he received the Nobel Prize in Economics in 1990 alongside with Harry Markowitz and Merton Miller. The model extends H. Markowitz's Theory and introduces the notions of **systematic** and **specific risk**.

The CAPM describes a straight line again that starts from the y-axis or the expected return axis and continues to climb. The following diagram will make the concept more understandable:

Diagram 1.2.8.2.a – Capital Asset Pricing Model (CAPM)



Source: Wikipedia, Security Market Line, Last Revision: September 20, 2016, https://es.wikipedia.org/wiki/L%C3%ADnea_del_mercado_de_valores

As we can see in the diagram, the ascending line or **Security Market Line (SML)** (as it is called) starts from the **r_F point** on the Expected Return axis and continues to climb past the point of the **Market Portfolio**. The **Market Portfolio** is the portfolio that **comprises all risky assets in the existing market**. **The market value of each asset is a proportion of the market value of the total number of all the assets that exist in this portfolio.** At this point, it is important to clarify that an investor can create a portfolio that outperforms the market, meaning that it is graphically higher than the Security Market Line. The **Security Market Line (SML)** or **CAPM** is **not a new Efficient Frontier**.

The assumptions that the CAPM is based on, are the following:

1. There are **no transaction costs**.
2. **Assets are infinitely divisible**, meaning that each investor can take any position in any investment regardless of the size of the wealth. Any investor can buy or sell any number of shares.
3. There are **no income taxes**.
4. **Perfect Competition exists**, meaning that no investor can affect in any way the existing prices.
5. Investors **decide only in terms of expected return and standard deviation**.
6. **Unlimited short-selling is allowed**. "*Short-selling is the sale of a security that is not owned by the seller or that the seller has borrowed. It is motivated by the belief that a security's price will decline, enabling it to be bought back at a lower price to make a profit.*"[37] Short-selling is usually used by speculators who are investors that care for profit and try to make the riskiest investments that offer the highest returns. This assumption also enhances the existence of portfolios higher than the SML.
7. **Unlimited lending and borrowing at the risk-free rate are allowed**.
8. **Homogeneity of Expectations**, meaning that all investors define in the same way the time period. In the CAPM is assumed a **standardized single-period transaction horizon** in order to make comparable the returns on different securities. For instance, we cannot compare results over six -6- months with results over twelve -12- months. Usually, a holding period of one -1- year is used.

[37] Investopedia, Short-selling, https://www.investopedia.com/terms/s/shortselling.asp

9. Investors have **identical expectations** regarding the **expected return and variance** of their investments. They act **rationally** and are **risk-averse**.
10. **All assets are marketable**, meaning that everyone can sell or buy every asset on the market.
11. **Perfect Capital Market**, meaning that **all securities are valued correctly** and **their returns will plot on to the SML**. Except for all the previous assumptions, a Perfect Capital Market also requires **a large number of buyers and sellers in the market**.

Now, it is time to introduce the mathematical equation of deriving expected returns in the CAPM. Let's assume that we have invested in a Portfolio Z. Then, the equation of its **Expected Return** based on the CAPM, will be the following:

$$E(R_Z) = r_F + (E(R_M) - r_F) * \beta_Z \quad \mathbf{(1.39)}$$

Where,

- **E(R_Z) =** The Expected Return of Portfolio Z.
- **r_F =** The return of the risk-free asset.
- **E(R_M) =** The Expected Return of the Market Portfolio.
- **β_Z =** The beta of Portfolio Z, where

$$\beta_Z = \frac{Cov(R_{Zt}, R_{mt})}{Var(R_{mt})} \quad \mathbf{(1.40)}$$

The above equation (**Equation 1.39**) will **only apply** when the **Market Portfolio (Portfolio M) is efficient**. This equation can be characterized as follows:

1. It is a **linear relationship**.
2. It has a **positive slope**.
3. It shows a **relationship between Expected Return and Risk for Stocks and Efficient or Inefficient Portfolios**.

Based on number 3 above, we have now answered the second -2nd- question of Capital Market Theory, meaning that we proved a linear relationship between the Expected Return and Risk for Stocks and Portfolios (irrespective of their efficiency). Furthermore, the term,

$$(E(R_M) - r_F) * \beta_Z$$

is the **risk premium** which shows the **Additional Return** that the investor demands in order to invest in Portfolio Z and accept its risk (meaning its volatility).

Also, as the Diagram 1.2.8.2.a shows, the **beta of the Market Portfolio** will be equal to one -1- because:

$$\beta_M = \frac{Cov(R_{Mt}, R_{Mt})}{Var(R_{Mt})} = \frac{Var(R_{Mt})}{Var(R_{Mt})} = 1$$

Moreover, we can extract the **Portfolio's Z beta** based on a different equation if we simply assume that **Portfolio Z is efficient**. Then, the **Equation 1.40** becomes:

$$\beta_Z = \frac{\sigma_Z}{\sigma_M} \qquad (\mathbf{1.41})$$

This is true because if Portfolio Z is efficient, then **both the CAPM and the CML apply**, meaning that combining **Equation 1.34** and **Equation 1.39** we get the previous result.

Since we connected the two asset pricing models, it would be helpful to compare their **similarities** and **differences**:

Similarities between CAPM & CML

1. Both the models are based on **Portfolio's M efficiency in the region of Expected Return and Standard Deviation**.
2. Both these models are **Linear, Positive Relationships** between **Expected Return and Risk**.

Differences between CAPM & CML

1. The **CML applies only to Efficient Portfolios** whereas the **CAPM applies for Stocks, Efficient and Inefficient Portfolios**.
2. The **CML measures risk by using the Standard Deviation**. The **CAPM**, on the other hand, **measures risk by using the beta**.
3. **CML is an Efficient Frontier**, whereas **CAPM is not**.

Because CAPM has received quite a lot of criticism in the last two decades, especially for being an unrealistic model to describe the reality in today's financial markets, in this last part of the 1.2.8.2 subparagraph, we will present the **Advantages** and **Disadvantages** of using it, in an objective manner. Certainly, the CAPM must have some advantages, otherwise, it would not have remained popular for the last fourty -40- years.

Specifically, the **Advantages** of the CAPM are the following:

- It considers only systematic risk, reflecting a reality in which most investors have diversified portfolios from which unsystematic risk has been essentially eliminated.
- It generates a theoretically-derived relationship between required return an systematic risk which has been subject to frequent empirical research and testing.
- It is generally seen as a much better method of calculating the cost of equity than the Dividend Growth Model (DGM) in that it explicitly takes into account a company's level of systematic risk relative to the stock market as a whole.
- It is clearly superior to the WACC in providing discount rates for use in investment appraisal.

On the other hand, the **Disadvantages** of the CAPM are as follows:

- ✓ Assigning values to the CAPM variables can prove a difficult task. The risk-free rate of return, the Equity Risk Premium (ERP) and the beta of each asset or company do not stay fixed but change periodically, something that can devalue the authenticity of its results.
- ✓ There is difficulty in using CAPM in investment appraisal because we cannot find easily a suitable proxy beta since proxy companies very rarely undertake only one business activity.
- ✓ The assumption of the single-period time horizon is at odds with the multi-period nature of investment appraisal.
- ✓ The ungearing of proxy company betas uses capital structure information that may not be readily available or it might be more complex with many different sources of finance.
- ✓ The simplifying assumption that the beta of debt is zero will also lead to inaccuracy in the calculated value of the project-specific discount rate.

1.2.9 Portfolio Performance Measures

Many investors used to evaluate the performance of their portfolios only by looking at the realized or expected returns. Well, it is obvious that this strategy is completely mistaken because it does not take into account the risk of the portfolio. In order to assess the efficiency of a portfolio in a more thorough manner, we will present three -3- measures that solved this problem; the **Sharpe Ratio**, the **Treynor Ratio,** and the **Jensen's Alpha**.

1.2.9.1 Sharpe Ratio

We will start off by explaining the **Sharpe Ratio**. The ratio was named after its creator, Bill Sharpe, and it is based on the **Capital Market Line (CML)**. The Sharpe Ratio takes into account both the **systematic** and the **unsystematic risk** of the portfolio and uses the **standard deviation** as a measure of risk. It works very well with strongly diversified portfolios and the result that it offers is a **risk-adjusted rate of return**. Specifically, it informs us with **how much additional return (meaning higher than the risk-free rate) we can receive based on the risk that we undertake**. The mathematical equation of the Sharpe Ratio is the following:

$$SP = \frac{(E(R_p) - r_F)}{\sigma_p} \quad (\mathbf{1.42})$$

Where,

- **$E(R_p)$ =** The **Expected Return** of the **Portfolio (p)**.
- **r_F =** The **risk-free rate of return**.
- **σ_p =** The **standard deviation** of the **Portfolio (p)**.

When we estimate the Sharpe Ratio, we always consider that a better result is a higher one. In order to help the reader understand the concept, we will present underneath, a small example.

Example 1.17

The table below shows four -4- portfolios with their expected returns and standard deviations for each of them and the corresponding numbers for the Market Portfolio:

Portfolios	Expected Return	Standard Deviation
Market Portfolio	0.06	0.28
Portfolio A	0.10	0.15
Portfolio B	0.16	0.12
Portfolio C	0.11	0.20
Portfolio D	0.09	0.25

We also consider a **risk-free rate of return** = **0.05**.

The calculation of the Sharpe Ratio for each portfolio is the following:

$$SP_{Market} = \frac{(0.06 - 0.05)}{0.28} = 0.0357$$

$$SP_A = \frac{(0.10 - 0.05)}{0.15} = 0.333$$

$$SP_B = \frac{(0.16 - 0.05)}{0.12} = 0.9166$$

$$SP_C = \frac{(0.11 - 0.05)}{0.20} = 0.30$$

$$SP_D = \frac{(0.09 - 0.05)}{0.25} = 0.16$$

As we can see from the above results, the portfolio with the **superior risk-adjusted return** is the **Portfolio B** with a **Sharpe Ratio = 0.9166**. Also, we can notice that every portfolio performed better than the Market Portfolio.

1.2.9.2 Treynor Ratio

The second measure that we will examine is the **Treynor Ratio**. This measure was again named after its creator, Jack L. Treynor, who was the first to provide investors with a composite measure of portfolio performance. The Treynor Ratio is based on the **Security Market Line (SML) or Capital Asset Pricing Model (CAPM)** and it is a measure of **risk-adjusted return**. However, instead of using the standard deviation to measure risk, Treynor used the **beta of the portfolio**. This change results in considering only the **systematic risk** and **not the unsystematic** and therefore, informally assuming that the portfolio we examine is well-diversified. It is also known as a **reward-to-volatility measure**, where the **numerator** identifies the **risk premium** and the **denominator** the **systematic risk**. Therefore, the resulting value represents the **portfolio's return per unit risk**.

The mathematical equation of Treynor Ratio is the following:

$$TR = \frac{(E(R_P) - r_F)}{\beta_P} \quad (\mathbf{1.43})$$

Again, we consider the superior portfolio based on the highest Treynor Ratio. An example will help in understanding this concept, as well.

<u>Example 1.18</u>

In the following table, we present three -3- different portfolios with their expected returns and their betas and the corresponding numbers of the Market Portfolio. We also consider a **risk-free rate of return = 0.05**:

Portfolios	Expected Returns	Betas
Market Portfolio	0.08	1.0
Portfolio E	0.15	1.2
Portfolio F	0.09	1.025
Portfolio G	0.20	1.4

The result of the Treynor Ratio for each of the above portfolios is the following:

$$TR_{Market} = \frac{(0.08 - 0.05)}{1.0} = 0.03$$

$$TR_E = \frac{(0.15 - 0.05)}{1.2} = 0.0833$$

$$TR_F = \frac{(0.09 - 0.05)}{1.025} = 0.039$$

$$TR_G = \frac{(0.20 - 0.05)}{1.4} = 0.107$$

As we can see from the previous results, the portfolio that offers the **superior risk-adjusted return** is the **Portfolio G** with a **Treynor Ratio of 0.107**. Also, we notice that every portfolio outperformed the Market Portfolio.

1.2.9.3 Jensen's Alpha

The third and last measure we are going to examine is **Jensen's Alpha**. Also, this measure was named after its developer, Michael C. Jensen, and calculates the **excess return that a portfolio generates over its expected return**. It is based on the CAPM, meaning that the **Portfolio (p) must be efficient**, and it is a **risk-adjusted return** that measures how much of the portfolio's return is above the average returns of the Market Portfolio. Again, **the higher the Alpha, the better the portfolio**. The mathematical equation for the Jensen's Alpha is the following:

$$R_{pt} - r_F = a_p + \left[(R_{mt} - r_F) * \beta_p\right] + e_{pt} \quad \mathbf{(1.44)}$$

Where,

- $\mathbf{R_{pt}}$ **=** The **realized return** of the **Portfolio (p)**.
- $\mathbf{r_F}$ **=** The **risk-free rate of return**.
- $\mathbf{a_p}$ **=** The **Jensen's Alpha**.
- $\mathbf{R_{mt}}$ **=** The **realized return** of the **Market Portfolio (m)**.
- $\boldsymbol{\beta_p}$ **=** The **beta** of the **Portfolio (p)**.
- $\mathbf{e_{pt}}$ **=** The **residual** of the **regression**.

At this point, we can introduce two -2- cases for the Jensen's Alpha:

1. If **a** > **0** then the **Portfolio (p) offers a positive excess return** and therefore **it has "beaten" the market**.
2. If **a < 0** then the **Portfolio (p) offers a negative excess return** and therefore **the Market Portfolio (m) is superior**.

Now we will present an example to better explain the model:

Example 1.19

In the next table, we can see three -3- portfolios and their average realized returns and betas. Also, we assume that there are **no residuals** in our data, that the realized market return is 10% and that the risk-free rate of return is 5%. Then:

Portfolios	Average Realized Returns	Betas
Portfolio X	0.12	0.88
Portfolio Y	0.16	1.15
Portfolio Z	0.22	1.25

We will compute the **Jensen's Alpha** by using the above equation (**Equation 2.44**), meaning:

$$a_X = \left(R_{pt} - r_F\right) - \left[(R_{mt} - r_F) * \beta_p\right] = (0.12 - 0.05) - [0.88 * (0.10 - 0.05)]$$
$$= 0.026 \; or \; 2.6\%$$

$$a_Y = (0.16 - 0.05) - [1.15 * (0.10 - 0.05)] = 0.0525 \; or \; 5.25\%$$

$$a_Z = (0.22 - 0.05) - [1.25 * (0.10 - 0.05)] = 0.1075 \; or \; 10.75\%$$

As we can see from the above results, the **Portfolio Z** is **superior** because it offers **the highest Jensen's Alpha**, meaning that it **outperformed the market by 10.75%**. Last but not least, we must mention that the Jensen's Alpha measure requires the use of a different risk-free rate of return for each time interval considered, whereas, the other two measures of portfolio performance (Sharpe and Treynor Ratios) use the same average returns for the total period examined.

"The stock market is filled with individuals who know the price of everything, but the value of nothing."

Philip Arthur Fisher

Chapter 2

Literature Review

After we examined carefully all the major aspects of the portfolio theory, it is now time to introduce, analyze and summarize the related literature review. Because our thesis is targeted on the CAPM, we will aim to present the findings of papers that are relevant to the Security Market Line Model. The CAPM was first introduced in 1961 and 1962 by Jack Treynor and developed further in 1964 by William F. Sharpe, in 1965 (1965a and 1965b) by John Lintner, in 1966 by Jan Mossin, in 1968 (1968a and 1968b) by Eugene Fama and in 1972 by John Long.

Therefore, the order in which we categorize the papers is chronological, meaning that we will start from 1972 with the paper "*The Capital Asset Pricing Model: Some Empirical Tests*" by Fisher Black, Michael C. Jensen, and Myron Scholes and we will end in 2015 with the paper "*A Five-Factor Asset Pricing Model*" by Eugene F. Fama and Kenneth R. French.

Moreover, our analysis will be three-folded. The first part represents the papers commenting on the CAPM before the Roll's Critique, meaning the subparts (2.1.1-2.1.5). The second part is the Roll's Critique (1977), meaning the subpart (2.2.1), and the third part is filled with the summaries of important papers of the CAPM, after the Roll's Critique, meaning the subparts (2.3.1-2.3.23). Also, in the last section of this chapter, we present a summary table with all the crucial information of every paper we discussed.

2.1 ANALYSIS BEFORE ROLL'S CRITIQUE

As we said at the beginning of this chapter, the first part of this review will be the analysis of papers **before Roll's Critique**, meaning **before 1977**. The papers that we will summarize in the following pages are:

- The Capital Asset Pricing Model: Some Empirical Tests (1972)
- An Intertemporal Capital Asset Pricing Model (1973)
- Risk, Return, & Equilibrium: Empirical Tests (1973)
- A Test on the Capital Asset Pricing Model on European Stock Markets (1973)
- The Option Pricing Model and the Risk Factor of Stock (1976)

2.1.1. The Capital Asset Pricing Model: Some Empirical Tests (Black Fischer, Jensen C. Michael & Scholes Myron, 1972)

Main Purpose

The main purpose of this paper is to test the validity of the CAPM and to provide additional insights into the security return structure. Specifically, the authors denote with ($\boldsymbol{\alpha}$) the following equation of the traditional CAPM:

$$\alpha_j = E(\tilde{R}_j) - E(\tilde{R}_m) * \beta_j \quad (\mathbf{2.1})$$

Where,

- $\boldsymbol{E(\tilde{R}_j)}$ **=** The **expected excess return** on the **jth asset**. It is calculated as follows:

$$E(\tilde{R}_j) = \frac{\left(E(\tilde{P}_t)\right) - P_{t-1} + E(\tilde{D}_t))}{P_{t-1}} - r_{Ft} \quad (\mathbf{2.2})$$

- $\boldsymbol{E(\widetilde{R}_m)}$ **=** The **expected excess return** on a **market portfolio** consisting of an investment in every asset outstanding in proportion to its value.
- $\boldsymbol{\beta_j}$ **=** The **beta** of the **jth asset**, meaning the **systematic risk**.
- $\boldsymbol{E(\widetilde{D}_t)}$ **=** The **expected return on dividends** paid on security j at time t.
- $\mathbf{r_{Ft}}$ = The **risk-free rate of return**.

The traditional model, therefore, implies that $\boldsymbol{\alpha_j = 0}$, on every asset. Using the cross-sectional methods that previous studies of the traditional model have been conducted with, we end up in the following equation:

$$\bar{R_J} = \gamma_0 + \gamma_1 * \widehat{\beta_J} + \widehat{u_J} \quad \mathbf{(2.3)}$$

Which is the regression of $\bar{R_J}$, meaning the **mean excess return** over a time interval for a set of securities on estimates of the **systematic risk**, $\widehat{\boldsymbol{\beta_J}}$, of each of the securities. The **purpose** of using this last equation (**Equation 2.3**) is to find out if $\boldsymbol{\gamma_0 = 0}$ and if $\boldsymbol{\gamma_1}$ = $\mathbf{E(R_m)}$. If this is not the case, then the traditional form of the CAPM (as denoted by **Equation 2.1**) **does not provide an accurate description of the structure of security returns**.

Furthermore, the traditional model of the CAPM implies that the **expected excess return on an asset is strictly proportional to its beta**. An additional purpose of this paper is to examine if this assumption holds. This means that the authors wanted to check if the **high-beta** and the **low-beta** securities perform in the same way as **Equation 2.1** suggests, meaning if the **high-beta portfolios offer positive alphas** and if the **low-beta portfolios offer negative alphas**. If this is not the case, then the traditional model of the CAPM does not hold.

Moreover, the authors made use of Black's assumption that there are no available riskless securities to borrow money from or lend money to. Therefore, the creation of a **two-factor model** appeared, a model which is the following:

$$E(\tilde{r}_j) = E(\tilde{r}_Z) * (1 - \beta_j) + \left(E(\tilde{r}_m) - E(\tilde{r}_Z)\right) * \beta_j \quad \mathbf{(2.4)}$$

Where the **two -2- factors** are $\boldsymbol{E(\tilde{r}_Z)}$ and $\boldsymbol{E(\tilde{r}_m)}$ and indicate the expected returns of Portfolio Z which is a portfolio with zero covariance (zero-beta) and Portfolio M which is the Market Portfolio. The term $E(\tilde{r}_Z)$ is called the **beta factor** and the $E(\tilde{r}_m)$is called the **market factor**. Using both Equations 2.3 and 2.4, if $\gamma_0 = E(\tilde{R}_Z) = 0$ and $\gamma_1 = E(\tilde{R}_m) - E(\tilde{R}_Z)$ then the traditional model holds, otherwise, the two-factor model and the assumption of the non-availability of riskless opportunities hold.

Methodology

In order to find an answer in everything that the authors wanted to check for, they firstly did a **time series analysis** for individual securities and they regressed the following:

$$\tilde{R}_{jt} = \alpha_j + \beta_j * \tilde{R}_{mt} + \tilde{e}_{jt} \quad \mathbf{(2.5)}$$

Although the model is structured based on expected returns, the authors used realized returns in their calculations, something that did not affect the theory test. Also, the above test is simple to understand but cannot give reliable results since it only checks one asset per time. Therefore, the authors grouped the data into **ten portfolios ranked by the beta coefficient, starting from the highest beta coefficients (1st portfolio) to the lowest beta coefficients 10th portfolio)**. Because the authors wanted to assess the stationarity of the empirical relations, the total time period was divided into four -4- equal subperiods, each containing 105 months of returns.

Furthermore, in order to have empirical results for the above two-factor model (see **Equation 2.4**), the authors did a **cross-sectional analysis** of the data, as well. They tested for the linearity of the relation between the returns and the risk implied by Equation 3.4. If the linearity existed for every cross-section then the intercept would be nonzero. The ten beta-portfolios were used again for the simulation and the tests were run firstly for the whole time period and then for each time interval of 105 months.

Last but not least, the **data** that the authors used in the tests were taken from the University of Chicago Center for Research in Security Prices Monthly Price Relative File, which contained the monthly dividend and adjusted prices for all the securities that were trading in the New York Stock Exchange at that time. The total period of the tests was a period of 35 years of data, meaning from January 1926 to March 1966. The monthly returns of the Market Portfolio ($\widetilde{\boldsymbol{R}}_{\boldsymbol{mt}}$) were assumed as the returns that could be earned by a portfolio with equal investments in every security listed on the NYSE at the beginning of each month. The definition of the risk-free rate of return was the 30-day rate on US Treasury Bills, but for only the period 1948-1966, because there were not available any rates for the period 1926-1947.

Results

The findings of this paper will be presented in this section. First of all, the results of the **time-series analysis** and the value of **alpha** of each portfolio in each subperiod are shown in the next table:

<u>Table 2.1.1.a – Summary of Coefficients for the 4 Subperiods</u>

Summary of Coefficients for the Subperiods

Item*	Subperiod†	Portfolio Number 1	2	3	4	5	6	7	8	9	10	$\bar{R}_M$
$\hat{\beta}$	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.

<u>Source</u>: Fisher, Black, Michael, C., Jensen, Myron, Scholes, "The Capital Asset Pricing Model: Some Empirical Tests", 1972, Page 18.

As we can see in the above table, the alpha coefficient is not equal to zero and therefore the assumption of the traditional model does not hold. Also, except for the first subperiod where the traditional model is in accordance with these findings, we can notice that in **all the other three subperiods**, the **alpha is negative for the high-beta portfolios and positive for the low-beta portfolios**, at least in the majority of the cases.

The negative alphas for the high-risk portfolios (β>1) indicate that these portfolios were earning **less than the amount predicted by the traditional model** and the **positive alphas for the low-risk portfolios (β<1)** indicate that these portfolios were earning **more than the amount predicted by the traditional model**. This finding states that the **expected excess return on an asset (or a portfolio) is not strictly proportional to its beta**, something that is in contrast with the traditional CAPM and therefore rejects it.

In the **cross-sectional analysis**, the results do not change dramatically, since even there the hypotheses of the traditional model are rejected. We present the findings for each of the subperiods of this test in the following table:

Table 2.1.1.b – Summary of Cross-Sectional Regression Coefficients and their t-values

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: Fisher, Black, Michael, C., Jensen, Myron, Scholes, "The Capital Asset Pricing Model: Some Empirical Tests", 1972, Page 25.

As we can see, the γ_0 is close but not equal to zero and also its t-value is high enough to support the importance of its result. Furthermore, in correlation with Equation 2.4, this means that the **beta factor is not equal to zero and its mean is not zero and not stationary over time**. Also, the **beta factor seems to be an important determinant of security returns**. Moreover, the market factor (γ_1) seems to be statistically significant and positive over the whole time period and each subperiod separately.

2.1.2 An Intertemporal Capital Asset Pricing Model (Robert C. Merton, 1973)

Main Purpose

The main purpose of this paper is to **generate testable specifications that derive from the traditional CAPM and to induce them into pursuing further empirical testing and analysis**. Therefore, it is **developed a new equilibrium model, similar to the CAPM, which is called Intertemporal Capital Asset Pricing Model (or ICAPM)** which is based on consumer-investor behavior. Also, the reason that this model was created, was because of the different investment behavior of an investor that can reset his portfolio choices instantaneously than one who cannot alternate his investment decisions for a fixed amount of time.

Methodology

The ICAPM is a linear model and its **three -3- basic characteristics** are the following:

“

- *It has the simplicity and empirical tractability of the CAPM.*
- *It is consistent with expected utility maximization and the limited liability of assets.*
- *It provides a specification of the relationship among yields that is more consistent with empirical evidence.*

”[38]

The **assumptions** that the model is based on, are the seven -7- basic assumptions of the traditional CAPM and three -3- additional assumptions that support the intertemporal character of this new model. The three -3- new assumptions are presented as follows:

“

[38] Robert, C., Merton, “*An Intertemporal Capital Asset Pricing Model*”, Econometrica, Vol.41, No.5, 1973, Page 868.

1. *The vector set of stochastic processes describing the opportunity set and its changes is a time-homogeneous Markov Process.*
2. *Only local changes in the state variables of the process are allowed.*
3. *For each asset in the opportunity set at each point in time (t), the expected rate of return per unit time, defined by:*

$$\alpha \equiv \frac{E_t\left[\frac{P_{t+h} - P_t}{P_t}\right]}{h} \quad \mathbf{(2.6)}$$

"[39]

Where,

- **α =** The **expected rate of return** per unit time
- **E_t =** The **conditional expectation operator** at time (t) of the state variables
- **P =** The **price per share** of the asset at times (t+h) and (t)
- **h =** The **discrete trading interval** of **length h**

Furthermore, in order to calculate the risk in this new transformation model of the CAPM, we show underneath the mathematical equation for the calculation of the **Variance**:

$$Var \equiv \frac{E_t\left[\left(\frac{[P_{t+h} - P_t]}{P_t} - ah\right)^2\right]}{h} \quad \mathbf{(2.7)}$$

The variance will be **always positive** and **both** the above functions will be **right continuous functions of h**. The mathematical expression of the Intertemporal Capital Asset Pricing Model is the following:

[39] Robert, C., Merton, "*An Intertemporal Capital Asset Pricing Model*", Econometrica, Vol.41, No.5, 1973, Page 868.

$$a_i - r = \frac{\sigma_i * [\rho_{iM} - \rho_{in} * \rho_{nM}]}{\sigma_M * (1 - \rho_{nM}^2)} * (a_M - r) + \frac{\sigma_i * [\rho_{in} - \rho_{iM} * \rho_{nM}]}{\sigma_n * (1 - \rho_{Mn}^2)} * (a_n - r) \quad (\mathbf{2.8})$$

$$(i = 1,2, \dots, n-1)$$

Where,

- $\alpha_i, \alpha_M, \alpha_n$ = The **expected returns of assets (i), (n) and the market portfolio (M)**, respectively.
- $\sigma_i, \sigma_M, \sigma_n$ = The **standard deviations of assets (i), (n) and the market portfolio (M)**, respectively.
- $\rho_{iM}, \rho_{in}, \rho_{nM}$ = The **correlation coefficients of the asset (i) the market portfolio (M)**, **the assets (i) and (n) and the asset (n) and the market portfolio (M)**, respectively.
- **r =** The **risk-free rate of return** of the riskless asset.

The above equation (**Equation 2.8**) "*... states that, in equilibrium, investors are compensated in terms of expected return, for bearing market (systematic) risk, and for bearing the risk of unfavorable (from the point of view of the aggregate) shifts in the investment opportunity set; and it is a natural generalization of the Security Market Line of the classical Capital Asset Pricing Model*"[40].

Last but not least, it is important to mention that the investor knows at each point in time the investment opportunity set and the stochastic processes that may alternate this specific set.

Results

Because this paper is a theoretical one, no empirical study has been conducted at the time that the ICAPM was introduced. Specifically, the author states that the model can be further analyzed using the empirical data from the paper of Black, Jensen, and Scholes in 1972 (see Subparagraph 2.1.1) and some relevant unpublished work that Myron Scholes has conducted after the 1972 paper.

[40] Robert, C., Merton, "*An Intertemporal Capital Asset Pricing Model*", Econometrica, Vol.41, No.5, 1973, Page 882.

2.1.3 Risk, Return & Equilibrium: Empirical Tests (Eugene F. Fama & James D. Macbeth, 1973)

Main Purpose

The main purpose of this paper is to **test the relationship** between the **average return** and **risk** of the New York Stock Exchange (NYSE) **common stocks**. The two authors based their analysis on the **two-parameter model** of Tobin (1958), Markowitz (1959) and Fama (1965b), and on equivalent models of **market equilibrium** that their structure is based on the two-parameter model. They wanted to test if the three -3- major implications of the two-parameter model (or the traditional CAPM – see **Equation 2.9**, underneath) hold, if the capital market is "efficient" and if the investors are risk-averse and hold efficient portfolios.

The Capital Asset Pricing Model equation is the following:

$$E(\tilde{R}_i) = E(\tilde{R}_0) + \left(E(\tilde{R}_m) - E(\tilde{R}_0)\right) * \beta_i \quad \mathbf{(2.9)}$$

Where,

- $\boldsymbol{E(\tilde{R}_i)}$ **=** The **expected return** of **security i**
- $\boldsymbol{E(\tilde{R}_0)}$ **=** The **risk-free rate of return**
- $\boldsymbol{E(\tilde{R}_m)}$ **=** The **expected return** of the **market portfolio (m)**
- $\boldsymbol{\beta_i}$ **=** The **beta** of the **security i**

Methodology

Firstly, the two authors supposed that **each investor is making portfolio decisions based on the CAPM** and that **every investor expresses a risk-averse behavior**. Assuming this, the three -3- implications of the CAPM must hold, meaning:

"

1. *The **relationship between the expected return on a security and its risk** in any efficient market portfolio (m) is **linear**.*
2. *The term **β** is a **complete measure of the risk** of **security (i)** in the **efficient portfolio (m)**.*
3. *In a market of **risk-averse investors**, **higher risk should be associated with higher expected return**, that is* $E(\widetilde{R_m}) - E(\widetilde{R_0}) > 0$

”[41]

They also assumed that the **market is perfect**, meaning that **all available information is reflected in the market prices of each security** and that **every investor** can calculate the **distribution of the future values** of any asset, investment, security or portfolio that he is interested in **without any associated cost** and with **the same and correct evaluation**.

The **regression model** that they used to test the two-parameter model was the following:

$$\tilde{R}_{it} = \tilde{\gamma}_{0t} + \tilde{\gamma}_{1t} * \beta_i + \tilde{\gamma}_{2t} * \beta_i^2 + \tilde{\gamma}_{3t} * s_i + \tilde{\eta}_{it} \quad (\mathbf{2.10})$$

Where,

- $\widetilde{\boldsymbol{R}}_{\boldsymbol{it}}$ = The **one-period percent-age return on security (i)** from the **t-1** to **t** (with t denoting the time interval between the realized returns).

Methodology

Firstly, the two authors supposed that **each investor is making portfolio decisions based on the CAPM** and that **every investor expresses a risk-averse behavior**. Assuming this, the three -3- implications of the CAPM must hold, meaning:

“

[41] Eugene, F., Fama, James, D., Macbeth, “*Risk, Return & Equilibrium: Empirical Tests*”, Journal of Political Economy, Vol.81, No.3, 1973, Page 610.

4. *The* ***relationship between the expected return on a security and its risk*** *in any efficient market portfolio (m) is* ***linear****.*
5. *The term* ***β*** *is a* ***complete measure of the risk*** *of* ***security (i)*** *in the* ***efficient portfolio (m)****.*
6. *In a market of* ***risk-averse investors****,* ***higher risk should be associated with higher expected return****, that is* $E(\widetilde{R_m}) - E(\widetilde{R_0}) > 0$

”[42]

They also assumed that the **market is perfect**, meaning that **all available information is reflected in the market prices of each security** and that **every investor** can calculate the **distribution of the future values** of any asset, investment, security or portfolio that he is interested in **without any associated cost** and with **the same and correct evaluation**.

The **regression model** that they used to test the two-parameter model was the following:

$$\tilde{R}_{it} = \tilde{\gamma}_{0t} + \tilde{\gamma}_{1t} * \beta_i + \tilde{\gamma}_{2t} * \beta_i^2 + \tilde{\gamma}_{3t} * s_i + \tilde{\eta}_{it} \quad (\mathbf{2.10})$$

Where,

- $\boldsymbol{\tilde{R}_{it}}$ = The **one-period percent-age return on security (i)** from the **t-1** to **t** (with t denoting the time interval between the realized returns).
- $\boldsymbol{\tilde{\gamma}_{0t}}$ = Based on the **Sharpe-Lintner hypothesis** $\boldsymbol{E(\tilde{\gamma}_{0t}) = E(\tilde{R}_0) = \tilde{R}_0}$, and based on **market efficiency**, it must hold that $\boldsymbol{\tilde{\gamma}_{0t} - \tilde{R}_0}$ should be a **fair game**.
- $\boldsymbol{\tilde{\gamma}_{1t}}$ = It is the **slope** of the regression, meaning that $\boldsymbol{E(\tilde{\gamma}_{1t}) = [E(\tilde{R}_m) - E(\tilde{R}_0)] > 0}$.
- $\boldsymbol{\beta_i}$ = The **beta** of the **security (i)**.
- $\boldsymbol{\tilde{\gamma}_{2t}}$ = It is the parameter that **tests the linearity of the model**. If the hypotheses hold, then it must also hold that $E(\tilde{\gamma}_{2t}) = 0$, otherwise the model will not be a

[42] Eugene, F., Fama, James, D., Macbeth, “*Risk, Return & Equilibrium: Empirical Tests*”, Journal of Political Economy, Vol.81, No.3, 1973, Page 610.

linear relationship between the **expected return and risk**. Nevertheless, $\tilde{\gamma}_{2t}$ is allowed to move stochastically through time.

- ❖ $\tilde{\gamma}_{3t}$ **=** It is the parameter that checks if **non-systematic effects of non-beta risk exist**. If implication 2 is correct, then it must apply that $E(\tilde{\gamma}_{3t}) = 0$. Also, $\tilde{\gamma}_{3t}$ can move stochastically period by period.
- ❖ s_i **=** It measures the **non-systematic risk**, if any.
- ❖ $\tilde{\eta}_{it}$ **=** It is the **disturbance term** which is assumed to **have a zero mean** and to **be independent of all other variables of Equation 2.10**.

The **data** that have been used for this study represent monthly percentage returns (adjusted for stock splits, dividends, and any other capital changes) for every common stock that traded in the NYSE from January 1926 to June 1968. They were taken from the Center for Research in Security Prices of the University of Chicago.

Based on these data, the authors **formed twenty -20- portfolios of equal weight**. Specifically, if **N is the total number of securities** that has to be allocated to the different portfolios and the **integer (N/20)** is the **largest integer** equal to or less than N/20, then, 20 portfolios are formed based on the **ranked** $\widehat{\beta_i}$ for **individual securities**. This first -1st- ranking is done using the first four -4- years of the whole time period, meaning from 1926 to 1929.

Furthermore, the **middle eighteen -18- portfolios**, have been formed with **integer (N/20)** number of securities. If **N is even**, the **first** and **last portfolios** have each **integer {(N/20) + ½*[N-(20*integer(N/20))]}** securities. On the other hand, if **N is odd**, then the **last portfolio** with **high betas** ($\widehat{\beta_i}$) receives an **additional security**. Moreover, the following **five -5- years (1930-1934)** are used to **recalculate** the **betas** ($\widehat{\beta_i}$) and then these recalculated betas are averaged across securities within the twenty -20- initial portfolios, to form the **new twenty -20- portfolios** $\widehat{\beta}_{pt}$ for the subsequent risk-return tests.

The regression equation (**Equation 2.10**) then becomes the following and **is run for each month of the subsequent four -4- year period (1935-1938)**:

$$R_{pt} = \hat{\gamma}_{0t} + \hat{\gamma}_{1t} * \hat{\beta}_{p,t-1} + \hat{\gamma}_{2t} * \hat{\beta}^2_{p,t-1} + \hat{\gamma}_{3t} * \bar{s}_{p,t-1} * (\hat{e}_i) + \hat{\eta}_{pt} \quad \mathbf{(2.11)}$$

$$p = 1,2,\ldots 20$$

Where,

- ❖ $\widehat{\boldsymbol{\beta}}_{\boldsymbol{p,t-1}}$ **=** The **average** of the **betas** $(\widehat{\boldsymbol{\beta}_{\boldsymbol{\iota}}})$ for securities in **portfolio (p)**.
- ❖ $\bar{\boldsymbol{s}}_{\boldsymbol{p,t-1}} * (\hat{\boldsymbol{e}}_{\boldsymbol{i}})$ = The **average** of $\boldsymbol{s}(\hat{\boldsymbol{e}}_{\boldsymbol{i}})$ for securities in **portfolio (p)**.
- ❖ Everything else represents the same quantity as in Equation 2.10, but now the model is not regressed for an individual security but for portfolios.

The same methodology applies for another **eight -8- periods**, meaning that for **each period**, the **seven -7- first years** are being used for the **formation of portfolios**, the next **five -5- years** are being used for the **calculation of the initial values of the independent variables** and the **last four -4- years** (only for the ninth -9th- portfolio are the last two -2- years) are being used for the **month-by-month risk-return regressions** of the model. The following table clarifies the methodology that the writers used:

❖ Table 2.1.3.a – Summary of the Time Periods of the Risk-Return Regressions

	Periods								
	1	2	3	4	5	6	7	8	9
Portfolio Formation Period	1926-1929	1927-1933	1931-1937	1935-1941	1939-1945	1943-1949	1947-1953	1951-1957	1955-1961
Initial Estimation Period	1930-1934	1934-1938	1938-1942	1942-1946	1946-1950	1950-1954	1954-1958	1958-1962	1962-1966
Testing Period	1935-1938	1939-1942	1943-1946	1947-1950	1951-1954	1955-1958	1959-1962	1963-1966	1967-1968

Results

The results of the study **support** the **three -3- fundamental implications** of the two-parameter model, meaning that **the three -3- following hypotheses cannot be rejected**; that **it exists a linear relationship between the expected return and risk** of a security, that **the beta is a complete measure of the risk of the security** in the efficient model (m) (meaning that no other measure of risk except for the portfolio risk can affect the average returns) and **that it exists a market of risk-averse investors that higher risk is compensated with higher expected return**. Therefore, the two authors **cannot reject the hypothesis that the pricing of common stocks reflects the existence of risk-averse investors who try to construct efficient portfolios**.

Furthermore, the proxy for the **market portfolio** that it was used in the study is also **approximately efficient**, meaning that the **hypothesis of a perfect market cannot be rejected**, which in turn means that all the available information is reflected in the price of each security. This last finding is **supported also by the existence of a fair game among the coefficients and the residuals of the risk-return regressions**.

2.1.4 A Test of the Capital Asset Pricing Model on European Stock Markets (Franco Modigliani, Gerald A. Pogue & Bruno H. Solnik, 1973)

Main Purpose

The main purpose of this paper is to **test the validity of the Capital Asset Pricing Model** in **eight -8- major European markets**, meaning the **U.K.**, **France**, **Italy**, **Germany**, **Switzerland**, **the Netherlands**, **Belgium,** and **Sweden**, and **compare their results with the ones derived from the U.S. Capital Market**. Specifically, at the time the paper was published, it was generally believed that the European Stock Markets are less efficient than the American one. Therefore, the authors tested if this the case, meaning that the **pricing of risk** was **less rational in the European markets than in the American Stock Market**.

Methodology

The methodology that it was followed can be summarized in three -3- steps. **Firstly**, the authors **transformed the original CAPM** equation (**Equation 2.9**) into the following **stochastic version**:

$$R_{jt} = R_{Ft} + (R_{mt} - R_{Ft}) * \beta_j + \varepsilon_{jt} = R_{Ft} * (1 - \beta_j) + R_{mt} * \beta_j + \varepsilon_{jt} \quad (\mathbf{2.12})$$

Where,

- ✓ $\boldsymbol{R_{jt}}$ = The **realized rate of return** on **security (j)** during period (t).
- ✓ $\boldsymbol{R_{Ft}}$ = The **risk-free rate of return** during period (t).
- ✓ $\boldsymbol{R_{mt}}$ = The **realized return on the market index** during period (t).
- ✓ $\boldsymbol{\beta_j}$ = The **beta** (or the **systematic risk)** of security (j).
- ✓ $\boldsymbol{\varepsilon_{jt}}$ = The **residual term**, which has a **zero expected value** under the CAPM.

The authors then regressed the following time series of realized security returns (computed on a bi-weekly basis) on the realized returns on the market index (market portfolio):

$$\hat{R}_{jt} = \hat{a}_j + \hat{\beta}_j * R_{mt} + \hat{\mu}_{jt} \quad \mathbf{(2.13)}$$

Where,

- ✓ $\boldsymbol{\hat{R}_{jt}}$ = It is an **estimate** of the **realized return** on **security (j)** during period (t).
- ✓ $\boldsymbol{\hat{a}_j}$ = The **estimate** of the quantity $\boldsymbol{R_{Ft} * (1 - \beta_j)}$. If $\hat{a}_j$ is considerably different from the quantity $R_{Ft} * (1 - \beta_j)$, then that means that the CAPM is not a valid model of measuring expected returns in the European Stock Markets.
- ✓ $\boldsymbol{\hat{\beta}_j}$ = The **estimate** of the **systematic risk** of the security (j).
- ✓ $\boldsymbol{R_{mt}}$ = The **realized return on the market index** during period (t).
- ✓ $\boldsymbol{\hat{\mu}_{jt}}$ = The **estimate** of the **residual term**.

This first -1st- step of their methodology provided results on a stock by stock basis. Because this methodology would not contribute to the full use of all the available data, the authors decided to proceed to the **second -2nd- step of their computations**, meaning that they **regressed** the **mean return** of **each security over the whole time period** of the research **on the corresponding estimates of the regression** of Equation 2.13. The regression equation for this second step of the methodology is the following:

$$\bar{R}_j = \gamma_0 + \gamma_1 * \hat{\beta}_j + \mu_j \quad \mathbf{(2.14)}$$

Where,

- ✓ $\boldsymbol{\bar{R}_j}$ = The **mean return** of **security (j)**.
- ✓ $\boldsymbol{\gamma_0}$ = The **mean return** of the **risk-free rate of return** ($\boldsymbol{\bar{R}_F}$).
- ✓ $\boldsymbol{\gamma_1}$ = The **result** of the following subtraction: ($\boldsymbol{\bar{R}_m - \bar{R}_F}$), where $\bar{R}_m$ is the **mean return** of the **market index**.

- ✓ $\widehat{\boldsymbol{\beta}}_{\boldsymbol{j}}$ **=** The **estimate** of the **systematic risk** of the security (j).
- ✓ $\boldsymbol{\mu}_{\boldsymbol{j}}$ **=** The **residual term**.

During this 2nd step of the methodology, the regression would help the authors identify if the terms γ_0 and γ_1 were significantly different from the quantities $\bar{R}_F$ and ($\bar{R}_m - \bar{R}_F$), respectively. If so, then the CAPM and its hypotheses could be rejected. The **third -3rd-** and **last part of the methodology** was to **group the regressed data into portfolios**. The reason to follow this path was because the **estimated betas ($\widehat{\boldsymbol{\beta}}_{\boldsymbol{j}}$) were measured with error** in the cross-section regressions and therefore this meant that $\widehat{\boldsymbol{\gamma}}_{\mathbf{0}}$ **and** $\widehat{\boldsymbol{\gamma}}_{\mathbf{1}}$ were subject to **bias** and **inconsistencies**.

Firstly, **the securities were ranked according to the betas** that were estimated in the regressions in the period from March 1966 to February 1967. Then, the portfolios of the securities were constructed, where the **first portfolio included the securities with the highest beta values**, and so on until all the securities were included in the portfolio construction. Four -4- such portfolios were developed, each for one of the four major European Markets (United Kingdom, France, Italy, and Germany). The **cross-sectional regressions of step 2 were rerun** by regressing the **mean portfolio returns** to the **corresponding estimated portfolio beta values**. These last regressions were run in the period from March 1967 to March 1971. That is how the authors obtained consistent and unbiased estimates of γ_0, γ_1.

Last but not least, we must mention that the **data** in this paper were taken from Eurofinance and they represented daily prices and dividend prices (corrected for any adjustments) of 234 common stocks of eight -8- major European stock markets, for the period from March 1966 to March 1971.

Results

Starting with the **cross-sectional regression results** where all the eight European countries were included, and using as a benchmark the results of the U.K., the authors concluded that generally, the results are in agreement with the CAPM model and its hypotheses. The $\hat{\gamma}_0$ **term was lower than its theoretical value** (derived from the CAPM) in **U.K., Italy, the Netherlands, Belgium, Switzerland, and Sweden** and **higher in France and Germany**. Also, **the** $\hat{\gamma}_1$ **term** was **positive and higher** in the **U.K., the Netherlands, Belgium, and Sweden**, meaning that **higher risk stocks offered positive and higher rates of return**. Moreover, it was **negative and lower** in **France and Germany**, meaning that **higher risk stocks offered lower and negative rates of return**, and **equal** (either positive or negative) **to the theoretical value** in **Italy and Switzerland**.

Furthermore, when the regressions of the cross-sectional data were rerun and the **portfolios** were constructed, the results showed that the **United Kingdom, France, and Italy** were consistent with the CAPM and only the data of **Germany** did not provide concluding results. Also, it is important to mention that in both cases, when the European results were compared to the ones in the U.S. Stock Market, it was found that they are rational, efficient, comparable and that both markets behave according to the hypotheses of the CAPM model. However, the authors state that the European results should not be supported firmly because the test period was short (only 5 years) and the data sample was limited in comparison to the U.S.data sample.

2.1.5. The Option Pricing Model and the Risk Factor of Stock (Dan Galai & Ronald, W. Masulis, 1976)

Main Purpose

The main purpose of this paper is to introduce a new model of **measuring equity value and market (or systematic) risk**. The new theoretical model is a **combination of the Option Pricing Model (OPM) and the Capital Asset Pricing Model (CAPM)** and it can provide more complete results on corporate security pricing. Many of the results of the OPM that are used in this paper originate from the papers of Black-Scholes (1973) and Merton (1973a & 1974). Generally, this paper tries to clarify the way in which the OPM can contribute to the understanding of corporate stock risk.

Methodology

In order to simplify the analysis of the OPM and the CAPM, the authors assume a firm with one **discount bond issue** and one with a **common stock issue**. The bond matures at T and at that time the firm will be liquidated. Also, up to T, the firm does not experience any cash flows and does not pay any dividends to its shareholders. Based on this simplifications, Black and Scholes in 1973 concluded that a **common stock** can be **regarded as a European Call Option**.

The **assumptions** that the OPM and the CAPM are derived from and the ones that the new theoretical model will be based on, are the following:

"

1. ***All individuals** have **a strictly concave von Neuman-Morgenstern utility function** and are **expected utility maximizers**.*
2. *There are **homogeneous expectations** about the dynamics of firm asset values and of security prices.*
3. *The capital markets are perfect: there are **no transaction costs or taxes** and **all traders have free and costless access to all available information**. **Traders are price takers** in the capital markets, i.e., they are **atomistic competitors** (meaning*

that exist "me first" rules that are not perfect but restrict the firm's management from changing its asset or capital structure in any way that improves the value of one class of securities at the expense of another class).

4. *There are* ***no costs of voluntary liquidation or bankruptcy****, e.g., court or reorganization costs, where bankruptcy is defined as the state when the value of the firm's assets is less than the face value of the maturing debt.*
5. *There is a* ***known instantaneously riskless interest rate*** *which is* ***constant through time*** *and is* ***equal for borrowers and lenders****.*
6. ***Borrowing and short-selling*** *by all investors and* ***free use of all proceeds*** *are* ***allowed****.*
7. *The* ***distribution*** *of firm asset value at the end of any finite time interval is* ***log-normal****. The* ***variance*** *of the rate of return on the firm is* ***constant****.*
8. ***Trading*** *takes place* ***continuously****,* ***price changes*** *are* ***continuous*** *and* ***assets*** *are* ***infinitely divisible****.*

"[43]

Next, the two authors used the equations of the CAPM and the OPM to extract the **expected rate of return due to financial risk** as follows:

$$(\bar{r}_V - \bar{r}_D) * \frac{D}{S} = (\bar{r}_V - r_F) * (\eta_S - 1) = (\bar{r}_V - r_F) * \frac{C * e^{-r_F * T} * N(d_2)}{S} \qquad (\mathbf{2.15})$$

Where,

- $\bar{r}_V$ = The **instantaneous expected rate of return of the firm**.
- $\bar{r}_D$ = The **instantaneous expected rate of return of the debt**.
- **D** = The **debt** of the Firm.
- **S** = The **equity** of the Firm, which in **Option Pricing** is equal to:

$$\boldsymbol{S = V * N(d_1) - C * e^{-r_F * T} * N(d_2)}$$

- r_F = The **riskless interest rate**.
- η_S = The **elasticity term** which is equal to: $\frac{V * N(d_1)}{S}$

[43] Dan, Galai, Ronald, W., Masulis, "*The Option Pricing Model and the Risk Factor of Stock*", Journal of Financial Economics 3, 1976, Pages 54-55.

- **C** = The **exercise price of the call option**.
- **T** = The **time interval**.
- **N(.)** = The **standardized normal cumulative probability density function**.
- $\boldsymbol{d_2 = d_1 - \sigma * \sqrt{T}}$ where, $d_1 = \frac{\ln\left(\frac{V}{C}\right)+\left(r_F+\left(\frac{1}{2}*\sigma^2\right)\right)*T}{\sigma*\sqrt{T}}$

Using the above assumptions and equation, the two authors tested their theoretical model in four -4- different case studies, making unanticipated changes in the systematic risk, the expected rate of return and the market value of a firm's Debt and Equity. They do so by comparing two identical firms at the beginning of each case study and then they change one or more relevant characteristics of the first or the second firm. The findings of these tests are shown in the Result area underneath.

Results

Starting with the **first -1st- case study**, the authors checked the **variability of the Rate of Return due to Acquisitions and/or Divestitures**. The conclusion of this case study is that every firm with **similar characteristics**, regarding **the face value of debt, the total market value** and **its profitability**, but with **different variance**, will have a **different capital structure** in market value terms. Also, it was shown that the **market value of (D/S)** will be **greater** for the **firm with a smaller variance**. Finally, the **value** of a firm's **equity** will be **higher** when its **expected rate of return** will be **lower**, ceteris paribus.

Furthermore, the **second -2nd- case study** refers to **the dilution and changes in the scale of any firm**. After this analysis, it is shown that if two firms are **identical** except for their differences (by the same proportion) in **firm asset value** and the **face value of debt**, then their **equities/debts** will differ by the same proportion. We should also mention that the **systematic risk** of both firms **is identical** and **unchangeable**.

Moreover, regarding the **third -3rd- case study** and the **conglomerate mergers**, it is assumed that "*... each bond of the two original firms is exchanged for a bond of **identical face value**, with the **same seniority and maturity**, and **guaranteed** by the new* *firm*"[44]. Also, the **bond market value** of the **new firm** is **greater** than the **sum of the bond market values** of the **two original firms** whereas, the **stock market value** of the **new firm** is **smaller** than the **sum of stock market values** of the **two original firms**. This phenomenon is pointed out by Rubinstein (1973), informing us that "... *the* ***bondholders receive more protection*** *than the* ***stockholders*** *because the last ones have to support the claims of the bondholders of the two firms, meaning that the* ***stockholders' limited liability*** *is substantially weakened*"[45].

Last but not least, the **fourth -4th-** and **final case study**, tests the effect of **spin-offs**, meaning the separation of a firm into two different entities. In this case, the **stockholders** become more benefited than the **bondholders**. This happens because when the original firm is divided into the two new separate corporations, the equity holders of the original firm become equity holders of the two new firms, whereas the debtholders of the original firm become debtholders of only one of the two new firms, meaning that **fewer assets serve as collateral for the debt** and therefore, **the value of collateral is deteriorated**.

[44] Dan, Galai, Ronald, W., Masulis, "*The Option Pricing Model and the Risk Factor of Stock*", Journal of Financial Economics 3, 1976, Page 68.
[45] ''

2.2 ANALYSIS OF ROLL'S CRITIQUE

In this second -2nd- part of Chapter 2, we will focus our analysis on the paper that Richard Roll published in 1977, under the title: "A Critique of the Asset Pricing Theory's Tests / Part I: On Past and Potential Testability of the Theory". The format that we will follow will be almost the same as before, meaning that we will start with the Main Purpose of the Paper, we will continue with the Critique on Past Papers regarding the Asset Pricing Theory and we will end with the Conclusions of Roll's Critique.

Main Purpose

The main purpose of Roll's paper is to **emphasize on the Asset Pricing Theory as it existed at that time and criticize some of the findings of the previous papers** regarding the **two-parameter model**. His main argument is that there **has not been a correct and unambiguous test** of the **Asset Pricing Theory** in the previous attempts and it **could not exist one in the future**. He will try to view this perspective objectively, purely mathematically and very skeptically. In the next part, we present the **core subjects of Roll's Critique** and the papers that he examined.

Critique

The main problem that appeared in Roll's research is that the **mean-variance portfolio** of the **market** may seem to be **efficient** but it **cannot be identifiable**, meaning that we **cannot identify all the assets that are included in it**. Specifically, if it is not easy for us to find the exact composition of the market portfolio, then it is not easy to test the validity of the CAPM itself, because CAPM assumes that the market portfolio is structured with all the investments, commodities, collectibles and every valuable asset that exists in the market (meaning that it is a value-weighted combination of all these assets).

Therefore, Roll does not reject the fact that it would be applicable if we used a **market proxy** (e.g. **market index**) instead. This alternation would possibly provide a portfolio close to a mean-variance efficient one which would **linearly connect the mean return with its beta**. Again though, any misspecification from the original market portfolio would create additional ambiguity in the linearity of CAPM and therefore, additional problems accepting the validity of the model.

In order for Roll to test the theory, he studied and criticized the papers of Black, Jensen & Scholes (1972), Fama & Macbeth (1973) and Blume and Friend (1973). Specifically, Roll criticized the previous papers not only on what to use as an efficient market portfolio but also on the fact that if the market portfolio is efficient then the CAPM equation holds and vice-versa, meaning that the relation between expected return and beta is **tautological**. This implies that the three -3- implications[46] of the Fama-Macbeth paper hold. That **tautology** might be the case why the previous studies never really criticized in depth the CAPM and that is why they found supporting results in their research.

Furthermore, Roll tested one of the three -3- previous implications and assumed that the market portfolio (m) is **not efficient**, meaning that the **mean returns** will **not be exactly linear** with the **betas** and a possible relationship will be one of the following form:

$$R = a + g * \beta \quad \mathbf{(2.16)}$$

Where,

- **R =** The **mean return** of the portfolio.
- **α =** A **vector** whose **elements are non-constant** and which is **unrelated** to the **beta**.
- **g =** A **scalar constant**.
- **β =** The **beta** of the portfolio.

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[46] See Page 11 of this Thesis.

On the other hand, the Black-Scholes-Jensen paper of 1972 does not mention at all the importance of the efficiency of the market portfolio and the linear connection between the expected return and beta, probably because the authors just wanted to test strictly the mathematical expression of the CAPM and nothing else. Nevertheless, Jensen in his papers (1972a, 1972b) tested for the linearity of the CAPM. His results were in accordance with the ones of Fama-Macbeth and showed, as Roll mentions, that the **market portfolios that were used in both studies, were not lying on the sample efficient frontier**.

Moreover, Roll informs us that the **Black-Scholes-Jensen paper** checked for a **joint-hypothesis**, meaning that it tested the validity of the **Sharpe-Lintner theory** and also if the **market proxy** that it was used was the original **market portfolio**. As it turned out, the joint-hypothesis was **rejected** leaving the literature with one of the following ambiguities:

1. Whether the Sharpe-Lintner theory is false
   or
2. The portfolio the authors used was not the original market portfolio
   or
3. Both of the above ambiguities

Roll can only be certain for one thing, that the proxy that Black-Jensen-Scholes used was not the true market portfolio, but cannot be certain if the proxy was statistically close to the original market portfolio.

Regarding the paper of Blume & Friend (1973), Roll states that they are correct in believing that a **riskless asset does exist** and that a **zero-beta portfolio** structured only by **common stocks** cannot be the **zero-beta portfolio** of the **whole market**. That is why they created **two market portfolios**, one consisting solely of **equities** and the other consisting of **every asset in the market**. However, their mistake, as Roll argues, is that they concluded that the previous **two market portfolio proxies** could be "... ***associated*** *with* ***zero-beta (or orthogonal) portfolios*** *having the* ***same mean return*** *and that this return must be* ***equal*** *to the* ***riskless rate of interest****. That conclusion is* ***false***"[47].

Conclusions

The conclusions that Richard Roll ended up with, are the following[48]:

"

- *The* ***only testable hypothesis*** *that is associated with the* ***two-parameter model*** *of Black (1972) is that the* ***market portfolio is mean-variance efficient****.*
- *The* ***linear relationship between expected return and beta*** *that follows the mean-variance efficiency of the market portfolio is not* ***independently testable****. Neither are any other implications that derive from the above efficiency.*
- ***In any sample of observations on individual returns****, regardless of the generating process, there will always be an* ***infinite number of ex-post mean-variance efficient portfolios****.*
- *The* ***theory*** *is* ***not testable*** *unless the* ***exact composition of the true market portfolio is known and used*** *in the tests. This implies that the theory is not testable unless all individual assets are included in the sample.*
- *Using a* ***proxy*** *for the* ***market portfolio*** *is subject to* ***two difficulties****.* ***First****, the proxy itself might be* ***mean-variance efficient*** *even when the true market portfolio* ***is not****.* ***Secondly****, most reasonable proxies will be* ***very highly correlated with each other and with the true market*** *whether or not they are mean-variance efficient. This high correlation will make it seem that the exact composition is* ***unimportant****, whereas it can cause quite different inferences.*
- *A* ***misspecification in the measured market portfolio*** *would have created* ***bias*** *and* ***non-stationarity*** *in the fitted cross-sectional risk/return lines even if there were a constant riskless return.*
- *A direct test of the proxy's mean-variance efficiency is difficult computationally because the* ***full sample covariance matrix of individual returns must be inverted***

[47] Richard, Roll, "*A Critique of the Asset Pricing Theory's Tests / Part I:On Past and Potential Testability of the Theory*", Journal of Financial Economics 4, 1977, Page 146.
[48] ″, Pages 130-132.

and ***statistically*** *because the* ***sampling distribution of the efficient set is generally unknown****.*

- *Testing for the proxy's efficiency by using the return/beta linearity relation also poses empirical difficulties:*

  1. *The* ***two-parameter theory does not make a prediction about parameter values*** *but only about the form (linear) of the cross-sectional relation.*
  2. *The* ***widely-used portfolio grouping procedure can support the theory even when it is false****.*

- *Several other tests are proposed for the linearity relations:*

  1. *An* ***Aitken-type procedure*** *that gives unbiased cross-sectional tests with individual assets, and*
  2. *A* ***procedure that exploits asymptotic exact linearity*** *by measuring the rate of decrease of cross-sectional residual variance with respect to increasing time-series sample size.*

- ***Deviations from the return/beta linearity relation*** *are frequently linked with some other phenomenon. They can be (significantly)* ***non-zero*** *only if the* ***proxy market portfolio*** *is (significantly)* ***not efficient****.*
- *The* ***beta*** *itself is criticized as a risk measure on* ***two grounds****:* ***First****, that it will* ***always be significantly positively related*** *to observed average individual returns if the market index is* ***on (not significantly off) the positive sloped section*** *of the* ***ex-post efficient frontier****, regardless of investor's attitudes towards risk.* ***Second****, that it* ***depends****,* ***non-monotonically****, on the particular market proxy used.*

"

In summarizing all of Roll's Critique, we can be certain that he concluded that there is not a single research attempt that contains a valid test of the Asset Pricing Theory. The main problem remains the **identification** of the **true market portfolio** and even if we can find a proxy that is statistically close to the real market portfolio, again, we will not be sure if it contains all the existing assets in the global market. Finally, it is also shown that all the results of the above three -3- papers are compatible with the results of the

Sharpe-Lintner model and all include a specification error in the measured market portfolio.

2.3 ANALYSIS AFTER ROLL'S CRITIQUE

The final part of this literature review will be the analysis of important papers that were published after the paper of Roll's Critique in 1977. The papers that we will summarize in this part, are the following:

- An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities (1979)
- An Alternative Test of the Capital Asset Pricing Model (1980)
- Multivariate Tests of Financial Models – A New Approach (1982)
- Multivariate Tests of the Zero-Beta CAPM (1985)
- On Correlations and Inferences about Mean-Variance Efficiency (1987)
- Tests of Asset Pricing with Time-Varying Expected Risk Premiums and Market Betas (1987)
- A Capital Asset Pricing Model with Time-Varying Covariances (1988)
- The Consumption-Based Capital Asset Pricing Model (1989)
- A Test of the Efficiency of a Given Portfolio (1989)
- The Cross-Section of Expected Stock Returns (1992)
- A Test of the International CAPM Using Business Cycles Indicators as Instrumental Variables (1994)
- The Capital Asset Pricing Model and the Liquidity Effect: A Theoretical Approach (2000)
- Risk and Return: CAPM & CCAPM (2002)
- CAPM, Higher Co-Moment and Factor Models of UK Stock Returns (2003)
- The Conditional CAPM Does Not Explain Asset-Pricing Anomalies (2003)
- The CAPM Relation for Inefficient Portfolios (2009)
- A Five-Factor Asset Pricing Model (2015)

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

Main Purpose

The main purpose of this paper is to **further develop into a continuous-time model the Merton's intertemporal extension of the CAPM in 1973**. Specifically, this paper takes into account the same continuous-time economic framework of Merton's paper in order to **derive a single-beta asset pricing model in a multi-good environment without knowing the consumption-goods prices and the investment opportunities that exist**, meaning that the model **permits stochastic consumption and investment opportunities**.

Methodology

In order to explain the methodology that the author used, we must first introduce the assumptions on which he based his analysis. It is important to clarify that the author started with a **one-good economy** and then expanded his theory in a **multi-good economy**.

The assumptions that he made are the following:

- ✓ There is **only one good** that can be consumed by individuals or that it can be invested by firms. This assumption changes when he introduces a **multi-good economy**.
- ✓ Individuals are **price takers** in **perfectly competitive**, **incomplete** and **frictionless capital markets**.
- ✓ Individuals can **trade continuously** and **short-sell any asset** by **fully using the proceeds**.
- ✓ The **trading** exists **only at equilibrium prices**.

- ✓ For every state of the world, **all investors** have the exact **identical probability beliefs**.
- ✓ Every individual can hold **wealth via risky asset shares** (this is the zero-beta portfolio with no riskless assets) or **via an instantaneously riskless asset**.

Also, the author states **three -3- fundamental theorems** which are the following:

Theorem 1: Every individual in this economy can invest in at most three -3- funds; the instantaneously riskless asset, the portfolios that have the highest correlation with the state variables and the market portfolio.

Theorem 2: At every moment, each individual's consumption level is identical to all the others individuals' consumption levels.

Theorem 3: At every moment, changes in the individual's optimal consumption level are correlated at the maximum possible rate with the aggregate consumption rate.

Furthermore, in explaining the state variables of **Theorem 1**, the author assumes that **exists an Nx1 vector with (θ) state variables**. This vector follows a **continuous time Markov process of the Ito type** that can be expressed in the following two -2- equations:

$$d\theta = \mu_\theta(\theta, t)d_t + \sigma_\theta(\theta, t)d_{z\theta} \quad (\mathbf{2.17})$$

Which is the general mathematical expression of an Ito type equation with **(μ)** being **the mean** and **(σ) the standard deviation**. This equation, if we want to translate it into asset pricing, becomes the following:

$$\frac{d_{Pq}}{P_q} = \left[\mu_q(\theta, t) - \delta_q(\theta, \tau)\right] + \sigma_q(\theta, \tau)d_{zq} \quad (\mathbf{2.18})$$

for each asset q

Where,

- ❖ $\boldsymbol{P_q}$ = The **asset price** of asset q.
- ❖ $\boldsymbol{\delta_q}$ = The **dividend yield** of asset q.

Generally, the asset prices and the dividend yields can follow continuous sample paths but their mean rates of return and standard deviations can be stochastic. The above economic model of Equation 2.18 is **consistent with endogenously-determined prices**, meaning that every shock in the economy is captured as an element of the (θ) vector of state variables. However, **stochastic production** and **stochastic technological advancement** are considered to be **exogenous variables**.

A **single beta intertemporal asset pricing model** can be derived if we take into account the **individual's direct utility function for consumption**. Specifically, the model that we describe in this **one-good economy** and later in the **multi-good economy** is based on **aggregate consumption**. "*If there exists a security whose return is perfectly correlated with changes in aggregate consumption over the next instant, then the risk-return relation can be written in terms of assets' betas measured relative to that security's return and the expected excess return on this security*"[49], meaning the following:

$$\mu_{\alpha} - r = \beta_C(\mu_C^* - r) \quad \mathbf{(2.19)}$$

Where,

- ❖ $\boldsymbol{\mu_{\alpha} - r}$ = The **vector of instantaneous expected excess return on security (α)**.
- ❖ $\boldsymbol{\beta_C}$ = The **consumption beta** of the **security**. It is calculated as follows:

$$\beta_C = \frac{Cov(R_a, Consumption\ Growth)}{Var(Consumption\ Growth)} \quad \mathbf{(2.20)}$$

- ❖ $\boldsymbol{\mu_C^* - r}$ = The **expected excess return on the aggregate consumption of the security**.
- ❖ $\boldsymbol{r}$ = The **risk-free rate of return**.

The model that is described by Equation 2.19 is built to hold for every instant in time but it is not certain that it will also hold for finite time periods. In general, we can see

[49] Douglas, T., Breeden, "*An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities*", Journal of Financial Economics 7, 1979, Page 276.

that the Equation 2.19 provides a **linear and positive relationship** between the **expected excess return on asset (α) and the consumption beta**, meaning that the **higher the consumption beta is**, the **higher the expected excess return will be**.

One last note that we can keep about consumption is that if we could freeze the wealth in an economy, then we could see that when **investment opportunities are high**, **consumption levels are low** (savings are high) and when **investment opportunities are low**, **consumption levels are high** (savings are low), meaning that according to Equation 2.19 in the **first** case we would have **low expected excess returns** and in the **second** case we would see **high expected excess returns**.

In the case of a **multi-good economy** (for instance in an economy of two -2- goods), the mathematical expression that represents the **intertemporal asset pricing model with stochastic consumption and investment opportunities** is the following:

$$\mu_i - r = \left(\frac{\beta_i}{\beta_k}\right) * (\mu_k - r) \quad \mathbf{(2.21)}$$

Where,

- $\boldsymbol{\mu_i - r}$ = The **vector of instantaneous expected excess return on asset (i)**.
- $\boldsymbol{\beta_i}$ = The **beta of asset (i)**.
- $\boldsymbol{\beta_k}$ = The **beta of asset (k)**.
- $\boldsymbol{\mu_k - r}$ = The **vector of instantaneous expected excess return on asset (k)**.
- $\boldsymbol{r}$ = The **risk-free rate of return**.

Results

Unfortunately, due to the fact that this was a theoretical and purely mathematical paper, there were no any empirical tests at that time. The author, however, states that this paper derives similar equations to the Merton's paper in 1973, which are simpler and more understandable, and they might be appropriate for empirical testing.

2.3.2 An Alternative Test of the Capital Asset Pricing Model (Pao L. Cheng & Robert R. Grauer, 1980)

Main Purpose

The main purpose of this paper is to **propose an alternative test of the CAPM** and show results that are **unambiguous** relatively to the past papers. Specifically, Cheng and Grauer tried to disapprove Roll's second opinion that there would be no possibility that an unambiguous test of the Asset Pricing Theory in the future can be accomplished.

Methodology

The two authors noticed that in the past tests of CAPM important quantities and coefficients were assumed as constants, whereas they could not be constant from equilibrium to equilibrium. Specifically, holding the **beta (β) constant** means that the **distribution of the returns should be stationary** and that **the mean return ($\bar{r}_{zt}$) would have to remain constant through time**, assumptions that are not in accordance with the original CAPM. Therefore, they proposed an **alternative test** of the **CAPM** which is **(i) equivalent to the Security Market Line (SML) Model** and **(ii) can be tested unambiguously**.

In this new approach, the only assumption that is compatible with the past papers of the CAPM is the **stationarity in the joint distributions of security returns**. This assumption is represented by the following equation:

$$p_{it} = b_{ijk}p_{jt} + c_{ijk}p_{kt} \quad \mathbf{(2.22)}$$

Where,

- $\boldsymbol{p_{it}}$ = The **value of firm (i)**, through time.
- $\boldsymbol{b_{ijk}}$ = The following quantity:

$$b_{ijk} = \frac{(u_i v_k - v_i u_k)}{(u_j v_k - v_j u_k)}$$

Where **(u)** and **(v)** are **time-independent vectors**.

- p_{jt} = The **value of firm (j)** through time.
- c_{ijk} = The following quantity:

$$\left[\frac{v_i}{v_k} - \frac{v_j}{v_k}\left(\frac{(u_i v_k - v_i u_k)}{(u_j v_k - v_j u_k)}\right)\right]$$

- p_{kt} = The **value of firm (k)** through time.

The above equation (**Equation 2.22**) was named by Cheng as the **Invariance Law of Relative Prices** or **Random March**. This Law can be extended to support **more than three -3- firms**, **portfolios** and **security prices** rather than firm values only. Let us consider the following regression:

$$p_{it} = b_{0k} + b_1 p_{1t} + \cdots + b_k p_{kt} + e_{it} \quad (\mathbf{2.23})$$

with $t \in T$

Where,

- p_{it} = The **value of firm (i)**, through time.
- b_{0k} = The **intercept** of the regression.
- $b_1 \ldots b_k$ = **Constants**.
- p_{kt} = The **value of firm (k)**.
- e_{it} = The **residual term**.
- T = The **total time period** of the regression.

If the above regression is used for k = 2 firm values then the following **five -5- hypotheses** are implied by the **Invariance Law** and must **jointly hold**, otherwise CAPM will be rejected:

Hypothesis #1: The intercept is always equal to zero ($b_{0k} = b_{02} = 0$).

Hypothesis #2: The constants (or slope coefficients, meaning $b_1, \ldots b_k = b_2$) must be different from zero.

Hypothesis #3: The adjusted coefficient of determination R_2^2 should be near one -1- if not exactly one.

Hypothesis #4: There should not be any trend in the intercept.

Hypothesis #5: There should not be any trend in the adjusted coefficient of determination (R^2).

In order to test this alternative approach, the **data** that the authors used are monthly values of equity from the firms that traded on the New York Stock Exchange from January 1926 to December 1977. The data were taken from the Center for Research in Security Prices (CRSP) of the University of Chicago. Cheng & Grauer were not supposed to follow the same portfolio grouping methodology as it was used in the previous studies, but, in order to provide comparable results, they used almost the same technique like the one in the Fama-Macbeth paper.

Specifically, they used **three -3- periods** to create a **time series risk-return data** in order to check for the **linearity of the risk-return tradeoff of the CAPM**. The **first -1st- period** was the **formation period** and it lasted for **sixty -60- months**. The **second -2nd- period** was the **test period** and it lasted for **twelve -12- months** after the formation period. The **third -3rd- period** was the **estimation period** and it lasted for **sixty -60- months** after the test period. We should also note that the first -1st- formation period of the whole sample lasted for only forty-eight -48- months so that the portfolio data could be generated from January 1935 (which is the starting date of the Fama-Macbeth paper).

Moreover, the **stocks** were **ranked according to their individual betas** from **higher** to **lower** and therefore, **twenty -20- portfolios were created** for each year, assigning the **highest 5% of ranked stocks to portfolio #1** and the **lowest 5% of ranked stocks to portfolio #20. Each portfolio's value** was calculated as the **sum of the prices times the number of shares outstanding** of each separate stock in the portfolio. These steps and the three -3- period procedure were repeated for each year from January 1930 to

January 1972 in order to be created 516 monthly sets of portfolio values from January 1935 to December 1977. Last but not least, we should mention that the **Regression Equation 2.23 was used** and that **portfolios 1, 10 and 20** were used as **dependent variables**, meaning that in every time-period **nine -9- regressions were run on each of the three -3- selected portfolios (1,10,20)**.

Results

Firstly, because it was not clear whether or not the Invariance Law holds more accurately in shorter or longer periods, the authors tested (ran regressions) also for **five -5- and three -3- year nonoverlapping periods** from January 1935 to December 1977. The results were **not very supportive of the joint Hypotheses #1, #2 and #3**. Secondly, the authors also noticed that the regressions that were run under the Ordinary Least Squares (OLS) methodology might have been somewhat biased. In order to address the issue, the authors reran a subset of regressions using the Cochrane-Orcutt (C-O) iterative method to adjust for autocorrelation. The results were similar to the ones of the OLS method and therefore, the conclusions of Hypotheses #1, #2 and #3 would not be altered.

On the other hand, **Hypotheses #4 and #5** were also tested and it was found that **as regressors are added to the model, there exist statistically significant trends of the intercept** (Hypothesis #4). Since though, the trends of the intercept are **not of the same sign** it can be concluded that **the results do not contradict the Hypothesis #4**. Also, **as the number of regressors augments, there is a statistically significant increase in the adjusted coefficient of determination** (Hypothesis #5). This, in turn, tells us that **the results are against Hypothesis #5** of the Invariance Law. Finally, the authors tested their previous regressions by creating portfolios without basing them on each firm’s beta. The results of this last method were quasi the same as before.

2.3.3. Multivariate Tests of Financial Models – A New Approach (Michael R. Gibbons_1982)

Main Purpose

The main purpose of this paper is to **present a multivariate statistical framework for estimating the expected return on the zero-beta portfolio**. Additionally, the paper's main goal is to **provide a test to check the multivariate restriction imposed by the CAPM**.

Methodology

The author assumed that the **market model** is **well-specified** and that it follows Equation 2.5, meaning that **asset returns are stationary** following a **multivariate normal distribution** and that they are **serially uncorrelated**. As we mentioned in the "Main Purpose", one of the goals of this paper is to test the multivariate restriction of the CAPM model. In order to derive this restriction, the author made use of the **Black risk-return relationship**, which is the following:

$$E(\tilde{R}_{it}) = \gamma + \beta_i[E(\tilde{R}_{mt}) - \gamma] \quad (\mathbf{2.24})$$

Where,

- $\boldsymbol{\gamma}$ **=** The **expected return** on the **zero-beta portfolio** or any **portfolio** whose **return is uncorrelated with the return on the market portfolio**, m.
- All the other variables of the above equation are described also in Equation 3.9.

The **restriction** of the CAPM on the **intercept** is the following:

$$a_i = \gamma(1 - \beta_i), \quad i = 1,2, \dots, N \quad (\mathbf{2.25})$$

The **Null Hypothesis** is the following:

$$H_o: a_i = \gamma(1 - \beta_i)$$

$$H_A: a_i \neq \gamma(1 - \beta_i)$$

Where,

- $\boldsymbol{\alpha}' = (\boldsymbol{\alpha_1}, \boldsymbol{\alpha_2}, \dots, \boldsymbol{\alpha_N})$ (1xN Vector)
- $\boldsymbol{i'_N} = (\mathbf{1}, \mathbf{1}, \dots, \mathbf{1})$ (1xN Vector of Ones)
- $\boldsymbol{\beta}' = (\boldsymbol{\beta_1}, \boldsymbol{\beta_2}, \dots, \boldsymbol{\beta_N})$ (1xN Vector)

The methodology that the author uses tests the CAPM by testing the restrictions across financial securities. If the **Null Hypothesis** is **rejected**, then this will mean that the **CAPM expression is not consistent with the data** of the statistical analysis. In addition, the suggested approach that is employed in this paper is similar to the one followed by Black, Scholes, and Jensen (BJS) in their paper in 1972. The calculations here, follow a **one-step Gauss-Newton procedure** which **linearizes the restriction** of Equation 2.25 by using a **Taylor series expansion about consistent estimators**.

Moreover, in order to test the **fitness** of the model, the author uses the **Likelihood Ratio Test (LRT)** which compares the statistical fit of the **unrestricted** (which is estimated under the **alternative hypothesis**) and the **restricted** (by the **null hypothesis**) model. Specifically, if the results between the **null** and the **alternative hypotheses** are similar, then the null hypothesis cannot be rejected. The measure of the fitness of the model is calculated by the **generalized variance**.

The **empirical procedure** that follows the above theoretical methodology is being done on **ten -10- different five -5-year subperiods using monthly returns**. The **data** are taken from the Center for Research in Security Prices (CRSP) of the University of Chicago and represent monthly stock returns of the US Stock Market. The market portfolio is represented by the monthly returns of the CRSP Equal-Weighted Index. The whole time period of the study stats from 1926 and ends in 1975.

Furthermore, strictly to the empirical methodology, **an estimate of the zero-beta portfolio expected return** and an **LRT** are **computed** for each of the 5-year subperiods. Next, a **First -1st- Order Taylor series expansion** of Equation 2.25 is **undertaken** about the **consistent estimators**. After this step, the **market model equations** are estimated subject to the **linearized restriction**. The estimator of the **(β_i)** is **unrestricted OLS** while the **(γ)** is estimated using the methodology of BJS (1972). The goal is to **estimate (β_i)** by using **sixty -60- months of data** (meaning each 5-year period). When these estimates are calculated, **forty -40- groups (portfolios) of securities are formed** (each with the same number of securities), starting from the **lowest betas** all the way to the **highest ones**. The portfolios are **equal-weighted** and **represent the Left-Hand-Side (LHS) Assets** in each 5-year period.

Results

The most significant result of this research is that the **parameter restriction of Equation 2.25 is rejected** in **five -5- out of ten -10- subperiods**. Also, the **test statistic is marginally insignificant for three -3- out of the remaining five -5- subperiods**. The rejection is confirmed at **reasonable significance levels**. Specifically, the **content of the CAPM is rejected at a significance level of less than 0.001**. This result simply means that the **mean-variance efficiency of the equally-weighted NYSE portfolio is rejected**. In addition, the author mentions that even if we assume that the CRSP Equal-Weighted Index is an adequate proxy for the market portfolio, the multivariate test **rejects** the **Sharpe-Lintner model**, the **Black model**, and the specific situations where the market portfolio is considered mean-variance efficient in the Black's framework.

Last but not least, the **Multivariate Regression Model (MVRM)** presented here, provides an **efficient estimator** of the **expected return of the zero-beta portfolio**. Also, this model seems to have **sufficient power** and is **well-suited** for **testing market efficiency**. Finally, the LRT **rejects** the **Null Hypothesis** when the **departures** from the CAPM are significantly **large**.

2.3.4 Multivariate Tests of the Zero-Beta CAPM (Jay Shanken, 1985)

Main Purpose

The main purpose of this paper is to **develop a Cross-Sectional Regression Test (CSRT)** of the **CAPM** and to **explore its connection to the Hotelling T^2 test of multivariate statistical analysis**. Also, the **main focus** of this paper is on the **small sample behavior** of the **chi-squared asymptotical distribution of this Cross-Sectional Regression (CSR)**.

Methodology

The CSRT is based on the assumption that **all securities in a certain set offer the same expected return**. It is also assumed that these returns are **serially uncorrelated**. The **Null Hypothesis** is that it **exists a scalar (γ) such that $\boldsymbol{E = \gamma * 1_N}$**, where E = the **mean** of an N-vector of returns which follow a **multivariate normal distribution**. Also, the 1_N is a **vector of ones**. In order to simplify the Null Hypothesis, the author states that $\boldsymbol{R_t^*}$ is an $\boldsymbol{N^*}$**-vector**, where $\boldsymbol{N^* \equiv N - 1}$**.** Then, the **Null Hypothesis** becomes $\boldsymbol{E(R_t^*) = 0}$, where $\boldsymbol{R_t^*}$ is **idependently and identically distributed over time**.

The equation that has been tested before and is tested here, as well, is the following:

$$E_i = \gamma_0 + \gamma_1 * \beta_i \quad \textbf{(2.26)}$$

Where,

- ❖ $\boldsymbol{E_i}$ **=** The **expected return** on asset (i).
- ❖ $\boldsymbol{\gamma_0}$ **=** The **expected return** on a zero-beta portfolio.
- ❖ $\boldsymbol{\gamma_1}$ **=** The **positive market risk premium**.
- ❖ $\boldsymbol{\beta_i}$ **=** The **beta** of asset (i).
- ❖ $\boldsymbol{i = 1, 2, \ldots, N}$

In order to test for **linearity,** the author uses a **goodness of fit** measure **Q^* (Wald Test)**, the **Likelihood Ratio Test (LRT)** and the **Lagrange Multiplier Test (LMT)**. As he mentions, all three -3- tests are based on the **same limiting chi-squared distribution**. Therefore, it must be true the following **ordering**:

$$LMT < LRT < Q^*$$

This ordering should hold in **every sample** and reveals the **mean of each test**, which can show us the **number of times** that **each test rejects the Null Hypothesis** when we rely on **asymptotic inference**. Moreover, in the above case, the **beta was known** in the model. The author also checks the **linearity** when the **beta is unknown**. He uses an **adjusted version of Q^***, the **Q^A** and LMT and LRT are adjusted accordingly.

Regarding the **empirical part** of this paper, the author tries to determine whether the CSRT rejects the Null Hypothesis or not. The **data** that have been used to assess this result represent monthly returns of US stocks, taken from the Center for Research in Security Prices (CRSP) of the University of Chicago. Also, the Equal-Weighted Index of the CRSP tape has been used as the market portfolio. The total time period is divided into three -3- subperiods, each of a length of seventy-four -74- months, meaning February 1953 – March 1959, April 1959 – May 1965, and June 1965 – July 1971.

The **empirical methodology** that was used can be summarized into **three -3- steps**:

1. All stocks are ranked based on their total value of outstanding shares at the end of the month preceding each subperiod.
2. The ranked stocks are then grouped into twenty equally-weighted portfolios, where each portfolio contains the same number of securities.
3. The twenty -20- portfolios are ranked based on the total value of each stock, meaning that portfolio one -1- would contain the smallest companies and portfolio twenty -20- the largest ones.

Last but not least, the author tested also whether the results of his study (**including the January effect**) were **consistent** with the results of the study **without the January effect**.

Results

The **equality of expected returns** was **generally rejected**, but it was surprisingly **not rejected** at a 0.05 significance level. In addition, the **efficiency of the Equally-Weighted Index** was **rejected** at the 0.01 level. In order for the author to check whether the rejection of Equation 2.26 implies a **size effect**, he **regressed** the mean vector $\bar{R}$ on a constant $\hat{\beta}$ and a proxy for size. It was found that **there exists a significant coefficient of the size variable** and therefore the **efficiency of the CRSP Index was rejected**.

Also, the test of using data with and without the **January returns** was run because the author wanted to assess if the above efficiency rejection has happened due to the **January effect**. It was proven that the CRSP Index was **inefficient** even **without the January returns**. Therefore, the rejection of efficiency was correct. Finally, this study has proven that it is better to use a multivariate test as a tool with other traditional tests and not as an alternative to those tests.

2.3.5 On Correlations and Inferences About Mean-Variance Efficiency (Shmuel Kandel & Robert F. Stambaugh, 1987)

Main Purpose

The main purpose of this paper is to **present a framework** that can **analyze the mean-variance efficiency of an unobservable portfolio based on its correlation with an observable proxy portfolio**.

Methodology

The authors base the assessment of an **alternative proxy portfolio** on the **correlation** between **its returns** and the **returns of the original proxy**. They also test whether the **ex-ante correlation** between the proxy and the **Sharpe-Lintner tangent portfolio** of the **global asset universe** is over a certain value. Specifically, they denote that a

Sharpe-Lintner (S-L) tangent portfolio is a **portfolio of N risky assets** that offers the **maximum Sharpe ratio**.

Furthermore, the above risky assets can be included in a portfolio that is **set on the minimum-variance boundary** and this portfolio is called the **minimum-variance portfolio**. In order for the authors to test the **correlation between the S-L tangent portfolio and the proxy**, they constructed **sample minimum-variance boundaries** using monthly data (returns) on various assets for the whole time period. They were able to prove that the **correlation depends on how one constructs the efficient frontier** and that it **only decreases** as **more assets are included in the construction of the efficient set**.

Moreover, the same result is given when they test for the **correlation between the proxy and portfolios on the minimum-variance boundary**. Adding more assets in the universe decreases the correlation. In addition, they check the **correlation between the proxy and an arbitrary portfolio** by assuming a universe of risky assets with a **non-singular variance-covariance matrix** and a proxy that **does not lie** on the minimum-variance boundary. They test the **expansion of the universe** as more assets are being included. Specifically, when $\rho_0 = 1$, the universe contains the proxy itself, but as the number of assets increases, the authors notice that for $\rho_0 = 0.48$, the **expanded region touches the minimum-variance boundary**, and more specifically, the **upper bound of the efficient set**. That is the point where the **mean return is the same as the proxy's** and this universe is constructed with **sixteen -16- portfolios of stocks and bonds**.

In addition, the authors prove that if a **portfolio (p)** of a subset of risky assets is **highly correlated** with a **benchmark portfolio (Q)** of the global universe, then if **Q** is on the **minimum-variance boundary**, then **p** should be on that boundary as well. On the other hand, if the **tangency** of **p** is **rejected** then the same should apply for **Q**.

In order to expand furthermore their analysis, the authors continue with the analysis of the **sensitivity of inferences** based on the **Likelihood Ratio Test (LRT)** of S-L tangency of a given portfolio in the presence of a **riskless asset**. In more detail, they try to answer Roll's (1977) question on **how highly correlated an alternative proxy can be with the original one and still provide a different inference about ex-ante mean-variance efficiency**. Specifically, they **compare** the Sharpe measure of the given portfolio with the one of the **finite sample tangent portfolio**. If the difference is large enough, they **reject** the **tangency**.

Last but not least, the paper also provides a **new test** of checking the **efficiency of an unobservable portfolio using partial information**. The **Null Hypothesis** is the following **joint hypothesis**:

H_0: The unobservable portfolio is **(i)** the **ex-ante tangent portfolio** of the global universe and **(ii) ex-ante correlated** (at least **ρ_0**) with the proxy.

The approach that is used to test the above Null Hypothesis is based on the Sensitivity Analysis and on the alternative approach of Shanken in 1987.

The **data** that the authors used to test all the above different theories are taken from the New York Stock Exchange (NYSE) and represent weekly and monthly returns for the time period starting in January 1926 and ending in November 1978. All returns are in excess of the one -1-month Treasury Bill rate and the market proxies that have been used are the Equal-Weighted (E-W) NYSE Index and the Value-Weighted (V-W) NYSE Index. The riskless rate is the return of the US Treasury Bill with one -1- week to maturity.

Results

Regarding the Sensitivity Analysis of Inferences and the LRT of S-L tangency, when the authors used **monthly data** and a **finite sample**, they found out that there **were no non-tangent portfolios** at a **significance level of 0.01 or less**. This is in contrast with the results of the **infinite sample** where **all the portfolios w**ere inferred as **non-tangent**. Also, it was proven that when monthly data were used, in some cases there was **no rejection region** existed and in other cases, the **reverse of inferences about the tangency of the NYSE portfolio was quite high**.

On the other hand, when using **weekly data**, the **tangency** of **both proxies** (meaning the E-W NYSE Index and the V-W NYSE Index) was **rejected in every subperiod** of the tests. Moreover, regarding the Null Hypothesis of the efficiency of an unobservable portfolio, this hypothesis is **rejected** at a **significance level of 0.01** for the tangency of the V-W proxy. In general, the authors say that if the correlation between the proxy and the market portfolio can exceed 0.9 or a lower value (meaning 0.7 or 0.8), then the **CAPM can be rejected**.

2.3.6 Tests of Asset Pricing with Time-Varying Expected Risk Premiums & Market Betas (Wayne E. Ferson, Shmuel Kandel & Robert F. Stambaugh, 1987)

Main Purpose

The main purpose of this paper is to **develop tests of asset-pricing models with time-varying expected risk premiums and market betas**. Based on recent studies, the authors claim that exists enough evidence to support the point of view that expected returns change over time with information. Therefore, the authors conducted a series of tests in order **to prove the time-variation of expected returns and conditional market betas**. Finally, the **main focus** of the paper is the **description of the multi-beta relation for assets' conditional expected excess returns**.

Methodology

We stated in the main purpose that the focus of the paper is the description of the multi-beta relation for assets' conditional expected excess returns. Therefore, the authors provide the mathematical equation of this relation which is the following:

$$E_t = a_t V w_t + \Omega h_t \quad (\mathbf{2.27})$$

Where,

- $\boldsymbol{E_t = E(\tilde{r}_{t+1} \mid \varphi_t)}$ = The **vector of expected excess return** on **N assets from time (t) to time (t+1)**.

- $\boldsymbol{\varphi_t}$ = The **information available** in the **market time (t)**.
- $\boldsymbol{a_t}$ = The **scalar** that is related to **aggregate relative risk aversion**.
- $\boldsymbol{V = cov(\tilde{r}_{t+1} \mid \varphi_t)}$ = The **conditional covariance matrix of returns**, assumed to be **constant**.
- $\boldsymbol{w_t}$ = The **N-vector of aggregate demands** (or the weights of the market portfolio).
- $\boldsymbol{\Omega}$ = The **matrix of the conditional covariances of the asset returns with the state variables,** which matrix is assumed to be **constant**.
- $\boldsymbol{h_t}$ = The **K-vector of time-varying risk premiums**.

In order to present a relationship that pre-assumes **rational expectations**, the authors provide the following equation of **realized excess returns**:

$$\tilde{r}_{t+1} = a_t V w_t + \Omega h_t + \tilde{\varepsilon}_{t+1} \quad (\mathbf{2.28})$$

Where,

- $\boldsymbol{\tilde{r}_{t+1}}$ = The **realized excess returns** in time **(t+1)**.
- $\boldsymbol{\tilde{\varepsilon}_{t+1}}$ = The **forecast error**.

In every test that the authors conducted, continued to assume that V and Ω are constants but all the other quantities of Equation 2.28 can vary through time. Therefore, using the above equation, the authors tested **ten -10- size-sorted portfolios of stocks** (as test assets) with a **value-weighted stock index** (as the market portfolio) under the following **three -3- hypotheses**:

Hypothesis 1: It tests for the conditional mean-variance efficiency of the value-weighted stock index, meaning K = 0 => $h_t = 0$. Also, $a_t \neq 0$.

Hypothesis 2: It tests for $a_t = 0$, for a certain number of risk premiums, K (say K = 1). This is an exact K-risk premium model.

Hypothesis 3: It tests for the existence of K-risk premiums (meaning $K \leq 1$) in addition to a market premium. This means that if the test results provide a positive answer to the existence of K-risk premiums, then we can interpret these as an upper bound for the total number of the non-market risk-premiums. Also, in this hypothesis applies that $a_t \neq 0$.

The statistical methodology that the three authors used is the **maximum-likelihood method** to a **pooled time series and cross-section of returns**. They also developed their tests using a **normal likelihood function** for the **unexpected component of returns**. Furthermore, in order to present the time variation of the expected returns in a **smoother manner**, the authors used a **two-week step function**, meaning that they allowed the **expected excess returns to change every two -2- weeks**.

Moreover, the **data** that they used in their study were weekly returns on common stocks from the New York Stock Exchange and other American Exchanges for the time period from 1963 to 1982 (meaning twenty -20- years). The weekly excess return of each common stock is calculated as follows:

Weekly Excess Return = Compounding Daily Returns over a Calendar Week – U.S. Treasury Bill's Return over a Calendar Week

We should also note that all the data were taken from the Center for Research in Security Prices (CRSP) of the University of Chicago.

As we said earlier, the **test assets** are **ten -10- portfolios of stocks**. The **stocks** are **ranked** according to their **market value** at the end of each year from **the lowest (portfolio 1) to the highest (portfolio 10)**. Each of the ten portfolios is a **value-weighted portfolio** with its **weights changing every week**. The tests are run for **four -4- 256-week periods** and for each period the **three -3- hypotheses are tested**. The authors conducted simulation experiments to investigate the behavior of their test statistics and for **each hypothesis three -3- simulation trials** are run. In each of these trials, estimates of the parameters are used to form conditional mean excess returns. All of the estimates are derived from the 256-week periods.

In addition, for **every simulation three hundred -300- samples of artificial data** are generated. The **random error term is drawn from a normal (0, V) distribution** where V is each trial's conditional covariance matrix. Following this methodology, the authors calculated 256 weekly excess returns for each of the 300 samples. Also, it is important to note that in every one of these tests, the **null hypothesis is K = 1** and every test is examined firstly under the assumption that the **null hypothesis is false** and then under the assumption that the **null hypothesis is true**.

Results

The first and most important result of this study is the fact that the **conditional mean-variance efficiency of a value-weighted stock index** (meaning the market portfolio) **is rejected** for the **whole time period** (1963-1982) and this rejection is **not sensitive to the variability of the expected risk premiums**. On the other hand, "*a* ***single risk-premium model of expected returns is not rejected*** *if the premium is allowed to vary over time and if the risk measures associated with that premium are not constrained to equal market betas*"[50]. Some of the explanations that the authors provide in order to justify the conditional mean-variance efficiency rejection are the following:

1. Expected returns can vary with a single risk-premium model that is different from a market portfolio.
2. This rejection can be consistent with the CAPM because the original market portfolio cannot be measured and therefore all the tests are run on smaller sets of assets.
3. A test of mean-variance efficiency shows a different sensitivity to the issue of missing assets than a test of the exact pricing with K-risk premiums.
4. The statistical assumptions of the constant conditional covariance matrices V and Ω might not apply for the conditional mean-variance efficiency tests.

[50] Wayne, E., Ferson, Shmuel, Kandel & Robert, F., Stambaugh, "*Tests of Asset Pricing with Time-Varying Expected Risk Premiums and Market Betas*", Journal of Finance, Vol.XLII, No.2, 1987, Page 219.

5. Other statistical anomalies.

Furthermore, if we want to translate the above results into the framework of the **three -3- hypotheses**, we can conclude that **Hypothesis 1 is rejected**, as it describes the conditional mean-variance efficiency, **Hypothesis 2 is not rejected**, as it describes the exact pricing with a single premium and **Hypothesis 3 is strongly not rejected in any individual subperiod**.

2.3.7 A Capital Asset Pricing Model with Time-Varying Covariances (Tim Bollerslev, Robert F. Engle & Jeffrey M. Wooldridge, 1988)

Main Purpose

The main purpose of this paper is to **derive** a **multivariate generalized autoregressive conditional heteroscedastic process for stocks, bonds, and T-bills**. Each **expected return** of every asset class **is proportional to its conditional covariance with the one of a well-diversified portfolio** (market portfolio). Also, the **main focus** of the paper is to prove if the agents have **conditional expectations on the moments of future expected returns** and therefore if these are **random variables rather than constants**.

Methodology

The approach of this paper is similar to the approaches of respective papers in the field. Specifically, one can support that the approach is relevant to the one of Engle, Lilien, and Robins (1987), which estimated the time-varying risk premium of a single asset as a function solely of the conditional variance of the asset’s return. Furthermore, this approach can be seen as a statistical interpretation of the intertemporal CAPM of the papers of Bodie et al. (1983, 1984). Last but not least, the statistical approach of this paper can be seen as a generalization of Frankel (1985).

The authors tested the following assumptions of the original CAPM:

Assumption #1: All investors choose mean-variance efficient portfolios with a one-time horizon and without the same utility functions.

Assumption #2: The expectations of every investor in the market on the means, variances, and covariances of returns are identical.

Assumption #3: The market is efficient, meaning that transaction costs, indivisibilities, taxes, and constraints on borrowing or lending at the risk-free rate are non-existent.

It is also assumed that the **conditional covariance matrix of a set of asset returns** can **vary between different time periods** and it will **follow the Generalized Autoregressive Conditional Heteroscedastic (GARCH) process**. This implies that any estimates on the means, the variances, and the covariances of the asset returns are **updated** to **include last period's financial information**. Thus, changes in the covariance matrix happen only when new data are available for the asset returns.

The GARCH (1,1)-M model that was used in the study is the following:

$$y_{it} = b_i + \delta \sum_j \omega_{jt} h_{ijt} + \varepsilon_{it} \quad \mathbf{(2.29)}$$

$$for\ i,j = 1, \dots, N$$

Where,

- $\boldsymbol{y_{it}}$ **=** The **expected excess return** of the **ith element** of vector N x 1 through time **(t)**.
- $\boldsymbol{b_i}$ **=** The **ith element** of N x 1 **vector of constants**.
- $\boldsymbol{\delta}$ **=** A **scalar constant of proportionality**.
- $\boldsymbol{\omega_{jt}}$ **=** The **jth element** of the **vector of value weights**.
- $\boldsymbol{h_{ijt}}$ = The **ijth element** of the **corresponding matrix of covariances**.
- $\boldsymbol{\varepsilon_{it}}$ = The **statistical error term**.

The **data** that were used in the study represent New York Stock Exchange value-weighted equity returns, whose market yields were taken from the Center for Research in Security Prices (CRSP) of the University of Chicago. Also, the data include six -6-month Treasury Bills, and twenty -20-year Treasury Bonds, whose yields were taken from Salomon Brothers. The data are quarterly percentage returns from the first -1st-quarter of 1959 up until the second -2nd- quarter of 1984. The total number of observations is 102. The risk-free rate of return is represented by the 3-month T-bill. Finally, two -2- data sets for these return series were analyzed.

Results

Firstly, based on the results of the study, the value of **(δ)** is **highly statistically significant**, something that supports the theory presented in the paper. Secondly, it is proven that the **conditional covariances can vary over time** (meaning that they are **extremely autoregressive**), that **they are a statistically significant determinant of the time-varying risk premia** and **any study** of the CAPM that **treats them as constants tends to falter**. Specifically, about the **risk-premia**, they are **influenced by the conditional second moments of the returns** and the authors conclude that **their increasing trend** over the volatile period around October 1979 and afterward, is completely **reasonable**.

Furthermore, the results provide evidence that the **risk-premia** might be **better represented by covariances with the involved market rather than by individual variances**. Moreover, **new information in addition to the old data in asset returns** is important in **the explanation of the risk-premia and the heteroscedasticity**. Last but not least, the **beta for stocks** reaches almost **one (1)**, the **beta for bonds** is somewhat **above one (> 1)** and the **beta for T-bills** is close to **zero (0)**.

2.3.8 The Consumption-Based Capital Asset Pricing Model (Darrell Duffie & William Zame, 1989)

Main Purpose

The main purpose of this paper is to **provide the basic conditions on a primitive model of a continuous-time economy, where there exist equilibria that follow the Consumption-Based Capital Asset Pricing Model (CCAPM)**. Also, the authors **present an asset pricing model** that **extends** the studies of Cox, Ingersoll, and Ross (1985), Rubinstein (1976) and Lucas (1978) **to a multi-agent economy**. Finally, we note that the **Markovian State Assumption is not taken into consideration** by the asset pricing model that the authors introduce and which is based on the CCAPM pricing equation.

Methodology

The CCAPM is given by the following equation:

$$E(R^n) - r = \beta_{en} * [E(R^e) - r] \quad (\mathbf{2.30})$$

Where,

- $\boldsymbol{R^n}$ = The **return on asset (n)**.
- $\boldsymbol{r}$ **=** The **risk-free rate of return.**
- $\boldsymbol{\beta_{en}}$ **=** The **beta** of **asset (n)** with respect to the **portfolio ($\boldsymbol{\theta^e}$)** which represents the **aggregate consumption**.
- $\boldsymbol{R^e}$ = The **return of any portfolio ($\boldsymbol{\theta^e}$)**.

Before we continue on describing how Equation 2.30 is generated and which is the continuous-time economy and its equilibria, it is important to state the **main principle** that the Consumption-Based CAPM is based on:

"***Marginal utility for actual consumption equals marginal indirect utility for total wealth***"[51].

Now, the entire **continuous-time and pure-exchange economy** of **(m) agents** in the **finite time interval [0, T]** with a **consumption space** equal to the **vector space L of square-integrable predictable stochastic processes** is described in this study as the following collection:

$$E = \left[(\Omega, F, F', P), \left(U^i, e^i\right), D\right] \quad (\mathbf{2.31})$$

$$i \in \{1, \dots, m\}$$

Where,

- ❖ $(\boldsymbol{\Omega}, \boldsymbol{F}, \boldsymbol{P})$ = The **probability space** on which is defined a **standard Brownian Motion B in** $\mathbb{R}^{\boldsymbol{k}}$.
- ❖ $\boldsymbol{F}' = \{\boldsymbol{F_t}: \boldsymbol{t} \in [\mathbf{0}, \boldsymbol{T}]\}$ = The **augmented filtration of sub-tribes** (σ-algebras) of F **naturally generated by B**.
- ❖ $\boldsymbol{U^i}$ = The **utility function** on the **positive cone ($\boldsymbol{L_+}$) of consumption processes**.
- ❖ $\boldsymbol{e^i} \in \boldsymbol{L_+}$ = The **endowment process** $\{\boldsymbol{e^1}, \dots, \boldsymbol{e^m}\}$ for $i \in \{1, \dots, m\}$.
- ❖ $\boldsymbol{D} = (\boldsymbol{D^0}, \dots, \boldsymbol{D^n})$ = The **(N + 1)-dimensional Ito cumulative dividend process**.

The economy that Equation 2.31 describes is a collection of **Equilibria** that each of them is described by the following collection:

$$E = [(S, p), (x^1, \theta^1), \dots, (x^m, \theta^m)] \quad (\mathbf{2.32})$$

Where,

- ❖ $\boldsymbol{S} = (\boldsymbol{S^0}, \dots, \boldsymbol{S^N})$ = The **(N + 1)-dimensional Ito security price process**.
- ❖ $\boldsymbol{p} = (\boldsymbol{p^0}, \dots, \boldsymbol{p^N})$ = The **(N + 1)-dimensional Ito consumption spot price process**.

[51] Darrell, Duffie, William, Zame, "*The Consumption Based Capital Asset Pricing Model*", Econometrica, Vol.57, No.6, 1989, Page 1282.

- $(\boldsymbol{x}, \boldsymbol{\theta})$ = **A budget feasible plan for each agent (i)**, meaning the **accounting restriction that current portfolio's wealth must be derived only from the combination of trading gains and net consumption purchases**. Also, $i \in \{1, \ldots, m\}$.
- $\boldsymbol{x^i}$ = The **consumption rate of (i)**, $i \in \{1, \ldots, m\}$.
- $\boldsymbol{\theta} = (\boldsymbol{\theta^0}, \ldots, \boldsymbol{\theta^N})$ = The **(N + 1)-dimensional Ito predictable portfolio process**.

It is important to clarify that when the authors refer to an **Ito process**, they mean the following **stochastic differential expression**:

$$dG_t = \mu_G(t)dt + \sigma_G(t)dB_t \quad (\mathbf{2.33})$$

Where **G is the asset (security) that follows this process**.

Furthermore, the authors provide information on the **conditions** that must **prevail** so that these **equilibria** can be developed. These conditions are:

Condition #1: For each agent (i), U^i is represented in the following form:

$$U^i(x) = E[\int_0^T u_i(x_t, t)dt\,] \quad (\mathbf{2.34})$$

where, $u_i\colon \mathbb{R}_+ X[0, T] \rightarrow \mathbb{R}$

Specifically, for each $t \in [0, T]$ the function u_i is strictly concave and it increases with the first derivative in (0, +∞).

Condition #2: "*The aggregate endowment process* $e = \sum_{i=1}^{m} e^i$*is an Ito process, bounded away from zero, where the stochastic differential representation* $de_t = \mu_e(t)dt + \sigma_e(t)dB_t$ *such that* $E(\int_0^T \sigma_e(t) * \sigma_e(t)dt) < \infty$"[52].

Condition #3: A Martingale generator is formed by martingales $M^1, \dots, M^N$ which are defined by the following mathematical expression:

$$M_t^n = E[\, D_T^n \mid F_t \,] \quad \mathbf{(2.35)}$$

$$t \in [0, T]$$

Results

Because this paper is a completely theoretical approach to the CCAPM model, the authors did not examine it empirically and therefore there are not any empirical results or a certain numerical procedure. Nevertheless, based on the above analysis, the authors state the following **Theorem** that is derived based primarily on the conditions that were described previously:

"***Under Conditions #1 - #3 on the economy E, there exists an equilibrium with a representative agent (*** U_λ***, e), such that, for any time (t), the vector*** $\widehat{S}_t$ ***of real security prices satisfies the representative agent pricing formula***

$$\hat{S}_t = \frac{1}{u_{\lambda c}(e_t, t)} E[\int_t^T u_{\lambda c}(e_s, s) d\widehat{D}_s \mid F_t] \quad \mathbf{(2.36)}$$

$$t \in [0, T)$$

[52] Darrell, Duffie, William, Zame, "*The Consumption Based Capital Asset Pricing Model*", Econometrica, Vol.57, No.6, 1989, Page 1285.

Moreover, for any agent (i) with $e^i \neq 0$, the equilibrium consumption process $x^i$is bounded away from zero”[53].

The direct **Consequence** of the above Theorem 1 is the following:

“***Further to the statement of the Theorem, for any cumulative (Ito) dividend process Y of finite variance and any terminal lump sum dividend δ of finite variance, the augmented economy $E^{Y\delta}$has an equilibrium with the same consumption allocation and the same representative agent in which the real price process $S^{Y\delta}$for the security (Y, δ) satisfies the following equation***”[54]:

$$S_t^{Y\delta} = \frac{1}{u_{\lambda c}(e_t, t)} E\left[\int_t^T u_{\lambda c}(e_s, s)dY_s + u_{\lambda c}(e_t, t)\delta \;\middle|\; F_t\right] \quad (\mathbf{2.37})$$

$$t \in [0, T]$$

Based on all the previous assumptions and using the Ito process, the authors generated the CCAPM equation which is the same as Equation 2.27. Last but not least, it is important to mention that **Equation 2.37** can be proven that **holds in Breeden’s sense of a single-agent economy** and therefore if the **equilibrium allocation is in a single-agent economy**, then **it is Pareto optimal**.

[53] Darrell, Duffie, William, Zame, “*The Consumption Based Capital Asset Pricing Model*”, Econometrica, Vol.57, No.6, 1989, Page 1287.
[54]”, Page 1289.

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

Main Purpose

The main purpose of this paper is to **identify if there exists an ex-ante efficiency of a given portfolio of assets**. Specifically, the paper **examines** whether **any particular portfolio is ex-ante mean-variance efficient** by using a canonical example of such a test. Also, the authors try to **provide some information on multivariate tests** and their **significance** in deriving results.

Methodology

The three -3- authors start their analysis by considering a multivariate statistic for checking the mean-variance efficiency of a portfolio. They assume throughout the paper that it exists a **riskless rate of interest (R_{ft})** for every time period. Using a multivariate linear regression, the authors assume that the **a term** is **equal to zero**. This is the **null hypothesis**. Furthermore, it is assumed that the **error terms (disturbances)** are **jointly normally distributed** with a **zero mean** and a **nonsingular** (meaning that the number of time-series observations should always exceed the number of assets under study) **covariance matrix Σ** that is conditional on the excess returns of a given portfolio. Also, one extra hypothesis is that the **disturbances** are **independent over time**.

The **null hypothesis** and any **departures from it** are tested by using the **W statistic** which is described by the following equation:

$$W = \left[\frac{\sqrt{1 + \hat{\theta}^{*2}}}{\sqrt{1 + \hat{\theta}_p^2}} \right]^2 - 1 = \psi^2 - 1 \quad (\mathbf{2.38})$$

Where,

- $\widehat{\boldsymbol{\theta}}^{*}$= The **ex-post price of risk**, meaning the **maximum excess sample mean return per unit of sample standard deviation**.
- $\widehat{\boldsymbol{\theta}}_{\boldsymbol{p}}$= The **ratio of ex-post average excess return on portfolio (p) to its standard deviation**.

The authors do mention that when $[\widehat{\theta}^{*} \gg \widehat{\theta}_{p}]$ then the hypothesis that the **portfolio (p) is ex-ante mean-variance efficient is rejected**. This is not true when $\frac{\widehat{\theta}_{p}}{\widehat{\theta}^{*}} = 1$. Then the null hypothesis is true. If the quantity $\frac{\widehat{\theta}_{p}}{\widehat{\theta}^{*}}$ approaches zero, then the portfolio is becoming **less efficient**, and as we mentioned earlier, the null hypothesis is **rejected**. They also describe **ψ** as a **new measure** for testing **portfolio performance**. In order to test the **power of the multivariate test**, the authors have used the **noncentrality parameter (λ)**, which is described by the following equation:

$$\lambda = \left[\frac{T}{1 + \widehat{\theta}_{p}^{2}}\right] a_{p}' \Sigma^{-1} a_{p} \quad (\mathbf{2.39})$$

Where,

- **T** = The **number of time-series observations on returns**.
- $\boldsymbol{a_p'} = (\widehat{\boldsymbol{a}}_{\boldsymbol{1p}} \widehat{\boldsymbol{a}}_{\boldsymbol{2p}} \ldots \widehat{\boldsymbol{a}}_{\boldsymbol{Np}})$

They use the above **λ** parameter and a different number of **N** and **T** to check the power of the test and to assess which is the proper choice of λ, N, and T. They also tested whether the results of the multivariate tests are in accordance with the results of **univariate tests** that can be employed. It turned out that the answers are somewhat different between multivariate and univariate tests. Last but not least, as a wrap-up for the methodology that the three -3- authors used, we can comment that they provided a test of the **ex-ante unconditional efficiency of a portfolio**. But, by using empirical data, this method is transformed into a test of the **conditional efficiency** of a portfolio, knowing also the risk-free rate of return.

Furthermore, regarding the **data**, these were taken from the Center for Research in Security Prices (CRSP) of the University of Chicago and represent monthly returns of the firms on the New York Stock Exchange (NYSE) for the period from 1926 to 1982 (meaning 684 observations). The portfolio (p) was represented by the CRSP Value-Weighted Index for the whole period. Also, the CRSP Equal-Weighted Index was used for the 1931-1965 period.

In the empirical study, **twelve -12- industry portfolios** were used to derive the data from. Then the firms were categorized into **ten -10- portfolios** regarding the **market value of their total outstanding equity**. The **first -1st- portfolio** contained all the firms with the **lowest value** and the **tenth -10th- portfolio** contained all the firms with the **highest value**. The firms in each of the portfolios were being **resorted every five -5- years** (meaning 1925, 1930, … 1980). The portfolio formation represented a **low transaction cost investment strategy**. Also, in order to construct the **Efficient Frontier**, the authors, in one case, used the twelve -12- industry portfolios and the CSRP Value-Weighted Index for the whole period (meaning 1926-1982) and in the other case the above ten -10- size-sorted portfolios and the CSRP Equal-Weighted Index for the period from 1931-1965.

Results

The most significant result is that the **multivariate test** that this paper provides **confirms the BJS (1972) conclusion**, meaning that the **ex-ante efficiency of the CRSP Equal-Weighted Index cannot be rejected**. The authors do mention that if this index is also the true market portfolio then the Sharpe-Lintner version of the CAPM cannot be rejected either. Furthermore, it is proven that the **ex-ante efficiency of the CRSP Value-Weighted Index cannot be rejected** either.

Moreover, the multivariate test **rejects the null hypothesis** at the 1% level, something totally contradictory to the results of the univariate tests. Finally, if it is assumed that the Equal-Weighted Index is an efficient portfolio, then the result that the authors come up with is that **high-beta portfolios earn too little** and **low-beta portfolios earn too much**.

2.3.10 The Cross-Section of Expected Stock Returns (Eugene F. Fama & Kenneth R. French, 1992)

Main Purpose

The main purpose of this paper is to use simultaneously in an asset-pricing model the **Size (ME)** and **Book-to-Market Equity (BE/ME) factors** in order to **trace** the **cross-sectional alternations in average stock returns** that are associated with the ratios of market beta (β), size, leverage, book-to-market equity (BE/ME) and earnings-price (E/P). Specifically, Fama and French tried to **assess** the **joint role** of **market beta** and other **alternative risk factors** (such as **Size**, **BE/ME**, **Leverage**, **E/P**) that can explain the cross-section of average returns on NYSE, AMEX, and NASDAQ stocks.

Methodology

The two -2- authors follow the same methodology as Fama and Macbeth (FM) did in their study in 1973. However, the only difference with the FM approach is that they try to **estimate portfolio betas first** and then **assign each beta to each individual stock** in the portfolio. Therefore, by doing so, they are able to use **individual stocks** and not portfolios in the cross-sectional regressions of the FM methodology. They choose the approach of studying individual stocks because **Size (ME)**, **E/P**, **Leverage** and **BE/ME** are measured primarily for stocks.

Specifically, in June of every year (suppose year t-1), all the NYSE stocks are **categorized based on Size (ME)** in order to be found the specific **decile breakpoints** for **ME**. Then, **ten -10- deciles are found** and in order to capture the **betas that are unrelated to the ME**, the authors **subdivide** each of these ten -10- deciles into **ten -10- portfolios**, **a pre-ranking beta procedure** for each stock. This procedure demands that there are available data for each stock for the **previous 24-60 months in the five -5- years preceding July of year t**. Furthermore, at the end of December in year t-1, the **BE/ME**, **Leverage** and **E/P ratios** are calculated. Finally, we should mention that the **accounting data** are **matched** for all fiscal year ends of year t-1 with the returns for July of year t to June of year t+1.

After the above procedure, the firms are assigned to the **β-sized portfolios** and for the **next twelve -12- months**, meaning from June of year t-1 to July of year t, **equally-weighted monthly portfolio returns** are computed. These returns represent the **post-ranking monthly return** on one hundred -100- (10x10) portfolios that were formed on **ME** and **pre-ranking betas (β's)**. Then, the **post-ranking betas (β's)** are estimated for each of the one hundred -100- portfolios. The **market proxy** for this **post-ranking estimation** is the simultaneous use of NYSE, AMEX, and NASDAQ (after 1972) stocks. Also, the **full period of post-ranking beta (β)** of a β-sized portfolio is **allocated** to each **individual stock** in the portfolio. These represent the betas that are used in the FM cross-sectional regressions. Last but not least, each **beta** is estimated as the **sum of the slopes in the regression of the return on a portfolio on the current and the previous month's market return**.

Moreover, the **data** that were used for this empirical study represent monthly returns for all the non-financial firms from the intersection of NYSE, AMEX and NASDAQ indices. They are taken from the Center for Research in Security Prices (CRSP) at the University of Chicago. In addition, data are also derived from the merged COMPUSTAT annual industrial files of income statement and balance sheet data, maintained by the CRSP, as well. The whole time period of the research is twenty-seven and a half -27.5- years, meaning that it starts from July 1962 and ends in December 1990. Finally, the total number of firm returns analyzed is 2317 stock returns.

Results

Firstly, when the model incorporates only the beta factor and the ME factor, it is clearly shown that **exists a positive relationship** (something that favors the CAPM model) **between the beta and the average return** and **a negative relationship between the ME and the average return**. But if we take a look closer and control for the ME, then the positive relationship completely vanishes and therefore, there is no relationship between the beta factor and average returns. Also, even when the beta is the only explanatory variable, still the relationship between the (β) and the average return is **flat**. Moreover, it is shown that **BE/ME**, **Leverage** and **E/P** are **not good proxies** for β, either.

On the other hand, the results indicate that **Size (ME)** is a **valid factor** that **can explain the cross-section of average returns**. In addition, it is also proven that **BE/ME is a valid and even a more powerful factor** than ME in explaining the cross-section of average returns. Specifically, exists a **strong positive relationship between BE/ME and average returns**. Also, the **relative-distress effect** that was introduced in the Chan & Chen paper (1991) is **captured by the BE/ME factor**. At last, the results show that the combination of ME and BE/ME **absorb the effects of Leverage and E/P**.

In conclusion, the **market beta** seems to be a factor that **cannot explain** the average returns on NYSE, AMEX, and NASDAQ, a finding that does not support the CAPM model where the average stock returns must be positively related to the β. In contrast, **ME** and **BE/ME** provide significant results in **capturing** the **cross-sectional variation effects** of **Leverage** and **E/P** on the average stock returns. These findings are also supported by the **average FM slopes** that show a **negative premium of ME**, a **positive premium of BE/ME** and a **zero -0- premium of beta (β)** in the cross-section of returns.

2.3.11 A Test of the International CAPM Using Business Cycles Indicators as Instrumental Variables (Bernard Dumas, 1994)

Main Purpose

The main purpose of the author of this paper is to **identify state variables of the economy**. Specifically, he **aims to use as instruments of state variables, economic variables that are external to the world financial markets, such as the business cycles indicators**. Also, the asset pricing models that he **tests** are **the International CAPM and the Classic CAPM** in order to find out which asset pricing model **works correctly with the data**. Finally, the author's last goal is to **highlight the existing links among the predicted activity levels and conditionally expected stock returns**.

Methodology

The **International CAPM** that the author incorporates in his research, is an asset pricing model that **uses foreign-exchange risk premia**. The mathematical expression of this financial model in a world of **L+1 countries**, **a set of $\boldsymbol{m = n + L + 1}$ assets**, **(n) equities or portfolios of equities**, **L non-measurement currency deposits** and a **world portfolio of equities** which is the **mth asset**, is the following:

$$E[r_{jt} \mid \Omega_{t-1}] = \sum_{i=1}^{L} \lambda_{i,t-1} Cov[r_{jt}, r_{n+i,t} \mid \Omega_{t-1}] + \lambda_{m,t-1} Cov[r_{jt}, r_{mt} \mid \Omega_{t-1}] \quad \mathbf{(2.40)}$$

Where,

- $\boldsymbol{r_{jt}}$ = The **nominal return on an asset (j) or a portfolio (j)**, with $j = 1, \dots, m$. This return is calculated from time (t-1) to (t), in excess of the rate of interest of the currency in which returns are measured.
- $\boldsymbol{\Omega_{t-1}}$ = The **information set** which investors use in choosing their portfolios.

- $\boldsymbol{\lambda_{i,t-1}}$ = The **time-varying coefficients** of the **world prices of foreign exchange risk**, $i = 1, \ldots, L$.
- $\boldsymbol{\lambda_{m,t-1}}$ = The **time-varying coefficient of the world's market risk price**.
- $\boldsymbol{r_{mt}}$ = The **excess return on the world market portfolio**.

Furthermore, in order for the author to proceed thoroughly to the econometric procedure of his study, **two -2- assumptions** are taken into consideration. These are the following:

1. The **information set $\boldsymbol{\Omega_{t-1}}$** is derived by a **predetermined instrumental variable vector $\boldsymbol{Z_{t-1}}$**. This vector contains all the information that investors know up to that moment.
2. There exists **an exact linear relationship** between the **market prices λs and the Zs variables**. This relationship is the following:

$$\lambda_{0,t-1} = -Z_{t-1}\delta \quad (\mathbf{2.41})$$

$$\lambda_{i,t-1} = Z_{t-1}\varphi_i \quad (\mathbf{2.42})$$

$$\lambda_{m,t-1} = Z_{t-1}\varphi_m \quad (\mathbf{2.43})$$

Where,

- $\boldsymbol{\delta \; and \; \varphi}$ are **time-invariant vectors of weights**. They are estimated by the **Generalized Method of Moments (GMM)**.

Moreover, regarding the **data** that the author used, these represent monthly excess returns on equity and currency holdings, all measured in a common currency, the US dollar. The total number of data points in the whole period of the study is 264 data-point series for four -4- countries; the USA, the United Kingdom, West Germany, and Japan. The time period that was covered started from January 1970 and ended in December 1991. Also, the author acknowledges the fact that he had to lag the rate of return on the world index by one -1- month in order to try to identify potential lags of instruments on the returns, and therefore the actual number of data-point series is 262, starting from March 1970 and ending in December 1991.

Regarding the **assets** that the study incorporates, these are **eight -8- assets in addition to the US dollar deposit**. These assets are the following:

1. The Equity Index of each country (meaning four -4- indices).
2. A Deutsche-mark Deposit.
3. A Pound Sterling Deposit.
4. A Yen Deposit.
5. The World Index of Equities.

Last but not least, the amount of **exchange-risk premia** that is used is **three -3- as are the exchange rates in the dataset**.

In addition, the **methodological approach** that the author deployed can be **split into two -2- parts**. The **first 1st- part** of this research deals with the behavior of worldwide asset returns on the US instrumental variables. Specifically, Dumas uses two -2- sets of US economic indicators; the Main Economic Indicators of the Organization for Economic Cooperation and Development (OECD) and the Component Indicators as they were selected by Stock and Watson in 1993.

The **Main Economic Indicators by OECD** are the following:

- ✓ US level in Total Inventories in Manufacturing Industries.
- ✓ US Residential Construction put in place.
- ✓ US Total Value of Retail Sales.
- ✓ US percentage of Unemployment out of the civilian labor force.
- ✓ US Commercial Bank Loans.
- ✓ US Money Supply (Type M3).

On the other hand, the **Component Indicators** in the Stock-Watson study (1993) were representing the **US Leading Economic Indicators** as they were defined by the **National Bureau of Economic Research (NBER)**. These were the following:

- ➢ New Housing Authorizations (in level form).

- Average Weekly Hours of Production Workers in the Manufacturing Sector (in level form).
- Vendor Performance (meaning the percentage of companies that reported slower deliveries – in level form).
- Manufacturers' Unfilled Orders in the Durable Goods Industry (passed through filter $1 + 2L + 2L^2 + L^3$).
- Capacity Utilization Rate in Manufacturing (in first difference form).
- Index of Help-wanted Advertising in Newspapers (in growth rates).

Furthermore, the **second -2nd- part** of this methodological approach explores the behavior of worldwide asset returns on the basis of country-specific instrumental variables. Specifically, the author uses the leading indices of the four -4- countries' business cycles as instrumental variables. The data for this part were taken from the Center for International Business Cycle Research (CIBCR) and they were also used to the investigation of the predictive ability of the components of each country's index. Finally, we should note that for both parts of the above statistical analysis, the method of Ordinary Least Squares (OLS) and the Generalized Method of Moments (GMM) were employed.

Results

Regarding the **first -1st- part** of the analysis and the Main Economic Indicators, it was observed that their **predictive power** was generally **lower than** the one of **internal financial variables**. Only the indicator of the **US level in Total Inventories in Manufacturing Industries** showed a **significant predictive power**. In this part, the **International** as the **Classic CAPM were both rejected**. Regarding the approach of the US Leading Economic Indicators, results showed that the **International CAPM is marginally accepted** and the **Classic CAPM is rejected**. Specifically, the **Vendor Performance** and the **Housing Authorizations** showed **high predictive power**. Also, the **foreign-exchange risk premia were statistically significant**.

On the other hand, the **second -2nd- part** of the procedure regarding the country-specific instrumental variables, showed **no better forecasting performance than** the **NBER**

series (meaning the US Leading Economic Indicators). Also, due to a large number of instruments, both the CAPM models could not be tested by the GMM. Because of these non-significant results, the author concludes that the method of **country leading indices was not powerful**, neither to forecast nor to discriminate among the CAPM models.

2.3.12 The Capital Asset Pricing Model and the Liquidity Effect: A Theoretical Approach (Gady Jacoby, David J. Fowler & Aron A. Gottesman, 2000)

Main Purpose

The main purpose of this paper is to **develop a liquidity-adjusted CAPM-based model in order to prove that the beta term and the liquidity factor are inseparable**. The authors do base their theoretical approach on the **net after bid-ask spread returns** and they also examine the **relationship between expected returns and the spread costs in a CAPM environment**.

Methodology

In order to derive their model, the authors assume a **one-period world with an uncertain future bid-ask spread**. **Liquid and illiquid assets are held for the whole period**, meaning that investors are **not allowed to trade liquid assets more frequently than the illiquid ones**. As the authors mention, this hypothesis eliminates the **clientele and concavity effects** of the Amihud and Mendelson approach (1986). Finally, the **systematic risk factor of the model incorporates the after-spread returns**.

The **assumptions** that this alternative model is based on, are the following:

- ❖ The majority of the assumptions of the Traditional CAPM are valid for this model.
- ❖ Market imperfection does not exist.
- ❖ The after-spread asset returns are not jointly normal.
- ❖ Assets are differently marketable, meaning that liquidity costs are involved and computed by the relative spread.
- ❖ The end-period bid-ask spread is a random variable.
- ❖ Investors are price-takers and cannot affect in any way the liquidity of an asset.
- ❖ There are no liquidity costs for the risk-free asset.
- ❖ There exist risk-averse market makers who can offer immediate services to the existing investors in the market for a fee equal to the bid-ask spread.
- ❖ Each asset return that is clear of liquidity costs is jointly normally distributed with all the other equivalent assets' returns.
- ❖ Both investors and market makers have a quadratic utility function.

The familiar **CAPM-based equation** of the model that the authors derive in this approach is the following:

$$E\left[\tilde{R}_j^*\right] = R_f + \beta_j^*\left(E[\tilde{R}_m^*] - R_f\right) \quad (\mathbf{2.44})$$

The **CAPM-based model equation** though, that the authors derive originally before transforming it into the familiar CAPM equation is the following:

$$E\left[\tilde{R}_j^*\right] = E\left[\tilde{R}_j \frac{(1-\tilde{S}_j)}{(1+S_j)}\right]$$

$$= R_f + \frac{Cov\left(\frac{(\tilde{R}_m - \tilde{C}_m)}{(1+S_m)}, \tilde{R}_j \frac{(1-\tilde{S}_j)}{(1+S_j)}\right)}{Var\left(\frac{(\tilde{R}_m - \tilde{C}_m)}{(1+S_m)}\right)}$$

$$* \left\{E\left[\frac{(\tilde{R}_m - \tilde{C}_m)}{(1+S_m)}\right] - R_f\right\} \quad (\mathbf{2.45})$$

Where,

- $\boldsymbol{E[\tilde{R}_j^*]}$ = The **expected net after-spread return on asset (j)**.
- $\boldsymbol{\tilde{R}_j}$ **=** The **return on risky asset (j) before liquidity costs**.
- $\boldsymbol{\tilde{S}_j}$ **=** The **end of period liquidity cost of asset (j)**, which is a random variable.
- $\boldsymbol{S_j}$ **=** The **liquidity cost of asset (j)**.
- $\boldsymbol{R_f}$ = The **risk-free rate of return**.
- $\boldsymbol{\tilde{R}_m}$ **=** The **return of the market portfolio (m) before liquidity costs**.
- $\boldsymbol{\tilde{C}_m}$ = The **dollar amount spent in liquidity costs at the end of the period, relative to the value of the market portfolio (m) today**.
- $\boldsymbol{S_m}$ **=** The **liquidity cost of the market portfolio (m)**.

Therefore, the **factors of Equation 2.45** are the following:

$$\beta_j^* = \frac{Cov\left(\frac{(\tilde{R}_m - \tilde{C}_m)}{(1+S_m)}, \tilde{R}_j \frac{(1-\tilde{S}_j)}{(1+S_j)}\right)}{Var\left(\frac{(\tilde{R}_m - \tilde{C}_m)}{(1+S_m)}\right)}$$

Which is the **measure of systematic risk of asset (j)**, meaning **its beta factor**.
Also,

$$E[\tilde{R}_m^*] = E\left[\frac{(\tilde{R}_m - \tilde{C}_m)}{(1+S_m)}\right]$$

Which is the **net (after-spread) market risk premium**.
The three -3- authors note that this model offers a **risk premium per unit of systematic risk lower than the classic CAPM**, meaning $E[\tilde{R}_m] > E[\tilde{R}_m^*]$.

Results

This study is a theoretical one and therefore the results that the authors provide are theoretical and not empirical. Specifically, the authors conclude that the **expected gross return is an increasing and convex function in the expected (next period) spread ratio**, a finding that is the opposite of the findings of Amihud and Mendelson (1986).

Furthermore, this result **holds for securities with high spreads**, because when the expected spread of the end period reaches almost 100% (meaning $E[\tilde{S}_j] = 1$), each investor before entering in a long position will demand extremely high compensation in terms of expected gross returns. Geometrically, this means that the graphical representation of the expected gross returns will move asymptotically to the vertical line where $E[\tilde{S}_j] = 1$. The authors call this phenomenon as the **level effect** which is also empirically approved by the study of Brennan and Subrahmanyam (1996).

Moreover, **the measure of systematic risk has to include possible adverse changes in the spread ratio level of the security (j)**. This model proves that the **beta** and the **liquidity** are two -2- **inseparable terms**. Last but not least, the authors **reject the traditional CAPM** because the **after spread beta measure is not linear in the classic form of the CAPM model**.

2.3.13 Risk and Return: CAPM and CCAPM (Ming Hsiang Chen, 2002)

Main Purpose

The main purpose of this paper is to **examine if a consumption beta (consumption growth risk) can serve as a better measure of systematic risk than the market beta**. In order to do so, the author examines the **validity of the CAPM and the Consumption-based CAPM (CCAPM)** across **seven -7- industry sectors** in the **emerging Taiwan Stock Market**.

Methodology

The author decided to cover the Taiwan Stock Market because it is characterized as a **very volatile market** and one that offers **extremely high returns**. As we said in the main purpose, the study took place across **seven -7- industry sectors** based on the **Taiwan Stock Exchange (TSE) classification** which sectors are the following:

- Cement and Ceramics Sector
- Construction Sector
- Electrical Sector
- Financial Sector
- Food Sector
- Plastic and Chemicals Sector
- Textile Industry Sector

The **data** that the author used are four -4- monthly time series including stock price indices, dividend payments, risk-free rates, and the consumer price index of Taiwan for a time period from July 1991 to March 2000. The data were taken from the publications of the Central Bank of China. The market composite stock price index is represented by the Taiwan Capitalization-Weighted Stock Index (TWSE) and the monthly dividend price yields are derived from the TSE Corporation publications.

Furthermore, for each separate industry sector, the price indices and the dividend yields are obtained from the Financial Database of the Taiwan Economic Journal. Also, the monthly consumer price index is taken from the Taiwan Statistical Data Book and its base period (= 100) is in June 1996. When the author computed these four -4- time series, then he calculated the real stock prices, real dividends, and their growth rates in order to be able to compute the annualized equity returns.

Using the above data, the author **tested** the **CAPM** by calculating **series of risk premium and equity premium in each sector**, the **CCAPM** and he tested also **if the market risk and the consumption growth rate risk are priced significantly**. Specifically, because the author used Lucas' (1978) CCAPM model and the previous study by Chen et al. (1986), instead of using the consumption growth rate for this test, he used the **dividend growth rate** because in the study of Lucas (1978) dividends are equivalent to consumption. Moreover, Chen tested the **consumption growth rates** by employing the **growth rates of imports** as a **proxy**. He did so because Asprem in 1989 suggested that any changes in the growth rate of imports show changes in consumption and investments rates. The **two -2- alternative hypotheses** for each of the above consumption growth rate proxies, are represented by the following regression equations:

Using **Dividend Growth (DG) Rates** the **Regression Equation** is the following:

$$R_{j,t} - R_{f,t} = \hat{\beta}_{j,m}\left(R_{m,t} - R_{f,t}\right) + \hat{\beta}_{j,c}DG_{j,t} + \zeta_{j,t} \quad \mathbf{(2.46)}$$

Where,

- ✓ $\boldsymbol{R_{j,t}}$ **=** The **realized rate of return of asset (j)** in time (t).
- ✓ $\boldsymbol{R_{f,t}}$ = The **risk-free rate of return** in time (t).
- ✓ $\boldsymbol{\widehat{\beta}_{j,m}}$ = The **estimated beta** (factor of systematic risk) **for the market portfolio (m)**.
- ✓ $\boldsymbol{R_{m,t}}$ = The **realized rate of return of the market portfolio (m)** in time (t).
- ✓ $\boldsymbol{\widehat{\beta}_{j,c}}$ = The **estimated consumption beta of asset (j)**.
- ✓ $\boldsymbol{DG_{j,t}}$ = The **dividend growth rate of asset (j)** in time (t).
- ✓ $\boldsymbol{\zeta_{j,t}}$ = The **residual of the regression**.

In the above regression, the **null hypothesis of the CCAPM is that $\boldsymbol{\beta_c > 0}$ and $\boldsymbol{\beta_m = 0}$**.

On the other hand, using **Import Growth (IG) Rates** the **Regression Equation** becomes the following:

$$R_{j,t} - R_{f,t} = \hat{\beta}_{j,m}\left(R_{m,t} - R_{f,t}\right) + \hat{\beta}_{j,I}IG_{j,t} + \xi_{j,t} \quad \mathbf{(2.47)}$$

Where,

- ➢ $\boldsymbol{R_{j,t}}$ = The **realized rate of return of asset (j)** in time (t).
- ➢ $\boldsymbol{R_{f,t}}$ = The **risk-free rate of return** in time (t).

- $\widehat{\beta}_{j,m}$ **=** The **estimated beta** (factor of systematic risk) **for the market portfolio (m)**.
- $R_{m,t}$ **=** The **realized rate of return of the market portfolio (m)** in time (t).
- $\widehat{\beta}_{j,I}$ **=** The **estimated import beta of asset (j)**.
- $IG_{j,t}$ **=** The **import growth rate of asset (j)** in time (t).
- $\xi_{j,t}$ **=** The **residual of the regression**.

In this case, the **null hypothesis is that $\beta_I > 0$ and $\beta_m = 0$**.

The statistical packages that were used to test the **null hypothesis of normality** and the **zero sample autocorrelations** are the **Lagrange Multiplier (LM test)** and the **Ljung-Box Q-statistic**, respectively. Moreover, the author **evaluated the CAPM and the CCAPM** based on the **implied equity returns** by using the **goodness-of-fit test** in which he employed the **Coefficient of Determination (R^2)** as suggested by Harvey

(1992) and in addition, by using the **Mean Square Pricing Error (MSPE)** and the **Mean Average Pricing Error (MAPE)** tests. Last but not least, Chen used **Theil's U-statistic** to **evaluate the ability of each model to forecast alternations in the asset returns**.

Results

Starting with the **CAPM** results, the study showed a **high value of the coefficient of determination (R^2)** for **each industry sector**. The **estimated market betas were efficient in general**, **all positive and statistically significant at the 1% level**. Based on the **Durbin-Watson (DW) statistic**, there were **no signs of autocorrelation**. The **LM test rejected the normality hypothesis** only in **two -2- of the seven -7- industry sectors (Construction and Financial Sectors)**. Finally, the **Ljung-Box Q-statistic** showed **no significant signs of sample autocorrelations** and only a possible **existence of Autoregressive Conditional Heteroscedasticity (ARCH)** in the **Food Sector**.

Furthermore, regarding the results of the **CCAPM**, these were not as positive as for the CAPM. Specifically, the **CAPM outperforms** the **CCAPM** based on its **ability to forecast mean returns and cross-sectional and time series return variations**. The

Ljung-Box Q-statistic for the CCAPM reveals that **in all seven -7- sectors**, **the residuals are serially uncorrelated, negatively skewed and fat-tailed**. In this case, **the LM test rejected the normality hypothesis** in **every sector**. In addition, regarding the **goodness-of-fit,** the CCAPM $\mathbf{R^2}$ **is negative** in every sector, which implies that the CCAPM is **not even better than the naïve (simple random walk) model**. Also, the **MSPE** and **MAPE** tests, reveal **smaller numbers** in each sector for the CAPM than the CCAPM, meaning that the CAPM **offers more accurate pricing** and that the CCAPM-implied returns **cannot capture significant changes in the real equity returns**.

Finally, regarding the **consumption growth proxies** of Chen et al. (1986) and of Asprem (1989), the author concludes that using the **dividend growth (DG)**, the results **reject the null hypothesis**, meaning $\boldsymbol{\beta_m \neq 0}$. Furthermore, the **estimated consumption betas** are **statistically significant at the 5% level (Plastic and Chemicals, Textile Industry Sectors) and at 10% level in the Electrical Sector**. Overall, the **dividend growth rate risk** is **not significantly priced**. Moreover, regarding the **imports growth rate (IG)** the results **reject the null hypothesis**, meaning $\boldsymbol{\beta_m \neq 0}$. The **estimated consumption betas are not statistically significant** in any statistical level and the $\mathbf{R^2}$ **decreases in each sector**. Overall, the **import growth rate risk is not significantly priced**. Last but not least, the **market betas are statistically significant at the 1% level**.

2.3.14 CAPM, Higher Co-Moments & Factor Models of UK Stock Returns (Daniel Chi-Hsiou Hung, Mark Shackleton & Xinzhong Xu, 2003)

Main Purpose

The main purpose of this paper is to **test which variables explain the cross-section of UK Stock Returns**. Specifically, the authors **test important factors that affect the**

cross-section of portfolio returns, some of which **are generated from the CAPM beta** and **strategies based on Value** and **Size aspects**.

Methodology

The paper is based on the methodology of the following **two -2- approaches**. Firstly, the authors make use of a **CAPM test that checks the realized market premia sign and which was developed in 1995 by Pettengill, Sundaram and Mathur** and secondly, they take into account the **approach of Harvey and Siddique in 2000**, in which **higher-order asset pricing models were employed** because they **include systematic risk factors** that are **greater than the classic CAPM beta covariance**.

Furthermore, the authors make use of the **Fama-French Size and Value factors**. The reason behind this approach is to **check whether these factors can have a significant explanatory power over the CAPM beta** under the Pettengill et al. methodology. Specifically, **six -6- value-weighted portfolios are constructed** from the **combination of the two -2- Size and the three -3- Value groups**. The **returns** on the **Size factor portfolio (SMB)** and on the **Value factor portfolio (HML)** are calculated as follows:

SMB Return = Simple Average of the Returns on the Three -3- Big Stock Portfolios – Simple Average of the Returns on the Three -3- Small Stock Portfolios

HML Return = Simple Average of the Returns on the Two -2- High-Value Portfolios – Simple Average of the Returns on the Two -2- Low-Value Portfolios

The **One-Period Cross-Sectional Regression Equation** that **includes all risk factors** is the following:

$$R_{pt} - R_{ft} = \eta_0 + \eta_{\beta}^{\pm} D^{\pm} \beta_p + \eta_{\gamma}^{\pm} D^{\pm} \gamma_p + \eta_{\delta}^{\pm} D^{\pm} \delta_p + \eta_{S}^{\pm} D^{\pm} s_p + \eta_{h}^{\pm} D^{\pm} h_p + \varepsilon_p \quad \mathbf{(2.48)}$$

Where,

- $\boldsymbol{R_{pt}}$ = The **realized return of portfolio (p)** in time (t).
- $\boldsymbol{R_{ft}}$ = The **risk-free rate of return** in time (t).
- $\boldsymbol{\eta_0}$ = The **intercept**.
- $\boldsymbol{\eta_\beta^\pm = (R_{mt} - R_{ft})}$ = The **market risk premium** associated with **covariance**.
- $\boldsymbol{D^\pm}$ = A **Dummy Variable** that **separates months into up (+) and down (-) markets**. Specifically, if $\boldsymbol{D^+ = 1, D^- = 0}$, then $\boldsymbol{\eta_\beta^+ > 0}$. Also, if $\boldsymbol{D^+ = 0, D^- = 1}$, then $\boldsymbol{\eta_\beta^- < 0}$.
- $\boldsymbol{\beta_p}$ = The **beta or systematic risk factor of portfolio (p)**.
- $\boldsymbol{\eta_\gamma^\pm = (R_{mt} - R_{ft})^2}$ = The **coskewness market risk premium**.
- $\boldsymbol{\gamma_p}$ = The **gamma factor of portfolio (p)**, or the **coskewness factor**.
- $\boldsymbol{\eta_\delta^\pm = (R_{mt} - R_{ft})^3}$ = The **cokurtosis market risk premium**.
- $\boldsymbol{\delta_p}$ = The **delta or cokurtosis factor of portfolio (p)**.
- $\boldsymbol{\eta_S^\pm}$ = The **Size risk premium**.
- $\boldsymbol{s_p}$ = The **portfolio (p) loading on Size**.
- $\boldsymbol{\eta_h^\pm}$ = The **Value risk premium**.
- $\boldsymbol{h_p}$ = The **portfolio (p) loading on Value**.
- $\boldsymbol{\varepsilon_p}$ = The **residual of the regression**.

The **data** that were used for this study represent UK Stock Returns taken from the London Stock Price Database 2000 (LSPD 2000). The risk-free rate of return is approximated by the 90-day Treasury Bill Rate and the accounting (book value) and market value of equity of stocks are collected from Datastream. The total sample period of the study starts in January 1975 and ends in December 2000, meaning 312 months or 26 years. Finally, the total amount of stocks that was employed is 3,580 stocks.

In this approach, the **portfolios are sorted based on the stock betas** which are calculated by using **time-series regressions of the previous sixty -60- monthly stock returns on the value-weighted market returns**. This method of calculation for the stock betas is being run for the period 1979-1999. The stocks are then **categorized into ten -10- portfolios** according to their estimated stock betas, meaning that the **first -1st- portfolio** includes the stocks of the **lowest beta decile** and the **tenth -10th- portfolio** incorporates the stocks of the **highest beta decile**. The estimation of stock betas after the portfolio ranking is done for the period from January 1980 to December 2000.

Moreover, because the authors wanted to identify the characteristics of **Size** and **Value portfolio returns**, they created **ten -10- equally-weighted deciles** at the end of June of every year starting from June 1975 and ending in June 2000. Specifically, in terms of **Size**, the **first -1st- portfolio (small size portfolio)** is structured with stocks in the **smallest size decile** and the **tenth -10th- portfolio (large size portfolio)** includes stocks in the **largest size decile**. In addition, in terms of **Value**, the **first 1st- portfolio (glamour portfolio)** is formed with stocks in the **lowest book-to-market decile** and the **tenth -10th- portfolio (value portfolio)** with stocks in the **highest book-to-market decile**. Last but not least, the total period that the portfolio betas were estimated (after the portfolio ranking procedure) was 306 months from July 1975 to December 2000.

Results

First and foremost, the results of the above analysis indicate that the **beta factor is statistically significant in every model**. It remains significant and **provides high explanatory power** even when the regression model incorporates **higher co-moments** and **Fama-French factors** (meaning **Size** and **Value**). Furthermore, the **intercept term** is statistically **insignificant**, the **book-to-market ratio is highly significant** and surprisingly when the factors of **coskewness** and **cokurtosis** are added, **the explanatory power of the model is not increased** because of not statistically significant estimated slope coefficients.

Moreover, the **Fama-French factors** are **very significant** with an **increased adjusted R-squared (R^2)**. In addition, in the case of the **beta sorting**, the portfolios with the higher betas show **increased levels of skewness and kurtosis**. However, when up (+) and down (-) markets are considered separately, it is clearly shown a **monotonic relationship between returns and beta**, meaning that in up markets returns increase with the beta and in down markets returns decrease with the beta. This phenomenon **favors the traditional CAPM**.

Furthermore, in terms of **Size sorting**, when a simple averaging of the regression results is being done, the **portfolio betas are not extremely significant**. The **higher co-**

moments and Fama-French factors remain statistically important. When the regression results are averaged separately between up and down markets, the **beta factor becomes significant in the down markets only**, even when is introduced to other factors as well. On the other hand, in the up markets, **none of the variables is statistically significant**.

Finally, in terms of **Value sorting**, the authors conclude that the **value portfolio** provides **the least negatively skewed returns** and the **glamour portfolio the most negatively skewed returns**. In addition, the **beta of the value portfolio** is **lower** than that of the **glamour portfolio**. Last but not least, regarding the **high order pricing factors (gamma and delta)** that are associated with market coskewness and cokurtosis, **limited evidence** is shown for their **existence**.

2.3.15 The Conditional CAPM Does Not Explain Asset-Pricing Anomalies (Jonathan Lewellen & Stefan Nagel, 2003)

Main Purpose

The main purpose of this paper is to **identify if the Conditional CAPM performs better than the Unconditional one**. Specifically, the main question that the authors strive to answer is **if a Conditional CAPM version can explain asset-pricing anomalies like Size, Book-to-Market (B/M) Ratios, and Momentum**. In addition, the two -2- authors try to answer the following three -3- questions:

1. Why over the last almost fourty -40- years (1964-2001) the small stocks behave a lot better than the large stocks?
2. Why high book-to-market ratio firms provide greater results than those of the low book-to-market ratio firms?
3. Why stocks with high returns in the past continue to be in better shape than the ones with low returns in the past?

Methodology

The authors use **short-window regressions** of the **CAPM without using conditioning variables** in order to provide **direct estimates of assets' conditional alphas and betas** for **Size, B/M** and **Momentum Portfolios**. In this procedure, the **betas must remain stable within a specific period** (say a month or a quarter). Firstly, **the properties of the time-series of conditional betas are studied** and are **related** to **unconditional deviations from the CAPM** and secondly, the authors test if the **average conditional alphas are zero**, which represents a hypothesis of the conditional CAPM. Throughout the whole paper, it is assumed that the **Conditional CAPM holds**.

The study is based **primarily on the Sharpe-Lintner CAPM**, but a **Consumption-mimicking Portfolio** in the position of the Market Portfolio is **tested as well**. Starting with the Sharpe-Lintner CAPM, the paper focuses on **stock portfolios** using the following general equation regression:

$$R_{it} = a_i + \beta_i R_{mt} + \varepsilon_{it} \quad (\mathbf{2.49})$$

Where,

- $\boldsymbol{R_{it}}$ **=** The **excess return on portfolio (i)** in time (t).
- $\boldsymbol{a_i}$ **=** The **intercept or alpha** of the portfolio (i).
- $\boldsymbol{\beta_i}$ **=** The **beta or the systematic risk factor** of portfolio (i).
- $\boldsymbol{R_{mt}}$ **=** The **excess return on the market portfolio (m)** in time (t).
- $\boldsymbol{\varepsilon_{it}}$ = The **regression residual term** on portfolio (i) in time (t).

In order to complete the **unconditional tests,** the authors assume that $\boldsymbol{a_i}$**,** $\boldsymbol{\beta_i}$ must be **constant**. The Equation 2.49 is estimated separately every quarter using daily or weekly returns. Doing so, a **direct estimate of each quarter's alpha and beta** is provided. Furthermore, in order to provide **robust results**, the authors estimate regressions on **different time intervals** (monthly, quarterly, semi-annually and yearly), and use daily, weekly and monthly returns. Following the above procedure, it is estimated:

- How volatile are the beta factors and how they correlate with both the business conditions and the market risk premium.
- If the average conditional alphas are zero (0), as implied by the Conditional CAPM.

Moreover, for **daily returns four -4- lags** of the **market returns** are included, for **weekly returns two -2- lags** are included and for **monthly returns one -1- lag** is included in the regressions.

The **data** that were required for this study include returns on Size, B/M, and Momentum Value-Weighted Portfolios which contain NYSE & Amex Stocks excluding ADRs, REITs, and Primes and Scores. The time period of the study starts from July 1964 and ends in June 2001. Prices and returns are taken from the Center for Research in Security Prices (CRSP) Daily Stock File of the University of Chicago, and the book values are generated from the merged CRSP / Compustat Database.

Regarding the methodology of the construction of the portfolios, in **June of every year**, the authors form **twenty-five -25- Size-B/M portfolios** that are based on the **intersection of five -5- Size** and **five -5- B/M portfolios**, with **breakpoints given by NYSE quintiles**. When the portfolios were formed as **Small** was identified the **average of the five -5- portfolios in the lowest Size quintile** and as **Big** was identified the **average of the five -5- portfolios in the highest Size quintile**. **S-B** is identified as the **difference between the two above averages**.

In addition, the same methodology applied for the **B/M Portfolios**, where, **Growth** is the **average of the five -5- portfolios in the lowest B/M quintile** and **Value** is the **average of the five -5- portfolios in the highest B/M quintile**. **V-G** represents their **difference**. These S-B and V-G portfolios are similar to the Fama-French's SMB and HML factors, but the difference is that in this paper the stocks of NASDAQ are excluded and the approach starts with twenty-five -25- basis portfolios rather than six -6- as in the paper of Fama-French.

Furthermore, regarding the **Momentum portfolios**, these are constructed using **all** the available **data** of the CRSP. Specifically, every month the **stocks are sorted into deciles** based on their **past six -6-month returns** and the portfolios that are formulated are being held for **six -6-month overlapping periods**. A **subset of ten -10- portfolios** is created, where **Losers** represent the **returns of the bottom decile** and **Winners** represent the **returns of the top (highest) decile**. **W-L** represents their **difference**.

Last but not least, the **market proxy** of the study is the **Excess Return on the CRSP value-weighted Index**, compounded weekly and monthly. All the tests that are run, make use of the **excess return net of the one-month Treasury Bill Rate**. **Each estimate** is expressed in **percentage terms (monthly)**, **multiplied by 21** (the number of trading days per month -**daily**) and **multiplied by 21/5 (weekly)**. Finally, the **Consumption-mimicking portfolio** is also estimated by **regressing quarterly consumption growth rates on a given set of assets**.

Results

The first result that the authors reach is that the **Size**, **B/M** and **Momentum betas can vary significantly over time** and **over the business cycle as well**. The betas show **high-frequency fluctuations** but these variations are not enough in order to **provide significant unconditional pricing errors**. Furthermore, regarding the relationship between the **beta** and the **market risk premium,** it is proven that the **time-varying betas cannot provide answers for the unconditional alphas** of **Size**, **B/M,** and **Momentum portfolios**. This, in turn, means that the **implied alphas are either close to zero or have the wrong sign**.

Moreover, when the authors checked whether the **betas covary with the market risk premium**, the **S-B's and W-L's predicted betas covary negatively with market returns** and only the **Size estimate** is **statistically significant**. As a result, the authors cannot conclude that the time-varying betas covary strongly with the market risk premium, something that informs us that the **unconditional pricing errors of the Conditional CAPM** are **significantly smaller than those estimated for the B/M and Momentum portfolios**. Also, the authors checked for a **time-varying market volatility** which proved that **it does not improve the Conditional CAPM**.

Regarding the **unconditional alphas** of **B/M** and **Momentum portfolios**, these seem to be **inconsistent with the Conditional CAPM**. In addition, it is proven that **conditional alphas are large and statistically significant**, something that is **against the alpha = zero hypothesis of the Conditional CAPM**. In summary, the **Conditional**

CAPM cannot explain asset pricing anomalies like B/M and Momentum, meaning that the Unconditional CAPM **performs nearly as poorly as** the Conditional CAPM. Finally, the **Consumption CAPM** showed that it **cannot either explain** the B/M and Momentum factors.

2.3.16 The CAPM Relation for Inefficient Portfolios (George Diacogiannis & David Feldman, 2009)

Main Purpose

The main purpose of this paper is to **introduce** a **well-specified asset-pricing model** relative to the **CAPM**, which can be **used for pricing inefficient portfolios**. This new approach is the **Capital Asset Pricing Model for Inefficient Portfolios (CAPMI)**. The authors worked on Roll's scruple about the incorrect use of the CAPM for inefficient proxies and tried to **generate** a more **general form** of the CAPM that can address this issue.

Methodology

The authors develop a general form of the CAPM, the CAPMI which can be used with **inefficient portfolios**. It is important to mention that the term **inefficient** means the **non-frontier portfolios**, meaning the ones that do not lie on the **Efficient Frontier** that exists in a **Markowitz world**. The **analysis** is completed in a **single-period mean-variance framework** but it is suggested that it can be applied to **multiperiod** and **multifactor models**. This happens because the one-period mean-variance environment can be translated as a **freeze frame** picture of a **dynamic framework**.

Using an **orthogonal decomposition** similar to the one of Jagannathan's (1996) **finite number of securities version**, which made use of the **conditioning information model** of Hansen and Richard in 1987, the **Equation of a well-specified CAPMI** is the following:

$$E = E(R_{zp})1 + [E(R_p) - E(R_{zp})]\frac{\sigma_p^2}{\sigma_q^2}\beta_p + [E(R_p) - E(R_{zp})]\frac{\sigma_e^2}{\sigma_q^2}\beta_e \quad \mathbf{(2.50)}$$

Where,

- $\boldsymbol{E}$ = The **efficient proxy portfolio**.
- $\boldsymbol{E(R_{zp})}$ = The **expected return of the zero-beta frontier portfolio with respect to the inefficient portfolio (p)**.
- **1** = The **beta** when $\boldsymbol{E(R_p) = E(R_q)}$.
- $\boldsymbol{E(R_p)}$ = The **expected return of the inefficient portfolio (p)**.
- $\boldsymbol{\sigma_p^2}$ = The **variance** of the inefficient portfolio (p).
- $\boldsymbol{\sigma_q^2}$ = The **variance of the efficient portfolio (q)**, meaning the **frontier** portfolio.
- $\boldsymbol{\beta_p}$ = The **beta or the systematic risk factor** of portfolio (p).
- $\boldsymbol{\sigma_e^2}$ = The **variance** of the **residual factor (e)**.
- $\boldsymbol{\beta_e}$ = The **beta** or **systematic factor** of the residual factor (e).

In order to present the above equation (Equation 2.50) in a more similar way to the original CAPM, the authors explain that the **efficient proxy portfolio** is nothing more than the sum of an **inefficient portfolio** and of the **difference between an efficient and an inefficient one**. It is also assumed that the efficient and the inefficient portfolios have the **same expected return**. Therefore, based on the above equation, **three -3- misspecifications** can arise:

1. The **second -2nd- addend** of Equation 2.50 might be **ignored**.
2. **Incorrect excess expected return value**s can be used if there exist **portfolios** that are zero-beta with respect to the portfolio (p), but **do not have the same expected return as that of (zq)**.
3. A potential use of **unadjusted betas**.

Furthermore, the authors examined the case where the CAPMI is **not well defined**. This happens when the **proxy** and the **Global Mean-Variance Portfolio (GMVP)** have the **same expected return**. If this is the case, then a **beta of one -1-** is **generated** for all securities, there is **no zero-beta portfolio** and **no zero-beta rate**. Specifically, if all the securities have the **same** expected return, then the efficient frontier is a **single point** which is also the **GMVP** and **every proxy** has the same expected return as the GMVP. So, this particular occasion is named as **indeterminate degeneracy** because of the following implications:

- Expected returns equal to a single value.
- The efficient frontier or the "hyperbola" is a single graphical point.
- The GMVP and the Market Portfolio become one portfolio.
- All security betas are equal to one (1).
- A zero-beta rate does not exist.

The above degeneracy allows the existence of a **theoretical zero relation** with all securities having the same expected returns. Moreover, the authors examine a **risk-free** situation and a **zero-beta** situation when tangency portfolio becomes the GMVP. Specifically, they demonstrate that in the first -1st- situation, we can **always** find a **zero-beta rate**. In contrast, in the zero-beta case, there is **no zero-beta rate**. This phenomenon is called **asymptotic discontinuity**.

In addition, Diacogiannis and Feldman checked the case where the CAPMI is **well defined**. In order to do so, they used a numerical example with only **four -4- assets** in a **Markowitz world**. They ended up in the following **three -3- propositions** and their respective **corollaries**:

"

Proposition #1: *In a Markowitz world any inefficient proxy induces a zero relation.*

Corollary #1: *If the variance of the inefficient proxy is double that of the frontier portfolio of the same expected return, then, the zero relation portfolio has the same variance (and, of course, the same expected return) as that of the inefficient proxy. As* *the inefficient portfolio proxy gets closer to the frontier, the variance of its zero relation grows to infinity. Conversely, as the variance of the inefficient portfolio proxy grows to infinity, its zero relation portfolio gets closer to the frontier.*

Proposition #2: *Consider the hyperbola spanned by some inefficient proxy and the GMVP. Then, the GMVP is the GMVP of this hyperbola as well, and the zero-beta portfolio of the inefficient proxy on this hyperbola is the minimum variance zero-beta portfolio of the inefficient proxy, among all the zero-beta portfolios of the inefficient proxy.*

Corollary #2: *The zero-beta portfolios, with respect to some inefficient proxy, identified in Propositions #1 and #2, are of different expected returns.*

Proposition #3: *Any inefficient proxy induces a hyperbola of zero-beta portfolios that extends to all expected returns. Such a hyperbola is the one spanned, for example, by the zero relation portfolio identified in Proposition #1, and by the minimum variance zero-beta portfolio identified in Proposition #2. Moreover, this hyperbola consists of the minimum variance zero-beta portfolios at every expected return. The hyperbola includes one frontier portfolio, the (single) frontier portfolio that is uncorrelated with the frontier portfolio that has the same expected return as the inefficient proxy.*

”[55]

Results

Because this paper is a theoretical approach to the development of the CAPMI, there are no empirical results to present. However, the two authors conclude that it would be **better to use the CAPMI** instead of the CAPM in the cases where **inefficient portfolios do exist** and therefore we will be forced to use **inefficient proxies**. This means that if someone chooses to use the CAPM in the above situations, then, the results of the model's **coefficients** and $\mathbf{R^2}$ might be **meaningless**.

[55] George, Diacogiannis, David, Feldman, "*The CAPM Relation for Inefficient Portfolios*", 2009, Pages 25-26.

2.3.17 A Five-Factor Asset Pricing Model (Eugene F. Fama & Kenneth R. French, 2015)

Main Purpose

The main purpose of this paper is to **introduce** an **upgrade** of the **three -3-factor model of Fama & French (1992)** to a **five -5-factor model** including the previous factors, meaning **Market**, **Size** and **BE/ME** and adding also the **Profitability** and **Investment Factors**. The two -2- authors try to **identify** whether the 5-factor model performs better than the 3-factor model in **explaining average returns** and also if the **asset-pricing problems are based on the same phenomenon as the statistical anomalies that produce them**.

Methodology

The **regression equation** of the 5-factor model of Fama and French is the following one:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it} \quad (\mathbf{2.51})$$

Where,

- $\boldsymbol{R_{it}}$ **=** The **realized return** of **portfolio (i)** in time (t).
- $\boldsymbol{R_{Ft}}$ **=** The **risk-free rate of return** in time (t).
- $\boldsymbol{a_i}$ **=** The **intercept** of the regression.
- $\boldsymbol{b_i}$ **=** The **beta or systematic risk factor** of portfolio (i).
- $\boldsymbol{R_{Mt}}$ **=** The **realized return** of the **market portfolio (M)**.
- $\boldsymbol{s_i}$ **=** The **size factor** of portfolio (i).
- $\boldsymbol{SMB_t}$ **=** The **realized return** on a **value-weighted, zero-investment, factor-mimicking portfolio for size** in time (t).

- h_i **= The BE/ME (value) factor** of portfolio (i).
- HML_t **=** The **realized return** on a **value-weighted, zero-investment, factor-mimicking portfolio for BE/ME** in time (t).
- r_i **=** The **profitability factor** of portfolio (i).
- RMW_t **=** The **difference** between the **realized returns** on diversified portfolios of stocks with **robust and weak profitability**.
- c_i **=** The **investment factor** of portfolio (i).
- CMA_t **=** The **difference** between the **realized returns** on diversified portfolios of **low and high investment firms** which the authors call **conservative and aggressive** respectively.
- e_{it} **=** The **residual term** of the regression on portfolio (i) in time (t).

The authors assume a **zero-intercept hypothesis** and provide **two -2- interpretations of it**. Specifically, the **first** interpretation is to construct a **mean-variance-efficient tangency portfolio** which can price all assets and includes the risk-free rate of return, the market portfolio, and SMB, HML, RMW, and CMA. The **second** interpretation proposes the use of Equation 2.51 as the regression equation for a **Merton's (1973) model** in which there exist **four -4- unspecified state variables** that lead to **risk premiums** and are **not captured** by the market factor. In the last approach, the factors just represent **diversified portfolios** that can **provide alternative combinations of exposures** to the unknown state variables.

The time horizon that Fama and French (FF) use in their study is a **one-month horizon**. Specifically, they use **606 monthly average excess returns** (excess of the one-month US Treasury Bill rate) for **twenty-five -25- value-weighted portfolios** that are created by sorting five **-5- Size groups** and five **-5- BE/ME groups**. The smallest and biggest Size quintiles are named **microcaps** and **megacaps** respectively. In addition, the **Size** and **BE/ME** quintile breakpoints make use of NYSE stocks only, but the whole study uses NYSE, AMEX, and NASDAQ stocks. Specifically, the **data** were taken from the Center for Reseach in Security Prices (CRSP) of the University of Chicago and the Compustat Database for the time period from July 1963 to December 2013.

Furthermore, the authors followed a **second sorting approach** as well, which was on **Profitability** rather than **BE/ME**. The variable that was used to interpret profitability was the **Operating Profitability (OP)**, meaning the annual revenues minus the cost of goods sold, interest expenses, and selling and administrative expenses, all of which divided by book-to-equity at the end of year t-1. All of the **OP breakpoints** used NYSE data.

Moreover, FF used sorts on **Size** and **pairs** of the other three -3- variables (meaning BE/ME, OP, Investment – Inv). They created **two -2- Size groups** (small and big) by using the **median market cap for NYSE stocks** as the breakpoint. Consequently, they used the NYSE quintiles and formed **four -4- groups** for each of the other two -2- sorting variables (BE/ME, OP, Inv). Therefore, each combination of variables would give **2x4x4 = 32 portfolios** which can be categorized as **32 Size-BE/ME-OP** portfolios, **32 Size-BE/ME-Inv** portfolios and **32 Size-OP-Inv** portfolios.

In addition, FF used **three -3- sets of factors** to **track** the **statistical patterns in average returns**. The **first** set is a **2x3 sorting procedure**, where **two -2- Size** groups and **three -3- BE/ME groups (or OP groups or Inv groups)** are intersected to create **six -6- value-weighted portfolios**. The **Size breakpoint** is the NYSE median market cap and the **BE/ME breakpoints** are the 30^{th} and 70^{th} percentiles of BE/ME for NYSE stocks. Also, the **Size (SMB) factor** is the **average** of three -3- small minus three -3- big stock portfolio returns and the **BE/ME** (**HML) factor** is the **average** of two -2- high BE/ME minus two -2- low BE/ME portfolio returns. The **RMW** and **CMA** factors are created in the same way but the **second sort** is either on OP or Inv. Finally, the **SMB factor** is the **average** of the $\mathbf{SMB_{BE/ME}}$, $\mathbf{SMB_{OP}}$, and $\mathbf{SMB_{Inv}}$ from the **three -3- 2x3 sorts**.

Consequently, the **second** set of factors is a **2x2 sorting procedure**, where **two -2- Size** groups and **two -2- BE/ME groups (or OP groups or Inv groups)** are intersected to create **four -4- value-weighted portfolios**. Again the breakpoints are **NYSE medians** for all variables. The **third** and **last approach** is a **2x2x2x2 sorting procedure**, where **two -2- Size** groups, **two -2- BE/ME groups**, **two -2- OP groups**, and **two -2- Inv groups** are intersected to create **sixteen -16- value-weighted portfolios**. In this case, the **SMB factor** is the **average** of eight -8- small stock minus eight -8- big stock portfolio returns, the **HML factor** is the **average** of eight -8- high BE/ME minus eight -8- low BE/ME portfolio returns, the **RMW factor** is the **difference** between eight -8- robust minus eight -8- weak average returns and the **CMA factor** is the **difference** between eight -8- conservative minus eight -8- aggressive average returns. Last but not least, the **breakpoints** for **all variables** are again the **NYSE medians**.

It is important to mention that each factor in the 2x2 and 2x3 sorting procedures **controls** for **Size** and **one** other variable, whereas in the 2x2x2x2 sorting procedure each factor **controls** for **all four -4- variables**. Furthermore, in order to test the ability of the three -3- sets of factors to explain the average excess returns, the authors considered **seven -7- asset-pricing models**, meaning **three 3-factor models** that include R_M-R_F, SMB and one of the HML, RMW, CMA factors, **three 4-factor models** that include R_M-R_F, SMB and pairs of HML, RMW, CMA factors, and **the 5-factor model** that includes all of the above variables. In these seven -7- models existed **six -6- sets of left-hand-side (LHS)** portfolios and **three -3- sets of right-hand-side (RHS)** portfolios.

Results

The most important result that derives from the FF research is that the **GRS statistic rejects the 5-factor model** and **every other model** that the authors tested because they are **incomplete descriptions of expected returns**. Nevertheless, the authors estimated that their 5-factor model **can explain 71%-94%** of the **cross-section variance** of expected returns for each of the **Size**, **BE/ME**, **OP**, and **Inv** portfolios that were examined. Specifically, in spite of the fact that the GRS test tends to reject this model, the 5-factor model **outperforms** the 3-factor model **on every metric** and also is better than any other multi-factor model that was examined.

In order to become more specific, regarding the **25 Size-BE/ME** portfolios the 5-factor model produces **minor improvements** in the **average absolute intercept**. Regarding the **25 Size-OP** portfolios, the 5-factor model **cannot address per se** a **low profitability issue** but the average absolute intercepts are the **lowest** than **every other LHS** portfolio. Furthermore, regarding the **25 Size-Inv** portfolios, we can see that **high investment** is a 5-factor problem and specifically the results show **negative 5-factor intercepts** for high investment portfolios of **small stocks** and **positive 5-factor intercepts** for high investment portfolios of **big stocks**. In general, the 5-factor model **improves** the results of the 25 Size-Inv portfolios than the 3-factor model.

Moreover, regarding the **32 Size-BE/ME-OP**, **32 Size-OP-Inv** and **32 Size-BE/ME-Inv** portfolios, the results are greater than those of the 25 (5x5) sorting procedures. Specifically, the **highest rate of improvement** regarding the average absolute intercept is produced by the 5-factor model when it was applied to the **32 Size-OP-Inv** portfolios. In addition, regarding the **factor sorting procedures**, they all provide similar results. In detail, the **2x2 sorting procedure** is better than the **2x3 sorting procedure** because the **2x2 includes all stocks** (meaning that it is better diversified), whereas the **2x3 excludes the stocks in the middle 40% of BE/ME**, **OP**, **Inv**. Also, the **2x3 sorting procedure** produces **larger averages** in the **HML**, **RMW**, and **CMA** returns. In the **2x2x2x2 sorting procedure,** the **Size** factor is almost **neutral** regarding **BE/ME (HML)**, **OP**, and **Inv** factors. Finally, in the **2x2x2x2 sorting procedure**, it is **not quite clear** if it **isolates better the exposures to variation in returns** related to Size, BE/ME, OP, and Inv than the other procedures.

Last but not least, the authors came across results that suggested that the **HML factor** is **redundant** and can be excluded from the model. Therefore, they concluded that a **4-factor model** would provide the same results as the **5-factor model**, in the cases where the only interest is the **abnormal returns**. However, if someone wants to use the **BE/ME factor** in his/her model, can use the 5-factor model but instead of using the factor HML can use the factor **HMLO** which is the **Orthogonal HML**. Also, FF found that in **four -4- out of six -6- LHS portfolios** that were examined, the **small stock portfolios** provided **negative exposures to RMW** and **CMA**. This issue was related to the phenomenon in which stocks of firms **invest impressive amounts of money despite their low profitability levels**.

2.4 SUMMARY TABLE

In this part of the chapter, we present a summary table where we provide the most important information regarding the papers that we examined previously. It is a brief summary of the crucial information in each paper.

Arithmetic Order	Authors, Date & Paper	Main Purpose	Data & Methodology	Results – Conclusions
Analysis Before Roll's Critique				
1	Black Fischer, Jensen C. Michael & Scholes Myron, 1972 "The Capital Asset Pricing Model: Some Empirical Tests"	Test the validity of the CAPM and provide additional insights into the security return structure.	Data: Monthly dividend and adjusted prices for all the securities on the New York Stock Exchange from January 1926 to March 1966. Time Series Analysis.	Rejection of the CAPM.
2	Merton C. Robert, 1973	The development of an intertemporal CAPM.	No Data.	No empirical results because it is a theoretical paper.

	"An Intertemporal Asset Pricing Model"		The methodology is similar to the derivation of the classic CAPM.	
3	Fama F. Eugene & Macbeth D. James, 1973 "Risk, Return & Equilibrium: Empirical Tests"	Test the relationship between the average return and risk of the New York Stock Exchange (NYSE) common stocks.	Data: Monthly percentage returns (adjusted for stock splits, dividends, and any other capital changes) for every common stock that traded on the NYSE from January 1926 to June 1968. The analysis is based on the two-parameter model of Tobin (1958), Markowitz (1959) and Fama (1965b), and on equivalent models of market equilibrium. They also used a Regression Analysis to perform the tests.	The results of the study support the three -3- fundamental implications of the two-parameter model and that it exists a market of risk-averse investors that higher risk is compensated with higher expected return. Therefore, the two authors cannot reject the hypothesis that the pricing of common stocks reflects the existence of risk-averse investors who try to construct efficient portfolios. All of the above show an acceptance of the traditional CAPM.

4	Modigliani Franco, Pogue A. Gerald & Solnik H. Bruno, 1973 “A Test of the Capital Asset Pricing Model on European Stock Markets”	Test the validity of the Capital Asset Pricing Model in eight -8- major European markets, meaning the U.K., France, Italy, Germany, Switzerland, the Netherlands, Belgium, and Sweden, and compare their results with the ones derived from the U.S. Capital Market.	Data: Daily prices and dividend prices (corrected for any adjustments) of 234 common stocks of eight -8- major European stock markets, for the period from March 1966 to March 1971. Regression Analysis.	The authors concluded that generally, the results are in agreement with the CAPM model and its hypotheses. Specifically, when the European results were compared to the ones in the U.S. Stock Market, it was found that they are rational, efficient, comparable and that both markets behave according to the hypotheses of the CAPM model.
5	Galai Dan & Masulis W. Ronald, 1976 “The Option Pricing Model and the Risk Factor of Stock”	Introduction of a new model of measuring equity value and market (or systematic) risk. The new theoretical model is a combination of the Option Pricing Model	No Data because it is a theoretical paper. The methodology is based on using the OPM and CAPM equations to derive the new model.	The authors tested the model in four -4- case studies. The conclusion of the first -1st- case study is that every firm with similar characteristics, regarding the face value of debt, the total market value and its profitability,

		(OPM) and the Capital Asset Pricing Model (CAPM) and it can provide more complete results on corporate security pricing.		but with different variance, will have a different capital structure in market value terms. The conclusion of the second -2nd- case study is that that if two firms are identical except for their differences (by the same proportion) in firm asset value and the face value of debt, then their equities/debts will differ by the same proportion. The conclusion of the third -3rd- case study is that the bondholders receive more protection than the stockholders in a conglomerate merger, because the last ones have to support the claims of the bondholders of the two firms,

				meaning that the stockholders' limited liability is substantially weakened. The conclusion of the fourth -4th- case study is that the stockholders become more benefited than the bondholders because of a spin-off.
Analysis of Roll's Critique				
6	Roll Richard, 1977 "A Critique of the Asset Pricing Theory's Tests / Part I: On Past and Potential Testability of the Theory"	Emphasize on the Asset Pricing Theory as it existed at that time and criticize some of the findings of the previous papers regarding the two-parameter model.	No Data because it is a theoretical paper. Roll studied and criticized the papers of Black, Jensen & Scholes (1972), Fama & Macbeth (1973) and Blume and Friend (1973).	Roll concluded that there is not a single research attempt that contains a valid test of the Asset Pricing Theory. In this Critique, it is also shown that all the results of the three -3- papers are compatible with the results of the Sharpe-Lintner model and all include a

				specification error in the measured market portfolio.
Analysis After Roll's Critique				
7	Breeden T. Douglas, 1979 "An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities"	The paper targets to further develop into a continuous-time model the Merton's intertemporal extension of the CAPM in 1973.	No Data because it is a theoretical paper. This paper takes into account the same continuous-time economic framework of Merton's paper in order to derive a single-beta asset pricing model in a multi-good environment without knowing the consumption-goods prices and the investment opportunities that exist. Also, the author uses a Markov process of the Ito type in the development of the model.	This paper derives similar equations to the Merton's paper in 1973, which are simpler and more understandable, and they might be appropriate for empirical testing.

8	Cheng L. Pao & Grauer R. Robert, 1980 “An Alternative Test of the Capital Asset Pricing Model”	Propose an alternative test of the CAPM and show results that are unambiguous relatively to the past papers.	Data: Monthly values of equity from the firms that traded on the New York Stock Exchange from January 1926 to December 1977. Regression Analysis.	1. The intercept is not always equal to zero. 2. The constants (or slope coefficients, meaning b_1, … $b_k = b_2$) are not always different from zero. 3. The adjusted coefficient of determination R_2^2 is not near or equal to one. 4. There should not be any trend in the intercept 5. There can be a trend in the adjusted coefficient of determination (R^2).
9	Gibbons R. Michael, 1982 “Multivariate Tests of Financial Models – A New Approach”	Present a multivariate statistical framework for estimating the expected return on the zero-beta portfolio. Additionally,	Data: Taken from the Center for Research in Security Prices (CRSP) of the University of Chicago and represent monthly stock returns of the US Stock	The parameter restriction of Equation 2.25 is rejected in five -5- out of ten -10- subperiods. Also, the test statistic is marginally insignificant for three -3- out of the remaining five -5- subperiods. The rejection is

		the paper's main goal is to provide a test to check the multivariate restriction imposed by the CAPM.	Market. The market portfolio is represented by the monthly returns of the CRSP Equal-Weighted Index. The whole time period of the study stats from 1926 and ends in 1975. BJS (1972) Methodology and Regression Analysis.	confirmed at reasonable significance levels. Specifically, the content of the CAPM is rejected at a significance level of less than 0.001. This result simply means that the mean-variance efficiency of the equally-weighted NYSE portfolio is rejected. The Multivariate Regression Model (MVRM) provides an efficient estimator of the expected return of the zero-beta portfolio. Also, this model is well-suited for testing market efficiency. Finally, the LRT rejects the Null Hypothesis when the departures from the CAPM are significantly large.
10	Shanken Jay, 1985 "Multivariate Tests of the Zero-Beta CAPM"	Develop a Cross-Sectional Regression Test (CSRT) of the CAPM and explore its connection to the Hotelling T^2 test of multivariate statistical analysis. Also, the main focus of this paper is on the small sample behavior	Data: Taken from the Center for Research in Security Prices (CRSP) of the University of Chicago and represent monthly stock returns of the US Stock Market. The market portfolio is	The equality of expected returns was generally rejected and the efficiency of the Equally-Weighted Index was rejected at the 0.01 level Also, it was found that there exists a significant coefficient of the size variable and therefore the

		of the chi-squared asymptotical distribution of this Cross-Sectional Regression (CSR).	represented by the monthly returns of the CRSP Equal-Weighted Index. The total time period is divided into three -3- subperiods, each of a length of seventy-four -74- months, meaning February 1953 – March 1959, April 1959 – May 1965, and June 1965 – July 1971. Regression Analysis.	efficiency of the CRSP Index was rejected. Finally, it was proven that the CRSP Index was inefficient even without the January returns.
11	Kandel Shmuel & Stambaugh F. Robert, 1987 "On Correlations and Inferences about Mean-Variance Efficiency"	Present a framework that can analyze the mean-variance efficiency of an unobservable portfolio based on its correlation with an observable proxy portfolio.	Data: Taken from the New York Stock Exchange (NYSE) and represent weekly and monthly returns for the time period starting in January 1926 and ending in November 1978. All returns are in excess of the one -1-month Treasury Bill rate and the market proxies that have been used are the	Regarding the Sensitivity Analysis of Inferences and the LRT of S-L tangency, when the authors used monthly data and a finite sample, they found out that there were no non-tangent portfolios at a significance level of 0.01 or less.

			Equal-Weighted (E-W) NYSE Index and the Value-Weighted (V-W) NYSE Index. The riskless rate is the return of the US Treasury Bill with one -1- week to maturity. Mean-Variance Efficiency Tests, S-L Tangency, Sensitivity Analysis, LRT, Shanken Methodology (1987), Regression Analysis.	On the other hand, when using weekly data, the tangency of both proxies (meaning the E-W NYSE Index and the V-W NYSE Index) was rejected in every subperiod of the tests. Moreover, regarding the Null Hypothesis of the efficiency of an unobservable portfolio, this hypothesis is rejected at a significance level of 0.01 for the tangency of the V-W proxy. In general, the authors say that if the correlation between the proxy and the market portfolio can exceed 0.9 or a lower value (meaning 0.7 or 0.8), then the CAPM can be rejected.

12	Ferson E. Wayne, Kandel Shmuel & Stambaugh F. Robert, 1987 "Tests of Asset Pricing with Time-Varying Expected Risk Premiums & Market Betas"	Develop tests of asset-pricing models with time-varying expected risk premiums and market betas, prove the time-variation of expected returns and conditional market betas and describe the multi-beta relation for assets' conditional expected excess returns.	Data: Weekly returns on common stocks from the New York Stock Exchange and other American Exchanges for the time period from 1963 to 1982. The analysis is based on the maximum-likelihood method to a pooled time series and cross-section of return and also on the normal likelihood function for the unexpected component of returns.	1. There is no conditional mean-variance efficiency of the value-weighted stock index. 2. There is is an exact K-risk premium model. 3. The test results provide a positive answer to the existence of K-risk premiums, meaning that there is an upper bound for the total number of the non-market risk-premiums.
13	Bollerslev Tim, Engle F. Robert & Wooldridge M. Jeffrey, 1988	Derive a multivariate generalized autoregressive conditional heteroscedastic process	Data: Value-weighted equity returns on the New York Stock Exchange, six -6-month Treasury Bills, and twenty -20-year	Firstly, based on the results of the study, the value of (δ) is highly statistically significant, something that supports the theory presented in the paper.

	"A Capital Asset Pricing Model with Time-Varying Covariances"	for stocks, bonds, and T-bills and to prove if the agents have conditional expectations on the moments of future expected returns and therefore if these are random variables rather than constants.	Treasury Bonds. All of the above are quarterly returns starting from the first -1st- quarter of 1959 and ending in the second -2nd- quarter of 1984. The total number of observations is 102. The risk-free rate of return is represented by the 3-month T-bill. The approach is similar to the one of Engle, Lilien, and Robins (1987), which estimated the time-varying risk premium of a single asset as a function solely of the conditional variance of the asset's return. Also, it can be seen as a statistical interpretation of the intertemporal CAPM of the papers of Bodie et al. (1983, 1984) and as a generalization of Frankel (1985).	Secondly, it is proven that the conditional covariances can vary over time, that they are a statistically significant determinant of the time-varying risk premia and that any study of the CAPM that treats them as constants tends to falter. Furthermore, the results provide evidence that the risk-premia might be better represented by covariances with the involved market rather than by individual variances. Last but not least, the beta for stocks reaches almost one (1), the beta for bonds is somewhat above one (> 1) and the beta for T-bills is close to zero (0).

14	Duffie Darrell & Zame William, 1989 "The Consumption-Based Capital Asset Pricing Model"	Provide the basic conditions on a primitive model of a continuous-time economy, where there exist equilibria that follow the Consumption-Based Capital Asset Pricing Model (CCAPM). Also, the authors present an asset pricing model that extends the studies of Cox, Ingersoll, and Ross (1985), Rubinstein (1976) and Lucas (1978) to a multi-agent economy.	No Data because it is a theoretical paper. The methodology is based on Utility functions, the CAPM equation, and Ito processes.	There exists an equilibrium with a representative agent (U_{λ}, e). Moreover, for any agent (i) with $e^{i} \neq 0$, the equilibrium consumption process $x^{i}$is bounded away from zero. Last but not least, for any cumulative (Ito) dividend process Y of finite variance and any terminal lump sum dividend δ of finite variance, the augmented economy $E^{Y\delta}$has an equilibrium with the same consumption allocation and the same representative agent.
15	Gibbons R. Michael, Ross A. Stephen & Shanken Jay, 1989	Identify if there exists an ex-ante efficiency of a	<u>Data</u>: Taken from the Center for Research in Security Prices	The most significant result is that the multivariate test that this

	"A Test of the Efficiency of a Given Portfolio"	given portfolio of assets. Specifically, the paper examines whether any particular portfolio is ex-ante mean-variance efficient by using a canonical example of such a test.	(CRSP) of the University of Chicago, represent monthly returns of the firms on the New York Stock Exchange (NYSE) for the period from 1926 to 1982 (meaning 684 observations). The portfolio (p) was represented by the CRSP Value-Weighted Index for the whole period. Also, the CRSP Equal-Weighted Index was used for the 1931-1965 period. The methodology is based on the BJS 1972 paper and Regression Analysis is used as well.	paper provides confirms the BJS (1972) conclusion, meaning that the ex-ante efficiency of the CRSP Equal-Weighted Index cannot be rejected. Furthermore, it is proven that the ex-ante efficiency of the CRSP Value-Weighted Index cannot be rejected either. Moreover, the multivariate test rejects the null hypothesis at the 1% level, something totally contradictory to the results of the univariate tests. Finally, if it is assumed that the Equal-Weighted Index is an efficient portfolio, then the result that the authors come up with is that high-beta portfolios earn too little and low-beta portfolios earn too much.

16	Fama, F. Eugene & French R. Kenneth, 1992 “The Cross-Section of Expected Stock Returns”	Use simultaneously in an asset-pricing model the Size (ME) and Book-to-Market Equity (BE/ME) factors in order to trace the cross-sectional alternations in average stock returns that are associated with the ratios of market beta (β), size, leverage, book-to-market equity (BE/ME) and earnings-price (E/P).	Data: Monthly returns for all the non-financial firms from the intersection of NYSE, AMEX and NASDAQ indices. The whole time period of the research is twenty-seven and a half -27.5- years, meaning that it starts from July 1962 and ends in December 1990. The two -2- authors follow the same methodology as Fama and Macbeth (FM) did in their study in 1973. However, the only difference with the FM approach is that they try to estimate portfolio betas first and then assign each beta to each individual stock in the portfolio.	Size (ME) is a valid factor that can explain the cross-section of average returns. In addition, it is also proven that BE/ME is a valid and even a more powerful factor than ME in explaining the cross-section of average returns. In conclusion, the market beta seems to be a factor that cannot explain the average returns on NYSE, AMEX, and NASDAQ, a finding that does not support the CAPM. In contrast, ME and BE/ME provide significant results in capturing the cross-sectional variation effects of Leverage and E/P on the average stock returns.

			Regression Analysis	
17	Dumas Bernard, 1994 "A Test of the International CAPM Using Business Cycles Indicators as Instrumental Variables"	Identify state variables of the economy. Specifically, he aims to use as instruments of state variables, economic variables that are external to the world financial markets, such as the business cycles indicators. Also, the asset pricing models that he tests are the International CAPM and the Classic CAPM in order to find out which asset pricing model works correctly with the data.	Data: Monthly excess returns on equity and currency holdings, all measured in a common currency, the US dollar. The total number of data points in the whole period of the study is 264 data-point series for four -4- countries; the USA, the United Kingdom, West Germany, and Japan. The time period that was covered started from January 1970 and ended in December 1991. The methodological approach that the author deployed can be split into two -2- parts. The first 1st- part of this research deals with the behavior of worldwide asset	Regarding the first -1st- part of the analysis and the Main Economic Indicators, it was observed that their predictive power was generally lower than the one of the internal financial variables. On the other hand, the second -2nd- part of the procedure regarding the country-specific instrumental variables, showed no better forecasting performance than the NBER series (meaning the US Leading Economic Indicators).

			returns on the US instrumental variables. The second -2nd- part of this methodological approach explores the behavior of worldwide asset returns on the basis of country-specific instrumental variables. Specifically, the author uses the leading indices of the four -4- countries' business cycles as instrumental variables.	
18	Jacoby Gady, Fowler J. David & Gottesman A. Aron, 2000 "The Capital Asset Pricing Model and the Liquidity Effect: A Theoretical Approach"	Develop a liquidity-adjusted CAPM-based model in order to prove that the beta term and the liquidity factor are inseparable.	No Data because it is a theoretical paper. The authors assume a one-period world with an uncertain future bid-ask spread. Liquid and illiquid assets are held for the whole	The authors conclude that the expected gross return is an increasing and convex function in the expected (next period) spread ratio, a finding that is the opposite of the findings of Amihud and Mendelson (1986).

			period, meaning that investors are not allowed to trade liquid assets more frequently than the illiquid ones. In order to derive their model, the authors employ the equation of the classic CAPM.	Furthermore, this model proves that the beta and the liquidity are two -2- inseparable terms. Last but not least, the authors reject the traditional CAPM because the after-spread beta measure is not linear in the classic form of the CAPM model.
19	Chen Hsiang Ming, 2002 "Risk and Return: CAPM and CCAPM"	Examine if a consumption beta (consumption growth risk) can serve as a better measure of systematic risk than the market beta.	Data: Four -4- monthly time series including stock price indices, dividend payments, risk-free rates, and the consumer price index of Taiwan for a time period from July 1991 to March 2000. The author examines the validity of the CAPM and the Consumption-based CAPM (CCAPM) across seven -7-	Starting with the CAPM results, the study showed a high value of the coefficient of determination (R^2) for each industry sector. The estimated market betas were efficient in general, all positive and statistically significant at the 1% level. Furthermore, regarding the results of the CCAPM, these were not as positive as for the CAPM. Specifically, the CAPM

			industry sectors in the emerging Taiwan Stock Market. He does a Regression Analysis.	outperforms the CCAPM based on its ability to forecast mean returns and cross-sectional and time series return variations. Moreover, regarding the consumption growth proxies of Chen et al. (1986) and of Asprem (1989), the author concludes that using the dividend growth (DG), the results reject the null hypothesis. Finally, regarding the imports growth rate (IG) the results reject the null hypothesis. The estimated consumption betas are not statistically significant in any statistical level and the R^2 decreases in each sector.

20	Hung-Chi-Hsiou Daniel, Shackleton Mark & Xu Xinzhong, 2003 “CAPM, Higher Co-Moments and Factor Models of UK Stock Returns”	Test which variables explain the cross-section of UK Stock Returns. Specifically, the authors test important factors that affect the cross-section of portfolio returns, some of which are generated from the CAPM beta and strategies based on Value and Size aspects.	Data: UK Stock Returns taken from the London Stock Price Database 2000 (LSPD 2000). The risk-free rate of return is approximated by the 90-day Treasury Bill Rate. The total sample period of the study starts in January 1975 and ends in December 2000, meaning 312 months or 26 years. The paper is based on the methodology of the following two -2- approaches. Firstly, the authors make use of a CAPM test that checks the realized market premia sign and which was developed in 1995 by Pettengill, Sundaram and Mathur and secondly, they take into account the approach of	First and foremost, the results of the analysis indicate that the beta factor is statistically significant in every model. It remains significant and provides high explanatory power even when the regression model incorporates higher co-moments and Fama-French factors (meaning Size and Value). Furthermore, the intercept term is statistically insignificant, the book-to-market ratio is highly significant and surprisingly when the factors of coskewness and cokurtosis are added, the explanatory power of the model is not increased because of not statistically significant estimated slope coefficients. Moreover, the

			Harvey and Siddique in 2000, in which higher-order asset pricing models were employed because they include systematic risk factors that are greater than the classic CAPM beta covariance. Finally, the authors make use of the Fama-French Size and Value factors. Regression Analysis.	Fama-French factors are very significant with an increased adjusted R-squared (R^2). In addition, in the case of the beta sorting, the portfolios with the higher betas show increased levels of skewness and kurtosis. Also, in terms of Size sorting, when a simple averaging of the regression results is being done, the portfolio betas are not extremely significant. Finally, in terms of Value sorting, the authors conclude that the value portfolio provides the least negatively skewed returns and the glamour portfolio the most negatively skewed returns.

21	Lewellen Jonathan & Nagel Stefan, 2003 "The Conditional CAPM Does Not Explain Asset-Pricing Anomalies"	Identify if the Conditional CAPM performs better than the Unconditional one. Specifically, the main question that the authors strive to answer is if a Conditional CAPM version can explain asset-pricing anomalies like Size, Book-to-Market (B/M) Ratios, and Momentum.	Data: Returns on Size, B/M, and Momentum Value-Weighted Portfolios which contain NYSE & Amex Stocks excluding ADRs, REITs, and Primes and Scores. The time period of the study starts from July 1964 and ends in June 2001. The authors use short-window regressions of the CAPM without using conditioning variables in order to provide direct estimates of assets' conditional alphas and betas for Size, B/M and Momentum Portfolios. The study is based primarily on the Sharpe-Lintner CAPM, but a Consumption-mimicking Portfolio	Size, B/M and Momentum betas can vary significantly over time and over the business cycle as well. Furthermore, regarding the relationship between the beta and the market risk premium, it is proven that the time-varying betas cannot provide answers for the unconditional alphas of Size, B/M, and Momentum portfolios. Moreover, the authors cannot conclude that the time-varying betas covary strongly with the market risk premium, something that informs us that the unconditional pricing errors of the Conditional CAPM are significantly smaller than those estimated for the B/M and Momentum portfolios.

			in the position of the Market Portfolio is tested as well. Regression Analysis.	Regarding the unconditional alphas of B/M and Momentum portfolios, these seem to be inconsistent with the Conditional CAPM. In summary, the Conditional CAPM cannot explain asset pricing anomalies like B/M and Momentum, meaning that the Unconditional CAPM performs nearly as poorly as the Conditional CAPM. Finally, the Consumption CAPM showed that it cannot either explain the B/M and Momentum factors.
22	Diacogiannis George & Feldman David, 2009	Introduce a well-specified asset-pricing model relative to the CAPM, which can be used for	No Data because it is a theoretical paper.	The two authors conclude that it would be better to use the CAPMI instead of the CAPM in the cases where inefficient

	"The CAPM Relation for Inefficient Portfolios"	pricing inefficient portfolios. This new approach is the Capital Asset Pricing Model for Inefficient Portfolios (CAPMI).	The authors used an orthogonal decomposition similar to the one of Jagannathan's (1996) finite number of securities version, which also made use of the conditioning information model of Hansen and Richard in 1987.	portfolios do exist and therefore we will be forced to use inefficient proxies.
23	Fama F. Eugene & French R. Kenneth, 2015 "A Five-Factor Asset Pricing Model"	Introduce an upgrade of the three -3-factor model of Fama & French (1992) to a five -5-factor model including the previous factors, meaning Market, Size and BE/ME and adding also the Profitability and Investment Factors.	Data: NYSE, AMEX, and NASDAQ stocks for the time period from July 1963 to December 2013. The methodology is similar to the Three-Factor Model. Regression Analysis.	The most important result that derives from the FF research is that the GRS statistic rejects the 5-factor model and every other model that the authors tested because they are incomplete descriptions of expected returns. Nevertheless, in spite of the fact that the GRS test tends to reject this model, the 5-factor model outperforms the 3-factor model on every metric and also is better

				than any other multi-factor model that was examined.

"Know what you own and know why you own it."

Peter Lynch

Chapter 3

Methodology & Data Selection

The purpose of this chapter is to present the methodology and the data selection of our procedure. We aim to prove that the FTSE 100 is an **inefficient index** and that the **Linear & Perfect Relationship** between **Expected Return and Beta** does not hold. In doing so, we will use **daily**, **weekly** and **monthly data** in our **3D Model** and for each different dataset, we will examine if the index proved inefficient. Therefore, the first -1st- part of this chapter will be devoted to the presentation of our methodology and the second -2nd- part will present the data selection. In all our methodology and calculations we used the **Microsoft Excel**, the **GNU-R Program** and the **Gretl Statistical Program**.

3.1 METHODOLOGY

In searching the best way to develop our analysis, we decided that the best model for our methodology would be the **1977 Roll's Modified Model** of Markowitz's approach. The reason that we chose this model is that it allows the possibility of short-selling the securities, something that the Markowitz's initial model did not. Roll calculated the minimum variance portfolio set by solving the following mathematical optimization problem.

3.1.1 Roll's Optimization Problem

Given a number of **n** individual securities, Roll defined the proportions that should be invested in each of them in order to **minimize the variance of the portfolio**, by taking into account these two -2- constraints:

$$X_p'R = E(R_p) \quad \mathbf{(3.1)}$$

$$X_p'u = 1 \quad \mathbf{(3.2)}$$

Where,

- **X_p = A (Nx1)** column vector containing the **proportions invested** in the securities included in the **portfolio p**.
- **R = A (Nx1)** column vector of the **expected returns** of the securities.
- **u** = The **(Nx1) unit vector**.
- ′ = The **transposed vector**.
- It is also assumed that **all the proportions add up** to **1**.

Roll also assumed that the **Covariance Matrix V** of all risky returns is **non-singular** and that the **Return vector R** contains **at least two -2- entries**. Following Roll's methodology, we end up in the following solution:

$$X_p = V^{-1} * (R\ u) * A^{-1} \begin{bmatrix} E(R_p) \\ 1 \end{bmatrix} \quad \mathbf{(3.3)}$$

Where,

- **V^{-1}** = The **inverted covariance matrix V**.
- **(R u) =** A **matrix** with two -2- columns, where the 1st column is the **return vector R** and the 2nd column is a **unit vector**.
- **A^{-1}** = The **inverted matrix of the Information Matrix A** of this efficient set of securities. The information matrix A is of the following form:

$$A = \begin{bmatrix} a & b \\ b & c \end{bmatrix} \quad \mathbf{(3.4)}$$

Where,

- $\boldsymbol{a = R' * V^{-1} * R}$
- $\boldsymbol{b = R' * V^{-1} * u}$
- $\boldsymbol{c = u' * V^{-1} * u}$

- **E(R_p) =** The **mean return** of the **minimum variance portfolio p**.

Furthermore, the **Variance** of a **minimum variance portfolio** can be expressed in the following way:

$$\sigma^2(R_p) = \frac{\alpha - 2bE(R_p) + c\left[E(R_p)\right]^2}{ac - b^2} \quad \mathbf{(3.5)}$$

Also, the **Expected Return E(R_p)** of the **Global Minimum Variance Portfolio (GMVP)**, which is the portfolio with the **lowest variance** among **all** the minimum variance portfolios, is the following:

$$E(R_{GMVP}) = \frac{b}{c} \quad \mathbf{(3.6)}$$

3.1.2 Thesis Methodology

Our methodology followed two -2- paths. The first -1st- path was to support our findings **mathematically-statistically** and the second -2nd- path was the **schematical one**.

3.1.2.1 Mathematical-Statistical Methodology

Let us imagine the **Portfolio p** which is the **FTSE 100 Index** and a **Minimum Variance Portfolio q**. We believe that **p** is **inefficient**. Therefore, we know that the **Return** of **p** will be the following:

$$R_p = R_q + u_p \quad \mathbf{(3.7)}$$

Where,

- $\mathbf{R_p}$ **=** The **return** of portfolio **p**.
- $\mathbf{R_q}$ **=** The **return** of portfolio **q**.
- $\mathbf{u_p}$ **=** The **residual term** due to the **inefficiency** of **portfolio p**.

We also know,

$$Vx_p = Vx_q + u_p \quad \mathbf{(3.8)}$$

Where,

- **V** = A **(NxN) Covariance Matrix**.
- $\mathbf{x_p}$ **=** The **(Nx1) Vector** that defines portfolio p.
- $\mathbf{x_q}$ **=** The **(Nx1) Vector** that defines the **minimum variance** portfolio **q**.
- $\mathbf{u_p}$ **=** The **(Nx1) Vector** with covariances Cov(R_i, u_p), i = 1,2,…,N.

We can then run simple **OLS Regressions** for every stock and calculate the residual terms. Each regression can be of the following form:

$$R_{it} = a_i + \beta_i R_{qt} + e_{it} \quad \mathbf{(3.9)}$$

Where,

- $\mathbf{a_i, \beta_i}$ **=** The **intercept** and the **beta term** of each stock.
- $\mathbf{R_{pt}}$ **=** The **return** of the **minimum variance portfolio q**.
- $\mathbf{e_{it}}$ **=** The **residual term** of the regression.

As a result, when we run all the regressions we get a **Covariance Matrix** of the **Residuals (Ve**). Therefore, we can prove:

$$V_e x_p = u_p \quad (\mathbf{3.10})$$

So, Equation 3.8 becomes:

$$Vx_p = Vx_q + V_e x_p \Longrightarrow (V - V_e)x_p = Vx_q \quad (\mathbf{3.11})$$

Based on the previous equation, if we prove that the **matrix (V-V_e)** is **different** from **V** then $\mathbf{u_p \neq 0}$. This would mean that **p** is **not efficient**.

The steps that we took to prove our findings **statistically** were the following:

Step 1: We calculated the **logarithmic returns R** of each of the 101 Constituents of the FTSE 100 Index for a total period of eight -8- years. We used logarithmic instead of arithmetic returns in order to correct for any existence of outliers.

Step 2: We calculated the **Covariance Matrix V** of the returns.

Step 3: We calculated the **Inverted Covariance Matrix V^{-1}** of the returns.

Step 4: We calculated the **Mean Return** of each security.

Step 5: We **transposed** the **mean return vector** and we created the **(R u)** and **(R u)’ matrices**.

Step 6: We multiplied the **(R u)’** with the **V^{-1}** matrix.

Step 7: Then, the result of **(R u)’*V^{-1} was multiplied with the (R u) matrix** and this provided the **2x2 Information Matrix A**.

Step 8: We **inverted** the Information Matrix and the result was the matrix **A^{-1}**.

Step 9: Then, we **multiplied V^{-1} with (R u)** and this result was then multiplied with **A^{-1}**, meaning **V^{-1}*(R u)*A^{-1}**.

Step 10: We set a preferred **portfolio mean return** that we aimed for (meaning that we set the same number as the mean return of the FTSE 100 Index because the **minimum variance portfolio q** that will be derived by our model and the index portfolio are assumed to offer the **same expected return** in order to be comparable). This is the **Matrix (M u)**.

Step 11: We did the following multiplication: **V^{-1}*(R u)*A^{-1}*(M u)**. This multiplication resulted in the creation of a **Weights Table** which shows the investment proportions of each stock. When the **sign is positive** it means that we have to **buy** the suggested proportion of the stock and when the **sign is negative** it means that we have to **short-sell** the suggested proportion. Last but not least, it was checked that the summation of all the investment proportions adds up to **one (1.0000)**.

Step 12: Using the above weights we created the **Portfolio q** with **returns R_q** equal to the result of the multiplication of **each weight with each stock return**, for each day, week, month, meaning that each **R_q** is the **weighted average** of all these multiplications. This procedure ended up in a **vector** of 2089 daily observations, 422 weekly observations, and 97 monthly observations.

Step 13: We regressed (using an OLS Regression) each vector of stock returns with the returns of R_q and we calculated the **Covariance Matrix Ve** of the **Residuals**. This matrix is a **101x101** table.

Step 14: We subtracted the **Covariance Matrix Ve** from the **Covariance Matrix V** and we checked whether the newly formed matrix was **different** (meaning **not equal**) from the **Covariance Matrix V**. Specifically, regarding this step, the methodology and the description of the test for this inequality control of the two matrices is the following:

The test deals with the problem of investigating the intertemporal stationarity of the covariance matrix. For this test the appropriate hypotheses, meaning the **Null** and the **Alternative Hypotheses** would be:

$$H_0: \Sigma_g = \Sigma_g^* \quad (\mathbf{3.12})$$

$$H_1: \Sigma_g \neq \Sigma_g^* \quad (\mathbf{3.13})$$

Furthermore, the **Box's M Test of equality of Covariance Matrices** can be described by the following mathematical expressions (3.14 & 3.15):

$$C = \left[T_2 - 1 - \frac{(2p^2 + 3p - 1)}{4(p+1)}\right] ln \frac{\frac{|s_g + s_g^*|^2}{4}}{|s_g||s_g^*|} \quad (\mathbf{3.14})$$

Where,

- **C =** An approximately distributed **chi-squared variate** with **p(p+1)/2** degrees of freedom.
- **p =** The **number of securities** in the group.
- **T_2 =** The **size** of its **random sample** in terms of **time period**.
- **ln =** The **natural logarithm operator**.
- **s_g =** An **unbiased estimate** of the **Population Covariance Matrix Σ_g**.
- **s_g^* =** An **unbiased estimate** of the **Population Covariance Matrix Σ_g^***.

Therefore, the **Null Hypothesis** of the homogeneity of the above covariance matrices, is accepted if the following expression holds:

$$C < x^2_{\alpha,\frac{1}{2}p(p+1)} \qquad \mathbf{(3.15)}$$

Where,

- **α = Level of Significance**.

Finally, regarding the **assumptions** that this test is based on, we will share the following:

1. For each security we must choose two -2- equally size samples which can be also regarded as randomly drawings from the multivariate normal distributed populations with unknown correlation matrices P_g and P_g^*, respectively.
2. For each security, the two -2- random samples of return observations are independent.

Last but not least, it is important to mention that we used the notation of **1** for **Daily Data**, **2** for **Weekly Data** and **3** for **Monthly Data**, meaning that, for instance, the Covariance Matrix of Returns for Daily Data is named as **V1**, the one for Weekly Data is named as **V2** and the one for Monthly Data is named as **V3**. The same numbering is used in every matrix, table, and vector.

Also, the **hypotheses** that we lie on are the following two -2:

1. **$V \neq 0$**
2. The **average returns** of the stocks are **different**, meaning that there are **at least two -2- different returns**, $R_1 \neq R_2 \neq R_3 \ldots$

3.1.2.2 Schematical Methodology

On the other hand, as we said before, we have proven our findings schematically, as well. Therefore, the steps that we took were the following:

Step 1: We calculated the **Expected Return**, **Variance** (see Equation 3.5) and the **Standard Deviation** of the **Portfolio q**.

Step 2: We calculated the **Expected Return** and the **Variance** of the **GMVP** (see Equations 3.5, 3.6).

Step 3: We set a **step** equal to **0.0001** which was the step backward and forward of the Portfolio q, in order to create the **Efficient Frontier** of each time interval. We calculated the expected returns, the variances and the standard deviations of **100 steps backward** and almost **250 steps forward**.

3.2 DATA SELECTION

In our thesis, we used **daily**, **weekly**, and **monthly data** of the **FTSE 100 Constituents** and of the **FTSE 100 Index** for the period starting from **11/10/2010** up until **11/10/2018**, meaning **eight -8- years**. All the data were taken from the Thomson Reuters Datastream database from the Department of Banking & Financial Management of the University of Piraeus. Underneath, you can find an information table regarding each stock.

Table 3.2.a – FTSE 100 Stock Information

Stock	Industry	Ticker
HSBC Holdings	Financial Services	HSBA
3I GROUP	Financial Services	III
BP	Oil & Gas Producers	BP.
Royal Dutch Shell B	Oil & Gas Producers	RDSB

British American Tobacco	Tobacco	BATS
GlaxoSmithKline	Pharmaceuticals & Biotechnology	GSK
AstraZeneca	Pharmaceuticals & Biotechnology	AZN
DIAGEO	Beverages	DGE
Scottish Mortgage Investment Trust	Equity Investment Instruments	SMT
Rio Tinto Group	Mining	RIO
Unilever	Personal Goods	ULVR
Vodafone Group	Mobile Telecommunications	VOD
Lloyds Banking Group	Banking	LLOY
Glencore	Mining	GLEN
Reckitt Benckiser Group	Household Goods & Home Construction	RB.
Prudential Plc	Life Insurance	PRU
Shire Plc	Pharmaceuticals & Biotechnology	SHP
Barclays	Banking	BARC
BHP Billiton	Mining	BLT
Royal Bank of Scotland Group	Banking	RBS
National Grid Plc	Gas, Water & Multi-Utilities	NG.
RELX Group	Media	REL
BT Group	Fixed Line Telecommunications	BT.A
Anglo American Plc	Mining	AAL
Imperial Brands	Tobacco	IMB
TESCO	Food & Drug Retailers	TSCO
Compass Group	Support Services	CPG
Standard Chartered	Banking	STAN

Associated British Foods	Food Producers	ABF
CRH Plc	Construction & Materials	CRH
AVIVA	Life Insurance	AV.
Rolls-Royce Holdings	Aerospace & Defence	RR.
BAE Systems	Aerospace & Defence	BA.
London Stock Exchange Group	Financial Services	LSE
Experian	Support Services	EXPN
Legal & General	Life Insurance	LGEN
Ferguson Plc	Support Services	FERG
SSE Plc	Electricity	SSE
WPP Plc	Media	WPP
International Airlines Group	Travel & Leisure	IAG
Smith & Nephew	Health Care Equipment & Services	SN.
Melrose Industries	Automobiles & Parts	MRO
NEXT Plc	General Retailers	NXT
Ashtead Group	Support Services	AHT
Burberry Group	Personal Goods	BRBY
Cocal Cola HBC AG	Beverages	CCH
Informa	Media	INF
Sainsbury’s	Food & Drug Retailers	SBRY
Whitbread	Retail Hospitality	WTB
Antofagasta	Mining	ANTO
Bunzl	Support Services	BNZL
Centrica	Gas, Water & Multi-Utilities	CNA
Evraz	Industrial Metals & Mining	EVR
Hargreaves Lansdown	Financial Services	HL.

InterContinental Hotels Group	Travel & Leisure	IHG
Intertek Group	Support Services	ITRK
Morrisons	Food & Drug Retailers	MRW
NMC Health	Healthcare Equipment & Services	NMC
Persimmon Plc	Household Goods & Home Construction	PSN
Standard Life Aberdeen	Financial Services	SLA
British Land	Real Estate Investment Trusts	BLND
Carnival Corporation & Plc	Travel & Leisure	CCL
Croda International	Chemicals	CRDA
DCC Plc	Support Services	DCC
Johnson Matthey	Chemicals	JMAT
Land Securities Group	Real Estate Investment Trusts	LAND
Marks & Spencer Group	General Retailers	MKS
Mondi	Forestry & Paper	MNDI
Ocado Group	Food & Drug Retailers	OCDO
Schroders	Financial Services	SDR
Segro	Real Estate Investment Trusts	SGRO
Smith, D.S.	General Industrials	SMDS
Easyjet	Travel & Leisure	EZJ
Fresnillo Plc	Mining	FRES
GVC Holdings	Travel & Leisure	GVC
Halma	Electronic & Electrical Equipment	HLMA
ITV Plc	Media	ITV
Just Eat Plc	Food Producers	JE.

Kingfisher Plc	General Retailers	KGF
Paddy Power Betfair	Travel & Leisure	PPB
Pearson Plc	Media	PSON
Randgold Resources	Mining	RRS
Rentokill Intitial	Support Services	RTO
RSA Insurance Group	Non-life Insurance	RSA
Sage Group	Software & Computer Services	SGE
Smiths Group	General Industrials	SMIN
St. James's Place Plc	Life Insurance	STJ
United Utilities Group	Gas, Water & Multi-Utilities	UU.
Admiral Group	Non-life Insurance	ADM
Barratt Developments	Household Goods & Home Construction	BDEV
Berkeley Group Holdings	Household Goods & Home Construction	BKG
Direct Line Group	Non-life Insurance	DLG
Micro Focus International	Software & Computer Services	MCRO
Rightmove	Media	RMV
Royal Mail Plc	Postal Services & Couriers	RMG
Severn Trent	Gas, Water & Multi-Utilities	SVT
Taylor Wimpey	Household Goods & Home Construction	TW.
Wood Group	Oil Equipment & Services	WG.
Royal Dutch Shell	Oil & Gas Producers	RDSA
Smurfitt Kappa	General Industrials	SKG
TUI Group	Travel & Leisure	TUI

"99 percent of all statistics only tell 49 percent of the story."

Ron DeLegge II

Chapter 4

Results Presentation & Analysis

This is our final chapter where we will present and discuss the results of our research. As we said in Chapter 3, we have followed two different approaches, the **schematical** approach and the **statistical** one. We will start by proving the **inefficiency** of **Portfolio p schematically** and then **statistically**.

4.1 SCHEMATICAL APPROACH

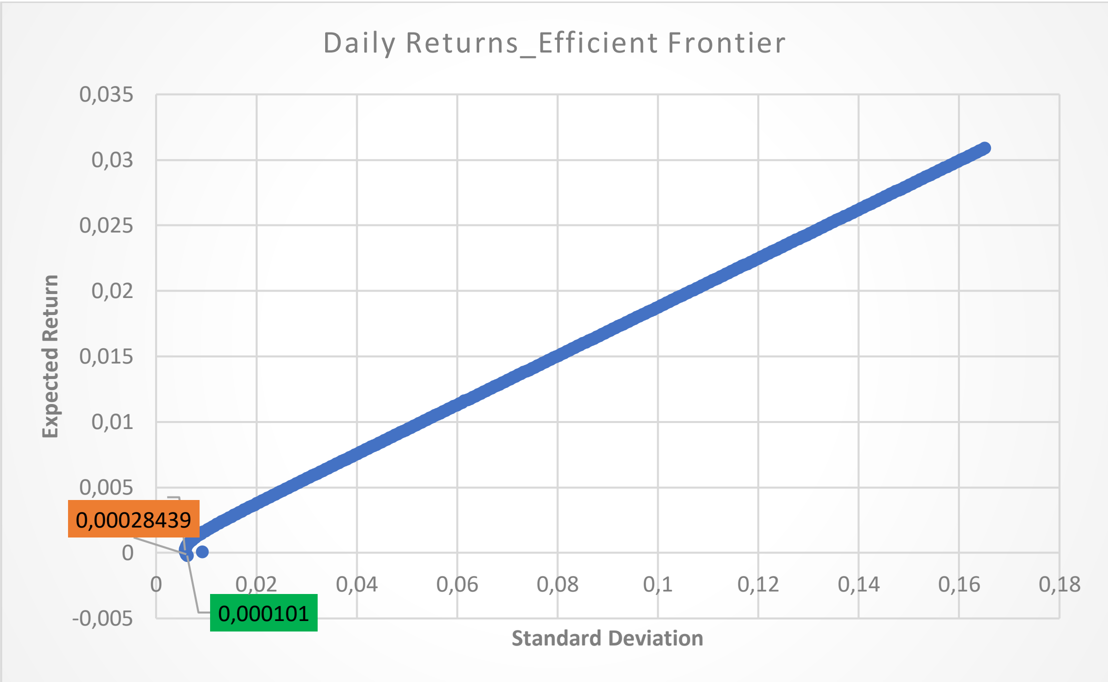
In this approach, we have constructed the **Efficient Frontier** and we have compared the **risk/return relationship** between the **Minimum Variance Portfolio q** and **Portfolio p**. In order to construct the minimum variance portfolio q, we had to set an **mean return equal** to the portfolio p, in order to be able to compare the two portfolios. Therefore, the mean return of the two portfolios, in all three -3- time periods, is equal, but the **standard deviation** of each one is **different** and this will prove the **inefficiency of Portfolio p**.

In order to provide the best possible results and an abundance of information, we have also compared the **Minimum Variance Portfolio q** with the **Global Minimum Variance Portfolio (GMVP)**, which is the portfolio with the **lowest possible variance**. Above this portfolio, lies the **Efficient Frontier** where **all portfolios** that are **on it** are

both efficient and minimum variant. Therefore, if $\mathbf{R_q} > \mathbf{R_g}$ (meaning the **Expected Return** of **Portfolio GMVP**) then **q is minimum variant and efficient**. If **not**, then **q is just minimum variant**.

Below, we will start with daily results, then weekly and finally monthly.

4.1.1 Daily Schematical Results



As we can see in the previous diagram, the **Portfolio q** is the **green portfolio** with an **mean return** equal to **0.000101**. The **Portfolio p** is the **blue dot** at the **right-hand side** of the **Efficient Frontier**. The standard deviation of each one is given below:

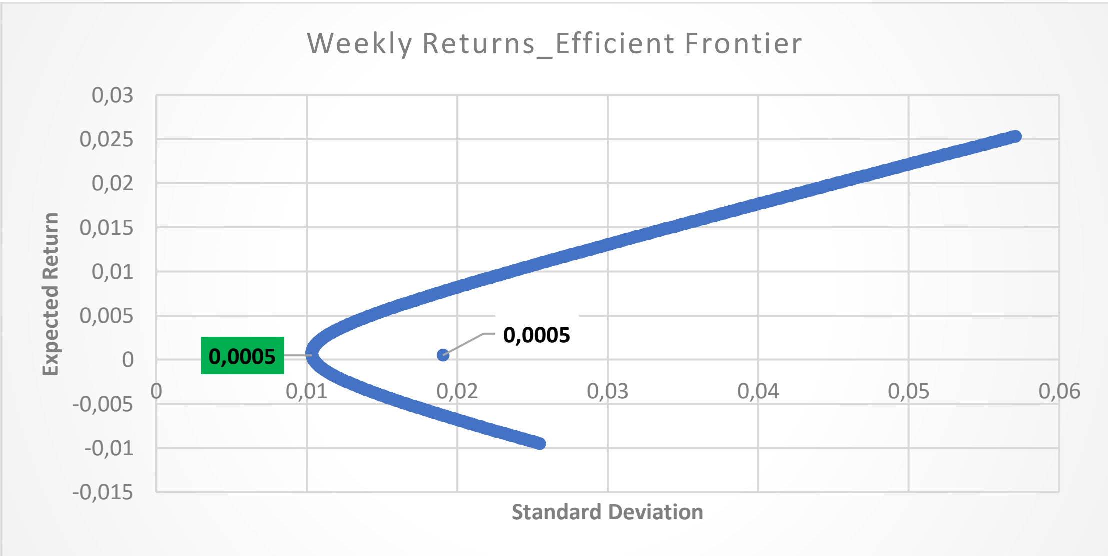
Standard Deviation of q	Standard Deviation of p
0.00581	0.00914

As a result, we can clearly state that **Portfolio p** is **not efficient** because it is situated at the **right-hand side** of the **Efficient Frontier**. The **orange portfolio** is the **Global Minimum Variance Portfolio (GMVP)**. As we can see, $\mathbf{R_g} > \mathbf{R_q}$ which means that **q** is just **minimum-variant** and not **efficient**.

A summary of the mean return and the standard deviation of Portfolios **p, q** and **g** (meaning the GMVP or **Spherical Portfolio**) is the following:

Portfolios	Mean Return	Standard Deviation
Portfolio p (FTSE 100)	0.000101	0.00914
Portfolio q (Minimum - Variant)	0.000101	0.00581
Portfolio g (GMVP)	0.00028439	0.00576

4.1.2 Weekly Schematical Results



As we can see in the previous diagram, the **Portfolio q** is the **green portfolio** with an **mean return** equal to **0.0005**. The **Portfolio p** is the **blue dot** at the **right-hand side** of the **Efficient Frontier**. The standard deviation of each one is given below:

Standard Deviation of q	Standard Deviation of p
0.01040	0.01904

As a result, we can clearly state that **Portfolio p** is **not efficient** because it is situated at the **right-hand side** of the **Efficient Frontier**. In this time interval, the step we used to create the efficient frontier was such that we could not depict the GMVP and therefore, for comparison reasons, we present below the R_g.

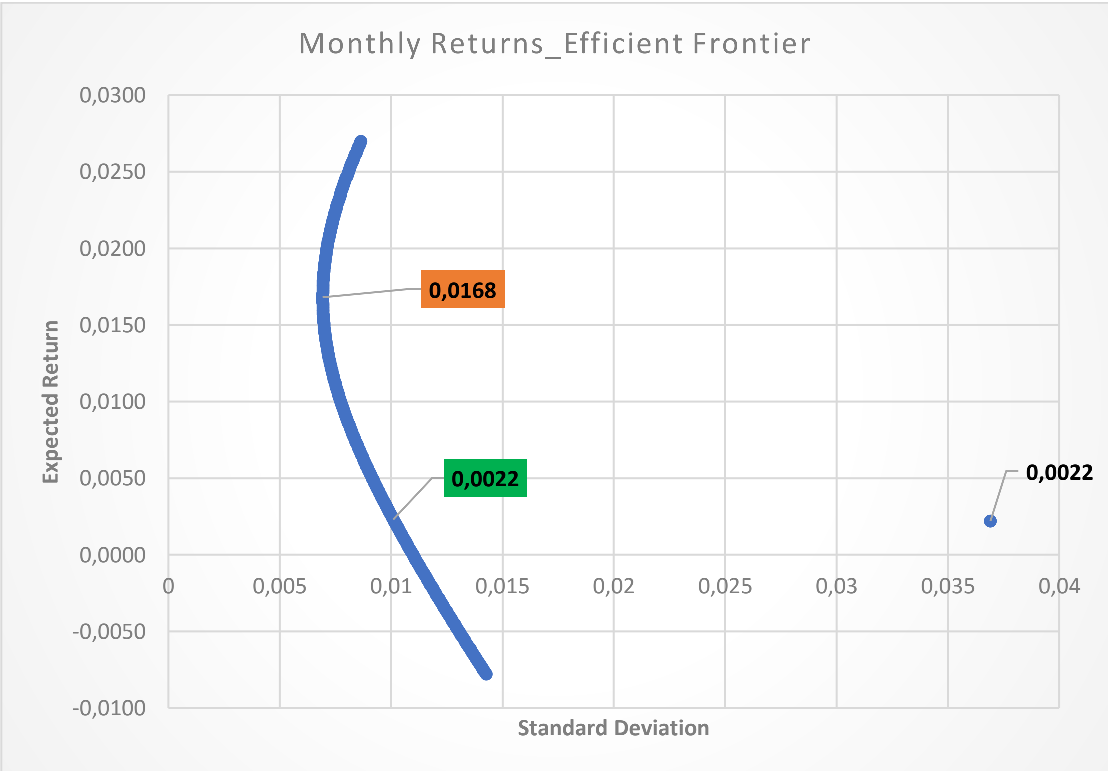
R_g	0.000693

Since, $R_g > R_q$, the **Portfolio q** is again **not efficient** and **only minimum variant**.

A summary of the mean return and the standard deviation of Portfolios **p, q** and **g** (meaning the GMVP or **Spherical Portfolio**) is the following:

Portfolios	Mean Return	Standard Deviation
Portfolio p (FTSE 100)	0.0005	0.01904
Portfolio q (Minimum - Variant)	0.0005	0.01040
Portfolio g (GMVP)	0.000693	0.01033

4.1.3 Monthly Schematical Results



As we can see in the previous diagram, the **Portfolio q** is the **green portfolio** with an **mean return** equal to **0.0022**. The **Portfolio p** is the **blue dot** at the **right-hand side** of the **Efficient Frontier**. The standard deviation of each one is given below:

Standard Deviation of q	Standard Deviation of p
0.01009	0.03691

As a result, we can clearly state that **Portfolio p** is **not efficient** because it is situated at the **right-hand side** of the **Efficient Frontier**. The **orange portfolio** is the **Global Minimum Variance Portfolio (GMVP)**. As we can see, $\mathbf{R_g} >> \mathbf{R_q}$ which means that **q** is just **minimum-variant** and not **efficient**.

A summary of the mean return and the standard deviation of Portfolios **p, q** and **g** (meaning the GMVP or **Spherical Portfolio**) is the following:

Portfolios	Mean Return	Standard Deviation
Portfolio p (FTSE 100)	0.0022	0.03691
Portfolio q (Minimum - Variant)	0.0022	0.01009
Portfolio g (GMVP)	0.0168	0.00692

4.2 STATISTICAL APPROACH

In order to be more thorough with our findings, we proved the inefficiency of **Portfolio p** statistically, as well. We followed the methodology that is described in Chapter 3 and we used Microsoft Excel to check whether the **(V-Ve) Matrix** was **different** from the **V Matrix**. Before we demonstrate the result of each time interval (meaning daily, weekly and monthly), it is crucial to present the **Information Matrix** and the **Weight Table**. Afterwards, the result is presented, meaning that if the two matrices are **heterogeneous** the result is **$C>X^2$** and if the two matrices **are homogeneous**, the result will be **$C<X^2$**.

4.2.1 Daily Statistical Results of the Test

The **Information Matrix** (see **Step 7** of the methodology) of daily data that was calculated is the following:

Information Matrix A1	
0,036090305	6,782309973
6,782309973	30158,34685

Where, based on Equation 3.5 we can extract the following numbers:

α = 0.036090305

b = 6.782309973

c = 30158.34685

We can clearly see that the covariance matrices that we calculated are **completely symmetrical** since the **upper-right side** and the **bottom-left side** of the **main diagonal** of the Information Matrix A1 are the **identical number** equal to **b**.

Moreover, regarding the **Weights Table** (see **Step 11** of the methodology) that we calculated, we can state that it offered us weights that sum to number 1.00 and that are the exact derivative of an **Expected Return** equal to **0.000101**.

4.2.1 – Weights Table of Daily Data

0,080177353
-0,050400979
0,027048201
-0,094060094
-0,014554462
0,05832431
0,006752165
0,027769746
-0,025137704
0,075740815
0,005454998
0,018993617
0,050239049
-0,018327203
0,014034234
-0,074305682
-0,00429753
-0,018040361
-0,055147123
0,019013549
0,04362794
0,040447233
-0,010417322
-0,027028209
0,052263495
0,016048272
0,036362989
0,01502229
-0,00191679
-0,048769071
-0,023213134
0,004178323
0,032012492
-0,015457738
-0,011642754
0,031304401
-0,000619672
0,056365159

-0,031756751
-0,021276656
0,008326447
0,011207402
0,037950507
-0,02213729
-0,00794885
0,005474758
-0,007517381
-0,001730872
0,024274922
0,022464504
0,004969396
0,03309789
0,004878234
-0,027850082
-0,047252287
0,002512766
0,064632609
0,004452484
-0,031473215
-0,022551753
0,007590136
0,0225036
0,028546736
0,057047388
-0,005241366
0,011254889
0,001000086
-0,030207244
-0,0020977
-0,046371631
0,031230244
0,00074568
0,027899999
-0,032745314
0,083337376
0,039683054
-0,016860933
0,013830934
0,026628304
0,052864972
0,035578672
0,080346201

0,039110912
0,05349077
0,016536892
0,012932208
-0,038005264
0,019463237
0,005537775
-0,013364766
0,041675242
0,103544002
0,013485846
0,001853949
0,039252723
0,017422713
-0,021331182
-8,95284E-05
0,106219845
-0,003744806
-0,001146236

Sum	**1,00000**

This table shows the investment proportions of each stock. When the **sign is positive** it means that we have to **buy** the suggested proportion of the stock and when the **sign is negative** it means that we have to **short-sell** the suggested proportion.

Moreover, based on Equations 3.14 and 3.15, we have computed the chi-squared variate **C** with p(p+1) degrees of freedom and we have compared it to the **chi-squared** critical value of **5,151 degrees of freedom** and a **95% significance level**. The result is the following:

C = 149,984.20 > 5,319.08 (X^2 critical value)

Since, **C** is **greater** than the **critical value**, then the **Null Hypothesis** of the **homogeneity** of the two -2- covariance matrices **V1** and **(V1-Ve1)** is **rejected** and therefore the **Portfolio p** is **inefficient**.

4.2.2 Weekly Statistical Results of the Test

The **Information Matrix** (see **Step 7** of the methodology) of weekly data that was calculated is the following:

Information Matrix A2	
0,196605792	6,497992
6,497992178	9378,453

Where, based on Equation 3.5 we can extract the following numbers:

α = 0.196605792

b = 6.497992178

c = 9378.453

It is obvious that the covariance matrices that we calculated are **completely symmetrical** since the **upper-right side** and the **bottom-left side** of the **main diagonal** of the Information Matrix A2 are the **identical number** equal to **b**.

Moreover, regarding the **Weights Table** (see **Step 11** of the methodology) that we calculated, we can state that it offered us weights that sum to number 1.00 and that are the exact derivative of an **Expected Return** equal to **0.0005**.

4.2.2 – Weights Table of Weekly Data

0,0709959
-0,03239
-0,002387
-0,170159
0,0377439
0,0910902
0,0020774
0,0404823
-0,227506
0,0605178
0,0677755
0,0284665
0,0157907
-0,016467
0,0458975

-0,067956
-0,010204
-0,028024
-0,083033
0,0777284
0,0898005
-0,109067
0,0357306
0,0065472
-0,038842
-0,029856
0,0009225
0,0203884
-0,039891
-0,036789
-0,022303
0,0175528
0,0281021
-0,021117
0,0884696
0,1155058
-0,031503
0,0159783
-0,098022
-0,018013
-0,046834
-0,007712
0,0087116
-0,012315
0,0312506
0,0149187
0,0567949
-0,057384
0,0524972
0,0224745
-0,023279
0,0918569
0,0151038
-0,037079
-0,072628
-0,015021
0,0247032
0,0618948
0,0094231

-0,063372
0,0073795
-0,014613
0,0646647
0,0691513
-0,082345
-0,026743
0,0265699
-0,064947
-0,007927
-0,047074
0,0094779
0,0513671
0,0362472
-0,022883
0,0310543
0,1125053
0,0006979
0,0787571
0,075042
-0,000222
-0,015234
0,0375565
0,0675602
0,0312544
-0,044597
0,0228454
-0,027809
0,030636
0,0370382
0,006642
0,0670909
0,126985
0,0125067
-0,043869
0,0768362
-0,013736
-0,092443
0,0364922
0,2588906
0,033873
0,1672858

Sum	**1,00000**

The above table, shows again the investment proportions of each stock. When the **sign is positive** it means that we have to **buy** the suggested proportion of the stock and when the **sign is negative** it means that we have to **short-sell** the suggested proportion.

In addition, based on Equations 3.14 and 3.15, we have computed the chi-squared variate **C** with p(p+1) degrees of freedom and we have compared it to the **chi-squared (X^2)** critical value of **5,151 degrees of freedom** and a **95% significance level**. The result is the following:

C = 21,989.69 > 5,319.08 (X^2 critical value)

Since, **C** is **greater** than the **critical value**, then the **Null Hypothesis** of the **homogeneity** of the two -2- covariance matrices **V2** and **(V2-Ve2)** is **rejected** and therefore the **Portfolio p** is **inefficient**.

4.2.3 Monthly Statistical Results of the Test

The **Information Matrix** (see **Step 7** of the methodology) of monthly data that was calculated is the following:

Information Matrix A3	
9,7654	350,2604585
350,2604585	20868,3803

Where, based on Equation 3.5 we can extract the following numbers:

α = 9.7654

b = 350.2604585

c = 20868.3803

The result is that the covariance matrices that we calculated are **completely symmetrical** since the **upper-right side** and the **bottom-left side** of the **main diagonal** of the Information Matrix A3 are the **identical number** equal to **b**.

Moreover, regarding the **Weights Table** (see **Step 11** of the methodology) that we calculated, we can state that it offered us weights that sum to number 1.00 and that are the exact derivative of an **Expected Return** equal to **0.0022**.

4.2.3 – Weights Table of Weekly Data

0,6756
-0,8462
0,0267
-0,4699
0,4233
0,5162
-0,0508
-1,1915
-0,5130
-0,0425
-0,2600
0,8548
-0,0184
-0,3185
-0,6914
-0,6207
-0,1176
0,2801
0,3198
-0,2152
-0,3534
0,8947
0,2057
0,0851
-0,1444
0,0040
1,1745
0,3967
0,5081
-0,4648
-0,2608
-0,2607
0,6129
0,2395
0,7733
0,5140
0,0617
-0,8976

-0,2176
0,0287
-0,2998
-0,1859
0,3060
0,1307
-0,0944
0,1232
-0,6591
-0,4841
-0,2573
0,1156
-0,6292
0,2996
0,0976
0,1393
0,1040
-0,3715
0,5128
0,0347
0,0503
-0,2201
0,1652
0,0079
0,3291
0,8586
-0,2456
0,0625
-0,0562
-0,3858
-0,0037
-0,5800
0,0663
0,3698
-0,0606
0,0678
-0,0258
0,5742
-0,1764
-0,0113
0,1015
-0,3816
0,0313
-0,1675

0,6021
0,1837
-0,7735
-0,0596
0,1114
0,7061
0,2801
0,0679
-0,5266
-0,2745
0,0138
0,1326
0,0369
-0,3565
0,6810
0,0438
0,5084
-0,2310
-0,0384

Sum	**1,0000**

The table 4.2.3, shows again the investment proportions of each stock. When the **sign is positive** it means that we have to **buy** the suggested proportion of the stock and when the **sign is negative** it means that we have to **short-sell** the suggested proportion.

Furthermore, based on Equations 3.14 and 3.15, we have calculated the chi-squared variate **C** with p(p+1) degrees of freedom and we have compared it to the **chi-squared (X^2)** critical value of **5,151 degrees of freedom** and a **95% significance level**. The result is the following:

C = 10,416.77 > 5,319.08 (X^2 critical value)

Since, **C** is **greater** than the **critical value**, then the **Null Hypothesis** of the **homogeneity** of the two -2- covariance matrices **V3** and **(V3-Ve3)** is **rejected** and therefore the **Portfolio p** is **inefficient**.

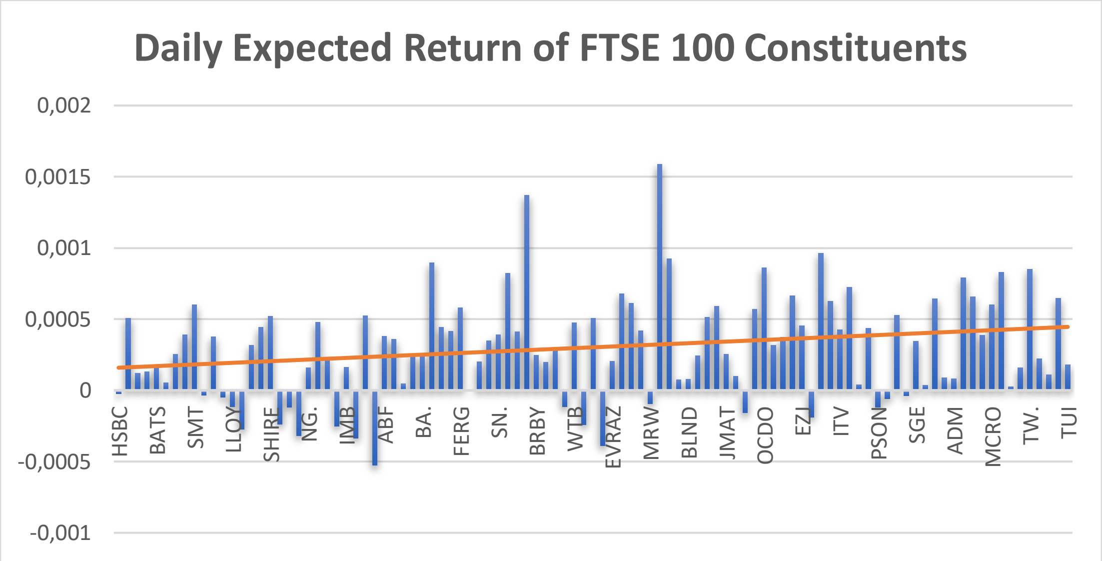
Last but not least, we must conclude that in both the **Schematical** and the **Mathematical/Statistical Approach**, the FTSE 100 Index (**Portfolio p**) proves to be an **inefficient portfolio**. Based on this result, we can comment that the **linear and**

perfect relationship between the Expected Return and Beta must be **rejected** and a better model (as the one examined in this thesis) should be employed. This result tends to be in accordance with the results of several papers which reject this kind of relationship but is contradictory to the ones that accept it. In general, we have seen (based on our literature review) that in most of the cases where this linear and perfect relationship was examined (as it is clearly used in the CAPM model), it was **rejected** and this finding supports the results of our research.

4.3 ADDITIONAL STATISTICAL INFORMATION

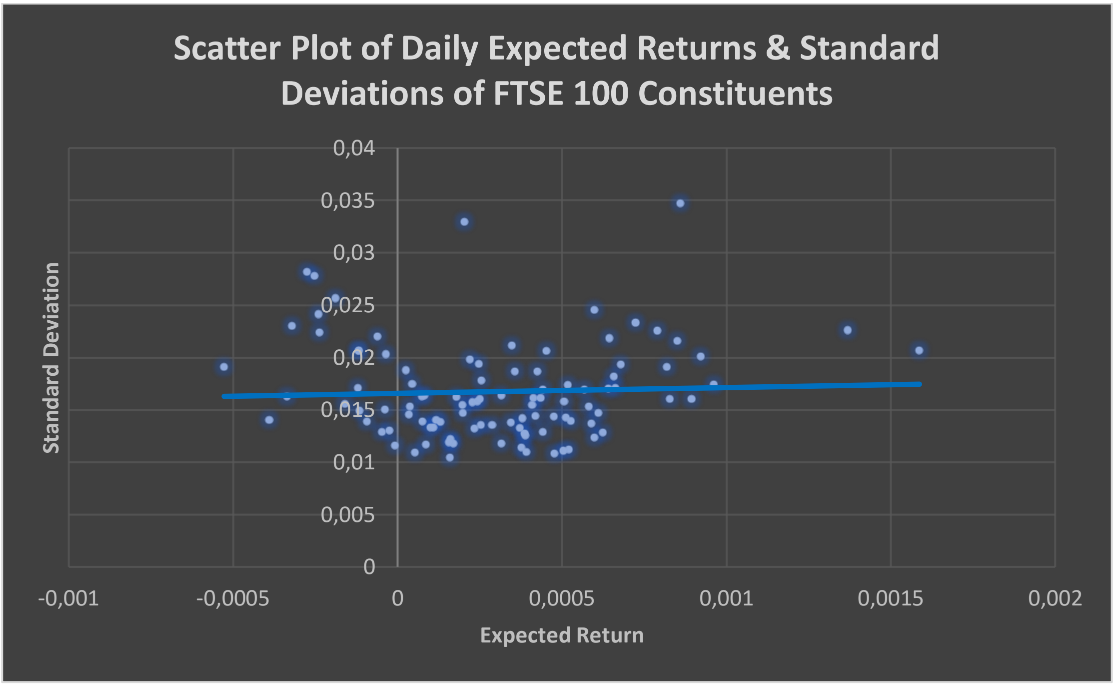
Because the Covariance Matrices are extremely huge to input them in a word sheet, in order to help our readers understand the risk/return relationship of each stock, we present below the **Expected Return Bar Charts** and the **Risk/Return Tradeoff** of all stocks for every time period (daily, weekly, monthly).

4.3.1 Daily Statistical Information



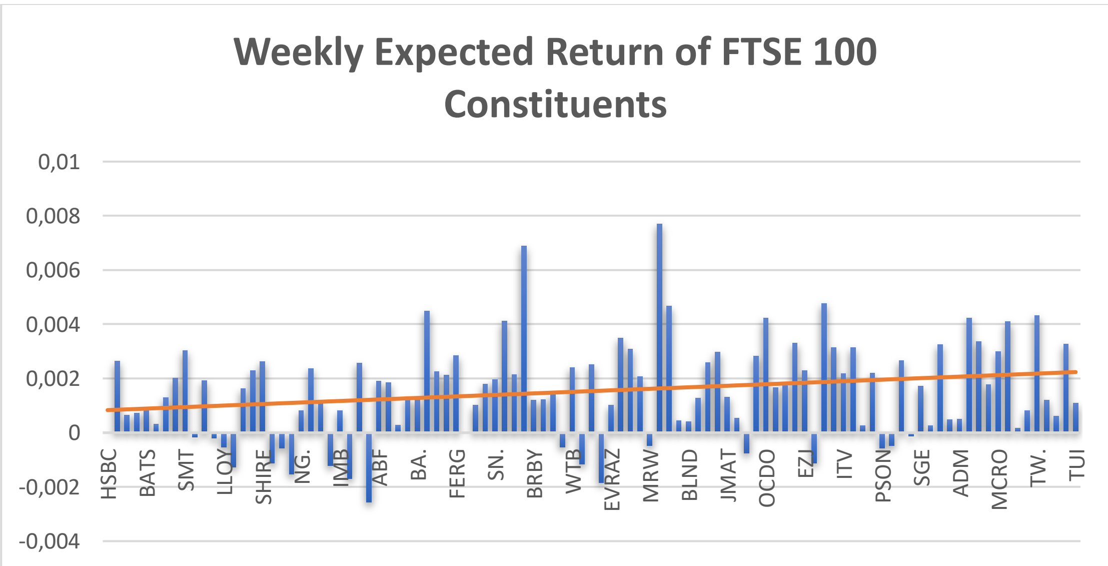
As we can see in the previous chart, the **trend** of the **daily expected return** is an **upward** one with few stocks which present negative expected returns for this 8-year period.

The **risk/return tradeoff** is presented in the following graph:



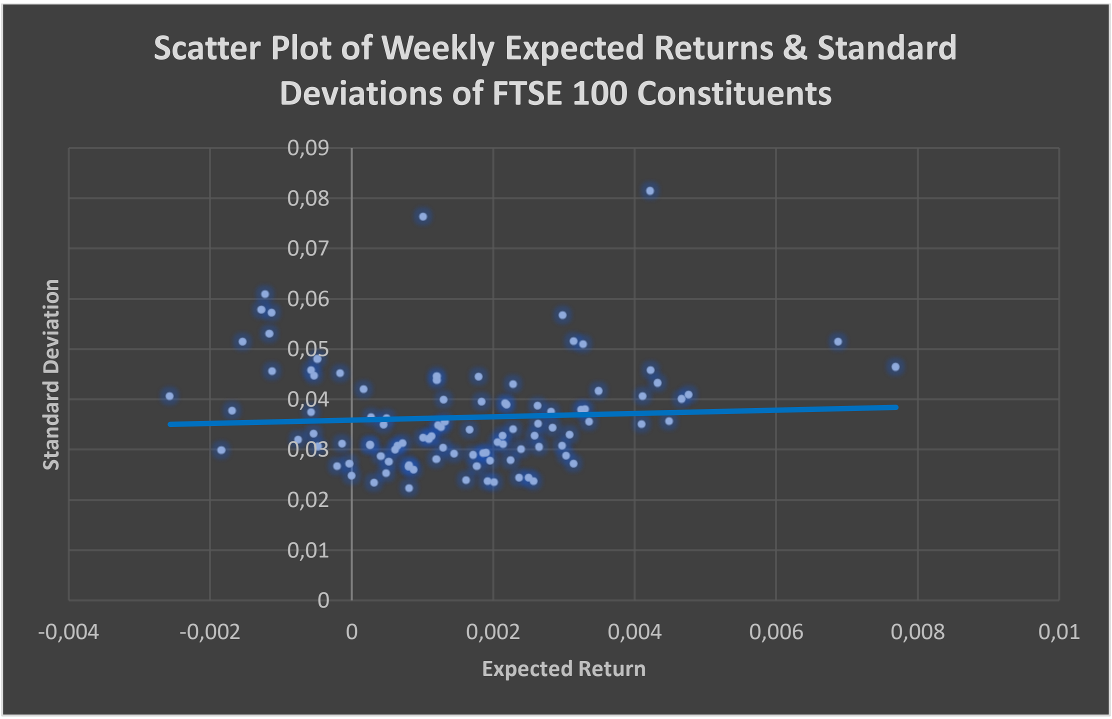
Based on the previous scatter plot, we can clearly notice that the area where we find most of the stock returns is around 0 to 0.0005 and the standard deviations fluctuate from 0.01 to 0.02. We can also comment that we have a **slight upward trend** which in turn means a **positive risk/return tradeoff**.

4.3.2 Weekly Statistical Information



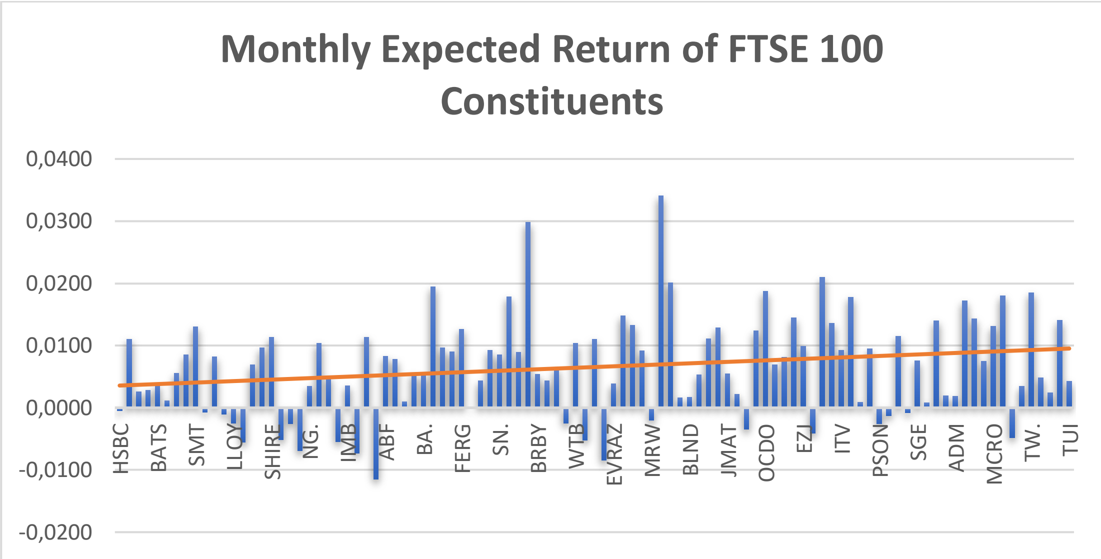
As we can see in the previous chart, the **trend** of the **daily expected return** is an **upward** one with few stocks which present negative expected returns for this 8-year period.

The **risk/return tradeoff** is presented in the following graph:



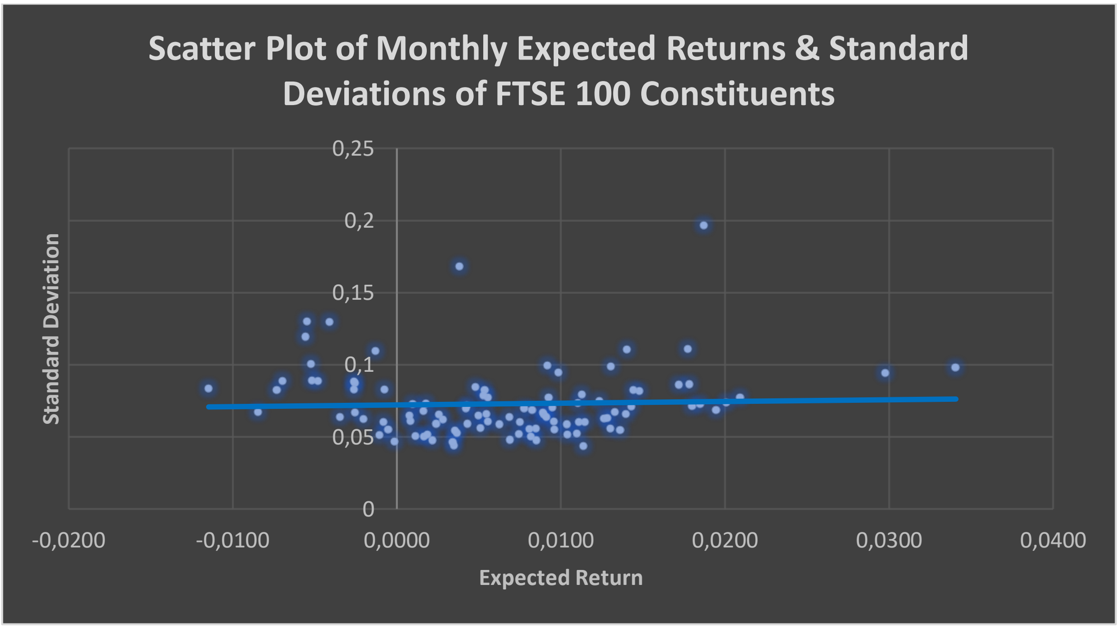
Based on the previous scatter plot, we can clearly notice that the area where we find most of the stock returns is around 0 to 0.004 and the standard deviations fluctuate from 0.02 to 0.04. We can also comment that we have a **slight upward trend** which in turn means a **positive risk/return tradeoff**.

4.3.3 Monthly Statistical Information



As we can see in the previous chart, the **trend** of the **daily expected return** is an **upward** one with few stocks which present negative expected returns for this 8-year period.

The **risk/return tradeoff** is presented in the following graph:



Based on the previous scatter plot, we can clearly notice that the area where we find most of the stock returns is around 0 to 0.0150 and the standard deviations fluctuate from 0.05 to 0.07. We can also comment that we have a **slight upward trend** which in turn means a **positive risk/return tradeoff**.

Conclusions

The purpose of this thesis was to prove the inefficiency of the FTSE 100 Index. As we searched the bibliography, we could not find any model, thesis or paper similar to ours. In order to prove this inefficiency, an appropriate asset pricing model should be one that confronts the index as inefficient. This is exactly what the 3D Model assumes and as it was proven, the FTSE 100 Index is an inefficient portfolio.

If someone would ask why we chose to study the London Exchange Market and not some other country or a different index, we will answer that we did not find any proof that a similar study in Great Britain has taken place. Apart from that, we also chose the UK area because it offers an abundance of financial information, the City is still the financial capital of Europe and because it can be a good indicator of the European Market, as well.

Regarding the study itself, we limited it in a period of eight -8- years. The model proved to be solid for the UK in all three -3- time periods, but it needs to be tested in other European or American markets and for other major market indices, as well. Also, whoever continues our study, should bear in mind that a greater time frame might show more interesting results.

Last but not least, the future researcher should try to find the causes of this inefficiency and how they can be limited or even stopped. Finding and correcting the inefficiencies will prove extremely important in the future and will lead to unbiased financial information that would help practitioners make better decisions and control financial instability.

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Appendix

Outliers

One of the tests that we ran, was the **Grubbs Test** that checks for **Outliers** in our Time-Series Data. We ran the test **three -3-** times in the **GNU-R Program** and we checked all of our three -3- sub-periods, meaning **daily**, **weekly** and **monthly** time periods. Wherever it was shown that an outlier was detected in the time-series, we corrected the issue by calculating and using in our methodology the logarithmic returns. In each of the following tests, the R-script is the following:

Daily Time-Series Data

```
y1=gretldata
grubbs.test(y1,type=11)

        Grubbs test for two opposite outliers

data:  y1
G = 6.3987, U = 0.9997, p-value = 1
alternative hypothesis: 46.49 and 10820.45 are outliers
```

Weekly Time-Series Data

```
y2=gretldata
grubbs.test(y2,type=11)

        Grubbs test for two opposite outliers

data:  y2
```

G = 6.36570, U = 0.99852, p-value = 1

alternative hypothesis: 47.33 and 10770 are outliers

Monthy Time-Series Data

y3=gretldata

grubbs.test(y3,type=11)

Grubbs test for two opposite outliers

data: y3

G = 5.6374, U = 0.9951, p-value = 1

alternative hypothesis: 48.36 and 9525 are outliers

Unit Root Tests

In every of the following stocks we firstly present the **Augmented Dickey-Fuller** test and then the **Philips-Perron** test for Unit Roots, with **25 lags** for **daily** and **weekly** data and **14 lags** for **monthly** data. If the **p-value is smaller than 0.10** then **we accept the Null Hypothesis** and the **Time-Series are Stationary**. The statistic program that was used to check the stationarity of each time-series was **Gretl**. It was proven that all our Time-Series Data, were stationary.

Daily Time-Series Data

HSBC

```
Augmented Dickey-Fuller test for HSBC
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)HSBC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
```

```
  εκτιμώμενη τιμή του (a - 1): -1,09198
  στατιστική ελέγχου: tau_c(1) = -24,3823
  ασυμπτωτική p-τιμή 4,071e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 2,136 [0,0937]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)HSBC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,0922
  στατιστική ελέγχου: tau_ct(1) = -24,3778
  ασυμπτωτική p-τιμή 6,046e-092
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 2,140 [0,0932]
```

```
Phillips-Perron unit-root test for HSBC, Bartlett bandwidth 25:

Z_t = -46,863 (p-value = 0,0001)

Test regression (OLS, dependent variable HSBC, T = 2087):

            συντελεστής    τυπ. σφάλμα      z       p-τιμή
  ---------------------------------------------------------
  const      -2,46706e-05   0,000284885   -0,08660   0,9310
  HSBC(-1)   -0,0226702     0,0219357     -1,033     0,3014

Sample variance of residual       0,000169379
Estimated long-run error variance 0,00014278
```

IGROUP

```
Augmented Dickey-Fuller test for IGROUP
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2083
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)IGROUP
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,06336
  στατιστική ελέγχου: tau_c(1) = -22,1515
  ασυμπτωτική p-τιμή 1,625e-050
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(4, 2077) = 2,809 [0,0243]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)IGROUP
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,06533
  στατιστική ελέγχου: tau_ct(1) = -22,1677
  ασυμπτωτική p-τιμή 8,697e-081
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(4, 2076) = 2,854 [0,0225]
```

```
Phillips-Perron unit-root test for IGROUP, Bartlett bandwidth 25:
```

```
Z_t = -43,5237 (p-value = 0,0000)

Test regression (OLS, dependent variable IGROUP, T = 2087):

               συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -------------------------------------------------------
  const        0,000483616   0,000344438   1,404   0,1603
  IGROUP(-1)   0,0443619     0,0219320     2,023   0,0431 **

Sample variance of residual       0,000247313
Estimated long-run error variance 0,000230741
```

BP

```
Augmented Dickey-Fuller test for BP
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2079
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)BP
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,02723
  στατιστική ελέγχου: tau_c(1) = -15,4751
  ασυμπτωτική p-τιμή 1,467e-036
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(8, 2069) = 3,296 [0,0010]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)BP
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,02844
  στατιστική ελέγχου: tau_ct(1) = -15,4775
  ασυμπτωτική p-τιμή 1,838e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(8, 2068) = 3,300 [0,0009]
```

```
Phillips-Perron unit-root test for BP, Bartlett bandwidth 25:

Z_t = -43,2644 (p-value = 0,0000)

Test regression (OLS, dependent variable BP, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,000115750   0,000306711   0,3774   0,7059
  BP(-1)     0,0527659     0,0218869     2,411    0,0159 **

Sample variance of residual       0,00019631
Estimated long-run error variance 0,000159422
```

RDSB

```
Augmented Dickey-Fuller test for RDSB
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RDSB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,95996
  στατιστική ελέγχου: tau_c(1) = -43,8159
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RDSB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,959966
  στατιστική ελέγχου: tau_ct(1) = -43,8054
  p-τιμή 1,074e-088
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001



Phillips-Perron unit-root test for RDSB, Bartlett bandwidth 25:

Z_t = -43,9318 (p-value = 0,0001)

Test regression (OLS, dependent variable RDSB, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      0,000126210   0,000302388   0,4174   0,6764
  RDSB(-1)   0,0400396     0,0219089     1,828    0,0676 *

Sample variance of residual       0,00019081
Estimated long-run error variance 0,000147691
```

BATS

```
Augmented Dickey-Fuller test for BATS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BATS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00351
  στατιστική ελέγχου: tau_c(1) = -45,8148
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BATS
```

```
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00456
  στατιστική ελέγχου: tau_ct(1) = -45,8526
  p-τιμή 1,788e-082
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for BATS, Bartlett bandwidth 25:

Z_t = -45,9803 (p-value = 0,0001)

Test regression (OLS, dependent variable BATS, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,000166024   0,000257278    0,6453   0,5187
  BATS(-1)   -0,00350609    0,0219035     -0,1601   0,8728

Sample variance of residual       0,000138111
Estimated long-run error variance 0,000117037
```

GSK

```
Augmented Dickey-Fuller test for GSK
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)GSK
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,02654
  στατιστική ελέγχου: tau_c(1) = -23,1958
  ασυμπτωτική p-τιμή 1,764e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 2,383 [0,0676]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)GSK
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,02682
  στατιστική ελέγχου: tau_ct(1) = -23,1956
  ασυμπτωτική p-τιμή 4,745e-086
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 2,383 [0,0676]
```

```
Phillips-Perron unit-root test for GSK, Bartlett bandwidth 25:

Z_t = -46,1796 (p-value = 0,0001)

Test regression (OLS, dependent variable GSK, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       5,13681e-05   0,000238712    0,2152   0,8296
  GSK(-1)    -0,0113150     0,0219184     -0,5162   0,6057

Sample variance of residual       0,000118921
```

```
Estimated long-run error variance 0,000111134
```

AZN

```
Augmented Dickey-Fuller test for AZN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2085
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)AZN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,984036
  στατιστική ελέγχου: tau_c(1) = -25,7911
  ασυμπτωτική p-τιμή 3,155e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(2, 2081) = 2,257 [0,1050]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)AZN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,984616
  στατιστική ελέγχου: tau_ct(1) = -25,7942
  ασυμπτωτική p-τιμή 9,876e-099
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(2, 2080) = 2,252 [0,1055]

Phillips-Perron unit-root test for AZN, Bartlett bandwidth 25:

Z_t = -45,4471 (p-value = 0,0001)

Test regression (OLS, dependent variable AZN, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,000250160   0,000295380   0,8469   0,3970
  AZN(-1)    0,00623577    0,0219049     0,2847   0,7759

Sample variance of residual       0,00018202
Estimated long-run error variance 0,000159037
```

DIAGEO

```
Augmented Dickey-Fuller test for DIAGEO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)DIAGEO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02175
  στατιστική ελέγχου: tau_c(1) = -46,5886
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)DIAGEO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02195
  στατιστική ελέγχου: tau_ct(1) = -46,588
  p-τιμή 5,654e-080
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001


Phillips-Perron unit-root test for DIAGEO, Bartlett bandwidth 25:

Z_t = -46,9712 (p-value = 0,0001)

Test regression (OLS, dependent variable DIAGEO, T = 2087):

               συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const         0,000396362   0,000239597    1,654    0,0981 *
  DIAGEO(-1)   -0,0217499     0,0219313     -0,9917   0,3213

Sample variance of residual       0,000119642
Estimated long-run error variance 9,56705e-005
```

SMT

```
Augmented Dickey-Fuller test for SMT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,933216
  στατιστική ελέγχου: tau_c(1) = -42,6725
  p-τιμή 4,512e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,933272
  στατιστική ελέγχου: tau_ct(1) = -42,6639
  p-τιμή 1,188e-091
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002


Phillips-Perron unit-root test for SMT, Bartlett bandwidth 25:

Z_t = -42,6138 (p-value = 0,0000)

Test regression (OLS, dependent variable SMT, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -----------------------------------------------------
  const      0,000563245   0,000269492   2,090   0,0366 **
```

```
  SMT(-1)    0,0667842     0,0218692     3,054   0,0023 ***

Sample variance of residual       0,000151197
Estimated long-run error variance 0,000120214
```

RIO

```
Augmented Dickey-Fuller test for RIO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RIO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,988744
  στατιστική ελέγχου: tau_c(1) = -45,1517
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RIO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,98894
  στατιστική ελέγχου: tau_ct(1) = -45,1495
  p-τιμή 9,748e-085
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001


Phillips-Perron unit-root test for RIO, Bartlett bandwidth 25:

Z_t = -45,591 (p-value = 0,0001)

Test regression (OLS, dependent variable RIO, T = 2087):

            συντελεστής    τυπ. σφάλμα      z       p-τιμή
  ---------------------------------------------------------
  const      -2,94641e-05   0,000443699   -0,06641   0,9471
  RIO(-1)     0,0112561     0,0218982      0,5140    0,6072

Sample variance of residual       0,000410863
Estimated long-run error variance 0,000303138
```

UNILEVER

```
Augmented Dickey-Fuller test for UNILEVER
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2085
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)UNILEVER
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,04611
  στατιστική ελέγχου: tau_c(1) = -26,3398
```

```
  ασυμπτωτική p-τιμή 4,429e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(2, 2081) = 2,085 [0,1245]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)UNILEVER
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,0462
  στατιστική ελέγχου: tau_ct(1) = -26,3353
  ασυμπτωτική p-τιμή 3,118e-101
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(2, 2080) = 2,084 [0,1247]


Phillips-Perron unit-root test for UNILEVER, Bartlett bandwidth 25:

Z_t = -48,4339 (p-value = 0,0001)

Test regression (OLS, dependent variable UNILEVER, T = 2087):

                 συντελεστής    τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------------
  const          0,000397254   0,000248793    1,597   0,1103
  UNILEVER(-1)   -0,0535532    0,0218907     -2,446   0,0144 **

Sample variance of residual       0,00012903
Estimated long-run error variance 0,00011148
```

VODAFONE

```
Augmented Dickey-Fuller test for VODAFONE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2077
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 10 υστερήσεων για (1-L)VODAFONE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,18074
  στατιστική ελέγχου: tau_c(1) = -15,3282
  ασυμπτωτική p-τιμή 3,928e-036
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(10, 2065) = 2,400 [0,0078]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 10 υστερήσεων για (1-L)VODAFONE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,19155
  στατιστική ελέγχου: tau_ct(1) = -15,4101
  ασυμπτωτική p-τιμή 4,093e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(10, 2064) = 2,458 [0,0064]


Phillips-Perron unit-root test for VODAFONE, Bartlett bandwidth 25:

Z_t = -46,9466 (p-value = 0,0001)

Test regression (OLS, dependent variable VODAFONE, T = 2087):

                 συντελεστής    τυπ. σφάλμα      z      p-τιμή
```

```
  ------------------------------------------------------------
  const          -4,65542e-05   0,000281066   -0,1656   0,8684
  VODAFONE(-1)   -0,0173241     0,0219022     -0,7910   0,4290

Sample variance of residual       0,000164867
Estimated long-run error variance 0,000126778
```

LLOY

```
Augmented Dickey-Fuller test for LLOY
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)LLOY
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,02917
  στατιστική ελέγχου: tau_c(1) = -34,4061
  ασυμπτωτική p-τιμή 1,215e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)LLOY
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,02928
  στατιστική ελέγχου: tau_ct(1) = -34,4004
  ασυμπτωτική p-τιμή 2,42e-130
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001


Phillips-Perron unit-root test for LLOY, Bartlett bandwidth 25:

Z_t = -42,9644 (p-value = 0,0000)

Test regression (OLS, dependent variable LLOY, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,000102374   0,000451695   -0,2266   0,8207
  LLOY(-1)    0,0598371     0,0218631      2,737    0,0062 ***

Sample variance of residual       0,000425796
Estimated long-run error variance 0,000345243
```

GLEN

```
Augmented Dickey-Fuller test for GLEN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 1912
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
```

```
  συμπεριλαμβανομένου 18 υστερήσεων για (1-L)GLEN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,954429
  στατιστική ελέγχου: tau_c(1) = -8,92689
  ασυμπτωτική p-τιμή 8,04e-016
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
  υστερήσεις πρώτων διαφορών: F(18, 1892) = 2,125 [0,0038]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 18 υστερήσεων για (1-L)GLEN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,963853
  στατιστική ελέγχου: tau_ct(1) = -8,96483
  ασυμπτωτική p-τιμή 8,256e-016
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
  υστερήσεις πρώτων διαφορών: F(18, 1891) = 2,121 [0,0039]
```

```
Phillips-Perron unit-root test for GLEN, Bartlett bandwidth 25:

Z_t = -44,2227 (p-value = 0,0001)

Test regression (OLS, dependent variable GLEN, T = 1930):

            συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const      -0,000274994   0,000640698   -0,4292   0,6678
  GLEN(-1)   -0,00667970    0,0227739     -0,2933   0,7693

Sample variance of residual       0,00079218
Estimated long-run error variance 0,000754036
```

RB

```
Augmented Dickey-Fuller test for RB
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)RB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09536
  στατιστική ελέγχου: tau_c(1) = -34,3405
  ασυμπτωτική p-τιμή 8,011e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)RB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09556
  στατιστική ελέγχου: tau_ct(1) = -34,3376
  ασυμπτωτική p-τιμή 3,471e-130
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for RB, Bartlett bandwidth 25:

Z_t = -49,1408 (p-value = 0,0001)

Test regression (OLS, dependent variable RB, T = 2087):

             συντελεστής    τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,000331676   0,000257574    1,288   0,1979
  RB(-1)     -0,0580956     0,0218784     -2,655   0,0079 ***

Sample variance of residual       0,000138353
Estimated long-run error variance 0,000106252
```

PRU

```
Augmented Dickey-Fuller test for PRU
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2074
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 13 υστερήσεων για (1-L)PRU
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,39644
  στατιστική ελέγχου: tau_c(1) = -14,247
  ασυμπτωτική p-τιμή 7,036e-033
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(13, 2059) = 3,652 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 13 υστερήσεων για (1-L)PRU
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,40294
  στατιστική ελέγχου: tau_ct(1) = -14,2876
  ασυμπτωτική p-τιμή 2,089e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(13, 2058) = 3,689 [0,0000]
```

```
Phillips-Perron unit-root test for PRU, Bartlett bandwidth 25:

Z_t = -47,7335 (p-value = 0,0001)

Test regression (OLS, dependent variable PRU, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ------------------------------------------------------
  const       0,000453714   0,000371033    1,223    0,2214
  PRU(-1)    -0,00805324    0,0219239     -0,3673   0,7134

Sample variance of residual       0,000287095
```

```
Estimated long-run error variance 0,000167132
```

SHIRE

```
Augmented Dickey-Fuller test for SHIRE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SHIRE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,951054
  στατιστική ελέγχου: tau_c(1) = -43,4605
  p-τιμή 2,288e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SHIRE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,951537
  στατιστική ελέγχου: tau_ct(1) = -43,4719
  p-τιμή 1,342e-089
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for SHIRE, Bartlett bandwidth 25:

Z_t = -43,4297 (p-value = 0,0000)

Test regression (OLS, dependent variable SHIRE, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  ---------------------------------------------------------
  const       0,000490208   0,000379616   1,291   0,1966
  SHIRE(-1)   0,0489463     0,0218832     2,237   0,0253 **

Sample variance of residual       0,000300472
Estimated long-run error variance 0,000253834
```

BARCLAYS

```
Augmented Dickey-Fuller test for BARCLAYS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2066
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 21 υστερήσεων για (1-L)BARCLAYS
```

```
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,05833
  στατιστική ελέγχου: tau_c(1) = -9,17529
  ασυμπτωτική p-τιμή 1,361e-016
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(21, 2043) = 2,599 [0,0001]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 21 υστερήσεων για (1-L)BARCLAYS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,05842
  στατιστική ελέγχου: tau_ct(1) = -9,17354
  ασυμπτωτική p-τιμή 1,388e-016
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(21, 2042) = 2,598 [0,0001]
```

```
Phillips-Perron unit-root test for BARCLAYS, Bartlett bandwidth 25:

Z_t = -43,8405 (p-value = 0,0001)

Test regression (OLS, dependent variable BARCLAYS, T = 2087):

                 συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ------------------------------------------------------------
  const          -0,000221026   0,000489602   -0,4514   0,6517
  BARCLAYS(-1)    0,0455218     0,0218807      2,080    0,0375 **

Sample variance of residual       0,000500224
Estimated long-run error variance 0,000365304
```

BLT

```
Augmented Dickey-Fuller test for BLT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2079
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)BLT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,05933
  στατιστική ελέγχου: tau_c(1) = -15,5964
  ασυμπτωτική p-τιμή 6,546e-037
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(8, 2069) = 2,644 [0,0069]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)BLT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,0615
  στατιστική ελέγχου: tau_ct(1) = -15,6081
  ασυμπτωτική p-τιμή 3,884e-046
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(8, 2068) = 2,652 [0,0068]
```

```
Phillips-Perron unit-root test for BLT, Bartlett bandwidth 25:

Z_t = -45,4639 (p-value = 0,0001)

Test regression (OLS, dependent variable BLT, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,000112490   0,000450600   -0,2496   0,8029
  BLT(-1)     0,0111071     0,0218980      0,5072   0,6120

Sample variance of residual       0,000423733
Estimated long-run error variance 0,000327568
```

RBS

```
Augmented Dickey-Fuller test for RBS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2079
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)RBS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09529
  στατιστική ελέγχου: tau_c(1) = -16,9409
  ασυμπτωτική p-τιμή 1,326e-040
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(8, 2069) = 2,273 [0,0203]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)RBS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09653
  στατιστική ελέγχου: tau_ct(1) = -16,9472
  ασυμπτωτική p-τιμή 3,809e-053
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(8, 2068) = 2,284 [0,0196]
```

```
Phillips-Perron unit-root test for RBS, Bartlett bandwidth 25:

Z_t = -42,2595 (p-value = 0,0000)

Test regression (OLS, dependent variable RBS, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,000295896   0,000502438   -0,5889   0,5559
  RBS(-1)     0,0772068     0,0218382      3,535    0,0004 ***
```

```
Sample variance of residual       0,000526755
Estimated long-run error variance 0,000384026
```

NG

```
Augmented Dickey-Fuller test for NG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)NG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,02583
  στατιστική ελέγχου: tau_c(1) = -33,2595
  ασυμπτωτική p-τιμή 1,143e-041
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)NG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,02729
  στατιστική ελέγχου: tau_ct(1) = -33,2862
  ασυμπτωτική p-τιμή 2,204e-127
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for NG, Bartlett bandwidth 25:

Z_t = -45,5963 (p-value = 0,0001)

Test regression (OLS, dependent variable NG, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  --------------------------------------------------------
  const      0,000156602   0,000228113   0,6865   0,4924
  NG(-1)     0,00853467    0,0219045     0,3896   0,6968

Sample variance of residual       0,000108571
Estimated long-run error variance 8,34469e-005
```

RELX

```
Augmented Dickey-Fuller test for RELX
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1
```

```
  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RELX
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,969855
  στατιστική ελέγχου: tau_c(1) = -44,3055
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RELX
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,969905
  στατιστική ελέγχου: tau_ct(1) = -44,2971
  p-τιμή 2,635e-087
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for RELX, Bartlett bandwidth 25:

Z_t = -44,2966 (p-value = 0,0001)

Test regression (OLS, dependent variable RELX, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -----------------------------------------------------
  const      0,000464844   0,000236767   1,963   0,0496 **
  RELX(-1)   0,0301452     0,0218902     1,377   0,1685

Sample variance of residual       0,000116766
Estimated long-run error variance 0,000104741
```

BTA

```
Augmented Dickey-Fuller test for BTA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)BTA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,16598
  στατιστική ελέγχου: tau_c(1) = -25,3772
  ασυμπτωτική p-τιμή 2,874e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 5,054 [0,0017]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)BTA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,17899
  στατιστική ελέγχου: tau_ct(1) = -25,5491
  ασυμπτωτική p-τιμή 1,396e-097
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 5,645 [0,0008]
```

```
Phillips-Perron unit-root test for BTA, Bartlett bandwidth 25:

Z_t = -47,2371 (p-value = 0,0001)

Test regression (OLS, dependent variable BTA, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000247289   0,000343164    0,7206   0,4711
  BTA(-1)    -0,0212758     0,0218786     -0,9724   0,3308

Sample variance of residual       0,000245716
Estimated long-run error variance 0,000187849
```

AAL

```
Augmented Dickey-Fuller test for AAL
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2079
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)AAL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,987732
  στατιστική ελέγχου: tau_c(1) = -14,6829
  ασυμπτωτική p-τιμή 3,273e-034
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(8, 2069) = 3,504 [0,0005]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)AAL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,993883
  στατιστική ελέγχου: tau_ct(1) = -14,7285
  ασυμπτωτική p-τιμή 1,252e-041
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(8, 2068) = 3,502 [0,0005]
```

```
Phillips-Perron unit-root test for AAL, Bartlett bandwidth 25:

Z_t = -45,4059 (p-value = 0,0001)

Test regression (OLS, dependent variable AAL, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -0,000249785   0,000608467   -0,4105   0,6814
  AAL(-1)     0,00574555    0,0219003      0,2624   0,7931
```

```
Sample variance of residual       0,000772614
Estimated long-run error variance 0,00079075
```

IMB

```
Augmented Dickey-Fuller test for IMB
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IMB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01377
  στατιστική ελέγχου: tau_c(1) = -46,2981
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IMB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01447
  στατιστική ελέγχου: tau_ct(1) = -46,3192
  p-τιμή 6,657e-081
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for IMB, Bartlett bandwidth 25:

Z_t = -46,6224 (p-value = 0,0001)

Test regression (OLS, dependent variable IMB, T = 2087):

            συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000162192   0,000266770    0,6080   0,5432
  IMB(-1)    -0,0137702     0,0218966     -0,6289   0,5294

Sample variance of residual       0,000148497
Estimated long-run error variance 0,000120104
```

TESCO

```
Augmented Dickey-Fuller test for TESCO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)TESCO
```

```
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,969657
  στατιστική ελέγχου: tau_c(1) = -32,337
  ασυμπτωτική p-τιμή 7,04e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)TESCO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,970185
  στατιστική ελέγχου: tau_ct(1) = -32,3426
  ασυμπτωτική p-τιμή 1,386e-124
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000


Phillips-Perron unit-root test for TESCO, Bartlett bandwidth 25:

Z_t = -42,8103 (p-value = 0,0000)

Test regression (OLS, dependent variable TESCO, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,000311392   0,000355606   -0,8757   0,3812
  TESCO(-1)   0,0625792     0,0218586      2,863    0,0042 ***

Sample variance of residual       0,000263798
Estimated long-run error variance 0,000242682
```

CPG

```
Augmented Dickey-Fuller test for CPG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2077
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 10 υστερήσεων για (1-L)CPG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,25951
  στατιστική ελέγχου: tau_c(1) = -15,5551
  ασυμπτωτική p-τιμή 8,612e-037
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(10, 2065) = 2,162 [0,0176]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 10 υστερήσεων για (1-L)CPG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,26166
  στατιστική ελέγχου: tau_ct(1) = -15,5711
  ασυμπτωτική p-τιμή 6,037e-046
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(10, 2064) = 2,174 [0,0169]


Phillips-Perron unit-root test for CPG, Bartlett bandwidth 25:
```

```
Z_t = -48,8801 (p-value = 0,0001)

Test regression (OLS, dependent variable CPG, T = 2087):

             συντελεστής    τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,000542812   0,000244549    2,220   0,0264 **
  CPG(-1)    -0,0502320     0,0218677     -2,297   0,0216 **

Sample variance of residual       0,000124542
Estimated long-run error variance 9,31639e-005
```

STAN

```
Augmented Dickey-Fuller test for STAN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2080
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)STAN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,17076
  στατιστική ελέγχου: tau_c(1) = -18,1131
  ασυμπτωτική p-τιμή 1,698e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(7, 2071) = 3,463 [0,0011]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)STAN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,17077
  στατιστική ελέγχου: tau_ct(1) = -18,1085
  ασυμπτωτική p-τιμή 2,599e-059
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(7, 2070) = 3,461 [0,0011]
```

```
Phillips-Perron unit-root test for STAN, Bartlett bandwidth 25:

Z_t = -44,5813 (p-value = 0,0001)

Test regression (OLS, dependent variable STAN, T = 2087):

             συντελεστής    τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      -0,000521145   0,000416766   -1,250   0,2111
  STAN(-1)    0,0312694     0,0218891      1,429   0,1531

Sample variance of residual       0,000362232
Estimated long-run error variance 0,000264388
```

ABF

```
Augmented Dickey-Fuller test for ABF
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2080
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)ABF
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,05755
  στατιστική ελέγχου: tau_c(1) = -16,2375
  ασυμπτωτική p-τιμή 1,022e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(7, 2071) = 2,959 [0,0043]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)ABF
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,07048
  στατιστική ελέγχου: tau_ct(1) = -16,3418
  ασυμπτωτική p-τιμή 5,847e-050
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(7, 2070) = 2,990 [0,0040]
```

```
Phillips-Perron unit-root test for ABF, Bartlett bandwidth 25:

Z_t = -47,0195 (p-value = 0,0001)

Test regression (OLS, dependent variable ABF, T = 2087):

             συντελεστής    τυπ. σφάλμα     z      p-τιμή
  -------------------------------------------------------
  const       0,000389234   0,000309934    1,256   0,2092
  ABF(-1)    -0,0296092     0,0218909     -1,353   0,1762

Sample variance of residual       0,000200328
Estimated long-run error variance 0,000205607
```

CRH

```
Augmented Dickey-Fuller test for CRH
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)CRH
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,19781
  στατιστική ελέγχου: tau_c(1) = -26,2952
  ασυμπτωτική p-τιμή 4,27e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 8,515 [0,0000]
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)CRH
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,19806
  στατιστική ελέγχου: tau_ct(1) = -26,2941
  ασυμπτωτική p-τιμή 4,815e-101
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 8,526 [0,0000]
```

```
Phillips-Perron unit-root test for CRH, Bartlett bandwidth 25:

Z_t = -47,3154 (p-value = 0,0001)

Test regression (OLS, dependent variable CRH, T = 2087):

            συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      0,000366782   0,000408547   0,8978   0,3693
  CRH(-1)    0,00241670    0,0219056     0,1103   0,9122

Sample variance of residual       0,000348204
Estimated long-run error variance 0,000198019
```

AV

```
Augmented Dickey-Fuller test for AV
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2081
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)AV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14648
  στατιστική ελέγχου: tau_c(1) = -18,1646
  ασυμπτωτική p-τιμή 1,291e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(6, 2073) = 7,405 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)AV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14648
  στατιστική ελέγχου: tau_ct(1) = -18,1604
  ασυμπτωτική p-τιμή 1,374e-059
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(6, 2072) = 7,402 [0,0000]
```

```
Phillips-Perron unit-root test for AV, Bartlett bandwidth 25:

Z_t = -43,2902 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable AV, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      4,70956e-05   0,000380561   0,1238   0,9015
  AV(-1)     0,0578179     0,0218721     2,643    0,0082 ***

Sample variance of residual       0,00030225
Estimated long-run error variance 0,000212759
```

RR

```
Augmented Dickey-Fuller test for RR
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2080
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)RR
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,19403
  στατιστική ελέγχου: tau_c(1) = -18,6561
  ασυμπτωτική p-τιμή 1,018e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(7, 2071) = 2,712 [0,0084]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)RR
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,19495
  στατιστική ελέγχου: tau_ct(1) = -18,6617
  ασυμπτωτική p-τιμή 2,911e-062
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(7, 2070) = 2,724 [0,0082]
```

```
Phillips-Perron unit-root test for RR, Bartlett bandwidth 25:

Z_t = -44,4442 (p-value = 0,0001)

Test regression (OLS, dependent variable RR, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      0,000244395   0,000389442   0,6276   0,5303
  RR(-1)     0,0317747     0,0218931     1,451    0,1467

Sample variance of residual       0,000316455
Estimated long-run error variance 0,000240185
```

BA

```
Augmented Dickey-Fuller test for BA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2078
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)BA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,20423
  στατιστική ελέγχου: tau_c(1) = -16,2979
  ασυμπτωτική p-τιμή 6,969e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(9, 2067) = 2,609 [0,0054]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)BA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,20487
  στατιστική ελέγχου: tau_ct(1) = -16,2957
  ασυμπτωτική p-τιμή 1,02e-049
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(9, 2066) = 2,613 [0,0053]
```

```
Phillips-Perron unit-root test for BA, Bartlett bandwidth 25:

Z_t = -47,0851 (p-value = 0,0001)

Test regression (OLS, dependent variable BA, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,000242701   0,000289244    0,8391   0,4014
  BA(-1)     -0,0233413     0,0219001     -1,066    0,2865

Sample variance of residual       0,000174544
Estimated long-run error variance 0,000141841
```

LSE

```
Augmented Dickey-Fuller test for LSE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2080
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)LSE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11504
  στατιστική ελέγχου: tau_c(1) = -17,1831
  ασυμπτωτική p-τιμή 3,148e-041
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(7, 2071) = 4,809 [0,0000]
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)LSE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,116
  στατιστική ελέγχου: tau_ct(1) = -17,1904
  ασυμπτωτική p-τιμή 1,97e-054
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(7, 2070) = 4,814 [0,0000]
```

```
Phillips-Perron unit-root test for LSE, Bartlett bandwidth 25:

Z_t = -45,5364 (p-value = 0,0001)

Test regression (OLS, dependent variable LSE, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      0,000885477   0,000350547   2,526    0,0115 **
  LSE(-1)    0,0125331     0,0219075     0,5721   0,5673

Sample variance of residual       0,000255635
Estimated long-run error variance 0,000186351
```

EXPN

```
Augmented Dickey-Fuller test for AXPN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AXPN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,992293
  στατιστική ελέγχου: tau_c(1) = -45,2838
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AXPN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,992351
  στατιστική ελέγχου: tau_ct(1) = -45,2761
  p-τιμή 2,44e-084
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for AXPN, Bartlett bandwidth 25:

Z_t = -45,4806 (p-value = 0,0001)
```

```
Test regression (OLS, dependent variable AXPN, T = 2087):

            συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const      0,000443163   0,000281051   1,577    0,1148
  AXPN(-1)   0,00770694    0,0219128     0,3517   0,7251

Sample variance of residual       0,000164645
Estimated long-run error variance 0,00013384
```

LGEN

```
Augmented Dickey-Fuller test for LGEN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2078
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)LGEN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14714
  στατιστική ελέγχου: tau_c(1) = -15,6845
  ασυμπτωτική p-τιμή 3,656e-037
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(9, 2067) = 5,466 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)LGEN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,15121
  στατιστική ελέγχου: tau_ct(1) = -15,7171
  ασυμπτωτική p-τιμή 1,059e-046
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(9, 2066) = 5,501 [0,0000]
```

```
Phillips-Perron unit-root test for LGEN, Bartlett bandwidth 25:

Z_t = -42,4772 (p-value = 0,0000)

Test regression (OLS, dependent variable LGEN, T = 2087):

            συντελεστής   τυπ. σφάλμα     z     p-τιμή
  --------------------------------------------------------
  const      0,000382592   0,000351405   1,089   0,2763
  LGEN(-1)   0,0766525     0,0218600     3,507   0,0005 ***

Sample variance of residual       0,00025753
Estimated long-run error variance 0,000168181
```

FERG

```
Augmented Dickey-Fuller test for FERG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2083
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)FERG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,17734
  στατιστική ελέγχου: tau_c(1) = -23,0154
  ασυμπτωτική p-τιμή 2,435e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(4, 2077) = 4,327 [0,0017]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)FERG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,17875
  στατιστική ελέγχου: tau_ct(1) = -23,028
  ασυμπτωτική p-τιμή 3,361e-085
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(4, 2076) = 4,368 [0,0016]
```

```
Phillips-Perron unit-root test for FERG, Bartlett bandwidth 25:

Z_t = -46,3481 (p-value = 0,0001)

Test regression (OLS, dependent variable FERG, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000588860   0,000334651    1,760    0,0785 *
  FERG(-1)   -0,00738139    0,0219055     -0,3370   0,7361

Sample variance of residual       0,000233396
Estimated long-run error variance 0,000183819
```

SSE

```
Augmented Dickey-Fuller test for SSE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)SSE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11723
  στατιστική ελέγχου: tau_c(1) = -25,4635
  ασυμπτωτική p-τιμή 2,897e-052
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 7,130 [0,0001]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)SSE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,12227
  στατιστική ελέγχου: tau_ct(1) = -25,5352
  ασυμπτωτική p-τιμή 1,624e-097
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 7,332 [0,0001]
```

```
Phillips-Perron unit-root test for SSE, Bartlett bandwidth 25:

Z_t = -46,3656 (p-value = 0,0001)

Test regression (OLS, dependent variable SSE, T = 2087):

             συντελεστής    τυπ. σφάλμα      z       p-τιμή
  --------------------------------------------------------
  const      -5,08844e-06   0,000253290   -0,02009   0,9840
  SSE(-1)    -0,00104615    0,0219053     -0,04776   0,9619

Sample variance of residual       0,000133893
Estimated long-run error variance 9,51116e-005
```

WPP

```
Augmented Dickey-Fuller test for WPP
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WPP
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00237
  στατιστική ελέγχου: tau_c(1) = -45,7653
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)WPP
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,1292
  στατιστική ελέγχου: tau_ct(1) = -22,2351
  ασυμπτωτική p-τιμή 3,901e-081
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(4, 2076) = 2,129 [0,0749]
```

Phillips-Perron unit-root test for WPP, Bartlett bandwidth 25:

Z_t = -45,9992 (p-value = 0,0001)

Test regression (OLS, dependent variable WPP, T = 2087):

	συντελεστής	τυπ. σφάλμα	z	p-τιμή
const	0,000198152	0,000321448	0,6164	0,5376
WPP(-1)	-0,00236713	0,0219024	-0,1081	0,9139

Sample variance of residual 0,000215605
Estimated long-run error variance 0,000176568

IAG

Augmented Dickey-Fuller test for IAG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2010
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

έλεγχος με σταθερό όρο
συμπεριλαμβανομένου 3 υστερήσεων για (1-L)IAG
υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
εκτιμώμενη τιμή του (a - 1): -1,06275
στατιστική ελέγχου: tau_c(1) = -24,2011
ασυμπτωτική p-τιμή 4,73e-052
συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
υστερήσεις πρώτων διαφορών: F(3, 2005) = 3,420 [0,0167]

με σταθερό όρο και τάση
συμπεριλαμβανομένου 3 υστερήσεων για (1-L)IAG
υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
εκτιμώμενη τιμή του (a - 1): -1,06302
στατιστική ελέγχου: tau_ct(1) = -24,1974
ασυμπτωτική p-τιμή 4,659e-091
συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
υστερήσεις πρώτων διαφορών: F(3, 2004) = 3,429 [0,0165]

Phillips-Perron unit-root test for IAG, Bartlett bandwidth 25:

Z_t = -42,3828 (p-value = 0,0000)

Test regression (OLS, dependent variable IAG, T = 2013):

	συντελεστής	τυπ. σφάλμα	z	p-τιμή	
const	0,000334577	0,000469506	0,7126	0,4761	
IAG(-1)	0,0558053	0,0222666	2,506	0,0122	**

Sample variance of residual 0,00044361
Estimated long-run error variance 0,000360345

SN

```
Augmented Dickey-Fuller test for SN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03276
  στατιστική ελέγχου: tau_c(1) = -47,1771
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03289
  στατιστική ελέγχου: tau_ct(1) = -47,1727
  p-τιμή 6,787e-078
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for SN, Bartlett bandwidth 25:

Z_t = -47,8974 (p-value = 0,0001)

Test regression (OLS, dependent variable SN, T = 2087):

             συντελεστής    τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,000406077   0,000274809    1,478   0,1395
  SN(-1)     -0,0327595     0,0218911     -1,496   0,1345

Sample variance of residual       0,000157454
Estimated long-run error variance 0,000117608
```

MRO

```
Augmented Dickey-Fuller test for MRO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MRO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02875
  στατιστική ελέγχου: tau_c(1) = -46,9798
  p-τιμή 0,0001
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MRO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02875
  στατιστική ελέγχου: tau_ct(1) = -46,9685
  p-τιμή 1,249e-078
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for MRO, Bartlett bandwidth 25:

Z_t = -46,9839 (p-value = 0,0001)

Test regression (OLS, dependent variable MRO, T = 2087):

             συντελεστής    τυπ. σφάλμα     z      p-τιμή
  -------------------------------------------------------
  const       0,000843700   0,000417696    2,020   0,0434 **
  MRO(-1)    -0,0287524     0,0218978     -1,313   0,1892

Sample variance of residual       0,000363426
Estimated long-run error variance 0,000360878
```

NEXT

```
Augmented Dickey-Fuller test for NEXT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2081
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)NEXT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,01423
  στατιστική ελέγχου: tau_c(1) = -16,572
  ασυμπτωτική p-τιμή 1,256e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(6, 2073) = 3,430 [0,0023]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)NEXT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,02075
  στατιστική ελέγχου: tau_ct(1) = -16,6315
  ασυμπτωτική p-τιμή 1,759e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(6, 2072) = 3,440 [0,0022]
```

```
Phillips-Perron unit-root test for NEXT, Bartlett bandwidth 25:
```

```
Z_t = -45,6091 (p-value = 0,0001)

Test regression (OLS, dependent variable NEXT, T = 2087):

             συντελεστής    τυπ. σφάλμα      z       p-τιμή
  ---------------------------------------------------------
  const       0,000413355   0,000338522    1,221     0,2221
  NEXT(-1)   -0,000817681   0,0219472     -0,03726   0,9703

Sample variance of residual       0,000238976
Estimated long-run error variance 0,000228046
```

AHT

```
Augmented Dickey-Fuller test for AHT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)AHT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,04217
  στατιστική ελέγχου: tau_c(1) = -33,7628
  ασυμπτωτική p-τιμή 2,244e-040
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)AHT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,04374
  στατιστική ελέγχου: tau_ct(1) = -33,7968
  ασυμπτωτική p-τιμή 8,705e-129
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for AHT, Bartlett bandwidth 25:

Z_t = -45,3006 (p-value = 0,0001)

Test regression (OLS, dependent variable AHT, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,00134864    0,000495311   2,723    0,0065 ***
  AHT(-1)    0,0103277     0,0219122     0,4713   0,6374

Sample variance of residual       0,000510079
Estimated long-run error variance 0,000425379
```

BRBY

```
Augmented Dickey-Fuller test for BRBY
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2085
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)BRBY
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,03676
  στατιστική ελέγχου: tau_c(1) = -27,9358
  ασυμπτωτική p-τιμή 4,74e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(2, 2081) = 4,828 [0,0081]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)BRBY
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,03691
  στατιστική ελέγχου: tau_ct(1) = -27,9329
  ασυμπτωτική p-τιμή 2,804e-108
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(2, 2080) = 4,831 [0,0081]
```

```
Phillips-Perron unit-root test for BRBY, Bartlett bandwidth 25:

Z_t = -44,2724 (p-value = 0,0001)

Test regression (OLS, dependent variable BRBY, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -------------------------------------------------------
  const      0,000238715   0,000423564   0,5636   0,5730
  BRBY(-1)   0,0347574     0,0218876     1,588    0,1123

Sample variance of residual       0,000374361
Estimated long-run error variance 0,000288059
```

COCA COLA

```
Augmented Dickey-Fuller test for COCACOLA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 1422
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)COCACOLA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00503
  στατιστική ελέγχου: tau_c(1) = -37,9365
  p-τιμή 1,929e-017
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)COCACOLA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00554
  στατιστική ελέγχου: tau_ct(1) = -37,9407
  p-τιμή 1,229e-084
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
```

```
Phillips-Perron unit-root test for COCACOLA, Bartlett bandwidth 25:

Z_t = -37,982 (p-value = 0,0000)

Test regression (OLS, dependent variable COCACOLA, T = 1422):

                 συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const           0,000222860   0,000409359    0,5444   0,5862
  COCACOLA(-1)   -0,00503163    0,0264925     -0,1899   0,8494

Sample variance of residual       0,000238255
Estimated long-run error variance 0,000218785
```

INF

```
Augmented Dickey-Fuller test for INF
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)INF
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,973388
  στατιστική ελέγχου: tau_c(1) = -44,4622
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)INF
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,973423
  στατιστική ελέγχου: tau_ct(1) = -44,4529
  p-τιμή 7,507e-087
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for INF, Bartlett bandwidth 25:

Z_t = -44,607 (p-value = 0,0001)

Test regression (OLS, dependent variable INF, T = 2087):
```

```
           συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const      0,000284415   0,000296116   0,9605   0,3368
  INF(-1)    0,0266115     0,0218925     1,216    0,2242

Sample variance of residual       0,000182913
Estimated long-run error variance 0,000145997
```

SBRY

```
Augmented Dickey-Fuller test for SBRY
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)SBRY
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,08716
  στατιστική ελέγχου: tau_c(1) = -24,6746
  ασυμπτωτική p-τιμή 3,379e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 2,725 [0,0428]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)SBRY
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,08857
  στατιστική ελέγχου: tau_ct(1) = -24,6874
  ασυμπτωτική p-τιμή 1,863e-093
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 2,773 [0,0401]
```

```
Phillips-Perron unit-root test for SBRY, Bartlett bandwidth 25:

Z_t = -45,1071 (p-value = 0,0001)

Test regression (OLS, dependent variable SBRY, T = 2087):

           συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ----------------------------------------------------------
  const      -0,000113340   0,000326337   -0,3473   0,7284
  SBRY(-1)    0,0141454     0,0219043      0,6458   0,5184

Sample variance of residual       0,000222245
Estimated long-run error variance 0,000187884
```

WTB

```
Augmented Dickey-Fuller test for WTB
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)WTB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,07043
  στατιστική ελέγχου: tau_c(1) = -24,5321
  ασυμπτωτική p-τιμή 3,668e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 4,441 [0,0041]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)WTB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,07146
  στατιστική ελέγχου: tau_ct(1) = -24,5417
  ασυμπτωτική p-τιμή 9,541e-093
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 4,478 [0,0039]
```

```
Phillips-Perron unit-root test for WTB, Bartlett bandwidth 25:

Z_t = -44,098 (p-value = 0,0001)

Test regression (OLS, dependent variable WTB, T = 2087):

            συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -------------------------------------------------------
  const      0,000460942   0,000313420   1,471   0,1414
  WTB(-1)    0,0385669     0,0218904     1,762   0,0781 *

Sample variance of residual       0,000204776
Estimated long-run error variance 0,000155224
```

ANTO

```
Augmented Dickey-Fuller test for ANTO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2071
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 16 υστερήσεων για (1-L)ANTO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,24753
  στατιστική ελέγχου: tau_c(1) = -12,7908
  ασυμπτωτική p-τιμή 2,836e-028
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
  υστερήσεις πρώτων διαφορών: F(16, 2053) = 2,382 [0,0016]

  με σταθερό όρο και τάση
```

```
  συμπεριλαμβανομένου 16 υστερήσεων για (1-L)ANTO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,25123
  στατιστική ελέγχου: tau_ct(1) = -12,804
  ασυμπτωτική p-τιμή 3,679e-032
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
  υστερήσεις πρώτων διαφορών: F(16, 2052) = 2,392 [0,0015]
```

```
Phillips-Perron unit-root test for ANTO, Bartlett bandwidth 25:

Z_t = -46,2278 (p-value = 0,0001)

Test regression (OLS, dependent variable ANTO, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -0,000233760   0,000528396   -0,4424   0,6582
  ANTO(-1)   -0,00318461    0,0219000     -0,1454   0,8844

Sample variance of residual       0,000582641
Estimated long-run error variance 0,000446413
```

BUNZL

```
Augmented Dickey-Fuller test for BUNZL
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2085
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)BUNZL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,04037
  στατιστική ελέγχου: tau_c(1) = -27,5109
  ασυμπτωτική p-τιμή 2,066e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(2, 2081) = 2,085 [0,1246]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)BUNZL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,04155
  στατιστική ελέγχου: tau_ct(1) = -27,527
  ασυμπτωτική p-τιμή 1,54e-106
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(2, 2080) = 2,126 [0,1196]
```

```
Phillips-Perron unit-root test for BUNZL, Bartlett bandwidth 25:

Z_t = -45,2598 (p-value = 0,0001)
```

```
Test regression (OLS, dependent variable BUNZL, T = 2087):

              συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,000498013   0,000242148   2,057    0,0397 **
  BUNZL(-1)   0,0105976     0,0218982     0,4839   0,6284

Sample variance of residual       0,000122116
Estimated long-run error variance 0,000105894
```

CENTRICA

```
Augmented Dickey-Fuller test for CENTRICA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CENTRICA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01981
  στατιστική ελέγχου: tau_c(1) = -46,4995
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CENTRICA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02016
  στατιστική ελέγχου: tau_ct(1) = -46,5066
  p-τιμή 2,946e-080
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for CENTRICA, Bartlett bandwidth 25:

Z_t = -46,8385 (p-value = 0,0001)

Test regression (OLS, dependent variable CENTRICA, T = 2087):

                 συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ------------------------------------------------------------
  const          -0,000394499   0,000306757   -1,286    0,1984
  CENTRICA(-1)   -0,0198112     0,0219317     -0,9033   0,3664

Sample variance of residual       0,000196248
Estimated long-run error variance 0,000158728
```

EVRAZ

```
Augmented Dickey-Fuller test for EVRAZ
testing down from 25 lags, criterion AIC
```

```
μέγεθος δείγματος 1808
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)EVRAZ
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,946713
  στατιστική ελέγχου: tau_c(1) = -40,2752
  p-τιμή 1,878e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)EVRAZ
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,948993
  στατιστική ελέγχου: tau_ct(1) = -40,354
  p-τιμή 1,078e-090
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for EVRAZ, Bartlett bandwidth 25:

Z_t = -40,4077 (p-value = 0,0000)

Test regression (OLS, dependent variable EVRAZ, T = 1808):

              συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -------------------------------------------------------
  const       0,000193305   0,000774177   0,2497   0,8028
  EVRAZ(-1)   0,0532873     0,0235061     2,267    0,0234 **

Sample variance of residual       0,00108357
Estimated long-run error variance 0,00117993
```

HL

```
Augmented Dickey-Fuller test for HL
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)HL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,00819
  στατιστική ελέγχου: tau_c(1) = -32,9692
  ασυμπτωτική p-τιμή 2,187e-042
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)HL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,00827
  στατιστική ελέγχου: tau_ct(1) = -32,9643
  ασυμπτωτική p-τιμή 1,855e-126
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for HL, Bartlett bandwidth 25:

Z_t = -44,1401 (p-value = 0,0001)

Test regression (OLS, dependent variable HL, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -------------------------------------------------------
  const      0,000654839   0,000423631   1,546   0,1222
  HL(-1)     0,0321669     0,0219266     1,467   0,1424

Sample variance of residual       0,000374041
Estimated long-run error variance 0,000323116
```

IHG

```
Augmented Dickey-Fuller test for IHG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IHG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01132
  στατιστική ελέγχου: tau_c(1) = -46,1532
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IHG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01134
  στατιστική ελέγχου: tau_ct(1) = -46,1432
  p-τιμή 1,678e-081
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for IHG, Bartlett bandwidth 25:

Z_t = -46,181 (p-value = 0,0001)

Test regression (OLS, dependent variable IHG, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ----------------------------------------------------------
  const       0,000618939   0,000321309    1,926    0,0541 *
  IHG(-1)    -0,0113230     0,0219123     -0,5167   0,6053
```

```
Sample variance of residual       0,000215073
Estimated long-run error variance 0,00020381
```

ITRK

```
Augmented Dickey-Fuller test for ITRK
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)ITRK
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,10105
  στατιστική ελέγχου: tau_c(1) = -24,4314
  ασυμπτωτική p-τιμή 3,926e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 2,469 [0,0603]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)ITRK
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,10112
  στατιστική ελέγχου: tau_ct(1) = -24,427
  ασυμπτωτική p-τιμή 3,47e-092
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 2,469 [0,0603]
```

```
Phillips-Perron unit-root test for ITRK, Bartlett bandwidth 25:

Z_t = -47,2214 (p-value = 0,0001)

Test regression (OLS, dependent variable ITRK, T = 2087):

             συντελεστής    τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------------
  const       0,000428260   0,000314191    1,363   0,1729
  ITRK(-1)   -0,0260061     0,0218925     -1,188   0,2349

Sample variance of residual       0,000205846
Estimated long-run error variance 0,000168301
```

MRW

```
Augmented Dickey-Fuller test for MRW
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
```

```
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MRW
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00938
  στατιστική ελέγχου: tau_c(1) = -46,1009
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MRW
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00973
  στατιστική ελέγχου: tau_ct(1) = -46,1053
  p-τιμή 1,249e-081
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for MRW, Bartlett bandwidth 25:

Z_t = -46,2121 (p-value = 0,0001)

Test regression (OLS, dependent variable MRW, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -8,65498e-05   0,000303385   -0,2853   0,7754
  MRW(-1)    -0,00938376    0,0218951     -0,4286   0,6682

Sample variance of residual       0,000192084
Estimated long-run error variance 0,000169932
```

NMC

```
Augmented Dickey-Fuller test for NMC
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 1703
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NMC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02999
  στατιστική ελέγχου: tau_c(1) = -42,4993
  p-τιμή 1,994e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NMC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03
  στατιστική ελέγχου: tau_ct(1) = -42,4871
  p-τιμή 4,471e-083
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for NMC, Bartlett bandwidth 25:

Z_t = -42,5479 (p-value = 0,0000)

Test regression (OLS, dependent variable NMC, T = 1703):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,00163555   0,000502371    3,256   0,0011 ***
  NMC(-1)    -0,0299929    0,0242355     -1,238   0,2159

Sample variance of residual       0,000427275
Estimated long-run error variance 0,000404558
```

PSN

```
Augmented Dickey-Fuller test for PSN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2081
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)PSN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,1177
  στατιστική ελέγχου: tau_c(1) = -17,8103
  ασυμπτωτική p-τιμή 8,809e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(6, 2073) = 7,805 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)PSN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,12478
  στατιστική ελέγχου: tau_ct(1) = -17,8798
  ασυμπτωτική p-τιμή 4,292e-058
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(6, 2072) = 7,907 [0,0000]
```

```
Phillips-Perron unit-root test for PSN, Bartlett bandwidth 25:

Z_t = -43,7176 (p-value = 0,0001)

Test regression (OLS, dependent variable PSN, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  ----------------------------------------------------
  const      0,000883369   0,000439714   2,009   0,0445 **
  PSN(-1)    0,0550742     0,0218782     2,517   0,0118 **

Sample variance of residual       0,000402631
Estimated long-run error variance 0,00025755
```

SLA

```
Augmented Dickey-Fuller test for SLA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2079
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)SLA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,05662
  στατιστική ελέγχου: tau_c(1) = -15,3553
  ασυμπτωτική p-τιμή 3,274e-036
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(8, 2069) = 4,598 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)SLA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,06319
  στατιστική ελέγχου: tau_ct(1) = -15,4123
  ασυμπτωτική p-τιμή 3,989e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(8, 2068) = 4,648 [0,0000]
```

```
Phillips-Perron unit-root test for SLA, Bartlett bandwidth 25:

Z_t = -42,3927 (p-value = 0,0000)

Test regression (OLS, dependent variable SLA, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      7,09576e-05   0,000355367   0,1997   0,8417
  SLA(-1)    0,0731815     0,0218652     3,347    0,0008 ***

Sample variance of residual       0,00026355
Estimated long-run error variance 0,000193548
```

BLND

```
Augmented Dickey-Fuller test for BLND
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2078
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)BLND
```

```
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,21152
  στατιστική ελέγχου: tau_c(1) = -16,0942
  ασυμπτωτική p-τιμή 2,548e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(9, 2067) = 5,170 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)BLND
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,2157
  στατιστική ελέγχου: tau_ct(1) = -16,1243
  ασυμπτωτική p-τιμή 8,04e-049
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(9, 2066) = 5,213 [0,0000]
```

```
Phillips-Perron unit-root test for BLND, Bartlett bandwidth 25:

Z_t = -43,7508 (p-value = 0,0001)

Test regression (OLS, dependent variable BLND, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      7,03117e-05   0,000303584   0,2316   0,8168
  BLND(-1)   0,0567794     0,0218701     2,596    0,0094 ***

Sample variance of residual       0,000192337
Estimated long-run error variance 0,000119556
```

CCL

```
Augmented Dickey-Fuller test for CCL
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)CCL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,03902
  στατιστική ελέγχου: tau_c(1) = -33,9379
  ασυμπτωτική p-τιμή 6,518e-040
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)CCL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,03934
  στατιστική ελέγχου: tau_ct(1) = -33,9368
  ασυμπτωτική p-τιμή 3,706e-129
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for CCL, Bartlett bandwidth 25:

Z_t = -44,7319 (p-value = 0,0001)

Test regression (OLS, dependent variable CCL, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const      0,000236003   0,000345200   0,6837   0,4942
  CCL(-1)    0,0226916     0,0219072     1,036    0,3003

Sample variance of residual       0,000248627
Estimated long-run error variance 0,000202615
```

CRDA

```
Augmented Dickey-Fuller test for CRDA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CRDA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00457
  στατιστική ελέγχου: tau_c(1) = -45,8446
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CRDA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00459
  στατιστική ελέγχου: tau_ct(1) = -45,8348
  p-τιμή 1,562e-082
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for CRDA, Bartlett bandwidth 25:

Z_t = -46,343 (p-value = 0,0001)

Test regression (OLS, dependent variable CRDA, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       0,000514434   0,000311771    1,650    0,0989 *
  CRDA(-1)   -0,00456747    0,0219125     -0,2084   0,8349

Sample variance of residual       0,000202586
Estimated long-run error variance 0,000151622
```

DCC

```
Augmented Dickey-Fuller test for DCC
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)DCC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,956166
  στατιστική ελέγχου: tau_c(1) = -43,6796
  p-τιμή 6,209e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)DCC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,956201
  στατιστική ελέγχου: tau_ct(1) = -43,6711
  p-τιμή 4,606e-089
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for DCC, Bartlett bandwidth 25:

Z_t = -43,6366 (p-value = 0,0001)

Test regression (OLS, dependent variable DCC, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  ---------------------------------------------------------
  const      0,000567540   0,000298623   1,901   0,0574 *
  DCC(-1)    0,0438339     0,0218905     2,002   0,0452 **

Sample variance of residual       0,000185748
Estimated long-run error variance 0,000166164
```

JMAT

```
Augmented Dickey-Fuller test for JMAT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2080
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)JMAT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,16081
```

```
  στατιστική ελέγχου: tau_c(1) = -17,7444
  ασυμπτωτική p-τιμή 1,27e-042
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(7, 2071) = 2,384 [0,0199]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)JMAT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,16155
  στατιστική ελέγχου: tau_ct(1) = -17,7485
  ασυμπτωτική p-τιμή 2,146e-057
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(7, 2070) = 2,390 [0,0196]
```

```
Phillips-Perron unit-root test for JMAT, Bartlett bandwidth 25:

Z_t = -45,5874 (p-value = 0,0001)

Test regression (OLS, dependent variable JMAT, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,000255164   0,000350946   0,7271   0,4672
  JMAT(-1)   0,00745214    0,0219154     0,3400   0,7338

Sample variance of residual       0,000256971
Estimated long-run error variance 0,000200213
```

LAND

```
Augmented Dickey-Fuller test for LAND
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)LAND
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14525
  στατιστική ελέγχου: tau_c(1) = -26,1654
  ασυμπτωτική p-τιμή 3,872e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 10,286 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)LAND
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14882
  στατιστική ελέγχου: tau_ct(1) = -26,2151
  ασυμπτωτική p-τιμή 1,108e-100
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 10,528 [0,0000]
```

```
Phillips-Perron unit-root test for LAND, Bartlett bandwidth 25:

Z_t = -43,165 (p-value = 0,0000)

Test regression (OLS, dependent variable LAND, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      9,51992e-05   0,000290893   0,3273   0,7435
  LAND(-1)   0,0625169     0,0218625     2,860    0,0042 ***

Sample variance of residual       0,000176588
Estimated long-run error variance 0,000119403
```

MKS

```
Augmented Dickey-Fuller test for MKS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)MKS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09274
  στατιστική ελέγχου: tau_c(1) = -24,7275
  ασυμπτωτική p-τιμή 3,292e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 3,059 [0,0272]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)MKS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09336
  στατιστική ελέγχου: tau_ct(1) = -24,7301
  ασυμπτωτική p-τιμή 1,156e-093
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 3,082 [0,0264]
```

```
Phillips-Perron unit-root test for MKS, Bartlett bandwidth 25:

Z_t = -44,8658 (p-value = 0,0001)

Test regression (OLS, dependent variable MKS, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ------------------------------------------------------
  const      -0,000159298   0,000340085   -0,4684   0,6395
  MKS(-1)     0,0216997     0,0218975      0,9910   0,3217

Sample variance of residual       0,000241355
```

```
Estimated long-run error variance 0,000190747
```

MNDI

```
Augmented Dickey-Fuller test for MNDI
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MNDI
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00699
  στατιστική ελέγχου: tau_c(1) = -45,9832
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MNDI
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00706
  στατιστική ελέγχου: tau_ct(1) = -45,9753
  p-τιμή 4,573e-082
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for MNDI, Bartlett bandwidth 25:

Z_t = -46,0835 (p-value = 0,0001)

Test regression (OLS, dependent variable MNDI, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,000575505   0,000371074    1,551    0,1209
  MNDI(-1)   -0,00699233    0,0218991     -0,3193   0,7495

Sample variance of residual       0,000287047
Estimated long-run error variance 0,000254448
```

OCDO

```
Augmented Dickey-Fuller test for OCDO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2078
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)OCDO
```

```
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,907593
  στατιστική ελέγχου: tau_c(1) = -14,1311
  ασυμπτωτική p-τιμή 1,606e-032
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(9, 2067) = 2,738 [0,0035]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)OCDO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,909074
  στατιστική ελέγχου: tau_ct(1) = -14,1407
  ασυμπτωτική p-τιμή 1,133e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(9, 2066) = 2,736 [0,0036]
```

```
Phillips-Perron unit-root test for OCDO, Bartlett bandwidth 25:

Z_t = -42,3001 (p-value = 0,0000)

Test regression (OLS, dependent variable OCDO, T = 2087):

            συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -----------------------------------------------------
  const      0,000795091   0,000758552   1,048   0,2946
  OCDO(-1)   0,0810260     0,0218300     3,712   0,0002 ***

Sample variance of residual       0,00120014
Estimated long-run error variance 0,0013147
```

SDR

```
Augmented Dickey-Fuller test for SDR
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2078
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)SDR
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,08212
  στατιστική ελέγχου: tau_c(1) = -14,7873
  ασυμπτωτική p-τιμή 1,585e-034
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(9, 2067) = 3,069 [0,0012]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)SDR
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,0837
  στατιστική ελέγχου: tau_ct(1) = -14,7974
  ασυμπτωτική p-τιμή 5,596e-042
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(9, 2066) = 3,076 [0,0011]
```

```
Phillips-Perron unit-root test for SDR, Bartlett bandwidth 25:

Z_t = -43,8445 (p-value = 0,0001)

Test regression (OLS, dependent variable SDR, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const      0,000305462   0,000358198   0,8528   0,3938
  SDR(-1)    0,0421414     0,0219147     1,923    0,0545 *

Sample variance of residual       0,000267661
Estimated long-run error variance 0,000203221
```

SGRO

```
Augmented Dickey-Fuller test for SGRO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)SGRO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,04798
  στατιστική ελέγχου: tau_c(1) = -24,5572
  ασυμπτωτική p-τιμή 3,611e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 3,206 [0,0223]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 10 υστερήσεων για (1-L)SGRO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,16936
  στατιστική ελέγχου: tau_ct(1) = -15,3946
  ασυμπτωτική p-τιμή 4,919e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(10, 2064) = 2,449 [0,0066]
```

```
Phillips-Perron unit-root test for SGRO, Bartlett bandwidth 25:

Z_t = -43,1081 (p-value = 0,0000)

Test regression (OLS, dependent variable SGRO, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -------------------------------------------------------
  const      0,000347396   0,000289770   1,199   0,2306
  SGRO(-1)   0,0634431     0,0218562     2,903   0,0037 ***
```

```
Sample variance of residual       0,000175098
Estimated long-run error variance 0,000119391
```

SMDS

```
Augmented Dickey-Fuller test for SMDS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SMDS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,991387
  στατιστική ελέγχου: tau_c(1) = -32,6777
  ασυμπτωτική p-τιμή 4,355e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SMDS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,992442
  στατιστική ελέγχου: tau_ct(1) = -32,6975
  ασυμπτωτική p-τιμή 1,144e-125
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for SMDS, Bartlett bandwidth 25:

Z_t = -43,6868 (p-value = 0,0001)

Test regression (OLS, dependent variable SMDS, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  ---------------------------------------------------
  const      0,000637208   0,000374032   1,704   0,0885 *
  SMDS(-1)   0,0437896     0,0218790     2,001   0,0453 **

Sample variance of residual       0,000291529
Estimated long-run error variance 0,000249056
```

EZJ

```
Augmented Dickey-Fuller test for EZJ
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)EZJ
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,03393
```

```
  στατιστική ελέγχου: tau_c(1) = -33,7531
  ασυμπτωτική p-τιμή 2,116e-040
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)EZJ
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,03525
  στατιστική ελέγχου: tau_ct(1) = -33,7789
  ασυμπτωτική p-τιμή 9,718e-129
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for EZJ, Bartlett bandwidth 25:

Z_t = -44,9523 (p-value = 0,0001)

Test regression (OLS, dependent variable EZJ, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,000455073   0,000451044   1,009    0,3130
  EZJ(-1)    0,0195991     0,0218938     0,8952   0,3707

Sample variance of residual       0,000424367
Estimated long-run error variance 0,000340329
```

FRES

```
Augmented Dickey-Fuller test for FRES
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2083
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)FRES
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,891214
  στατιστική ελέγχου: tau_c(1) = -18,548
  ασυμπτωτική p-τιμή 1,757e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(4, 2077) = 3,766 [0,0047]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)FRES
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,89159
  στατιστική ελέγχου: tau_ct(1) = -18,5466
  ασυμπτωτική p-τιμή 1,198e-061
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(4, 2076) = 3,754 [0,0048]
```

```
Phillips-Perron unit-root test for FRES, Bartlett bandwidth 25:

Z_t = -46,4089 (p-value = 0,0001)

Test regression (OLS, dependent variable FRES, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,000191076   0,000561731   -0,3402   0,7337
  FRES(-1)   -0,0153914     0,0219529     -0,7011   0,4832

Sample variance of residual       0,000658484
Estimated long-run error variance 0,000791681
```

GVC

```
Augmented Dickey-Fuller test for GVC
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2078
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)GVC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,08205
  στατιστική ελέγχου: tau_c(1) = -16,3547
  ασυμπτωτική p-τιμή 4,871e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(9, 2067) = 2,620 [0,0052]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)GVC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,08282
  στατιστική ελέγχου: tau_ct(1) = -16,3579
  ασυμπτωτική p-τιμή 4,815e-050
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(9, 2066) = 2,624 [0,0051]
```

```
Phillips-Perron unit-root test for GVC, Bartlett bandwidth 25:

Z_t = -43,0896 (p-value = 0,0000)

Test regression (OLS, dependent variable GVC, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  ------------------------------------------------------
  const      0,000906667   0,000380141   2,385   0,0171 **
  GVC(-1)    0,0590964     0,0218621     2,703   0,0069 ***

Sample variance of residual       0,000300665
Estimated long-run error variance 0,000228417
```

HLMA

```
Augmented Dickey-Fuller test for HLMA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)HLMA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,07052
  στατιστική ελέγχου: tau_c(1) = -34,1885
  ασυμπτωτική p-τιμή 3,079e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)HLMA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,07052
  στατιστική ελέγχου: tau_ct(1) = -34,1802
  ασυμπτωτική p-τιμή 8,675e-130
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,004
```

```
Phillips-Perron unit-root test for HLMA, Bartlett bandwidth 25:

Z_t = -46,6687 (p-value = 0,0001)

Test regression (OLS, dependent variable HLMA, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       0,000645038   0,000280296    2,301    0,0214 **
  HLMA(-1)   -0,0161457     0,0218937     -0,7375   0,4608

Sample variance of residual       0,000163566
Estimated long-run error variance 0,000136436
```

ITV

```
Augmented Dickey-Fuller test for ITV
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2083
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)ITV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,19104
```

```
  στατιστική ελέγχου: tau_c(1) = -23,0436
  ασυμπτωτική p-τιμή 2,311e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(4, 2077) = 6,308 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)ITV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,1986
  στατιστική ελέγχου: tau_ct(1) = -23,1308
  ασυμπτωτική p-τιμή 1,01e-085
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(4, 2076) = 6,596 [0,0000]
```

```
Phillips-Perron unit-root test for ITV, Bartlett bandwidth 25:

Z_t = -45,0586 (p-value = 0,0001)

Test regression (OLS, dependent variable ITV, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,000420946   0,000408878   1,030    0,3032
  ITV(-1)    0,0180151     0,0219066     0,8224   0,4109

Sample variance of residual       0,000348714
Estimated long-run error variance 0,000272353
```

JE

```
Augmented Dickey-Fuller test for JE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 1180
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)JE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,954531
  στατιστική ελέγχου: tau_c(1) = -32,9784
  p-τιμή 2,604e-030
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)JE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,954974
  στατιστική ελέγχου: tau_ct(1) = -32,9752
  p-τιμή 7,739e-082
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for JE, Bartlett bandwidth 25:

Z_t = -32,9593 (p-value = 0,0000)

Test regression (OLS, dependent variable JE, T = 1180):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      0,000621027   0,000674164   0,9212   0,3570
  JE(-1)     0,0454692     0,0289442     1,571    0,1162

Sample variance of residual       0,000535787
Estimated long-run error variance 0,000491747
```

KGF

```
Augmented Dickey-Fuller test for KGF
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2081
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)KGF
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,15028
  στατιστική ελέγχου: tau_c(1) = -18,0387
  ασυμπτωτική p-τιμή 2,532e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(6, 2073) = 4,295 [0,0003]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)KGF
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,15742
  στατιστική ελέγχου: tau_ct(1) = -18,0976
  ασυμπτωτική p-τιμή 2,968e-059
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(6, 2072) = 4,383 [0,0002]
```

```
Phillips-Perron unit-root test for KGF, Bartlett bandwidth 25:

Z_t = -45,7369 (p-value = 0,0001)

Test regression (OLS, dependent variable KGF, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      4,25921e-05   0,000334859   0,1272   0,8988
  KGF(-1)    0,00562832    0,0219190     0,2568   0,7974

Sample variance of residual       0,000234014
Estimated long-run error variance 0,000178122
```

PPB

```
Augmented Dickey-Fuller test for PPB
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2078
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)PPB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,05966
  στατιστική ελέγχου: tau_c(1) = -15,9404
  ασυμπτωτική p-τιμή 6,869e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(9, 2067) = 3,323 [0,0005]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)PPB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,07082
  στατιστική ελέγχου: tau_ct(1) = -16,0341
  ασυμπτωτική p-τιμή 2,378e-048
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(9, 2066) = 3,385 [0,0004]
```

```
Phillips-Perron unit-root test for PPB, Bartlett bandwidth 25:

Z_t = -43,1465 (p-value = 0,0000)

Test regression (OLS, dependent variable PPB, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -----------------------------------------------------
  const      0,000409685   0,000352489   1,162   0,2451
  PPB(-1)    0,0552262     0,0218711     2,525   0,0116 **

Sample variance of residual       0,00025911
Estimated long-run error variance 0,000218599
```

PSON

```
Augmented Dickey-Fuller test for PSON
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)PSON
```

```
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,996662
  στατιστική ελέγχου: tau_c(1) = -45,5074
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)PSON
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,996807
  στατιστική ελέγχου: tau_ct(1) = -45,5031
  p-τιμή 1,293e-083
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for PSON, Bartlett bandwidth 25:

Z_t = -45,5174 (p-value = 0,0001)

Test regression (OLS, dependent variable PSON, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -0,000121059   0,000374103   -0,3236   0,7462
  PSON(-1)    0,00333801    0,0219011      0,1524   0,8789

Sample variance of residual       0,000292068
Estimated long-run error variance 0,000277374
```

RRS

```
Augmented Dickey-Fuller test for RRS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2081
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)RRS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,886816
  στατιστική ελέγχου: tau_c(1) = -15,2744
  ασυμπτωτική p-τιμή 5,646e-036
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(6, 2073) = 2,418 [0,0248]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)RRS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,88693
  στατιστική ελέγχου: tau_ct(1) = -15,2718
  ασυμπτωτική p-τιμή 2,107e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(6, 2072) = 2,414 [0,0250]
```

```
Phillips-Perron unit-root test for RRS, Bartlett bandwidth 25:

Z_t = -47,4861 (p-value = 0,0001)

Test regression (OLS, dependent variable RRS, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -6,16444e-05   0,000480207   -0,1284   0,8979
  RRS(-1)    -0,0413504     0,0219520     -1,884    0,0596 *

Sample variance of residual       0,000481251
Estimated long-run error variance 0,000577595
```

RTO

```
Augmented Dickey-Fuller test for RTO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RTO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,987464
  στατιστική ελέγχου: tau_c(1) = -45,0825
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RTO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,988213
  στατιστική ελέγχου: tau_ct(1) = -45,1042
  p-τιμή 7,044e-085
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for RTO, Bartlett bandwidth 25:

Z_t = -45,0784 (p-value = 0,0001)

Test regression (OLS, dependent variable RTO, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,000523014   0,000305036   1,715    0,0864 *
  RTO(-1)    0,0125361     0,0219035     0,5723   0,5671

Sample variance of residual       0,000193902
Estimated long-run error variance 0,000188215
```

RSA

```
Augmented Dickey-Fuller test for RSA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2085
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)RSA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,06537
  στατιστική ελέγχου: tau_c(1) = -27,6982
  ασυμπτωτική p-τιμή 2,927e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(2, 2081) = 2,105 [0,1222]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)RSA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,06586
  στατιστική ελέγχου: tau_ct(1) = -27,6999
  ασυμπτωτική p-τιμή 2,767e-107
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(2, 2080) = 2,118 [0,1205]
```

```
Phillips-Perron unit-root test for RSA, Bartlett bandwidth 25:

Z_t = -46,9151 (p-value = 0,0001)

Test regression (OLS, dependent variable RSA, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -3,43511e-05   0,000328053   -0,1047   0,9166
  RSA(-1)    -0,0219890     0,0219032     -1,004    0,3154

Sample variance of residual       0,000224599
Estimated long-run error variance 0,000188944
```

SGE

```
Augmented Dickey-Fuller test for SGE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SGE
```

```
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,037
  στατιστική ελέγχου: tau_c(1) = -47,3863
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SGE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03723
  στατιστική ελέγχου: tau_ct(1) = -47,3858
  p-τιμή 4,06e-077
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for SGE, Bartlett bandwidth 25:

Z_t = -47,4668 (p-value = 0,0001)

Test regression (OLS, dependent variable SGE, T = 2087):

             συντελεστής    τυπ. σφάλμα     z      p-τιμή
  -------------------------------------------------------
  const       0,000356008   0,000300873    1,183   0,2367
  SGE(-1)    -0,0369982     0,0218839     -1,691   0,0909 *

Sample variance of residual       0,000188805
Estimated long-run error variance 0,00017686
```

SMIN

```
Augmented Dickey-Fuller test for SMIN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2084
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)SMIN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11355
  στατιστική ελέγχου: tau_c(1) = -24,6118
  ασυμπτωτική p-τιμή 3,497e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(3, 2079) = 2,569 [0,0528]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)SMIN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11378
  στατιστική ελέγχου: tau_ct(1) = -24,607
  ασυμπτωτική p-τιμή 4,586e-093
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(3, 2078) = 2,575 [0,0523]
```

```
Phillips-Perron unit-root test for SMIN, Bartlett bandwidth 25:

Z_t = -46,1201 (p-value = 0,0001)

Test regression (OLS, dependent variable SMIN, T = 2087):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       3,43922e-05   0,000318212    0,1081   0,9139
  SMIN(-1)   -0,00504268    0,0219330     -0,2299   0,8182

Sample variance of residual       0,000211325
Estimated long-run error variance 0,000168682
```

STJ

```
Augmented Dickey-Fuller test for STJ
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2083
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)STJ
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,1463
  στατιστική ελέγχου: tau_c(1) = -23,1023
  ασυμπτωτική p-τιμή 2,078e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(4, 2077) = 4,725 [0,0009]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)STJ
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14861
  στατιστική ελέγχου: tau_ct(1) = -23,129
  ασυμπτωτική p-τιμή 1,032e-085
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(4, 2076) = 4,799 [0,0007]
```

```
Phillips-Perron unit-root test for STJ, Bartlett bandwidth 25:

Z_t = -45,1211 (p-value = 0,0001)

Test regression (OLS, dependent variable STJ, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  ------------------------------------------------------
  const      0,000627035   0,000372448   1,684   0,0923 *
  STJ(-1)    0,0268534     0,0219041     1,226   0,2202

Sample variance of residual       0,000289074
Estimated long-run error variance 0,000190809
```

UU

```
Augmented Dickey-Fuller test for UU
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)UU
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,997235
  στατιστική ελέγχου: tau_c(1) = -45,49
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)UU
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,997889
  στατιστική ελέγχου: tau_ct(1) = -45,5109
  p-τιμή 1,369e-083
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for UU, Bartlett bandwidth 25:

Z_t = -45,5558 (p-value = 0,0001)

Test regression (OLS, dependent variable UU, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      8,74958e-05   0,000255981   0,3418   0,7325
  UU(-1)     0,00276506    0,0219221     0,1261   0,8996

Sample variance of residual       0,000136744
Estimated long-run error variance 0,000121331
```

ADM

```
Augmented Dickey-Fuller test for ADM
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2079
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)ADM
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11262
  στατιστική ελέγχου: tau_c(1) = -16,1908
  ασυμπτωτική p-τιμή 1,374e-038
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
  υστερήσεις πρώτων διαφορών: F(8, 2069) = 3,096 [0,0018]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)ADM
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11576
  στατιστική ελέγχου: tau_ct(1) = -16,2082
  ασυμπτωτική p-τιμή 2,928e-049
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
  υστερήσεις πρώτων διαφορών: F(8, 2068) = 3,118 [0,0017]
```

```
Phillips-Perron unit-root test for ADM, Bartlett bandwidth 25:

Z_t = -44,3253 (p-value = 0,0001)

Test regression (OLS, dependent variable ADM, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      8,50147e-05   0,000358071   0,2374   0,8123
  ADM(-1)    0,0305006     0,0219134     1,392    0,1640

Sample variance of residual       0,000267574
Estimated long-run error variance 0,00021761
```

BDEV

```
Augmented Dickey-Fuller test for BDEV
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2080
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)BDEV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09616
  στατιστική ελέγχου: tau_c(1) = -16,6531
  ασυμπτωτική p-τιμή 7,615e-040
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(7, 2071) = 4,733 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)BDEV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,10479
  στατιστική ελέγχου: tau_ct(1) = -16,739
  ασυμπτωτική p-τιμή 4,776e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(7, 2070) = 4,824 [0,0000]
```

```
Phillips-Perron unit-root test for BDEV, Bartlett bandwidth 25:

Z_t = -42,6533 (p-value = 0,0000)

Test regression (OLS, dependent variable BDEV, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  ---------------------------------------------------------
  const      0,000754669   0,000492790   1,531   0,1257
  BDEV(-1)   0,0596285     0,0220298     2,707   0,0068 ***

Sample variance of residual       0,000506073
Estimated long-run error variance 0,000380198
```

BKG

```
Augmented Dickey-Fuller test for BKG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2081
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)BKG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,12163
  στατιστική ελέγχου: tau_c(1) = -17,7414
  ασυμπτωτική p-τιμή 1,291e-042
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(6, 2073) = 5,528 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)BKG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,12834
  στατιστική ελέγχου: tau_ct(1) = -17,8051
  ασυμπτωτική p-τιμή 1,072e-057
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(6, 2072) = 5,611 [0,0000]



Phillips-Perron unit-root test for BKG, Bartlett bandwidth 25:

Z_t = -44,9753 (p-value = 0,0001)

Test regression (OLS, dependent variable BKG, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  ---------------------------------------------------------
  const      0,000646072   0,000397911   1,624   0,1044
  BKG(-1)    0,0285442     0,0219126     1,303   0,1927

Sample variance of residual       0,000329982
Estimated long-run error variance 0,000219269
```

DLG

```
Augmented Dickey-Fuller test for DLG
testing down from 25 lags, criterion AIC
```

```
μέγεθος δείγματος 1558
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)DLG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,2181
  στατιστική ελέγχου: tau_c(1) = -16,0779
  ασυμπτωτική p-τιμή 2,829e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(7, 1549) = 2,555 [0,0129]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 11 υστερήσεων για (1-L)DLG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,30323
  στατιστική ελέγχου: tau_ct(1) = -13,2734
  ασυμπτωτική p-τιμή 2,07e-034
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(11, 1540) = 2,462 [0,0047]



Phillips-Perron unit-root test for DLG, Bartlett bandwidth 25:

Z_t = -40,7125 (p-value = 0,0000)

Test regression (OLS, dependent variable DLG, T = 1565):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const      0,000342407   0,000318076   1,076     0,2817
  DLG(-1)    0,000592999   0,0250650     0,02366   0,9811

Sample variance of residual       0,000158175
Estimated long-run error variance 0,000108299
```

MCRO

```
Augmented Dickey-Fuller test for MCRO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MCRO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,993889
  στατιστική ελέγχου: tau_c(1) = -45,4102
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MCRO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,994212
  στατιστική ελέγχου: tau_ct(1) = -45,413
  p-τιμή 6,642e-084
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for MCRO, Bartlett bandwidth 25:

Z_t = -45,4947 (p-value = 0,0001)

Test regression (OLS, dependent variable MCRO, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,000578724   0,000536846   1,078    0,2810
  MCRO(-1)   0,00611098    0,0218869     0,2792   0,7801

Sample variance of residual       0,000601117
Estimated long-run error variance 0,000525578
```

RMV

```
Augmented Dickey-Fuller test for RMV
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2083
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)RMV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11941
  στατιστική ελέγχου: tau_c(1) = -22,52
  ασυμπτωτική p-τιμή 6,732e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(4, 2077) = 3,207 [0,0123]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)RMV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,12494
  στατιστική ελέγχου: tau_ct(1) = -22,5883
  ασυμπτωτική p-τιμή 5,921e-083
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(4, 2076) = 3,369 [0,0093]
```

```
Phillips-Perron unit-root test for RMV, Bartlett bandwidth 25:

Z_t = -44,3867 (p-value = 0,0001)

Test regression (OLS, dependent variable RMV, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -----------------------------------------------------
  const      0,000799371   0,000350726   2,279   0,0227 **
  RMV(-1)    0,0335728     0,0218877     1,534   0,1251

Sample variance of residual       0,000256034
Estimated long-run error variance 0,000192446
```

RMG

```
Augmented Dickey-Fuller test for RMG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 1304
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RMG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,941176
  στατιστική ελέγχου: tau_c(1) = -38,6661
  p-τιμή 1,758e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,022

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RMG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,942229
  στατιστική ελέγχου: tau_ct(1) = -38,6642
  p-τιμή 2,516e-079
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,021
```

```
Phillips-Perron unit-root test for RMG, Bartlett bandwidth 25:

Z_t = -38,7661 (p-value = 0,0000)

Test regression (OLS, dependent variable RMG, T = 1304):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -0,000222772   0,000456150   -0,4884   0,6253
  RMG(-1)     0,0588242     0,0243411      2,417    0,0157 **

Sample variance of residual       0,000271325
Estimated long-run error variance 0,000263509
```

SVT

```
Augmented Dickey-Fuller test for SVT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SVT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,985512
  στατιστική ελέγχου: tau_c(1) = -44,9943
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SVT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
```

```
  εκτιμώμενη τιμή του (a - 1): -0,986081
  στατιστική ελέγχου: tau_ct(1) = -45,0096
  p-τιμή 3,582e-085
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for SVT, Bartlett bandwidth 25:

Z_t = -45,23 (p-value = 0,0001)

Test regression (OLS, dependent variable SVT, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------
  const      0,000150366   0,000260250   0,5778   0,5634
  SVT(-1)    0,0144883     0,0219030     0,6615   0,5083

Sample variance of residual       0,000141326
Estimated long-run error variance 0,000111301
```

TW

```
Augmented Dickey-Fuller test for TW
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2081
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)TW
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14008
  στατιστική ελέγχου: tau_c(1) = -18,1868
  ασυμπτωτική p-τιμή 1,147e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(6, 2073) = 8,502 [0,0000]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)TW
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,15374
  στατιστική ελέγχου: tau_ct(1) = -18,3241
  ασυμπτωτική p-τιμή 1,841e-060
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(6, 2072) = 8,735 [0,0000]
```

```
Phillips-Perron unit-root test for TW, Bartlett bandwidth 25:

Z_t = -43,6012 (p-value = 0,0000)

Test regression (OLS, dependent variable TW, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  ---------------------------------------------------
```

```
  const      0,000811041   0,000472156   1,718   0,0858 *
  TW(-1)     0,0570732     0,0218834     2,608   0,0091 ***

Sample variance of residual       0,000464496
Estimated long-run error variance 0,00029605
```

WG

```
Augmented Dickey-Fuller test for WG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2086
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)WG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,00308
  στατιστική ελέγχου: tau_c(1) = -32,8231
  ασυμπτωτική p-τιμή 9,684e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)WG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,00348
  στατιστική ελέγχου: tau_ct(1) = -32,8267
  ασυμπτωτική p-τιμή 4,713e-126
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for WG, Bartlett bandwidth 25:

Z_t = -44,5821 (p-value = 0,0001)

Test regression (OLS, dependent variable WG, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -------------------------------------------------------
  const      0,000223817   0,000433099   0,5168   0,6053
  WG(-1)     0,0300117     0,0219146     1,369    0,1708

Sample variance of residual       0,000391409
Estimated long-run error variance 0,000285442
```

RDSA

```
Augmented Dickey-Fuller test for RDSA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2087
```

```
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RDSA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,957421
  στατιστική ελέγχου: tau_c(1) = -43,7043
  p-τιμή 6,929e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RDSA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,957462
  στατιστική ελέγχου: tau_ct(1) = -43,6949
  p-τιμή 5,346e-089
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for RDSA, Bartlett bandwidth 25:

Z_t = -43,7873 (p-value = 0,0001)

Test regression (OLS, dependent variable RDSA, T = 2087):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      0,000108622   0,000291242   0,3730   0,7092
  RDSA(-1)   0,0425788     0,0219068     1,944    0,0519 *

Sample variance of residual       0,000177007
Estimated long-run error variance 0,000138457
```

SKG

```
Augmented Dickey-Fuller test for SKG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 2081
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)SKG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09234
  στατιστική ελέγχου: tau_c(1) = -19,0799
  ασυμπτωτική p-τιμή 1,286e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(6, 2073) = 2,270 [0,0346]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)SKG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09235
  στατιστική ελέγχου: tau_ct(1) = -19,0743
  ασυμπτωτική p-τιμή 1,83e-064
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(6, 2072) = 2,269 [0,0347]
```

```
Phillips-Perron unit-root test for SKG, Bartlett bandwidth 25:

Z_t = -42,1072 (p-value = 0,0000)

Test regression (OLS, dependent variable SKG, T = 2087):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -------------------------------------------------------
  const      0,000583722   0,000476590   1,225   0,2207
  SKG(-1)    0,0778609     0,0218383     3,565   0,0004 ***

Sample variance of residual       0,000473602
Estimated long-run error variance 0,00042451
```

TUI

```
Augmented Dickey-Fuller test for TUI
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 991
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)TUI
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,1813
  στατιστική ελέγχου: tau_c(1) = -16,0534
  ασυμπτωτική p-τιμή 3,312e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
  υστερήσεις πρώτων διαφορών: F(4, 985) = 2,597 [0,0350]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)TUI
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,1813
  στατιστική ελέγχου: tau_ct(1) = -16,0444
  ασυμπτωτική p-τιμή 2,1e-048
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
  υστερήσεις πρώτων διαφορών: F(4, 984) = 2,594 [0,0352]
```

```
Phillips-Perron unit-root test for TUI, Bartlett bandwidth 25:

Z_t = -31,8702 (p-value = 0,0000)

Test regression (OLS, dependent variable TUI, T = 995):

             συντελεστής    τυπ. σφάλμα      z       p-τιμή
  ---------------------------------------------------------
```

```
  const       0,000180108   0,000514634    0,3500    0,7264
  TUI(-1)    -0,000754128   0,0317438     -0,02376   0,9810

Sample variance of residual       0,000263487
Estimated long-run error variance 0,000195378
```

Weekly Time-Series Data

HSBC

```
Augmented Dickey-Fuller test for HSBC
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)HSBC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0225
  στατιστική ελέγχου: tau_c(1) = -20,8917
  p-τιμή 1,374e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)HSBC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02296
  στατιστική ελέγχου: tau_ct(1) = -20,8746
  p-τιμή 6,858e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for HSBC, Bartlett bandwidth 25:

Z_t = -20,8939 (p-value = 0,0000)

Test regression (OLS, dependent variable HSBC, T = 420):

             συντελεστής    τυπ. σφάλμα      z       p-τιμή
  --------------------------------------------------------
  const      -2,44280e-05   0,00132947    -0,01837   0,9853
  HSBC(-1)   -0,0224990     0,0489427     -0,4597    0,6457

Sample variance of residual       0,00074235
Estimated long-run error variance 0,000803038
```

IGROUP

```
Augmented Dickey-Fuller test for IGROUP
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IGROUP
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,05782
  στατιστική ελέγχου: tau_c(1) = -21,5857
  p-τιμή 1,67e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IGROUP
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06032
  στατιστική ελέγχου: tau_ct(1) = -21,6087
  p-τιμή 1,345e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
```

```
Phillips-Perron unit-root test for IGROUP, Bartlett bandwidth 25:

Z_t = -21,6382 (p-value = 0,0000)

Test regression (OLS, dependent variable IGROUP, T = 420):

               συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const         0,00273949   0,00172042     1,592   0,1113
  IGROUP(-1)   -0,0578238    0,0490058     -1,180   0,2380

Sample variance of residual       0,00123526
Estimated long-run error variance 0,00160696
```

BP

```
Augmented Dickey-Fuller test for BP
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BP
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01328
  στατιστική ελέγχου: tau_c(1) = -20,653
  p-τιμή 1,408e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BP
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01413
  στατιστική ελέγχου: tau_ct(1) = -20,6416
  p-τιμή 1,258e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for BP, Bartlett bandwidth 25:

Z_t = -21,3243 (p-value = 0,0000)

Test regression (OLS, dependent variable BP, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,000666104   0,00150108     0,4437   0,6572
  BP(-1)     -0,0132773     0,0490620     -0,2706   0,7867

Sample variance of residual       0,000945762
Estimated long-run error variance 0,000571281
```

RDSB

```
Augmented Dickey-Fuller test for RDSB
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 418
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)RDSB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,20658
  στατιστική ελέγχου: tau_c(1) = -13,6185
  ασυμπτωτική p-τιμή 6,454e-031
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(2, 414) = 2,778 [0,0634]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)RDSB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,20725
  στατιστική ελέγχου: tau_ct(1) = -13,6083
  ασυμπτωτική p-τιμή 4,851e-036
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(2, 413) = 2,783 [0,0630]
```

```
Phillips-Perron unit-root test for RDSB, Bartlett bandwidth 25:

Z_t = -21,8859 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable RDSB, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,000705444   0,00152487     0,4626   0,6436
  RDSB(-1)   -0,0327821     0,0489650     -0,6695   0,5032

Sample variance of residual       0,000975917
Estimated long-run error variance 0,000591996
```

BATS

```
Augmented Dickey-Fuller test for BATS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)BATS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,13962
  στατιστική ελέγχου: tau_c(1) = -16,1811
  ασυμπτωτική p-τιμή 1,462e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)BATS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,15066
  στατιστική ελέγχου: tau_ct(1) = -16,2971
  ασυμπτωτική p-τιμή 1,003e-049
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for BATS, Bartlett bandwidth 25:

Z_t = -21,553 (p-value = 0,0000)

Test regression (OLS, dependent variable BATS, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,000854933   0,00126715     0,6747   0,4999
  BATS(-1)   -0,0387170     0,0489347     -0,7912   0,4288

Sample variance of residual       0,000673456
Estimated long-run error variance 0,000502147
```

GSK

```
Augmented Dickey-Fuller test for GSK
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 418
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)GSK
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,991784
  στατιστική ελέγχου: tau_c(1) = -11,5379
  ασυμπτωτική p-τιμή 3,365e-024
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,007
  υστερήσεις πρώτων διαφορών: F(2, 414) = 1,603 [0,2025]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)GSK
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,99292
  στατιστική ελέγχου: tau_ct(1) = -11,5389
  ασυμπτωτική p-τιμή 2,478e-026
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,007
  υστερήσεις πρώτων διαφορών: F(2, 413) = 1,596 [0,2039]
```

```
Phillips-Perron unit-root test for GSK, Bartlett bandwidth 25:

Z_t = -20,3192 (p-value = 0,0000)

Test regression (OLS, dependent variable GSK, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const      0,000304201   0,00114078    0,2667   0,7897
  GSK(-1)    0,00706856    0,0491456     0,1438   0,8856

Sample variance of residual       0,000546392
Estimated long-run error variance 0,000421204
```

AZN

```
Augmented Dickey-Fuller test for AZN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AZN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00143
  στατιστική ελέγχου: tau_c(1) = -20,3699
  p-τιμή 1,541e-035
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AZN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00274
  στατιστική ελέγχου: tau_ct(1) = -20,3672
  p-τιμή 2,716e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for AZN, Bartlett bandwidth 25:

Z_t = -21,8193 (p-value = 0,0000)

Test regression (OLS, dependent variable AZN, T = 420):

             συντελεστής   τυπ. σφάλμα      z       p-τιμή
  --------------------------------------------------------
  const       0,00126202   0,00148478     0,8500    0,3953
  AZN(-1)    -0,00142820   0,0491623     -0,02905   0,9768

Sample variance of residual       0,000923763
Estimated long-run error variance 0,000424431
```

DIAGEO

```
Augmented Dickey-Fuller test for DIAGEO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)DIAGEO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,15578
  στατιστική ελέγχου: tau_c(1) = -16,5525
  ασυμπτωτική p-τιμή 1,416e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)DIAGEO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,15679
  στατιστική ελέγχου: tau_ct(1) = -16,545
  ασυμπτωτική p-τιμή 5,019e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
```

```
Phillips-Perron unit-root test for DIAGEO, Bartlett bandwidth 25:

Z_t = -22,2359 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable DIAGEO, T = 420):

               συντελεστής   τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------------
  const         0,00202897   0,00114867     1,766    0,0773 *
  DIAGEO(-1)   -0,0255506    0,0493189     -0,5181   0,6044

Sample variance of residual       0,000549356
Estimated long-run error variance 0,000263974
```

SMT

```
Augmented Dickey-Fuller test for SMT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0807
  στατιστική ελέγχου: tau_c(1) = -21,4158
  p-τιμή 1,535e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08169
  στατιστική ελέγχου: tau_ct(1) = -21,3954
  p-τιμή 2,065e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
Phillips-Perron unit-root test for SMT, Bartlett bandwidth 25:

Z_t = -21,9289 (p-value = 0,0000)

Test regression (OLS, dependent variable SMT, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------------
  const       0,00331398   0,00141228     2,347   0,0189 **
  SMT(-1)    -0,0807022    0,0504629     -1,599   0,1098

Sample variance of residual       0,000825396
Estimated long-run error variance 0,00054392
```

RIO

```
Augmented Dickey-Fuller test for RIO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)RIO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,17318
  στατιστική ελέγχου: tau_c(1) = -16,3395
  ασυμπτωτική p-τιμή 5,36e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)RIO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,1773
  στατιστική ελέγχου: tau_ct(1) = -16,3657
  ασυμπτωτική p-τιμή 4,382e-050
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
```

```
Phillips-Perron unit-root test for RIO, Bartlett bandwidth 25:

Z_t = -22,8348 (p-value = 0,0000)

Test regression (OLS, dependent variable RIO, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,000266595   0,00219892    -0,1212   0,9035
  RIO(-1)    -0,0775291     0,0488483     -1,587    0,1125

Sample variance of residual       0,0020308
Estimated long-run error variance 0,001349
```

UNILEVER

```
Augmented Dickey-Fuller test for UNILEVER
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)UNILEVER
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,05798
  στατιστική ελέγχου: tau_c(1) = -15,3672
  ασυμπτωτική p-τιμή 3,022e-036
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)UNILEVER
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,05804
  στατιστική ελέγχου: tau_ct(1) = -15,3497
  ασυμπτωτική p-τιμή 8,375e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for UNILEVER, Bartlett bandwidth 25:

Z_t = -20,4666 (p-value = 0,0000)

Test regression (OLS, dependent variable UNILEVER, T = 420):

                 συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const          0,00187286    0,00116300    1,610    0,1073
  UNILEVER(-1)   0,0153213     0,0491329     0,3118   0,7552

Sample variance of residual       0,000563868
Estimated long-run error variance 0,000350922
```

VODAFONE

```
Augmented Dickey-Fuller test for VODAFONE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 418
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)VODAFONE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,18424
  στατιστική ελέγχου: tau_c(1) = -13,7881
  ασυμπτωτική p-τιμή 1,887e-031
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
  υστερήσεις πρώτων διαφορών: F(2, 414) = 6,650 [0,0014]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)VODAFONE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,19797
  στατιστική ελέγχου: tau_ct(1) = -13,8995
  ασυμπτωτική p-τιμή 1,786e-037
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(2, 413) = 7,077 [0,0010]
```

```
Phillips-Perron unit-root test for VODAFONE, Bartlett bandwidth 25:

Z_t = -19,3796 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable VODAFONE, T = 420):

                 συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------------
  const          -0,000283571   0,00129636    -0,2187   0,8268
  VODAFONE(-1)    0,0551525     0,0490314      1,125    0,2607

Sample variance of residual       0,00070583
Estimated long-run error variance 0,000478801
```

LLOY

```
Augmented Dickey-Fuller test for LLOY
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 414
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)LLOY
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,08232
  στατιστική ελέγχου: tau_c(1) = -8,42988
  ασυμπτωτική p-τιμή 2,639e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,010
  υστερήσεις πρώτων διαφορών: F(6, 406) = 2,812 [0,0108]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)LLOY
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,08278
  στατιστική ελέγχου: tau_ct(1) = -8,41519
  ασυμπτωτική p-τιμή 7,608e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,010
  υστερήσεις πρώτων διαφορών: F(6, 405) = 2,806 [0,0110]
```

```
Phillips-Perron unit-root test for LLOY, Bartlett bandwidth 25:

Z_t = -21,5174 (p-value = 0,0000)

Test regression (OLS, dependent variable LLOY, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,000504119   0,00218030    -0,2312   0,8171
  LLOY(-1)   -0,0499120     0,0488420     -1,022    0,3068

Sample variance of residual       0,00199625
Estimated long-run error variance 0,0024929
```

GLEN

```
Augmented Dickey-Fuller test for GLEN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 385
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)GLEN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,812188
  στατιστική ελέγχου: tau_c(1) = -8,05949
  ασυμπτωτική p-τιμή 3,343e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005
  υστερήσεις πρώτων διαφορών: F(3, 380) = 3,449 [0,0168]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)GLEN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,819797
  στατιστική ελέγχου: tau_ct(1) = -8,08476
  ασυμπτωτική p-τιμή 1,018e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005
  υστερήσεις πρώτων διαφορών: F(3, 379) = 3,334 [0,0196]
```

```
Phillips-Perron unit-root test for GLEN, Bartlett bandwidth 25:

Z_t = -20,6053 (p-value = 0,0000)

Test regression (OLS, dependent variable GLEN, T = 388):

            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ------------------------------------------------------
  const      -0,00135810   0,00293659    -0,4625   0,6437
  GLEN(-1)   -0,0318221    0,0509512     -0,6246   0,5323

Sample variance of residual       0,00334472
Estimated long-run error variance 0,00511469
```

RB

```
Augmented Dickey-Fuller test for RB
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)RB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,10394
  στατιστική ελέγχου: tau_c(1) = -15,6478
  ασυμπτωτική p-τιμή 4,66e-037
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)RB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,10451
  στατιστική ελέγχου: tau_ct(1) = -15,6394
  ασυμπτωτική p-τιμή 2,675e-046
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for RB, Bartlett bandwidth 25:

Z_t = -21,0532 (p-value = 0,0000)

Test regression (OLS, dependent variable RB, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00163860   0,00117008     1,400    0,1614
  RB(-1)     -0,0242879    0,0496153     -0,4895   0,6245

Sample variance of residual       0,000571581
Estimated long-run error variance 0,000376965
```

PRU

```
Augmented Dickey-Fuller test for PRU
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)PRU
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,21304
  στατιστική ελέγχου: tau_c(1) = -16,9746
  ασυμπτωτική p-τιμή 1,084e-040
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)PRU
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,21614
  στατιστική ελέγχου: tau_ct(1) = -16,9979
  ασυμπτωτική p-τιμή 2,054e-053
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009
```

```
Phillips-Perron unit-root test for PRU, Bartlett bandwidth 25:

Z_t = -22,6725 (p-value = 0,0000)

Test regression (OLS, dependent variable PRU, T = 420):
```

```
             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00247542   0,00166149     1,490   0,1363
  PRU(-1)    -0,0680665    0,0489308     -1,391   0,1642

Sample variance of residual       0,00115359
Estimated long-run error variance 0,000734715
```

SHIRE

```
Augmented Dickey-Fuller test for SHIRE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SHIRE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,05311
  στατιστική ελέγχου: tau_c(1) = -15,502
  ασυμπτωτική p-τιμή 1,226e-036
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SHIRE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,05707
  στατιστική ελέγχου: tau_ct(1) = -15,5354
  ασυμπτωτική p-τιμή 9,234e-046
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for SHIRE, Bartlett bandwidth 25:

Z_t = -19,7264 (p-value = 0,0000)

Test regression (OLS, dependent variable SHIRE, T = 420):

              συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -------------------------------------------------------
  const       0,00243824    0,00188970    1,290    0,1970
  SHIRE(-1)   0,0350485     0,0489624     0,7158   0,4741

Sample variance of residual       0,00149203
Estimated long-run error variance 0,00121437
```

BARCLAYS

```
Augmented Dickey-Fuller test for BARCLAYS
testing down from 25 lags, criterion AIC
```

```
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BARCLAYS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06324
  στατιστική ελέγχου: tau_c(1) = -21,7924
  p-τιμή 1,911e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BARCLAYS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06324
  στατιστική ελέγχου: tau_ct(1) = -21,7664
  p-τιμή 1,003e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
```

```
Phillips-Perron unit-root test for BARCLAYS, Bartlett bandwidth 25:

Z_t = -21,7629 (p-value = 0,0000)

Test regression (OLS, dependent variable BARCLAYS, T = 420):

                 συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const          -0,00112422   0,00222426    -0,5054   0,6133
  BARCLAYS(-1)   -0,0632376    0,0487893     -1,296    0,1949

Sample variance of residual       0,00207664
Estimated long-run error variance 0,00250283
```

BLT

```
Augmented Dickey-Fuller test for BLT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BLT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08252
  στατιστική ελέγχου: tau_c(1) = -22,1453
  p-τιμή 2,609e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BLT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08367
  στατιστική ελέγχου: tau_ct(1) = -22,1407
  p-τιμή 5,431e-045
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

Phillips-Perron unit-root test for BLT, Bartlett bandwidth 25:

Z_t = -22,2658 (p-value = 0,0000)

Test regression (OLS, dependent variable BLT, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,000648297   0,00222751    -0,2910   0,7710
  BLT(-1)    -0,0825201     0,0488827     -1,688    0,0914 *

Sample variance of residual       0,00208379
Estimated long-run error variance 0,00186369
```

RBS

```
Augmented Dickey-Fuller test for RBS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 411
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)RBS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,27645
  στατιστική ελέγχου: tau_c(1) = -7,46914
  ασυμπτωτική p-τιμή 1,679e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
  υστερήσεις πρώτων διαφορών: F(9, 400) = 2,643 [0,0055]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 9 υστερήσεων για (1-L)RBS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,28171
  στατιστική ελέγχου: tau_ct(1) = -7,47173
  ασυμπτωτική p-τιμή 9,605e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
  υστερήσεις πρώτων διαφορών: F(9, 399) = 2,647 [0,0055]
```

```
Phillips-Perron unit-root test for RBS, Bartlett bandwidth 25:

Z_t = -21,6907 (p-value = 0,0000)

Test regression (OLS, dependent variable RBS, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -0,00155848   0,00251075    -0,6207   0,5348
  RBS(-1)    -0,0518737    0,0488336     -1,062    0,2881

Sample variance of residual       0,00264524
Estimated long-run error variance 0,00225088
```

NG

```
Augmented Dickey-Fuller test for NG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 417
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)NG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,22489
  στατιστική ελέγχου: tau_c(1) = -11,8091
  ασυμπτωτική p-τιμή 4,379e-025
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(3, 412) = 5,578 [0,0009]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)NG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,24688
  στατιστική ελέγχου: tau_ct(1) = -11,924
  ασυμπτωτική p-τιμή 4,564e-028
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 411) = 5,863 [0,0006]
```

```
Phillips-Perron unit-root test for NG, Bartlett bandwidth 25:

Z_t = -21,9453 (p-value = 0,0000)

Test regression (OLS, dependent variable NG, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       0,000826150   0,00108885     0,7587   0,4480
  NG(-1)     -0,0161275     0,0489171     -0,3297   0,7416

Sample variance of residual       0,000497317
Estimated long-run error variance 0,000260225
```

RELX

```
Augmented Dickey-Fuller test for RELX
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 415
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
```

```
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)RELX
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,15788
  στατιστική ελέγχου: tau_c(1) = -8,97644
  ασυμπτωτική p-τιμή 5,65e-016
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(5, 408) = 3,011 [0,0111]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)RELX
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,15828
  στατιστική ελέγχου: tau_ct(1) = -8,97048
  ασυμπτωτική p-τιμή 7,871e-016
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(5, 407) = 2,998 [0,0114]
```

```
Phillips-Perron unit-root test for RELX, Bartlett bandwidth 25:

Z_t = -21,2412 (p-value = 0,0000)

Test regression (OLS, dependent variable RELX, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       0,00243341   0,00119358     2,039    0,0415 **
  RELX(-1)   -0,0342466    0,0496372     -0,6899   0,4902

Sample variance of residual       0,000591475
Estimated long-run error variance 0,000398525
```

BTA

```
Augmented Dickey-Fuller test for BTA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 415
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)BTA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,30742
  στατιστική ελέγχου: tau_c(1) = -9,80654
  ασυμπτωτική p-τιμή 1,381e-018
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
  υστερήσεις πρώτων διαφορών: F(5, 408) = 2,263 [0,0475]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)BTA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,5746
  στατιστική ελέγχου: tau_ct(1) = -10,0409
  ασυμπτωτική p-τιμή 5,825e-020
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
```

```
  υστερήσεις πρώτων διαφορών: F(6, 405) = 3,154 [0,0049]



Phillips-Perron unit-root test for BTA, Bartlett bandwidth 25:

Z_t = -22,1489 (p-value = 0,0000)

Test regression (OLS, dependent variable BTA, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00117975   0,00158737     0,7432   0,4574
  BTA(-1)    -0,0798490    0,0488028     -1,636    0,1018

Sample variance of residual       0,00105718
Estimated long-run error variance 0,00102679
```

AAL

```
Augmented Dickey-Fuller test for AAL
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 396
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 24 υστερήσεων για (1-L)AAL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,766258
  στατιστική ελέγχου: tau_c(1) = -3,57611
  ασυμπτωτική p-τιμή 0,006265
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
  υστερήσεις πρώτων διαφορών: F(24, 370) = 2,036 [0,0031]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 24 υστερήσεων για (1-L)AAL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,855604
  στατιστική ελέγχου: tau_ct(1) = -3,79844
  ασυμπτωτική p-τιμή 0,01655
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,005
  υστερήσεις πρώτων διαφορών: F(24, 369) = 2,010 [0,0037]



Phillips-Perron unit-root test for AAL, Bartlett bandwidth 25:

Z_t = -20,4951 (p-value = 0,0000)

Test regression (OLS, dependent variable AAL, T = 420):

             συντελεστής   τυπ. σφάλμα      z       p-τιμή
  --------------------------------------------------------
  const      -0,00131561   0,00297520    -0,4422    0,6584
```

```
  AAL(-1)     0,00483053   0,0489606      0,09866   0,9214

Sample variance of residual       0,00371664
Estimated long-run error variance 0,00470218
```

IMB

```
Augmented Dickey-Fuller test for IMB
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)IMB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11859
  στατιστική ελέγχου: tau_c(1) = -16,0012
  ασυμπτωτική p-τιμή 4,636e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)IMB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,12609
  στατιστική ελέγχου: tau_ct(1) = -16,061
  ασυμπτωτική p-τιμή 1,72e-048
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004



Phillips-Perron unit-root test for IMB, Bartlett bandwidth 25:

Z_t = -21,7878 (p-value = 0,0000)

Test regression (OLS, dependent variable IMB, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000800873   0,00129804     0,6170   0,5372
  IMB(-1)    -0,0277509     0,0488773     -0,5678   0,5702

Sample variance of residual       0,000706989
Estimated long-run error variance 0,000432432
```

TESCO

```
Augmented Dickey-Fuller test for TESCO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TESCO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
```

```
  εκτιμώμενη τιμή του (a - 1): -1,02769
  στατιστική ελέγχου: tau_c(1) = -21,0217
  p-τιμή 1,383e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TESCO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02899
  στατιστική ελέγχου: tau_ct(1) = -21,0232
  p-τιμή 4,762e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for TESCO, Bartlett bandwidth 25:

Z_t = -21,093 (p-value = 0,0000)

Test regression (OLS, dependent variable TESCO, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       -0,00170054   0,00184107    -0,9237   0,3557
  TESCO(-1)   -0,0276931    0,0488873     -0,5665   0,5711

Sample variance of residual       0,00142069
Estimated long-run error variance 0,00125235
```

CPG

```
Augmented Dickey-Fuller test for CPG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 409
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 11 υστερήσεων για (1-L)CPG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,25547
  στατιστική ελέγχου: tau_c(1) = -5,95993
  ασυμπτωτική p-τιμή 1,495e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(11, 396) = 2,841 [0,0014]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 11 υστερήσεων για (1-L)CPG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,26082
  στατιστική ελέγχου: tau_ct(1) = -5,96988
  ασυμπτωτική p-τιμή 1,373e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(11, 395) = 2,837 [0,0014]
```

```
Phillips-Perron unit-root test for CPG, Bartlett bandwidth 25:

Z_t = -22,7578 (p-value = 0,0000)

Test regression (OLS, dependent variable CPG, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00274464   0,00116338     2,359   0,0183 **
  CPG(-1)    -0,0743125    0,0495601     -1,499   0,1338

Sample variance of residual       0,000560462
Estimated long-run error variance 0,000321619
```

STAN

```
Augmented Dickey-Fuller test for STAN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)STAN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,15398
  στατιστική ελέγχου: tau_c(1) = -16,3136
  ασυμπτωτική p-τιμή 6,312e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)STAN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,154
  στατιστική ελέγχου: tau_ct(1) = -16,293
  ασυμπτωτική p-τιμή 1,054e-049
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
```

```
Phillips-Perron unit-root test for STAN, Bartlett bandwidth 25:

Z_t = -21,2949 (p-value = 0,0000)

Test regression (OLS, dependent variable STAN, T = 420):

             συντελεστής   τυπ. σφάλμα      z       p-τιμή
  --------------------------------------------------------
  const      -0,00274191   0,00198063    -1,384    0,1662
  STAN(-1)   -0,0442553    0,0490195     -0,9028   0,3666

Sample variance of residual       0,00164183
Estimated long-run error variance 0,0016763
```

ABF

```
Augmented Dickey-Fuller test for ABF
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 409
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 11 υστερήσεων για (1-L)ABF
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,10125
  στατιστική ελέγχου: tau_c(1) = -6,78643
  ασυμπτωτική p-τιμή 1,232e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,009
  υστερήσεις πρώτων διαφορών: F(11, 396) = 2,552 [0,0040]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 11 υστερήσεων για (1-L)ABF
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,1894
  στατιστική ελέγχου: tau_ct(1) = -7,0511
  ασυμπτωτική p-τιμή 1,767e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,008
  υστερήσεις πρώτων διαφορών: F(11, 395) = 2,666 [0,0026]
```

```
Phillips-Perron unit-root test for ABF, Bartlett bandwidth 25:

Z_t = -19,6501 (p-value = 0,0000)

Test regression (OLS, dependent variable ABF, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const      0,00182232    0,00143639    1,269    0,2046
  ABF(-1)    0,0389131     0,0489033     0,7957   0,4262

Sample variance of residual       0,000863103
Estimated long-run error variance 0,000853257
```

CRH

```
Augmented Dickey-Fuller test for CRH
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CRH
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,24501
  στατιστική ελέγχου: tau_c(1) = -26,2023
  p-τιμή 9,847e-031
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CRH
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,24516
  στατιστική ελέγχου: tau_ct(1) = -26,1797
  p-τιμή 1,228e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009
```

```
Phillips-Perron unit-root test for CRH, Bartlett bandwidth 25:

Z_t = -26,3484 (p-value = 0,0000)

Test regression (OLS, dependent variable CRH, T = 420):

             συντελεστής   τυπ. σφάλμα     z       p-τιμή
  --------------------------------------------------------
  const       0,00245665   0,00187269     1,312   0,1896
  CRH(-1)    -0,245012     0,0475153     -5,156   2,52e-07 ***

Sample variance of residual       0,00146909
Estimated long-run error variance 0,00139863
```

AV

```
Augmented Dickey-Fuller test for AV
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 418
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)AV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,06392
  στατιστική ελέγχου: tau_c(1) = -11,4863
  ασυμπτωτική p-τιμή 4,959e-024
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(2, 414) = 1,783 [0,1695]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)AV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,06386
  στατιστική ελέγχου: tau_ct(1) = -11,4718
  ασυμπτωτική p-τιμή 4,926e-026
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(2, 413) = 1,778 [0,1702]
```

```
Phillips-Perron unit-root test for AV, Bartlett bandwidth 25:

Z_t = -22,8634 (p-value = 0,0000)

Test regression (OLS, dependent variable AV, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000338271   0,00177153     0,1909   0,8486
  AV(-1)     -0,104255      0,0488111     -2,136    0,0327 **

Sample variance of residual       0,00131792
Estimated long-run error variance 0,00112102
```

RR

```
Augmented Dickey-Fuller test for RR
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RR
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,13871
  στατιστική ελέγχου: tau_c(1) = -23,3289
  p-τιμή 1,545e-034
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RR
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,13924
  στατιστική ελέγχου: tau_ct(1) = -23,3175
  p-τιμή 1,679e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
Phillips-Perron unit-root test for RR, Bartlett bandwidth 25:

Z_t = -23,4164 (p-value = 0,0000)

Test regression (OLS, dependent variable RR, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00144415   0,00193286     0,7472   0,4550
  RR(-1)     -0,138705     0,0488109     -2,842    0,0045 ***

Sample variance of residual       0,00156667
Estimated long-run error variance 0,00147615
```

BA

```
Augmented Dickey-Fuller test for BA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08137
  στατιστική ελέγχου: tau_c(1) = -22,193
  p-τιμή 2,742e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08173
  στατιστική ελέγχου: tau_ct(1) = -22,1748
  p-τιμή 5,164e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for BA, Bartlett bandwidth 25:

Z_t = -22,4884 (p-value = 0,0000)

Test regression (OLS, dependent variable BA, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00121757   0,00136363     0,8929   0,3719
  BA(-1)     -0,0813686    0,0487257     -1,670    0,0949 *

Sample variance of residual       0,000779347
Estimated long-run error variance 0,000633037
```

LSE

```
Augmented Dickey-Fuller test for LSE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)LSE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,21254
  στατιστική ελέγχου: tau_c(1) = -16,539
  ασυμπτωτική p-τιμή 1,54e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)LSE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,21327
  στατιστική ελέγχου: tau_ct(1) = -16,5291
  ασυμπτωτική p-τιμή 6,081e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
```

```
Phillips-Perron unit-root test for LSE, Bartlett bandwidth 25:

Z_t = -24,4443 (p-value = 0,0000)

Test regression (OLS, dependent variable LSE, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00496909   0,00174328     2,850   0,0044 ***
  LSE(-1)    -0,111174     0,0490340     -2,267   0,0234 **

Sample variance of residual       0,00125386
Estimated long-run error variance 0,000668613
```

EXPN

```
Augmented Dickey-Fuller test for AXPN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AXPN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03611
  στατιστική ελέγχου: tau_c(1) = -20,8251
  p-τιμή 1,377e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AXPN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0361
  στατιστική ελέγχου: tau_ct(1) = -20,801
  p-τιμή 8,268e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
```

```
Phillips-Perron unit-root test for AXPN, Bartlett bandwidth 25:

Z_t = -21,3628 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable AXPN, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       0,00226236   0,00136509     1,657    0,0975 *
  AXPN(-1)   -0,0361148    0,0497531     -0,7259   0,4679

Sample variance of residual       0,000776083
Estimated long-run error variance 0,000489752
```

LGEN

```
Augmented Dickey-Fuller test for LGEN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)LGEN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09326
  στατιστική ελέγχου: tau_c(1) = -15,8751
  ασυμπτωτική p-τιμή 1,049e-037
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)LGEN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,09685
  στατιστική ελέγχου: tau_ct(1) = -15,9035
  ασυμπτωτική p-τιμή 1,139e-047
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for LGEN, Bartlett bandwidth 25:

Z_t = -21,1738 (p-value = 0,0000)

Test regression (OLS, dependent variable LGEN, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const      0,00208377    0,00159928    1,303     0,1926
  LGEN(-1)   0,00387673    0,0489009     0,07928   0,9368

Sample variance of residual       0,00106956
Estimated long-run error variance 0,000600931
```

FERG

```
Augmented Dickey-Fuller test for FERG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)FERG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,22562
  στατιστική ελέγχου: tau_c(1) = -16,1631
  ασυμπτωτική p-τιμή 1,64e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)FERG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,22766
  στατιστική ελέγχου: tau_ct(1) = -16,1726
  ασυμπτωτική p-τιμή 4,497e-049
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
```

```
Phillips-Perron unit-root test for FERG, Bartlett bandwidth 25:

Z_t = -23,675 (p-value = 0,0000)

Test regression (OLS, dependent variable FERG, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,00317996   0,00165984     1,916   0,0554 *
  FERG(-1)   -0,147386     0,0486796     -3,028   0,0025 ***

Sample variance of residual       0,00114781
Estimated long-run error variance 0,00107634
```

SSE

```
Augmented Dickey-Fuller test for SSE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SSE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,16697
  στατιστική ελέγχου: tau_c(1) = -16,3788
  ασυμπτωτική p-τιμή 4,185e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SSE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,18155
  στατιστική ελέγχου: tau_ct(1) = -16,5309
  ασυμπτωτική p-τιμή 5,952e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for SSE, Bartlett bandwidth 25:

Z_t = -23,2413 (p-value = 0,0000)

Test regression (OLS, dependent variable SSE, T = 420):

             συντελεστής    τυπ. σφάλμα      z       p-τιμή
  ---------------------------------------------------------
  const       4,78968e-05   0,00120421     0,03977   0,9683
  SSE(-1)    -0,0659915     0,0487757     -1,353     0,1761

Sample variance of residual       0,000609053
Estimated long-run error variance 0,000335667
```

WPP

```
Augmented Dickey-Fuller test for WPP
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WPP
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,09308
  στατιστική ελέγχου: tau_c(1) = -22,3507
  p-τιμή 3,276e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WPP
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,09833
  στατιστική ελέγχου: tau_ct(1) = -22,4484
  p-τιμή 3,574e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for WPP, Bartlett bandwidth 25:

Z_t = -22,3442 (p-value = 0,0000)

Test regression (OLS, dependent variable WPP, T = 420):
```

```
            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,00102774   0,00156763     0,6556   0,5121
  WPP(-1)    -0,0930769    0,0489058     -1,903    0,0570 *

Sample variance of residual       0,00103071
Estimated long-run error variance 0,00103312
```

IAG

```
Augmented Dickey-Fuller test for IAG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 405
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IAG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01311
  στατιστική ελέγχου: tau_c(1) = -20,4225
  p-τιμή 3,853e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IAG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01348
  στατιστική ελέγχου: tau_ct(1) = -20,3974
  p-τιμή 1,493e-042
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005
```

```
Phillips-Perron unit-root test for IAG, Bartlett bandwidth 25:

Z_t = -20,4664 (p-value = 0,0000)

Test regression (OLS, dependent variable IAG, T = 405):

            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,00208949   0,00220339     0,9483   0,3430
  IAG(-1)    -0,0131116    0,0496075     -0,2643   0,7915

Sample variance of residual       0,00196236
Estimated long-run error variance 0,00232299
```

SN

```
Augmented Dickey-Fuller test for SN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,18616
  στατιστική ελέγχου: tau_c(1) = -16,346
  ασυμπτωτική p-τιμή 5,145e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,18711
  στατιστική ελέγχου: tau_ct(1) = -16,3406
  ασυμπτωτική p-τιμή 5,932e-050
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
```

```
Phillips-Perron unit-root test for SN, Bartlett bandwidth 25:

Z_t = -23,4362 (p-value = 0,0000)

Test regression (OLS, dependent variable SN, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,00224071   0,00134902     1,661   0,0967 *
  SN(-1)     -0,0921125    0,0491026     -1,876   0,0607 *

Sample variance of residual       0,000759659
Estimated long-run error variance 0,000449439
```

MRO

```
Augmented Dickey-Fuller test for MRO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 413
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)MRO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,86696
  στατιστική ελέγχου: tau_c(1) = -6,1281
  ασυμπτωτική p-τιμή 5,856e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
  υστερήσεις πρώτων διαφορών: F(7, 404) = 2,047 [0,0483]
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)MRO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,866632
  στατιστική ελέγχου: tau_ct(1) = -6,09772
  ασυμπτωτική p-τιμή 6,67e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
  υστερήσεις πρώτων διαφορών: F(7, 403) = 2,041 [0,0489]
```

```
Phillips-Perron unit-root test for MRO, Bartlett bandwidth 25:

Z_t = -21,4579 (p-value = 0,0000)

Test regression (OLS, dependent variable MRO, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00426902   0,00199404     2,141    0,0323 **
  MRO(-1)    -0,0391942    0,0496071     -0,7901   0,4295

Sample variance of residual       0,00164942
Estimated long-run error variance 0,00259006
```

NEXT

```
Augmented Dickey-Fuller test for NEXT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NEXT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,933406
  στατιστική ελέγχου: tau_c(1) = -19,1271
  p-τιμή 4,976e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NEXT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,937549
  στατιστική ελέγχου: tau_ct(1) = -19,1817
  p-τιμή 1,46e-041
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for NEXT, Bartlett bandwidth 25:

Z_t = -19,1037 (p-value = 0,0000)
```

Test regression (OLS, dependent variable NEXT, T = 420):

	συντελεστής	τυπ. σφάλμα	z	p-τιμή
const	0,00198269	0,00151654	1,307	0,1911
NEXT(-1)	0,0665944	0,0488002	1,365	0,1724

Sample variance of residual 0,000961401
Estimated long-run error variance 0,000917618

AHT

Augmented Dickey-Fuller test for AHT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

έλεγχος με σταθερό όρο
συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AHT
υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
εκτιμώμενη τιμή του (a - 1): -1,13875
στατιστική ελέγχου: tau_c(1) = -23,2295
p-τιμή 1,275e-034
συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

με σταθερό όρο και τάση
συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AHT
υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
εκτιμώμενη τιμή του (a - 1): -1,14203
στατιστική ελέγχου: tau_ct(1) = -23,2936
p-τιμή 1,7e-045
συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

Phillips-Perron unit-root test for AHT, Bartlett bandwidth 25:

Z_t = -23,1197 (p-value = 0,0000)

Test regression (OLS, dependent variable AHT, T = 420):

	συντελεστής	τυπ. σφάλμα	z	p-τιμή	
const	0,00785701	0,00251571	3,123	0,0018	***
AHT(-1)	-0,138750	0,0490216	-2,830	0,0046	***

Sample variance of residual 0,00260481
Estimated long-run error variance 0,00288186

BRBY

```
Augmented Dickey-Fuller test for BRBY
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 413
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)BRBY
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,32866
  στατιστική ελέγχου: tau_c(1) = -7,66202
  ασυμπτωτική p-τιμή 4,761e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,016
  υστερήσεις πρώτων διαφορών: F(7, 404) = 3,765 [0,0006]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)BRBY
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,32824
  στατιστική ελέγχου: tau_ct(1) = -7,65029
  ασυμπτωτική p-τιμή 2,649e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,015
  υστερήσεις πρώτων διαφορών: F(7, 403) = 3,756 [0,0006]
```

```
Phillips-Perron unit-root test for BRBY, Bartlett bandwidth 25:

Z_t = -23,6627 (p-value = 0,0000)

Test regression (OLS, dependent variable BRBY, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00158038   0,00211376     0,7477   0,4547
  BRBY(-1)   -0,131213     0,0491689     -2,669    0,0076 ***

Sample variance of residual       0,00187396
Estimated long-run error variance 0,00136572
```

COCA COLA

```
Augmented Dickey-Fuller test for COCACOLA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 285
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)COCACOLA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02136
  στατιστική ελέγχου: tau_c(1) = -16,9118
  p-τιμή 1,181e-029
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,018

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)COCACOLA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02467
  στατιστική ελέγχου: tau_ct(1) = -16,9278
  p-τιμή 1,005e-031
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,020
```

```
Phillips-Perron unit-root test for COCACOLA, Bartlett bandwidth 25:

Z_t = -17,0371 (p-value = 0,0000)

Test regression (OLS, dependent variable COCACOLA, T = 285):

                 συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const           0,00100559   0,00205446     0,4895   0,6245
  COCACOLA(-1)   -0,0213642    0,0603935     -0,3538   0,7235

Sample variance of residual       0,00120003
Estimated long-run error variance 0,00090663
```

INF

```
Augmented Dickey-Fuller test for INF
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)INF
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0661
  στατιστική ελέγχου: tau_c(1) = -21,7912
  p-τιμή 1,91e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)INF
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06642
  στατιστική ελέγχου: tau_ct(1) = -21,7695
  p-τιμή 9,98e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for INF, Bartlett bandwidth 25:

Z_t = -22,586 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable INF, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,00156888   0,00141912     1,106   0,2689
  INF(-1)    -0,0660994    0,0489234     -1,351   0,1767

Sample variance of residual       0,000843425
Estimated long-run error variance 0,000544391
```

SBRY

```
Augmented Dickey-Fuller test for SBRY
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SBRY
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04759
  στατιστική ελέγχου: tau_c(1) = -21,415
  p-τιμή 1,534e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SBRY
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04956
  στατιστική ελέγχου: tau_ct(1) = -21,426
  p-τιμή 1,937e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
```

```
Phillips-Perron unit-root test for INF, Bartlett bandwidth 25:

Z_t = -22,586 (p-value = 0,0000)

Test regression (OLS, dependent variable INF, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,00156888   0,00141912     1,106   0,2689
  INF(-1)    -0,0660994    0,0489234     -1,351   0,1767

Sample variance of residual       0,000843425
Estimated long-run error variance 0,000544391
```

WTB

```
Augmented Dickey-Fuller test for WTB
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 400
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 20 υστερήσεων για (1-L)WTB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,776588
  στατιστική ελέγχου: tau_c(1) = -2,97751
  ασυμπτωτική p-τιμή 0,03706
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,012
  υστερήσεις πρώτων διαφορών: F(20, 378) = 2,070 [0,0047]
```

```
Phillips-Perron unit-root test for WTB, Bartlett bandwidth 25:

Z_t = -21,2757 (p-value = 0,0000)

Test regression (OLS, dependent variable WTB, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,00248488   0,00147190     1,688    0,0914 *
  WTB(-1)    -0,0367534    0,0488782     -0,7519   0,4521

Sample variance of residual       0,000904105
Estimated long-run error variance 0,000812672
```

ANTO

```
Augmented Dickey-Fuller test for ANTO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)ANTO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,16376
  στατιστική ελέγχου: tau_c(1) = -16,4706
  ασυμπτωτική p-τιμή 2,357e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)ANTO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,16568
  στατιστική ελέγχου: tau_ct(1) = -16,4692
  ασυμπτωτική p-τιμή 1,255e-050
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
Phillips-Perron unit-root test for ANTO, Bartlett bandwidth 25:

Z_t = -21,7021 (p-value = 0,0000)

Test regression (OLS, dependent variable ANTO, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,00123249   0,00259029    -0,4758   0,6342
  ANTO(-1)   -0,0425779    0,0491600     -0,8661   0,3864

Sample variance of residual       0,00281726
Estimated long-run error variance 0,00192262
```

BUNZL

```
Augmented Dickey-Fuller test for BUNZL
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BUNZL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,07644
  στατιστική ελέγχου: tau_c(1) = -21,6121
  p-τιμή 1,696e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BUNZL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,07802
  στατιστική ελέγχου: tau_ct(1) = -21,6334
  p-τιμή 1,283e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for BUNZL, Bartlett bandwidth 25:

Z_t = -21,8355 (p-value = 0,0000)

Test regression (OLS, dependent variable BUNZL, T = 420):

              συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const         0,00269692   0,00119118     2,264   0,0236 **
  BUNZL(-1)   -0,0764359    0,0498070     -1,535   0,1249

Sample variance of residual       0,000588074
```

```
Estimated long-run error variance 0,000466565
```

CENTRICA

```
Augmented Dickey-Fuller test for CENTRICA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CENTRICA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01974
  στατιστική ελέγχου: tau_c(1) = -20,872
  p-τιμή 1,374e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CENTRICA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02158
  στατιστική ελέγχου: tau_ct(1) = -20,8887
  p-τιμή 6,62e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for CENTRICA, Bartlett bandwidth 25:

Z_t = -21,3326 (p-value = 0,0000)

Test regression (OLS, dependent variable CENTRICA, T = 420):
```

	συντελεστής	τυπ. σφάλμα	z	p-τιμή
const	-0,00181278	0,00145998	-1,242	0,2144
CENTRICA(-1)	-0,0197367	0,0488567	-0,4040	0,6862

```
Sample variance of residual       0,000891847
Estimated long-run error variance 0,000605332
```

EVRAZ

```
Augmented Dickey-Fuller test for EVRAZ
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 357
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)EVRAZ
```

```
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,818714
  στατιστική ελέγχου: tau_c(1) = -6,6554
  ασυμπτωτική p-τιμή 2,719e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
  υστερήσεις πρώτων διαφορών: F(6, 349) = 3,283 [0,0037]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)EVRAZ
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,883149
  στατιστική ελέγχου: tau_ct(1) = -6,95348
  ασυμπτωτική p-τιμή 3,387e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
  υστερήσεις πρώτων διαφορών: F(6, 348) = 3,151 [0,0051]
```

```
Phillips-Perron unit-root test for EVRAZ, Bartlett bandwidth 25:

Z_t = -18,5557 (p-value = 0,0000)

Test regression (OLS, dependent variable EVRAZ, T = 363):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -------------------------------------------------------
  const       0,000825685   0,00401145    0,2058   0,8369
  EVRAZ(-1)   0,0380465     0,0526617     0,7225   0,4700

Sample variance of residual       0,00583968
Estimated long-run error variance 0,00767433
```

HL

```
Augmented Dickey-Fuller test for HL
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)HL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,989574
  στατιστική ελέγχου: tau_c(1) = -20,0536
  p-τιμή 1,842e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)HL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,989611
  στατιστική ελέγχου: tau_ct(1) = -20,032
  p-τιμή 7,524e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for HL, Bartlett bandwidth 25:

Z_t = -20,0856 (p-value = 0,0000)

Test regression (OLS, dependent variable HL, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,00343641    0,00204055    1,684    0,0922 *
  HL(-1)     0,0104264     0,0493465     0,2113   0,8327

Sample variance of residual       0,00173432
Estimated long-run error variance 0,00142581
```

IHG

```
Augmented Dickey-Fuller test for IHG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IHG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04262
  στατιστική ελέγχου: tau_c(1) = -21,099
  p-τιμή 1,397e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IHG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0426
  στατιστική ελέγχου: tau_ct(1) = -21,0732
  p-τιμή 4,23e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for IHG, Bartlett bandwidth 25:

Z_t = -21,6049 (p-value = 0,0000)

Test regression (OLS, dependent variable IHG, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00317426   0,00161383     1,967    0,0492 **
  IHG(-1)    -0,0426225    0,0494157     -0,8625   0,3884

Sample variance of residual       0,00108249
Estimated long-run error variance 0,000721158
```

ITRK

```
Augmented Dickey-Fuller test for ITRK
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ITRK
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,07782
  στατιστική ελέγχου: tau_c(1) = -21,6364
  p-τιμή 1,721e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ITRK
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,07777
  στατιστική ελέγχου: tau_ct(1) = -21,6109
  p-τιμή 1,339e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
Phillips-Perron unit-root test for ITRK, Bartlett bandwidth 25:

Z_t = -21,7738 (p-value = 0,0000)

Test regression (OLS, dependent variable ITRK, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00223208   0,00153862     1,451   0,1469
  ITRK(-1)   -0,0778172    0,0498150     -1,562   0,1183

Sample variance of residual       0,000988367
Estimated long-run error variance 0,00083367
```

MRW

```
Augmented Dickey-Fuller test for MRW
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MRW
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04617
  στατιστική ελέγχου: tau_c(1) = -21,3332
  p-τιμή 1,486e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MRW
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04829
  στατιστική ελέγχου: tau_ct(1) = -21,3442
  p-τιμή 2,301e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for MRW, Bartlett bandwidth 25:

Z_t = -21,4097 (p-value = 0,0000)

Test regression (OLS, dependent variable MRW, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -0,000462153   0,00149346    -0,3095   0,7570
  MRW(-1)    -0,0461680     0,0490395     -0,9414   0,3465

Sample variance of residual       0,000936656
Estimated long-run error variance 0,000834219
```

NMC

```
Augmented Dickey-Fuller test for NMC
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 342
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NMC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02863
  στατιστική ελέγχου: tau_c(1) = -18,8916
  p-τιμή 7,972e-033
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NMC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02899
  στατιστική ελέγχου: tau_ct(1) = -18,8682
  p-τιμή 2,514e-037
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for NMC, Bartlett bandwidth 25:

Z_t = -19,03 (p-value = 0,0000)

Test regression (OLS, dependent variable NMC, T = 342):
```

	συντελεστής	τυπ. σφάλμα	z	p-τιμή	
const	0,00786821	0,00255194	3,083	0,0020	***
NMC(-1)	-0,0286286	0,0544489	-0,5258	0,5990	

```
Sample variance of residual       0,00216344
Estimated long-run error variance 0,0017434
```

PSN

```
Augmented Dickey-Fuller test for PSN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)PSN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0802
  στατιστική ελέγχου: tau_c(1) = -22,1393
  p-τιμή 2,593e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)PSN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08438
  στατιστική ελέγχου: tau_ct(1) = -22,2089
  p-τιμή 4,916e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for PSN, Bartlett bandwidth 25:

Z_t = -22,5889 (p-value = 0,0000)

Test regression (OLS, dependent variable PSN, T = 420):
```

	συντελεστής	τυπ. σφάλμα	z	p-τιμή	
const	0,00501164	0,00196256	2,554	0,0107	**
PSN(-1)	-0,0801962	0,0487908	-1,644	0,1002	

```
Sample variance of residual       0,0015951
Estimated long-run error variance 0,00120277
```

SLA

```
Augmented Dickey-Fuller test for SLA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SLA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08946
  στατιστική ελέγχου: tau_c(1) = -22,3281
  p-τιμή 3,19e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SLA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0926
  στατιστική ελέγχου: tau_ct(1) = -22,3778
  p-τιμή 3,907e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for SLA, Bartlett bandwidth 25:

Z_t = -22,3855 (p-value = 0,0000)

Test regression (OLS, dependent variable SLA, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000506103   0,00170148     0,2974   0,7661
  SLA(-1)    -0,0894587     0,0487933     -1,833    0,0667 *

Sample variance of residual       0,00121561
Estimated long-run error variance 0,00114771
```

BLND

```
Augmented Dickey-Fuller test for BLND
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 415
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)BLND
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,40594
  στατιστική ελέγχου: tau_c(1) = -10,1451
  ασυμπτωτική p-τιμή 1,135e-019
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007
  υστερήσεις πρώτων διαφορών: F(5, 408) = 2,732 [0,0192]
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)BLND
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,42259
  στατιστική ελέγχου: tau_ct(1) = -10,2269
  ασυμπτωτική p-τιμή 1,022e-020
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,008
  υστερήσεις πρώτων διαφορών: F(5, 407) = 2,840 [0,0156]
```

```
Phillips-Perron unit-root test for BLND, Bartlett bandwidth 25:

Z_t = -22,7665 (p-value = 0,0000)

Test regression (OLS, dependent variable BLND, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000400113   0,00139542     0,2867   0,7743
  BLND(-1)   -0,0772749     0,0488515     -1,582    0,1137

Sample variance of residual       0,000817556
Estimated long-run error variance 0,00055404
```

CCL

```
Augmented Dickey-Fuller test for CCL
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CCL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,996539
  στατιστική ελέγχου: tau_c(1) = -20,2884
  p-τιμή 1,601e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CCL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,997584
  στατιστική ελέγχου: tau_ct(1) = -20,2799
  p-τιμή 3,512e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for CCL, Bartlett bandwidth 25:

Z_t = -20,8541 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable CCL, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const      0,00126927    0,00168123    0,7550    0,4503
  CCL(-1)    0,00346131    0,0491187     0,07047   0,9438

Sample variance of residual       0,0011851
Estimated long-run error variance 0,000714717
```

CRDA

```
Augmented Dickey-Fuller test for CRDA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CRDA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,18173
  στατιστική ελέγχου: tau_c(1) = -23,9673
  p-τιμή 6,392e-034
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CRDA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,18166
  στατιστική ελέγχου: tau_ct(1) = -23,9366
  p-τιμή 1,443e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009
```

```
Phillips-Perron unit-root test for CRDA, Bartlett bandwidth 25:

Z_t = -26,0554 (p-value = 0,0000)

Test regression (OLS, dependent variable CRDA, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00312249   0,00158118     1,975   0,0483 **
  CRDA(-1)   -0,181733     0,0493061     -3,686   0,0002 ***

Sample variance of residual       0,00104126
Estimated long-run error variance 0,00056936
```

DCC

```
Augmented Dickey-Fuller test for DCC
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)DCC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03268
  στατιστική ελέγχου: tau_c(1) = -20,9296
  p-τιμή 1,374e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)DCC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03268
  στατιστική ελέγχου: tau_ct(1) = -20,9059
  p-τιμή 6,342e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for DCC, Bartlett bandwidth 25:

Z_t = -21,0357 (p-value = 0,0000)

Test regression (OLS, dependent variable DCC, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00308348   0,00150945     2,043    0,0411 **
  DCC(-1)    -0,0326779    0,0493405     -0,6623   0,5078

Sample variance of residual       0,000946602
Estimated long-run error variance 0,000788273
```

JMAT

```
Augmented Dickey-Fuller test for JMAT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 418
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)JMAT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14319
  στατιστική ελέγχου: tau_c(1) = -11,8897
  ασυμπτωτική p-τιμή 2,39e-025
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(2, 414) = 2,291 [0,1025]
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)JMAT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,22707
  στατιστική ελέγχου: tau_ct(1) = -16,5159
  ασυμπτωτική p-τιμή 7,136e-051
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,006
```

```
Phillips-Perron unit-root test for JMAT, Bartlett bandwidth 25:

Z_t = -23,7897 (p-value = 0,0000)

Test regression (OLS, dependent variable JMAT, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00140018   0,00171736     0,8153   0,4149
  JMAT(-1)   -0,130375     0,0486661     -2,679    0,0074 ***

Sample variance of residual       0,00123645
Estimated long-run error variance 0,000950038
```

LAND

```
Augmented Dickey-Fuller test for LAND
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)LAND
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,12284
  στατιστική ελέγχου: tau_c(1) = -15,9618
  ασυμπτωτική p-τιμή 5,978e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)LAND
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,13214
  στατιστική ελέγχου: tau_ct(1) = -16,0578
  ασυμπτωτική p-τιμή 1,788e-048
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for LAND, Bartlett bandwidth 25:
```

```
Z_t = -21,4234 (p-value = 0,0000)

Test regression (OLS, dependent variable LAND, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,000555374   0,00134601     0,4126   0,6799
  LAND(-1)   -0,0307243     0,0489906     -0,6271   0,5306

Sample variance of residual       0,000760551
Estimated long-run error variance 0,00054089
```

MKS

```
Augmented Dickey-Fuller test for MKS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MKS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03578
  στατιστική ελέγχου: tau_c(1) = -21,1761
  p-τιμή 1,419e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MKS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03663
  στατιστική ελέγχου: tau_ct(1) = -21,1645
  p-τιμή 3,422e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for MKS, Bartlett bandwidth 25:

Z_t = -21,4314 (p-value = 0,0000)

Test regression (OLS, dependent variable MKS, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const      -0,000828228   0,00156014    -0,5309   0,5955
  MKS(-1)    -0,0357829     0,0489129     -0,7316   0,4644

Sample variance of residual       0,00102161
Estimated long-run error variance 0,000789853
```

MNDI

```
Augmented Dickey-Fuller test for MNDI
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MNDI
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08805
  στατιστική ελέγχου: tau_c(1) = -21,788
  p-τιμή 1,905e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MNDI
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08803
  στατιστική ελέγχου: tau_ct(1) = -21,7645
  p-τιμή 1,007e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for MNDI, Bartlett bandwidth 25:

Z_t = -21,9905 (p-value = 0,0000)

Test regression (OLS, dependent variable MNDI, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00308269   0,00183179     1,683   0,0924 *
  MNDI(-1)   -0,0880487    0,0499380     -1,763   0,0779 *

Sample variance of residual       0,00139841
Estimated long-run error variance 0,00113437
```

OCDO

```
Augmented Dickey-Fuller test for OCDO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)OCDO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,942445
  στατιστική ελέγχου: tau_c(1) = -13,4588
  ασυμπτωτική p-τιμή 2,066e-030
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)OCDO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,944204
```

```
  στατιστική ελέγχου: tau_ct(1) = -13,4582
  ασυμπτωτική p-τιμή 2,625e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
```

```
Phillips-Perron unit-root test for OCDO, Bartlett bandwidth 25:

Z_t = -21,1278 (p-value = 0,0000)

Test regression (OLS, dependent variable OCDO, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       0,00426617   0,00398431     1,071    0,2843
  OCDO(-1)   -0,0171270    0,0492128     -0,3480   0,7278

Sample variance of residual       0,00664522
Estimated long-run error variance 0,0101238
```

SDR

```
Augmented Dickey-Fuller test for SDR
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SDR
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0225
  στατιστική ελέγχου: tau_c(1) = -20,9004
  p-τιμή 1,374e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SDR
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02316
  στατιστική ελέγχου: tau_ct(1) = -20,8904
  p-τιμή 6,592e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for SDR, Bartlett bandwidth 25:

Z_t = -20,9293 (p-value = 0,0000)

Test regression (OLS, dependent variable SDR, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       0,00170736   0,00165956     1,029    0,3036
```

```
  SDR(-1)    -0,0225016    0,0489226     -0,4599   0,6456

Sample variance of residual       0,00115376
Estimated long-run error variance 0,0010669
```

SGRO

```
Augmented Dickey-Fuller test for SGRO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SGRO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,17464
  στατιστική ελέγχου: tau_c(1) = -16,3488
  ασυμπτωτική p-τιμή 5,055e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SGRO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,18112
  στατιστική ελέγχου: tau_ct(1) = -16,3939
  ασυμπτωτική p-τιμή 3,117e-050
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
```

```
Phillips-Perron unit-root test for SGRO, Bartlett bandwidth 25:

Z_t = -22,18 (p-value = 0,0000)

Test regression (OLS, dependent variable SGRO, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,00195994   0,00142624     1,374   0,1694
  SGRO(-1)   -0,0751967    0,0489348     -1,537   0,1244

Sample variance of residual       0,000850365
Estimated long-run error variance 0,000712463
```

SMDS

```
Augmented Dickey-Fuller test for SMDS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1
```

```
  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMDS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08381
  στατιστική ελέγχου: tau_c(1) = -21,73
  p-τιμή 1,828e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMDS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08598
  στατιστική ελέγχου: tau_ct(1) = -21,7677
  p-τιμή 1,001e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,004
```

```
Phillips-Perron unit-root test for SMDS, Bartlett bandwidth 25:

Z_t = -22,1828 (p-value = 0,0000)

Test regression (OLS, dependent variable SMDS, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -------------------------------------------------------
  const       0,00359300   0,00186005     1,932   0,0534 *
  SMDS(-1)   -0,0838058    0,0498761     -1,680   0,0929 *

Sample variance of residual       0,00143886
Estimated long-run error variance 0,00102108
```

EZJ

```
Augmented Dickey-Fuller test for EZJ
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 418
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)EZJ
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,00808
  στατιστική ελέγχου: tau_c(1) = -11,1569
  ασυμπτωτική p-τιμή 5,901e-023
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,008
  υστερήσεις πρώτων διαφορών: F(2, 414) = 6,113 [0,0024]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)EZJ
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,01884
  στατιστική ελέγχου: tau_ct(1) = -11,2366
  ασυμπτωτική p-τιμή 5,369e-025
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007
```

```
  υστερήσεις πρώτων διαφορών: F(2, 413) = 6,114 [0,0024]
```

```
Phillips-Perron unit-root test for EZJ, Bartlett bandwidth 25:

Z_t = -21,3305 (p-value = 0,0000)

Test regression (OLS, dependent variable EZJ, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00236368   0,00210355     1,124    0,2612
  EZJ(-1)    -0,0282764    0,0489030     -0,5782   0,5631

Sample variance of residual       0,001853
Estimated long-run error variance 0,0027358
```

FRES

```
Augmented Dickey-Fuller test for FRES
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)FRES
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,872487
  στατιστική ελέγχου: tau_c(1) = -17,9672
  p-τιμή 4,555e-034
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,010

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)FRES
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,873
  στατιστική ελέγχου: tau_ct(1) = -17,9559
  p-τιμή 2,614e-039
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,010
```

```
Phillips-Perron unit-root test for FRES, Bartlett bandwidth 25:

Z_t = -17,8108 (p-value = 0,0000)

Test regression (OLS, dependent variable FRES, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const      -0,00109944   0,00277311    -0,3965   0,6918
  FRES(-1)    0,127513     0,0485600      2,626    0,0086 ***
```

```
Sample variance of residual       0,00322893
Estimated long-run error variance 0,00253252
```

GVC

```
Augmented Dickey-Fuller test for GVC
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)GVC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,16796
  στατιστική ελέγχου: tau_c(1) = -16,9455
  ασυμπτωτική p-τιμή 1,29e-040
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)GVC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,16863
  στατιστική ελέγχου: tau_ct(1) = -16,9357
  ασυμπτωτική p-τιμή 4,381e-053
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009
```

```
Phillips-Perron unit-root test for GVC, Bartlett bandwidth 25:

Z_t = -21,3814 (p-value = 0,0000)

Test regression (OLS, dependent variable GVC, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00484349   0,00201143     2,408    0,0160 **
  GVC(-1)    -0,00779040   0,0490012     -0,1590   0,8737

Sample variance of residual       0,00167512
Estimated long-run error variance 0,000954489
```

HLMA

```
Augmented Dickey-Fuller test for HLMA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
```

```
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)HLMA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08684
  στατιστική ελέγχου: tau_c(1) = -21,4607
  p-τιμή 1,566e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)HLMA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08684
  στατιστική ελέγχου: tau_ct(1) = -21,4289
  p-τιμή 1,926e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for HLMA, Bartlett bandwidth 25:

Z_t = -22,5535 (p-value = 0,0000)

Test regression (OLS, dependent variable HLMA, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,00347197   0,00133806     2,595   0,0095 ***
  HLMA(-1)   -0,0868395    0,0506433     -1,715   0,0864 *

Sample variance of residual       0,000738774
Estimated long-run error variance 0,000398104
```

ITV

```
Augmented Dickey-Fuller test for ITV
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 418
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)ITV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,00066
  στατιστική ελέγχου: tau_c(1) = -10,9357
  ασυμπτωτική p-τιμή 3,108e-022
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
  υστερήσεις πρώτων διαφορών: F(2, 414) = 2,092 [0,1248]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ITV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,15589
  στατιστική ελέγχου: tau_ct(1) = -23,8989
  p-τιμή 1,443e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005
```

```
Phillips-Perron unit-root test for ITV, Bartlett bandwidth 25:

Z_t = -23,5055 (p-value = 0,0000)

Test regression (OLS, dependent variable ITV, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00245646   0,00189703     1,295   0,1954
  ITV(-1)    -0,149142     0,0483571     -3,084   0,0020 ***

Sample variance of residual       0,00150663
Estimated long-run error variance 0,00206133
```

JE

```
Augmented Dickey-Fuller test for JE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 231
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)JE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,29846
  στατιστική ελέγχου: tau_c(1) = -7,73793
  ασυμπτωτική p-τιμή 2,884e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,013
  υστερήσεις πρώτων διαφορών: F(5, 224) = 1,573 [0,1687]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)JE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,33412
  στατιστική ελέγχου: tau_ct(1) = -7,9117
  ασυμπτωτική p-τιμή 3,806e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,014
  υστερήσεις πρώτων διαφορών: F(5, 223) = 1,704 [0,1347]
```

```
Phillips-Perron unit-root test for JE, Bartlett bandwidth 25:

Z_t = -15,9551 (p-value = 0,0000)

Test regression (OLS, dependent variable JE, T = 236):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,00391404    0,00324116    1,208    0,2272
  JE(-1)     0,0414439     0,0630431     0,6574   0,5109

Sample variance of residual       0,00246815
Estimated long-run error variance 0,00137481
```

KGF

```
Augmented Dickey-Fuller test for KGF
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 414
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)KGF
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,03156
  στατιστική ελέγχου: tau_c(1) = -7,665
  ασυμπτωτική p-τιμή 4,668e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,007
  υστερήσεις πρώτων διαφορών: F(6, 406) = 2,093 [0,0531]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)KGF
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,06378
  στατιστική ελέγχου: tau_ct(1) = -7,79997
  ασυμπτωτική p-τιμή 8,791e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,008
  υστερήσεις πρώτων διαφορών: F(6, 405) = 2,095 [0,0529]
```

```
Phillips-Perron unit-root test for KGF, Bartlett bandwidth 25:

Z_t = -21,7012 (p-value = 0,0000)

Test regression (OLS, dependent variable KGF, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000202938   0,00150045     0,1353   0,8924
  KGF(-1)    -0,0488775     0,0487856     -1,002    0,3164

Sample variance of residual       0,000945499
Estimated long-run error variance 0,000776317
```

PPB

```
Augmented Dickey-Fuller test for PPB
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)PPB
```

```
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,18681
  στατιστική ελέγχου: tau_c(1) = -16,7392
  ασυμπτωτική p-τιμή 4,495e-040
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)PPB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,19803
  στατιστική ελέγχου: tau_ct(1) = -16,8611
  ασυμπτωτική p-τιμή 1,085e-052
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for PPB, Bartlett bandwidth 25:

Z_t = -21,4484 (p-value = 0,0000)

Test regression (OLS, dependent variable PPB, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00225598   0,00190006     1,187    0,2351
  PPB(-1)    -0,0480844    0,0492203     -0,9769   0,3286

Sample variance of residual       0,00151026
Estimated long-run error variance 0,00124791
```

PSON

```
Augmented Dickey-Fuller test for PSON
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)PSON
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,06997
  στατιστική ελέγχου: tau_c(1) = -15,7314
  ασυμπτωτική p-τιμή 2,687e-037
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,007

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)PSON
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,07112
  στατιστική ελέγχου: tau_ct(1) = -15,7339
  ασυμπτωτική p-τιμή 8,663e-047
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,007
```

```
Phillips-Perron unit-root test for PSON, Bartlett bandwidth 25:

Z_t = -19,6346 (p-value = 0,0000)

Test regression (OLS, dependent variable PSON, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,000522260   0,00182566    -0,2861   0,7748
  PSON(-1)    0,0385091     0,0491426      0,7836   0,4333

Sample variance of residual       0,00139974
Estimated long-run error variance 0,00102869
```

RRS

```
Augmented Dickey-Fuller test for RRS
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RRS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,934089
  στατιστική ελέγχου: tau_c(1) = -19,1092
  p-τιμή 5,107e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RRS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,934153
  στατιστική ελέγχου: tau_ct(1) = -19,0867
  p-τιμή 2,102e-041
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for RRS, Bartlett bandwidth 25:

Z_t = -19,0891 (p-value = 0,0000)

Test regression (OLS, dependent variable RRS, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const      -0,000448525   0,00233942    -0,1917   0,8480
  RRS(-1)     0,0659107     0,0488816      1,348    0,1775

Sample variance of residual       0,0022985
Estimated long-run error variance 0,00177345
```

RTO

```
Augmented Dickey-Fuller test for RTO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 416
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)RTO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,876602
  στατιστική ελέγχου: tau_c(1) = -7,91675
  ασυμπτωτική p-τιμή 8,753e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(4, 410) = 2,386 [0,0506]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)RTO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,893421
  στατιστική ελέγχου: tau_ct(1) = -7,96932
  ασυμπτωτική p-τιμή 2,461e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(4, 409) = 2,242 [0,0639]
```

```
Phillips-Perron unit-root test for RTO, Bartlett bandwidth 25:

Z_t = -21,5239 (p-value = 0,0000)

Test regression (OLS, dependent variable RTO, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00281017   0,00149248     1,883   0,0597 *
  RTO(-1)    -0,0567531    0,0491588     -1,154   0,2483

Sample variance of residual       0,000927459
Estimated long-run error variance 0,000880576
```

RSA

```
Augmented Dickey-Fuller test for RSA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)RSA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,08086
  στατιστική ελέγχου: tau_c(1) = -15,3679
  ασυμπτωτική p-τιμή 3,007e-036
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)RSA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,08339
  στατιστική ελέγχου: tau_ct(1) = -15,3696
  ασυμπτωτική p-τιμή 6,615e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for RSA, Bartlett bandwidth 25:

Z_t = -21,5308 (p-value = 0,0000)

Test regression (OLS, dependent variable RSA, T = 420):

             συντελεστής    τυπ. σφάλμα      z       p-τιμή
  ---------------------------------------------------------
  const      -0,000115276   0,00151972    -0,07585   0,9395
  RSA(-1)    -0,0141736     0,0489590     -0,2895    0,7722

Sample variance of residual       0,000970009
Estimated long-run error variance 0,000562298
```

SGE

```
Augmented Dickey-Fuller test for SGE
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SGE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02413
  στατιστική ελέγχου: tau_c(1) = -20,896
  p-τιμή 1,374e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SGE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02517
  στατιστική ελέγχου: tau_ct(1) = -20,8958
  p-τιμή 6,503e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for SGE, Bartlett bandwidth 25:

Z_t = -21,2009 (p-value = 0,0000)

Test regression (OLS, dependent variable SGE, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00173775   0,00141664     1,227    0,2199
  SGE(-1)    -0,0241269    0,0490107     -0,4923   0,6225

Sample variance of residual       0,000839552
Estimated long-run error variance 0,000613776
```

SMIN

```
Augmented Dickey-Fuller test for SMIN
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMIN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,10521
  στατιστική ελέγχου: tau_c(1) = -22,5913
  p-τιμή 4,469e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMIN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,10565
  στατιστική ελέγχου: tau_ct(1) = -22,5699
  p-τιμή 3,097e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for SMIN, Bartlett bandwidth 25:

Z_t = -22,5261 (p-value = 0,0000)

Test regression (OLS, dependent variable SMIN, T = 420):
```

```
            συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000318711   0,00150097     0,2123   0,8318
  SMIN(-1)   -0,105214      0,0489221     -2,151    0,0315 **

Sample variance of residual       0,000946037
Estimated long-run error variance 0,00101919
```

STJ

```
Augmented Dickey-Fuller test for STJ
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)STJ
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,26822
  στατιστική ελέγχου: tau_c(1) = -16,9061
  ασυμπτωτική p-τιμή 1,634e-040
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)STJ
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,27316
  στατιστική ελέγχου: tau_ct(1) = -16,9471
  ασυμπτωτική p-τιμή 3,811e-053
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for STJ, Bartlett bandwidth 25:

Z_t = -25,4033 (p-value = 0,0000)

Test regression (OLS, dependent variable STJ, T = 420):

            συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00384412   0,00183067     2,100   0,0357 **
  STJ(-1)    -0,172055     0,0483449     -3,559   0,0004 ***

Sample variance of residual       0,00139625
Estimated long-run error variance 0,000959428
```

UU

```
Augmented Dickey-Fuller test for UU
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)UU
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00749
  στατιστική ελέγχου: tau_c(1) = -20,5927
  p-τιμή 1,427e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)UU
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01094
  στατιστική ελέγχου: tau_ct(1) = -20,6374
  p-τιμή 1,273e-043
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
```

```
Phillips-Perron unit-root test for UU, Bartlett bandwidth 25:

Z_t = -21,1936 (p-value = 0,0000)

Test regression (OLS, dependent variable UU, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       0,000504470   0,00123336     0,4090   0,6825
  UU(-1)     -0,00749435    0,0489248     -0,1532   0,8783

Sample variance of residual       0,000638682
Estimated long-run error variance 0,000396084
```

ADM

```
Augmented Dickey-Fuller test for ADM
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ADM
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11754
  στατιστική ελέγχου: tau_c(1) = -22,9972
  p-τιμή 8,383e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ADM
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11938
  στατιστική ελέγχου: tau_ct(1) = -23,0096
  p-τιμή 2,042e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007
```

```
Phillips-Perron unit-root test for ADM, Bartlett bandwidth 25:

Z_t = -22,9476 (p-value = 0,0000)

Test regression (OLS, dependent variable ADM, T = 420):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000573148   0,00175993     0,3257   0,7447
  ADM(-1)    -0,117544      0,0485949     -2,419    0,0156 **

Sample variance of residual       0,00130058
Estimated long-run error variance 0,001349
```

BDEV

```
Augmented Dickey-Fuller test for BDEV
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BDEV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04812
  στατιστική ελέγχου: tau_c(1) = -21,4784
  p-τιμή 1,579e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BDEV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,05194
  στατιστική ελέγχου: tau_ct(1) = -21,5412
  p-τιμή 1,534e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,005
```

```
Phillips-Perron unit-root test for BDEV, Bartlett bandwidth 25:

Z_t = -21,4747 (p-value = 0,0000)

Test regression (OLS, dependent variable BDEV, T = 420):
```

```
            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,00454450   0,00224145     2,027    0,0426 **
  BDEV(-1)   -0,0481197    0,0487989     -0,9861   0,3241

Sample variance of residual       0,00209208
Estimated long-run error variance 0,00209765
```

BKG

```
Augmented Dickey-Fuller test for BKG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BKG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04893
  στατιστική ελέγχου: tau_c(1) = -21,4519
  p-τιμή 1,56e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BKG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,05319
  στατιστική ελέγχου: tau_ct(1) = -21,5236
  p-τιμή 1,589e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for BKG, Bartlett bandwidth 25:

Z_t = -21,7043 (p-value = 0,0000)

Test regression (OLS, dependent variable BKG, T = 420):

            συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,00353602   0,00174048     2,032   0,0422 **
  BKG(-1)    -0,0489277    0,0488967     -1,001   0,3170

Sample variance of residual       0,00126046
Estimated long-run error variance 0,000997144
```

DLG

```
Augmented Dickey-Fuller test for DLG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 313
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)DLG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,18949
  στατιστική ελέγχου: tau_c(1) = -14,2412
  ασυμπτωτική p-τιμή 7,329e-033
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)DLG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,20925
  στατιστική ελέγχου: tau_ct(1) = -14,4091
  ασυμπτωτική p-τιμή 5,13e-040
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
Phillips-Perron unit-root test for DLG, Bartlett bandwidth 25:

Z_t = -20,7846 (p-value = 0,0000)

Test regression (OLS, dependent variable DLG, T = 314):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00185502   0,00150356     1,234   0,2173
  DLG(-1)    -0,0906503    0,0563768     -1,608   0,1078

Sample variance of residual       0,00070696
Estimated long-run error variance 0,000381139
```

MCRO

```
Augmented Dickey-Fuller test for MCRO
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MCRO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0474
  στατιστική ελέγχου: tau_c(1) = -21,412
  p-τιμή 1,532e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MCRO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04879
  στατιστική ελέγχου: tau_ct(1) = -21,418
  p-τιμή 1,97e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for MCRO, Bartlett bandwidth 25:

Z_t = -21,889 (p-value = 0,0000)

Test regression (OLS, dependent variable MCRO, T = 420):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00305846   0,00277353     1,103    0,2701
  MCRO(-1)   -0,0473979    0,0489165     -0,9690   0,3326

Sample variance of residual       0,00322089
Estimated long-run error variance 0,00227135
```

RMV

```
Augmented Dickey-Fuller test for RMV
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 412
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)RMV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,19468
  στατιστική ελέγχου: tau_c(1) = -6,72093
  ασυμπτωτική p-τιμή 1,832e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(8, 402) = 2,343 [0,0180]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 8 υστερήσεων για (1-L)RMV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,26938
  στατιστική ελέγχου: tau_ct(1) = -6,99971
  ασυμπτωτική p-τιμή 2,492e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
  υστερήσεις πρώτων διαφορών: F(8, 401) = 2,422 [0,0145]
```

```
Phillips-Perron unit-root test for RMV, Bartlett bandwidth 25:

Z_t = -22,6008 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable RMV, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,00455615   0,00171616     2,655   0,0079 ***
  RMV(-1)    -0,105188     0,0492771     -2,135   0,0328 **

Sample variance of residual       0,00121746
Estimated long-run error variance 0,00105782
```

RMG

```
Augmented Dickey-Fuller test for RMG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 262
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RMG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,853817
  στατιστική ελέγχου: tau_c(1) = -15,8141
  p-τιμή 8,552e-028
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,062

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RMG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,857768
  στατιστική ελέγχου: tau_ct(1) = -15,7974
  p-τιμή 6,64e-029
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,059
```

```
Phillips-Perron unit-root test for RMG, Bartlett bandwidth 25:

Z_t = -15,8995 (p-value = 0,0000)

Test regression (OLS, dependent variable RMG, T = 262):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ----------------------------------------------------------
  const      -0,00110386   0,00226007    -0,4884   0,6253
  RMG(-1)     0,146183     0,0539908      2,708    0,0068 ***

Sample variance of residual       0,00133819
Estimated long-run error variance 0,00122194
```

SVT

```
Augmented Dickey-Fuller test for SVT
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 419
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SVT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,10685
  στατιστική ελέγχου: tau_c(1) = -16,1166
  ασυμπτωτική p-τιμή 2,207e-038
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,011

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SVT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11314
  στατιστική ελέγχου: tau_ct(1) = -16,1625
  ασυμπτωτική p-τιμή 5,076e-049
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,011
```

```
Phillips-Perron unit-root test for SVT, Bartlett bandwidth 25:

Z_t = -22,4777 (p-value = 0,0000)

Test regression (OLS, dependent variable SVT, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const      0,000810926   0,00131343    0,6174   0,5370
  SVT(-1)    0,00673948    0,0489375     0,1377   0,8905

Sample variance of residual       0,000723941
Estimated long-run error variance 0,000281479
```

TW

```
Augmented Dickey-Fuller test for TW
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TW
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,10114
  στατιστική ελέγχου: tau_c(1) = -22,6313
  p-τιμή 4,727e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,005
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TW
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,10909
  στατιστική ελέγχου: tau_ct(1) = -22,7958
  p-τιμή 2,45e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007
```

```
Phillips-Perron unit-root test for TW, Bartlett bandwidth 25:

Z_t = -22,5976 (p-value = 0,0000)

Test regression (OLS, dependent variable TW, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00483357   0,00211286     2,288   0,0222 **
  TW(-1)     -0,101144     0,0486558     -2,079   0,0376 **

Sample variance of residual       0,00185586
Estimated long-run error variance 0,00190847
```

WG

```
Augmented Dickey-Fuller test for WG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06968
  στατιστική ελέγχου: tau_c(1) = -21,9199
  p-τιμή 2,114e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,07055
  στατιστική ελέγχου: tau_ct(1) = -21,9166
  p-τιμή 7,735e-045
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
```

```
Phillips-Perron unit-root test for WG, Bartlett bandwidth 25:

Z_t = -22,5692 (p-value = 0,0000)

Test regression (OLS, dependent variable WG, T = 420):
```

```
            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00137325   0,00217677     0,6309   0,5281
  WG(-1)     -0,0696810    0,0487995     -1,428    0,1533

Sample variance of residual       0,00198842
Estimated long-run error variance 0,00136741
```

RDSA

```
Augmented Dickey-Fuller test for RDSA
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 420
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RDSA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02796
  στατιστική ελέγχου: tau_c(1) = -20,9866
  p-τιμή 1,378e-035
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RDSA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02843
  στατιστική ελέγχου: tau_ct(1) = -20,9698
  p-τιμή 5,419e-044
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for RDSA, Bartlett bandwidth 25:

Z_t = -22,0345 (p-value = 0,0000)

Test regression (OLS, dependent variable RDSA, T = 420):

            συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,000602564   0,00146193     0,4122   0,6802
  RDSA(-1)   -0,0279616     0,0489817     -0,5709   0,5681

Sample variance of residual       0,000897117
Estimated long-run error variance 0,0004965
```

SKG

```
Augmented Dickey-Fuller test for SKG
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 418
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)SKG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,946849
  στατιστική ελέγχου: tau_c(1) = -10,2241
  ασυμπτωτική p-τιμή 6,318e-020
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
  υστερήσεις πρώτων διαφορών: F(2, 414) = 5,198 [0,0059]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)SKG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,947005
  στατιστική ελέγχου: tau_ct(1) = -10,2082
  ασυμπτωτική p-τιμή 1,219e-020
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
  υστερήσεις πρώτων διαφορών: F(2, 413) = 5,180 [0,0060]
```

```
Phillips-Perron unit-root test for SKG, Bartlett bandwidth 25:

Z_t = -22,9903 (p-value = 0,0000)

Test regression (OLS, dependent variable SKG, T = 420):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,00368580   0,00247788     1,487   0,1369
  SKG(-1)    -0,132295     0,0489622     -2,702   0,0069 ***

Sample variance of residual       0,00256552
Estimated long-run error variance 0,00341985
```

TUI

```
Augmented Dickey-Fuller test for TUI
testing down from 25 lags, criterion AIC
μέγεθος δείγματος 199
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TUI
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,1274
  στατιστική ελέγχου: tau_c(1) = -15,8012
  p-τιμή 2,8e-025
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,007

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TUI
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,12744
  στατιστική ελέγχου: tau_ct(1) = -15,7588
  p-τιμή 3,071e-025
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,007
```

```
Phillips-Perron unit-root test for TUI, Bartlett bandwidth 25:

Z_t = -15,825 (p-value = 0,0000)

Test regression (OLS, dependent variable TUI, T = 199):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,00131479   0,00226699     0,5800   0,5619
  TUI(-1)    -0,127404     0,0713494     -1,786    0,0742 *

Sample variance of residual       0,00102069
Estimated long-run error variance 0,000983762
```

Monthly Time-Series Data

HSBC

```
Augmented Dickey-Fuller test for HSBC
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 94
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)HSBC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,804872
  στατιστική ελέγχου: tau_c(1) = -5,26288
  ασυμπτωτική p-τιμή 5,737e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,040

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)HSBC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,807304
  στατιστική ελέγχου: tau_ct(1) = -5,22428
  ασυμπτωτική p-τιμή 6,436e-005
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,040
```

```
Phillips-Perron unit-root test for HSBC, Bartlett bandwidth 14:

Z_t = -10,738 (p-value = 0,0000)

Test regression (OLS, dependent variable HSBC, T = 95):

             συντελεστής    τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -0,000882276   0,00562508    -0,1568   0,8754
  HSBC(-1)   -0,102699      0,103128      -0,9958   0,3193

Sample variance of residual       0,00300592
Estimated long-run error variance 0,00461747
```

IGROUP

```
Augmented Dickey-Fuller test for IGROUP
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IGROUP
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,992994
  στατιστική ελέγχου: tau_c(1) = -9,54578
  p-τιμή 3,024e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IGROUP
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0027
  στατιστική ελέγχου: tau_ct(1) = -9,58136
  p-τιμή 7,615e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for IGROUP, Bartlett bandwidth 14:

Z_t = -9,74544 (p-value = 0,0000)

Test regression (OLS, dependent variable IGROUP, T = 95):

               συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const        0,0103214     0,00767545    1,345     0,1787
  IGROUP(-1)   0,00700594    0,104024      0,06735   0,9463
```

```
Sample variance of residual       0,00545038
Estimated long-run error variance 0,00766816
```

BP

```
Augmented Dickey-Fuller test for BP
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BP
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11693
  στατιστική ελέγχου: tau_c(1) = -10,8609
  p-τιμή 7,07e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,010

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BP
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11974
  στατιστική ελέγχου: tau_ct(1) = -10,8417
  p-τιμή 1,436e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,012
```

```
Phillips-Perron unit-root test for BP, Bartlett bandwidth 14:

Z_t = -11,965 (p-value = 0,0001)

Test regression (OLS, dependent variable BP, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,00248363   0,00670783     0,3703   0,7112
  BP(-1)     -0,116932     0,102840      -1,137    0,2555

Sample variance of residual       0,00426865
Estimated long-run error variance 0,00207076
```

RDSB

```
Augmented Dickey-Fuller test for RDSB
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
```

```
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RDSB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,16409
  στατιστική ελέγχου: tau_c(1) = -11,4094
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RDSB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,16427
  στατιστική ελέγχου: tau_ct(1) = -11,3525
  p-τιμή 3,799e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
Phillips-Perron unit-root test for RDSB, Bartlett bandwidth 14:

Z_t = -11,6 (p-value = 0,0001)

Test regression (OLS, dependent variable RDSB, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,00285241   0,00630179     0,4526   0,6508
  RDSB(-1)   -0,164094     0,102030      -1,608    0,1078

Sample variance of residual       0,00376513
Estimated long-run error variance 0,0031217
```

BATS

```
Augmented Dickey-Fuller test for BATS
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BATS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08876
  στατιστική ελέγχου: tau_c(1) = -10,4972
  p-τιμή 1,116e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,008

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BATS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11565
  στατιστική ελέγχου: tau_ct(1) = -10,7531
  p-τιμή 1,84e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,015
```

```
Phillips-Perron unit-root test for BATS, Bartlett bandwidth 14:

Z_t = -10,4707 (p-value = 0,0000)

Test regression (OLS, dependent variable BATS, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,00402921   0,00546565     0,7372   0,4610
  BATS(-1)   -0,0887643    0,103720      -0,8558   0,3921

Sample variance of residual       0,00282007
Estimated long-run error variance 0,00314434
```

GSK

```
Augmented Dickey-Fuller test for GSK
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)GSK
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,15184
  στατιστική ελέγχου: tau_c(1) = -11,2917
  p-τιμή 7,779e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)GSK
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,15407
  στατιστική ελέγχου: tau_ct(1) = -11,2742
  p-τιμή 4,604e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,008
```

```
Phillips-Perron unit-root test for GSK, Bartlett bandwidth 14:

Z_t = -12,2054 (p-value = 0,0001)

Test regression (OLS, dependent variable GSK, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,00197236   0,00514750     0,3832   0,7016
  GSK(-1)    -0,151842     0,102008      -1,489    0,1366

Sample variance of residual       0,00251503
Estimated long-run error variance 0,00141494
```

AZN

```
Augmented Dickey-Fuller test for AZN
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 94
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)AZN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,47815
  στατιστική ελέγχου: tau_c(1) = -9,53325
  ασυμπτωτική p-τιμή 1,02e-017
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,016

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)AZN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,49009
  στατιστική ελέγχου: tau_ct(1) = -9,52418
  ασυμπτωτική p-τιμή 6,413e-018
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,017
```

```
Phillips-Perron unit-root test for AZN, Bartlett bandwidth 14:

Z_t = -13,1054 (p-value = 0,0001)

Test regression (OLS, dependent variable AZN, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,00745565   0,00612923     1,216   0,2238
  AZN(-1)    -0,166816     0,101147      -1,649   0,0991 *

Sample variance of residual       0,00353588
Estimated long-run error variance 0,00164995
```

DIAGEO

```
Augmented Dickey-Fuller test for DIAGEO
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 94
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)DIAGEO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,4187
  στατιστική ελέγχου: tau_c(1) = -8,65097
  ασυμπτωτική p-τιμή 5,647e-015
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,020

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)DIAGEO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,42721
  στατιστική ελέγχου: tau_ct(1) = -8,67023
  ασυμπτωτική p-τιμή 9,629e-015
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,019
```

```
Phillips-Perron unit-root test for DIAGEO, Bartlett bandwidth 14:

Z_t = -11,8734 (p-value = 0,0001)

Test regression (OLS, dependent variable DIAGEO, T = 95):

               συντελεστής   τυπ. σφάλμα     z      p-τιμή
  --------------------------------------------------------
  const         0,0101102    0,00491225     2,058   0,0396 **
  DIAGEO(-1)   -0,199404     0,102692      -1,942   0,0522 *

Sample variance of residual       0,00220643
Estimated long-run error variance 0,001848
```

SMT

```
Augmented Dickey-Fuller test for SMT
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,18582
  στατιστική ελέγχου: tau_c(1) = -11,0519
  p-τιμή 2,005e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,19212
  στατιστική ελέγχου: tau_ct(1) = -11,0206
  p-τιμή 8,834e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007
```

```
Phillips-Perron unit-root test for SMT, Bartlett bandwidth 14:

Z_t = -11,198 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable SMT, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -------------------------------------------------------
  const       0,0155440    0,00589487     2,637   0,0084 ***
  SMT(-1)    -0,185820     0,107295      -1,732   0,0833 *

Sample variance of residual       0,00306122
Estimated long-run error variance 0,00246803
```

RIO

```
Augmented Dickey-Fuller test for RIO
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RIO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,10763
  στατιστική ελέγχου: tau_c(1) = -10,8617
  p-τιμή 7,1e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RIO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11508
  στατιστική ελέγχου: tau_ct(1) = -10,9213
  p-τιμή 1,154e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,008
```

```
Phillips-Perron unit-root test for RIO, Bartlett bandwidth 14:

Z_t = -10,9135 (p-value = 0,0000)

Test regression (OLS, dependent variable RIO, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -0,00215642   0,00840860    -0,2565   0,7976
  RIO(-1)    -0,107633     0,101976      -1,055    0,2912

Sample variance of residual       0,0067156
Estimated long-run error variance 0,00612585
```

UNILEVER

```
Augmented Dickey-Fuller test for UNILEVER
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 92
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)UNILEVER
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,28546
  στατιστική ελέγχου: tau_c(1) = -5,55836
  ασυμπτωτική p-τιμή 1,283e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(3, 87) = 2,211 [0,0925]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)UNILEVER
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,28295
  στατιστική ελέγχου: tau_ct(1) = -5,51923
  ασυμπτωτική p-τιμή 1,515e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000
  υστερήσεις πρώτων διαφορών: F(3, 86) = 2,192 [0,0948]
```

```
Phillips-Perron unit-root test for UNILEVER, Bartlett bandwidth 14:

Z_t = -12,4664 (p-value = 0,0001)

Test regression (OLS, dependent variable UNILEVER, T = 95):

               συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const          0,00932913   0,00522801     1,784   0,0744 *
  UNILEVER(-1)  -0,148954     0,104450      -1,426   0,1538

Sample variance of residual       0,00250879
Estimated long-run error variance 0,00107075
```

VODAFONE

```
Augmented Dickey-Fuller test for VODAFONE
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)VODAFONE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11406
  στατιστική ελέγχου: tau_c(1) = -10,6819
  p-τιμή 2,777e-006
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,013

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)VODAFONE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,1382
  στατιστική ελέγχου: tau_ct(1) = -10,9074
  p-τιμή 1,198e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,012
```

```
Phillips-Perron unit-root test for VODAFONE, Bartlett bandwidth 14:

Z_t = -10,7989 (p-value = 0,0000)

Test regression (OLS, dependent variable VODAFONE, T = 95):

                 συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const          -0,00162772   0,00521644    -0,3120   0,7550
  VODAFONE(-1)   -0,114061     0,104295      -1,094    0,2741

Sample variance of residual       0,00258507
Estimated long-run error variance 0,00212638
```

LLOY

```
Augmented Dickey-Fuller test for LLOY
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)LLOY
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01268
  στατιστική ελέγχου: tau_c(1) = -9,79841
  p-τιμή 6,466e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)LLOY
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0139
  στατιστική ελέγχου: tau_ct(1) = -9,75074
  p-τιμή 4,245e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for LLOY, Bartlett bandwidth 14:

Z_t = -10,1612 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable LLOY, T = 95):

            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ------------------------------------------------------
  const      -0,00181283  0,00899472    -0,2015   0,8403
  LLOY(-1)   -0,0126842   0,103352      -0,1227   0,9023

Sample variance of residual       0,00768053
Estimated long-run error variance 0,0131629
```

GLEN

```
Augmented Dickey-Fuller test for GLEN
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 82
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)GLEN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,817332
  στατιστική ελέγχου: tau_c(1) = -4,13968
  ασυμπτωτική p-τιμή 0,0008311
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,039
  υστερήσεις πρώτων διαφορών: F(5, 75) = 2,543 [0,0351]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)GLEN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,847289
  στατιστική ελέγχου: tau_ct(1) = -4,18868
  ασυμπτωτική p-τιμή 0,004587
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,036
  υστερήσεις πρώτων διαφορών: F(5, 74) = 2,564 [0,0340]
```

```
Phillips-Perron unit-root test for GLEN, Bartlett bandwidth 14:

Z_t = -7,18467 (p-value = 0,0000)

Test regression (OLS, dependent variable GLEN, T = 87):

            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ------------------------------------------------------
  const      -0,00363668   0,0125647    -0,2894   0,7722
  GLEN(-1)    0,234403     0,105744      2,217    0,0266 **

Sample variance of residual       0,0136933
Estimated long-run error variance 0,0125515
```

RB

```
Augmented Dickey-Fuller test for RB
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,09322
  στατιστική ελέγχου: tau_c(1) = -10,6182
  p-τιμή 2,015e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,011

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)RB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,49313
  στατιστική ελέγχου: tau_ct(1) = -4,76173
  ασυμπτωτική p-τιμή 0,0005075
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
  υστερήσεις πρώτων διαφορών: F(5, 82) = 1,411 [0,2290]
```

```
Phillips-Perron unit-root test for RB, Bartlett bandwidth 14:

Z_t = -10,8921 (p-value = 0,0000)

Test regression (OLS, dependent variable RB, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const       0,00715686   0,00495549     1,444    0,1487
  RB(-1)     -0,0932160    0,102957      -0,9054   0,3653

Sample variance of residual       0,00228258
Estimated long-run error variance 0,00163934
```

PRU

```
Augmented Dickey-Fuller test for PRU
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 91
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)PRU
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,760819
  στατιστική ελέγχου: tau_c(1) = -2,77068
  ασυμπτωτική p-τιμή 0,06253
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,061
```

```
  υστερήσεις πρώτων διαφορών: F(4, 85) = 2,076 [0,0911]
```

```
Phillips-Perron unit-root test for PRU, Bartlett bandwidth 14:

Z_t = -11,4599 (p-value = 0,0001)

Test regression (OLS, dependent variable PRU, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,0117485    0,00624345     1,882   0,0599 *
  PRU(-1)    -0,187408     0,102554      -1,827   0,0676 *

Sample variance of residual       0,0035962
Estimated long-run error variance 0,00413324
```

SHIRE

```
Augmented Dickey-Fuller test for SHIRE
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SHIRE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03848
  στατιστική ελέγχου: tau_c(1) = -10,0237
  p-τιμή 1,444e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SHIRE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04993
  στατιστική ελέγχου: tau_ct(1) = -10,0841
  p-τιμή 1,403e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for SHIRE, Bartlett bandwidth 14:

Z_t = -10,0255 (p-value = 0,0000)

Test regression (OLS, dependent variable SHIRE, T = 95):

              συντελεστής   τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const        0,0113818    0,00829122     1,373    0,1698
  SHIRE(-1)   -0,0384780    0,103602      -0,3714   0,7103

Sample variance of residual       0,00639254
Estimated long-run error variance 0,00709668
```

BARCLAYS

```
Augmented Dickey-Fuller test for BARCLAYS
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 90
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)BARCLAYS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14154
  στατιστική ελέγχου: tau_c(1) = -5,05491
  ασυμπτωτική p-τιμή 1,574e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,008
  υστερήσεις πρώτων διαφορών: F(5, 83) = 1,889 [0,1050]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 5 υστερήσεων για (1-L)BARCLAYS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14367
  στατιστική ελέγχου: tau_ct(1) = -5,02792
  ασυμπτωτική p-τιμή 0,0001594
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,008
  υστερήσεις πρώτων διαφορών: F(5, 82) = 1,873 [0,1080]
```

```
Phillips-Perron unit-root test for BARCLAYS, Bartlett bandwidth 14:

Z_t = -8,52962 (p-value = 0,0000)

Test regression (OLS, dependent variable BARCLAYS, T = 95):

                 συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const          -0,00414928   0,00913668    -0,4541   0,6497
  BARCLAYS(-1)    0,120079     0,102910       1,167    0,2433

Sample variance of residual       0,00790737
Estimated long-run error variance 0,00475116
```

BLT

```
Augmented Dickey-Fuller test for BLT
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BLT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02472
  στατιστική ελέγχου: tau_c(1) = -9,96617
  p-τιμή 1,164e-007
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BLT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02975
  στατιστική ελέγχου: tau_ct(1) = -9,98824
  p-τιμή 1,918e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
Phillips-Perron unit-root test for BLT, Bartlett bandwidth 14:

Z_t = -9,99382 (p-value = 0,0000)

Test regression (OLS, dependent variable BLT, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const      -0,00390099   0,00905973    -0,4306   0,6668
  BLT(-1)    -0,0247231    0,102820      -0,2404   0,8100

Sample variance of residual       0,00778797
Estimated long-run error variance 0,00689664
```

RBS

```
Augmented Dickey-Fuller test for RBS
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 81
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 14 υστερήσεων για (1-L)RBS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,5082
  στατιστική ελέγχου: tau_c(1) = -4,28587
  ασυμπτωτική p-τιμή 0,000465
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,018
  υστερήσεις πρώτων διαφορών: F(14, 65) = 2,830 [0,0023]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 14 υστερήσεων για (1-L)RBS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,49519
  στατιστική ελέγχου: tau_ct(1) = -4,23543
  ασυμπτωτική p-τιμή 0,003888
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,023
  υστερήσεις πρώτων διαφορών: F(14, 64) = 2,777 [0,0028]
```

```
Phillips-Perron unit-root test for RBS, Bartlett bandwidth 14:

Z_t = -9,38673 (p-value = 0,0000)

Test regression (OLS, dependent variable RBS, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const      -0,00518169   0,00906631    -0,5715   0,5676
  RBS(-1)     0,0401923    0,102224       0,3932   0,6942

Sample variance of residual       0,00776137
Estimated long-run error variance 0,0072663
```

NG

```
Augmented Dickey-Fuller test for NG
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,17574
  στατιστική ελέγχου: tau_c(1) = -11,5187
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,19792
  στατιστική ελέγχου: tau_ct(1) = -11,7223
  p-τιμή 1,626e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,014
```

```
Phillips-Perron unit-root test for NG, Bartlett bandwidth 14:

Z_t = -11,7877 (p-value = 0,0001)

Test regression (OLS, dependent variable NG, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,00395479   0,00446823     0,8851   0,3761
  NG(-1)     -0,175735     0,102072      -1,722    0,0851 *

Sample variance of residual       0,00188361
Estimated long-run error variance 0,0014918
```

RELX

```
Augmented Dickey-Fuller test for RELX
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RELX
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0992
  στατιστική ελέγχου: tau_c(1) = -10,4187
  p-τιμή 7,714e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,023

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RELX
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0988
  στατιστική ελέγχου: tau_ct(1) = -10,3698
  p-τιμή 5,704e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,024
```

```
Phillips-Perron unit-root test for RELX, Bartlett bandwidth 14:

Z_t = -10,6101 (p-value = 0,0000)

Test regression (OLS, dependent variable RELX, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,0120087    0,00544091     2,207    0,0273 **
  RELX(-1)   -0,0992001    0,105502      -0,9403   0,3471

Sample variance of residual       0,00267038
Estimated long-run error variance 0,00193978
```

BTA

```
Augmented Dickey-Fuller test for BTA
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 92
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)BTA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,817369
  στατιστική ελέγχου: tau_c(1) = -3,60442
  ασυμπτωτική p-τιμή 0,005706
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,015
  υστερήσεις πρώτων διαφορών: F(3, 87) = 2,393 [0,0739]
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)BTA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,41523
  στατιστική ελέγχου: tau_ct(1) = -8,30085
  ασυμπτωτική p-τιμή 1,887e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,005
```

```
Phillips-Perron unit-root test for BTA, Bartlett bandwidth 14:

Z_t = -12,1794 (p-value = 0,0001)

Test regression (OLS, dependent variable BTA, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00456769   0,00636545     0,7176   0,4730
  BTA(-1)    -0,229250     0,0987693     -2,321    0,0203 **

Sample variance of residual       0,00383116
Estimated long-run error variance 0,00857104
```

AAL

```
Augmented Dickey-Fuller test for AAL
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AAL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,71738
  στατιστική ελέγχου: tau_c(1) = -7,219
  p-τιμή 3,218e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,023

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AAL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,726833
  στατιστική ελέγχου: tau_ct(1) = -7,28173
  p-τιμή 5,794e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,023
```

```
Phillips-Perron unit-root test for AAL, Bartlett bandwidth 14:

Z_t = -6,97155 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable AAL, T = 95):

            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const      -0,00482699    0,0128873    -0,3746   0,7080
  AAL(-1)     0,282620      0,0993738     2,844    0,0045 ***

Sample variance of residual       0,0157375
Estimated long-run error variance 0,0112065
```

IMB

```
Augmented Dickey-Fuller test for IMB
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IMB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,25899
  στατιστική ελέγχου: tau_c(1) = -12,6074
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,038

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)IMB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,28118
  στατιστική ελέγχου: tau_ct(1) = -12,802
  p-τιμή 2,473e-015
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,034
```

```
Phillips-Perron unit-root test for IMB, Bartlett bandwidth 14:

Z_t = -12,2264 (p-value = 0,0001)

Test regression (OLS, dependent variable IMB, T = 95):

            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00392970   0,00541817     0,7253   0,4683
  IMB(-1)    -0,258988     0,0998611     -2,593    0,0095 ***

Sample variance of residual       0,0027785
Estimated long-run error variance 0,00392162
```

TESCO

```
Augmented Dickey-Fuller test for TESCO
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TESCO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,973912
  στατιστική ελέγχου: tau_c(1) = -9,38018
  p-τιμή 1,999e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TESCO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,979753
  στατιστική ελέγχου: tau_ct(1) = -9,36187
  p-τιμή 1,657e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005
```

```
Phillips-Perron unit-root test for TESCO, Bartlett bandwidth 14:

Z_t = -9,65646 (p-value = 0,0000)

Test regression (OLS, dependent variable TESCO, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       -0,00650312   0,00850745    -0,7644   0,4446
  TESCO(-1)    0,0260885    0,103827       0,2513   0,8016

Sample variance of residual       0,00683234
Estimated long-run error variance 0,00377528
```

CPG

```
Augmented Dickey-Fuller test for CPG
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CPG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,12057
  στατιστική ελέγχου: tau_c(1) = -10,8125
  p-τιμή 5,468e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CPG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,12457
  στατιστική ελέγχου: tau_ct(1) = -10,8047
  p-τιμή 1,592e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
```

```
Phillips-Perron unit-root test for CPG, Bartlett bandwidth 14:

Z_t = -11,9538 (p-value = 0,0001)

Test regression (OLS, dependent variable CPG, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,0124620    0,00460415     2,707   0,0068 ***
  CPG(-1)    -0,120567     0,103636      -1,163   0,2447

Sample variance of residual       0,0018671
Estimated long-run error variance 0,000876336
```

STAN

```
Augmented Dickey-Fuller test for STAN
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 94
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)STAN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,868531
  στατιστική ελέγχου: tau_c(1) = -5,67986
  ασυμπτωτική p-τιμή 6,786e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,034

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)STAN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,868027
  στατιστική ελέγχου: tau_ct(1) = -5,64109
  ασυμπτωτική p-τιμή 8,095e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,035
```

```
Phillips-Perron unit-root test for STAN, Bartlett bandwidth 14:

Z_t = -10,4824 (p-value = 0,0000)

Test regression (OLS, dependent variable STAN, T = 95):
```

```
            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const      -0,0130053   0,00864683    -1,504    0,1326
  STAN(-1)   -0,0869931   0,103403      -0,8413   0,4002

Sample variance of residual       0,00698527
Estimated long-run error variance 0,00787317
```

ABF

```
Augmented Dickey-Fuller test for ABF
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ABF
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08917
  στατιστική ελέγχου: tau_c(1) = -10,5615
  p-τιμή 1,523e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ABF
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11995
  στατιστική ελέγχου: tau_ct(1) = -10,8013
  p-τιμή 1,607e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007
```

```
Phillips-Perron unit-root test for ABF, Bartlett bandwidth 14:

Z_t = -10,5259 (p-value = 0,0000)

Test regression (OLS, dependent variable ABF, T = 95):

            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,00851413  0,00712060     1,196    0,2318
  ABF(-1)    -0,0891737   0,103127      -0,8647   0,3872

Sample variance of residual       0,0047522
Estimated long-run error variance 0,00555271
```

CRH

```
Augmented Dickey-Fuller test for CRH
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CRH
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06132
  στατιστική ελέγχου: tau_c(1) = -10,1818
  p-τιμή 2,717e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CRH
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06209
  στατιστική ελέγχου: tau_ct(1) = -10,1393
  p-τιμή 1,175e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for CRH, Bartlett bandwidth 14:

Z_t = -10,8062 (p-value = 0,0000)

Test regression (OLS, dependent variable CRH, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,00807612   0,00724046     1,115    0,2647
  CRH(-1)    -0,0613200    0,104237      -0,5883   0,5563

Sample variance of residual       0,00490289
Estimated long-run error variance 0,00256731
```

AV

```
Augmented Dickey-Fuller test for AV
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11616
  στατιστική ελέγχου: tau_c(1) = -10,7546
  p-τιμή 4,038e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11612
  στατιστική ελέγχου: tau_ct(1) = -10,6977
  p-τιμή 2,156e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for AV, Bartlett bandwidth 14:

Z_t = -10,8928 (p-value = 0,0000)

Test regression (OLS, dependent variable AV, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,00111236   0,00746056     0,1491   0,8815
  AV(-1)     -0,116163     0,103785      -1,119    0,2630

Sample variance of residual       0,00528405
Estimated long-run error variance 0,00430114
```

RR

```
Augmented Dickey-Fuller test for RR
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RR
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03465
  στατιστική ελέγχου: tau_c(1) = -9,86532
  p-τιμή 8,11e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RR
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03825
  στατιστική ελέγχου: tau_ct(1) = -9,86822
  p-τιμή 2,855e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,007
```

```
Phillips-Perron unit-root test for RR, Bartlett bandwidth 14:

Z_t = -9,89849 (p-value = 0,0000)

Test regression (OLS, dependent variable RR, T = 95):
```

```
            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,00608062   0,00801262     0,7589   0,4479
  RR(-1)     -0,0346469    0,104877      -0,3304   0,7411

Sample variance of residual       0,00605084
Estimated long-run error variance 0,00503515
```

BA

```
Augmented Dickey-Fuller test for BA
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,13782
  στατιστική ελέγχου: tau_c(1) = -10,9896
  p-τιμή 1,421e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,017

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,1391
  στατιστική ελέγχου: tau_ct(1) = -10,9349
  p-τιμή 1,112e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,016
```

```
Phillips-Perron unit-root test for BA, Bartlett bandwidth 14:

Z_t = -11,2823 (p-value = 0,0001)

Test regression (OLS, dependent variable BA, T = 95):

            συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,00602830   0,00576872     1,045   0,2960
  BA(-1)     -0,137820     0,103536      -1,331   0,1831

Sample variance of residual       0,00312658
Estimated long-run error variance 0,00230002
```

LSE

```
Augmented Dickey-Fuller test for LSE
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)LSE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,17439
  στατιστική ελέγχου: tau_c(1) = -11,1495
  p-τιμή 3,463e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,030

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)LSE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,17567
  στατιστική ελέγχου: tau_ct(1) = -11,1166
  p-τιμή 6,867e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,028
```

```
Phillips-Perron unit-root test for LSE, Bartlett bandwidth 14:

Z_t = -12,3977 (p-value = 0,0001)

Test regression (OLS, dependent variable LSE, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,0226092    0,00732850     3,085   0,0020 ***
  LSE(-1)    -0,174393     0,105331      -1,656   0,0978 *

Sample variance of residual       0,00462504
Estimated long-run error variance 0,00215743
```

EXPN

```
Augmented Dickey-Fuller test for AXPN
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AXPN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,12641
  στατιστική ελέγχου: tau_c(1) = -10,6816
  p-τιμή 2,774e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,008
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AXPN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,12644
  στατιστική ελέγχου: tau_ct(1) = -10,6291
  p-τιμή 2,628e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007
```

```
Phillips-Perron unit-root test for AXPN, Bartlett bandwidth 14:

Z_t = -11,4391 (p-value = 0,0001)

Test regression (OLS, dependent variable AXPN, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,0106579    0,00573308     1,859   0,0630 *
  AXPN(-1)   -0,126414     0,105453      -1,199   0,2306

Sample variance of residual       0,00299645
Estimated long-run error variance 0,00157973
```

LGEN

```
Augmented Dickey-Fuller test for LGEN
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)LGEN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,238
  στατιστική ελέγχου: tau_c(1) = -12,3198
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,026

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)LGEN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,25189
  στατιστική ελέγχου: tau_ct(1) = -12,4718
  p-τιμή 3,991e-015
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,037
```

```
Phillips-Perron unit-root test for LGEN, Bartlett bandwidth 14:

Z_t = -12,2656 (p-value = 0,0001)

Test regression (OLS, dependent variable LGEN, T = 95):
```

```
            συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,0117739    0,00662174     1,778   0,0754 *
  LGEN(-1)   -0,238004     0,100489      -2,368   0,0179 **

Sample variance of residual       0,00408178
Estimated long-run error variance 0,00415653
```

FERG

```
Augmented Dickey-Fuller test for FERG
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)FERG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,03594
  στατιστική ελέγχου: tau_c(1) = -9,85706
  p-τιμή 7,882e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)FERG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04004
  στατιστική ελέγχου: tau_ct(1) = -9,85162
  p-τιμή 3,018e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
```

```
Phillips-Perron unit-root test for FERG, Bartlett bandwidth 14:

Z_t = -10,7158 (p-value = 0,0000)

Test regression (OLS, dependent variable FERG, T = 95):

            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,0121506    0,00657298     1,849    0,0645 *
  FERG(-1)   -0,0359381    0,105096      -0,3420   0,7324

Sample variance of residual       0,00389534
Estimated long-run error variance 0,00165744
```

SSE

```
Augmented Dickey-Fuller test for SSE
testing down from 14 lags, criterion AIC
```

```
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SSE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,20453
  στατιστική ελέγχου: tau_c(1) = -11,5175
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)SSE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -2,15646
  στατιστική ελέγχου: tau_ct(1) = -5,33622
  ασυμπτωτική p-τιμή 3,761e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,034
  υστερήσεις πρώτων διαφορών: F(6, 80) = 2,688 [0,0198]
```

```
Phillips-Perron unit-root test for SSE, Bartlett bandwidth 14:

Z_t = -12,0218 (p-value = 0,0001)

Test regression (OLS, dependent variable SSE, T = 95):

             συντελεστής    τυπ. σφάλμα       z       p-τιμή
  ---------------------------------------------------------
  const       2,84045e-05   0,00472505     0,006011   0,9952
  SSE(-1)    -0,204530      0,104582      -1,956      0,0505 *

Sample variance of residual       0,00211994
Estimated long-run error variance 0,00143896
```

WPP

```
Augmented Dickey-Fuller test for WPP
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WPP
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01057
  στατιστική ελέγχου: tau_c(1) = -9,63578
  p-τιμή 3,895e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,005

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WPP
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04097
  στατιστική ελέγχου: tau_ct(1) = -9,90696
```

```
  p-τιμή 2,509e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for WPP, Bartlett bandwidth 14:

Z_t = -9,69005 (p-value = 0,0000)

Test regression (OLS, dependent variable WPP, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,00400310   0,00610867     0,6553   0,5123
  WPP(-1)    -0,0105702    0,104877      -0,1008   0,9197

Sample variance of residual       0,0035154
Estimated long-run error variance 0,00408334
```

IAG

```
Augmented Dickey-Fuller test for IAG
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 89
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)IAG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,739631
  στατιστική ελέγχου: tau_c(1) = -3,82343
  ασυμπτωτική p-τιμή 0,002688
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,036
  υστερήσεις πρώτων διαφορών: F(2, 85) = 4,171 [0,0187]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)IAG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,738334
  στατιστική ελέγχου: tau_ct(1) = -3,78676
  ασυμπτωτική p-τιμή 0,01715
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,036
  υστερήσεις πρώτων διαφορών: F(2, 84) = 4,124 [0,0196]
```

```
Phillips-Perron unit-root test for IAG, Bartlett bandwidth 14:

Z_t = -11,3478 (p-value = 0,0001)

Test regression (OLS, dependent variable IAG, T = 91):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
```

```
  const       0,0123062     0,0102990     1,195   0,2321
  IAG(-1)    -0,208258      0,104654     -1,990   0,0466 **

Sample variance of residual       0,00953539
Estimated long-run error variance 0,0133759
```

SN

```
Augmented Dickey-Fuller test for SN
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 92
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)SN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,52828
  στατιστική ελέγχου: tau_c(1) = -5,98416
  ασυμπτωτική p-τιμή 1,308e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,006
  υστερήσεις πρώτων διαφορών: F(3, 87) = 1,629 [0,1886]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)SN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,52711
  στατιστική ελέγχου: tau_ct(1) = -5,94293
  ασυμπτωτική p-τιμή 1,595e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,006
  υστερήσεις πρώτων διαφορών: F(3, 86) = 1,608 [0,1934]
```

```
Phillips-Perron unit-root test for SN, Bartlett bandwidth 14:

Z_t = -13,5455 (p-value = 0,0001)

Test regression (OLS, dependent variable SN, T = 95):

            συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,0107273    0,00563206     1,905   0,0568 *
  SN(-1)     -0,262345     0,101196      -2,592   0,0095 ***

Sample variance of residual       0,00292887
Estimated long-run error variance 0,00177867
```

MRO

```
Augmented Dickey-Fuller test for MRO
```

```
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 94
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)MRO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,768481
  στατιστική ελέγχου: tau_c(1) = -5,11924
  ασυμπτωτική p-τιμή 1,157e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,022

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)MRO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,76606
  στατιστική ελέγχου: tau_ct(1) = -5,05702
  ασυμπτωτική p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,022
```

```
Phillips-Perron unit-root test for MRO, Bartlett bandwidth 14:

Z_t = -9,51669 (p-value = 0,0000)

Test regression (OLS, dependent variable MRO, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,0170301    0,00919011    1,853    0,0639 *
  MRO(-1)     0,0522759    0,109115      0,4791   0,6319

Sample variance of residual       0,00754179
Estimated long-run error variance 0,0131953
```

NEXT

```
Augmented Dickey-Fuller test for NEXT
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NEXT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,07944
  στατιστική ελέγχου: tau_c(1) = -10,4618
  p-τιμή 9,434e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,005

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NEXT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,10495
  στατιστική ελέγχου: tau_ct(1) = -10,7231
```

```
  p-τιμή 2,005e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,015
```

```
Phillips-Perron unit-root test for NEXT, Bartlett bandwidth 14:

Z_t = -10,7207 (p-value = 0,0000)

Test regression (OLS, dependent variable NEXT, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,0102566    0,00691460     1,483    0,1380
  NEXT(-1)   -0,0794407    0,103179      -0,7699   0,4413

Sample variance of residual       0,00445367
Estimated long-run error variance 0,00805693
```

AHT

```
Augmented Dickey-Fuller test for AHT
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AHT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,894715
  στατιστική ελέγχου: tau_c(1) = -8,50837
  p-τιμή 6,889e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,030

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)AHT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,90964
  στατιστική ελέγχου: tau_ct(1) = -8,60805
  p-τιμή 2,784e-010
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,022
```

```
Phillips-Perron unit-root test for AHT, Bartlett bandwidth 14:

Z_t = -8,39925 (p-value = 0,0000)

Test regression (OLS, dependent variable AHT, T = 95):

             συντελεστής   τυπ. σφάλμα     z     p-τιμή
  -----------------------------------------------------
  const       0,0249909     0,0101846    2,454   0,0141 **
  AHT(-1)     0,105285      0,105157     1,001   0,3167
```

```
Sample variance of residual       0,00876947
Estimated long-run error variance 0,00652626
```

BRBY

```
Augmented Dickey-Fuller test for BRBY
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BRBY
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,18655
  στατιστική ελέγχου: tau_c(1) = -11,3283
  p-τιμή 9,599e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,009

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BRBY
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,18631
  στατιστική ελέγχου: tau_ct(1) = -11,2759
  p-τιμή 4,584e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,010
```

```
Phillips-Perron unit-root test for BRBY, Bartlett bandwidth 14:

Z_t = -11,9658 (p-value = 0,0001)

Test regression (OLS, dependent variable BRBY, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,00712767   0,00839045     0,8495   0,3956
  BRBY(-1)   -0,186547     0,104742      -1,781    0,0749 *

Sample variance of residual       0,00663194
Estimated long-run error variance 0,00411336
```

COCA COLA

```
Augmented Dickey-Fuller test for COCACOLA
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 64
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1
```

```
  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)COCACOLA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,032
  στατιστική ελέγχου: tau_c(1) = -8,08216
  p-τιμή 1,73e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,010

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)COCACOLA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,50832
  στατιστική ελέγχου: tau_ct(1) = -4,99444
  ασυμπτωτική p-τιμή 0,0001853
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,032
  υστερήσεις πρώτων διαφορών: F(3, 55) = 1,513 [0,2214]
```

```
Phillips-Perron unit-root test for COCACOLA, Bartlett bandwidth 14:

Z_t = -8,08223 (p-value = 0,0000)

Test regression (OLS, dependent variable COCACOLA, T = 64):

                 συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const           0,00573094   0,00901543     0,6357   0,5250
  COCACOLA(-1)   -0,0319955    0,127688      -0,2506   0,8021

Sample variance of residual       0,00516587
Estimated long-run error variance 0,00498821
```

INF

```
Augmented Dickey-Fuller test for INF
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 92
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)INF
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,54256
  στατιστική ελέγχου: tau_c(1) = -6,28746
  ασυμπτωτική p-τιμή 2,364e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,033
  υστερήσεις πρώτων διαφορών: F(3, 87) = 1,870 [0,1406]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 3 υστερήσεων για (1-L)INF
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,58053
  στατιστική ελέγχου: tau_ct(1) = -6,33221
  ασυμπτωτική p-τιμή 1,694e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,035
```

```
  υστερήσεις πρώτων διαφορών: F(3, 86) = 2,040 [0,1143]
```

```
Phillips-Perron unit-root test for INF, Bartlett bandwidth 14:

Z_t = -10,644 (p-value = 0,0000)

Test regression (OLS, dependent variable INF, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       0,00638359   0,00610532     1,046    0,2958
  INF(-1)    -0,0386193    0,104002      -0,3713   0,7104

Sample variance of residual       0,00349317
Estimated long-run error variance 0,00173106
```

SBRY

```
Augmented Dickey-Fuller test for SBRY
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SBRY
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,1656
  στατιστική ελέγχου: tau_c(1) = -11,4069
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,007

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SBRY
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,17492
  στατιστική ελέγχου: tau_ct(1) = -11,4293
  p-τιμή 3,159e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,006
```

```
Phillips-Perron unit-root test for SBRY, Bartlett bandwidth 14:

Z_t = -11,5404 (p-value = 0,0001)

Test regression (OLS, dependent variable SBRY, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const      -0,00235307   0,00680996    -0,3455   0,7297
  SBRY(-1)   -0,165603     0,102184      -1,621    0,1051
```

```
Sample variance of residual       0,00440137
Estimated long-run error variance 0,00380682
```

WTB

```
Augmented Dickey-Fuller test for WTB
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WTB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,12875
  στατιστική ελέγχου: tau_c(1) = -10,9816
  p-τιμή 1,359e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,000

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WTB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,13501
  στατιστική ελέγχου: tau_ct(1) = -10,9911
  p-τιμή 9,557e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for WTB, Bartlett bandwidth 14:

Z_t = -10,9982 (p-value = 0,0000)

Test regression (OLS, dependent variable WTB, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,0113736    0,00611812     1,859   0,0630 *
  WTB(-1)    -0,128753     0,102786      -1,253   0,2103

Sample variance of residual       0,00344135
Estimated long-run error variance 0,00559453
```

ANTO

```
Augmented Dickey-Fuller test for ANTO
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
```

```
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ANTO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11515
  στατιστική ελέγχου: tau_c(1) = -10,9565
  p-τιμή 1,185e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ANTO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11834
  στατιστική ελέγχου: tau_ct(1) = -10,9567
  p-τιμή 1,048e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
Phillips-Perron unit-root test for ANTO, Bartlett bandwidth 14:

Z_t = -10,9224 (p-value = 0,0000)

Test regression (OLS, dependent variable ANTO, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const      -0,00750040    0,0102291    -0,7332   0,4634
  ANTO(-1)   -0,115149      0,101780     -1,131    0,2579

Sample variance of residual       0,00990873
Estimated long-run error variance 0,0102475
```

BUNZL

```
Augmented Dickey-Fuller test for BUNZL
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BUNZL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,17405
  στατιστική ελέγχου: tau_c(1) = -11,3606
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BUNZL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,18314
  στατιστική ελέγχου: tau_ct(1) = -11,4735
  p-τιμή 2,847e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,011
```

```
Phillips-Perron unit-root test for BUNZL, Bartlett bandwidth 14:

Z_t = -12,0264 (p-value = 0,0001)

Test regression (OLS, dependent variable BUNZL, T = 95):

              συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ----------------------------------------------------------
  const        0,0138011    0,00541865     2,547   0,0109 **
  BUNZL(-1)   -0,174048     0,103344      -1,684   0,0921 *

Sample variance of residual       0,0026418
Estimated long-run error variance 0,00164648
```

CENTRICA

```
Augmented Dickey-Fuller test for CENTRICA
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CENTRICA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,2331
  στατιστική ελέγχου: tau_c(1) = -12,2353
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CENTRICA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,24207
  στατιστική ελέγχου: tau_ct(1) = -12,2814
  p-τιμή 5,472e-015
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,010
```

```
Phillips-Perron unit-root test for CENTRICA, Bartlett bandwidth 14:

Z_t = -12,6016 (p-value = 0,0001)

Test regression (OLS, dependent variable CENTRICA, T = 95):

                 συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ----------------------------------------------------------
  const          -0,0106416    0,00682215    -1,560   0,1188
  CENTRICA(-1)   -0,233100     0,100782      -2,313   0,0207 **

Sample variance of residual       0,00435415
Estimated long-run error variance 0,00344114
```

EVRAZ

```
Augmented Dickey-Fuller test for EVRAZ
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 82
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)EVRAZ
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,879693
  στατιστική ελέγχου: tau_c(1) = -7,91063
  p-τιμή 3,816e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)EVRAZ
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,921635
  στατιστική ελέγχου: tau_ct(1) = -8,22019
  p-τιμή 2,747e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
Phillips-Perron unit-root test for EVRAZ, Bartlett bandwidth 14:

Z_t = -7,91203 (p-value = 0,0000)

Test regression (OLS, dependent variable EVRAZ, T = 82):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,00363965     0,0186334    0,1953   0,8451
  EVRAZ(-1)   0,120307       0,111204     1,082    0,2793

Sample variance of residual       0,0284633
Estimated long-run error variance 0,0278397
```

HL

```
Augmented Dickey-Fuller test for HL
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)HL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06664
  στατιστική ελέγχου: tau_c(1) = -10,0643
  p-τιμή 1,69e-007
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,008

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)HL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06665
  στατιστική ελέγχου: tau_ct(1) = -10,0132
  p-τιμή 1,767e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007
```

```
Phillips-Perron unit-root test for HL, Bartlett bandwidth 14:

Z_t = -10,1124 (p-value = 0,0000)

Test regression (OLS, dependent variable HL, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,0150202    0,00857465     1,752    0,0798 *
  HL(-1)     -0,0666396    0,105983      -0,6288   0,5295

Sample variance of residual       0,00668429
Estimated long-run error variance 0,00548664
```

IHG

```
Augmented Dickey-Fuller test for IHG
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 91
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)IHG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11397
  στατιστική ελέγχου: tau_c(1) = -3,75287
  ασυμπτωτική p-τιμή 0,003445
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,017
  υστερήσεις πρώτων διαφορών: F(4, 85) = 2,081 [0,0904]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)IHG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,42483
  στατιστική ελέγχου: tau_ct(1) = -7,33088
  ασυμπτωτική p-τιμή 2,597e-010
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
  υστερήσεις πρώτων διαφορών: F(2, 88) = 2,960 [0,0570]
```

```
Phillips-Perron unit-root test for IHG, Bartlett bandwidth 14:
```

```
Z_t = -11,4755 (p-value = 0,0001)

Test regression (OLS, dependent variable IHG, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ------------------------------------------------------
  const       0,0152677    0,00705287     2,165    0,0304 **
  IHG(-1)    -0,0897206    0,104205      -0,8610   0,3892

Sample variance of residual       0,00451096
Estimated long-run error variance 0,00206877
```

ITRK

```
Augmented Dickey-Fuller test for ITRK
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ITRK
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,23772
  στατιστική ελέγχου: tau_c(1) = -11,9946
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,036

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ITRK
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,23751
  στατιστική ελέγχου: tau_ct(1) = -11,9306
  p-τιμή 1,054e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,036
```

```
Phillips-Perron unit-root test for ITRK, Bartlett bandwidth 14:

Z_t = -11,7738 (p-value = 0,0001)

Test regression (OLS, dependent variable ITRK, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,0114647    0,00652419     1,757   0,0789 *
  ITRK(-1)   -0,237716     0,103189      -2,304   0,0212 **

Sample variance of residual       0,00393153
Estimated long-run error variance 0,00553483
```

MRW

```
Augmented Dickey-Fuller test for MRW
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MRW
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04792
  στατιστική ελέγχου: tau_c(1) = -10,157
  p-τιμή 2,452e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,005

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MRW
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,05675
  στατιστική ελέγχου: tau_ct(1) = -10,1469
  p-τιμή 1,147e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
```

```
Phillips-Perron unit-root test for MRW, Bartlett bandwidth 14:

Z_t = -10,2052 (p-value = 0,0000)

Test regression (OLS, dependent variable MRW, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const      -0,00113543   0,00638132    -0,1779   0,8588
  MRW(-1)    -0,0479167    0,103171      -0,4644   0,6423

Sample variance of residual       0,00386691
Estimated long-run error variance 0,00334312
```

NMC

```
Augmented Dickey-Fuller test for NMC
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 77
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NMC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08881
  στατιστική ελέγχου: tau_c(1) = -9,31519
  p-τιμή 9,193e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,008
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)NMC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08885
  στατιστική ελέγχου: tau_ct(1) = -9,23294
  p-τιμή 4,367e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,008
```

```
Phillips-Perron unit-root test for NMC, Bartlett bandwidth 14:

Z_t = -10,0966 (p-value = 0,0000)

Test regression (OLS, dependent variable NMC, T = 77):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,0387705     0,0119498     3,244    0,0012 ***
  NMC(-1)    -0,0888129     0,116886     -0,7598   0,4474

Sample variance of residual       0,00959338
Estimated long-run error variance 0,00452019
```

PSN

```
Augmented Dickey-Fuller test for PSN
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)PSN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06595
  στατιστική ελέγχου: tau_c(1) = -10,2366
  p-τιμή 3,423e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,013

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)PSN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,09449
  στατιστική ελέγχου: tau_ct(1) = -10,5547
  p-τιμή 3,269e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,011
```

```
Phillips-Perron unit-root test for PSN, Bartlett bandwidth 14:

Z_t = -10,2355 (p-value = 0,0000)

Test regression (OLS, dependent variable PSN, T = 95):
```

```
            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,0222090    0,00789824     2,812    0,0049 ***
  PSN(-1)    -0,0659481    0,104131      -0,6333   0,5265

Sample variance of residual       0,00546351
Estimated long-run error variance 0,00537519
```

SLA

```
Augmented Dickey-Fuller test for SLA
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SLA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,18267
  στατιστική ελέγχου: tau_c(1) = -11,377
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SLA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,20085
  στατιστική ελέγχου: tau_ct(1) = -11,5948
  p-τιμή 2,155e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,014
```

```
Phillips-Perron unit-root test for SLA, Bartlett bandwidth 14:

Z_t = -11,2951 (p-value = 0,0001)

Test regression (OLS, dependent variable SLA, T = 95):

            συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,00251312   0,00689753     0,3644   0,7156
  SLA(-1)    -0,182673     0,103953      -1,757    0,0789 *

Sample variance of residual       0,00451047
Estimated long-run error variance 0,00682235
```

BLND

```
Augmented Dickey-Fuller test for BLND
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BLND
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,13959
  στατιστική ελέγχου: tau_c(1) = -10,9781
  p-τιμή 1,333e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,012

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)BLND
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,25838
  στατιστική ελέγχου: tau_ct(1) = -7,76903
  ασυμπτωτική p-τιμή 1,106e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,007
```

```
Phillips-Perron unit-root test for BLND, Bartlett bandwidth 14:

Z_t = -10,9577 (p-value = 0,0000)

Test regression (OLS, dependent variable BLND, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00165420   0,00514385     0,3216   0,7478
  BLND(-1)   -0,139593     0,103806      -1,345    0,1787

Sample variance of residual       0,00250718
Estimated long-run error variance 0,00254547
```

CCL

```
Augmented Dickey-Fuller test for CCL
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CCL
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,2529
  στατιστική ελέγχου: tau_c(1) = -12,4225
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,021
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CCL
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,25813
  στατιστική ελέγχου: tau_ct(1) = -12,4145
  p-τιμή 4,375e-015
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,025
```

```
Phillips-Perron unit-root test for CCL, Bartlett bandwidth 14:

Z_t = -12,6791 (p-value = 0,0001)

Test regression (OLS, dependent variable CCL, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00653524   0,00790167     0,8271   0,4082
  CCL(-1)    -0,252898     0,100857      -2,507    0,0122 **

Sample variance of residual       0,00589464
Estimated long-run error variance 0,00496493
```

CRDA

```
Augmented Dickey-Fuller test for CRDA
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CRDA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,17822
  στατιστική ελέγχου: tau_c(1) = -11,3101
  p-τιμή 8,65e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)CRDA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,17774
  στατιστική ελέγχου: tau_ct(1) = -11,2522
  p-τιμή 4,863e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for CRDA, Bartlett bandwidth 14:

Z_t = -12,5466 (p-value = 0,0001)

Test regression (OLS, dependent variable CRDA, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
```

```
  ----------------------------------------------------
  const       0,0138305    0,00625668     2,211   0,0271 **
  CRDA(-1)   -0,178218     0,104174      -1,711   0,0871 *

Sample variance of residual       0,00355937
Estimated long-run error variance 0,00173386
```

DCC

```
Augmented Dickey-Fuller test for DCC
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)DCC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,09132
  στατιστική ελέγχου: tau_c(1) = -10,3534
  p-τιμή 5,721e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)DCC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,16757
  στατιστική ελέγχου: tau_ct(1) = -7,33168
  ασυμπτωτική p-τιμή 2,582e-010
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
```

```
Phillips-Perron unit-root test for DCC, Bartlett bandwidth 14:

Z_t = -10,362 (p-value = 0,0000)

Test regression (OLS, dependent variable DCC, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,0142397    0,00665433     2,140    0,0324 **
  DCC(-1)    -0,0913190    0,105407      -0,8663   0,3863

Sample variance of residual       0,0039959
Estimated long-run error variance 0,00480108
```

JMAT

```
Augmented Dickey-Fuller test for JMAT
testing down from 14 lags, criterion AIC
```

```
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)JMAT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01717
  στατιστική ελέγχου: tau_c(1) = -9,61171
  p-τιμή 3,634e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)JMAT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01945
  στατιστική ελέγχου: tau_ct(1) = -9,59442
  p-τιμή 7,276e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,004
```

```
Phillips-Perron unit-root test for JMAT, Bartlett bandwidth 14:

Z_t = -10,372 (p-value = 0,0000)

Test regression (OLS, dependent variable JMAT, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00525183   0,00681198     0,7710   0,4407
  JMAT(-1)   -0,0171665    0,105826      -0,1622   0,8711

Sample variance of residual       0,00435809
Estimated long-run error variance 0,00179925
```

LAND

```
Augmented Dickey-Fuller test for LAND
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)LAND
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00817
  στατιστική ελέγχου: tau_c(1) = -9,61744
  p-τιμή 3,694e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)LAND
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,11187
  στατιστική ελέγχου: tau_ct(1) = -7,31217
  ασυμπτωτική p-τιμή 2,959e-010
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,011
```

```
Phillips-Perron unit-root test for LAND, Bartlett bandwidth 14:

Z_t = -9,61902 (p-value = 0,0000)

Test regression (OLS, dependent variable LAND, T = 95):

             συντελεστής   τυπ. σφάλμα      z       p-τιμή
  ---------------------------------------------------------
  const       0,00193144   0,00490773     0,3935    0,6939
  LAND(-1)   -0,00817089   0,104827      -0,07795   0,9379

Sample variance of residual       0,00227904
Estimated long-run error variance 0,00199861
```

MKS

```
Augmented Dickey-Fuller test for MKS
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MKS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06717
  στατιστική ελέγχου: tau_c(1) = -10,3273
  p-τιμή 5,09e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MKS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,07274
  στατιστική ελέγχου: tau_ct(1) = -10,3338
  p-τιμή 6,373e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,011
```

```
Phillips-Perron unit-root test for MKS, Bartlett bandwidth 14:

Z_t = -10,4077 (p-value = 0,0000)

Test regression (OLS, dependent variable MKS, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  --------------------------------------------------------
  const      -0,00333307   0,00657242    -0,5071   0,6121
  MKS(-1)    -0,0671676    0,103334      -0,6500   0,5157
```

```
Sample variance of residual       0,00409073
Estimated long-run error variance 0,00342145
```

MNDI

```
Augmented Dickey-Fuller test for MNDI
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MNDI
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08352
  στατιστική ελέγχου: tau_c(1) = -10,3014
  p-τιμή 4,537e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MNDI
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,08328
  στατιστική ελέγχου: tau_ct(1) = -10,2655
  p-τιμή 7,88e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for MNDI, Bartlett bandwidth 14:

Z_t = -10,6547 (p-value = 0,0000)

Test regression (OLS, dependent variable MNDI, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,0146720    0,00777147     1,888    0,0590 *
  MNDI(-1)   -0,0835163    0,105182      -0,7940   0,4272

Sample variance of residual       0,0055267
Estimated long-run error variance 0,00345659
```

OCDO

```
Augmented Dickey-Fuller test for OCDO
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 94
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
```

```
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)OCDO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,995856
  στατιστική ελέγχου: tau_c(1) = -6,87682
  ασυμπτωτική p-τιμή 7,087e-010
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)OCDO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,94688
  στατιστική ελέγχου: tau_ct(1) = -9,02294
  p-τιμή 5,737e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
```

```
Phillips-Perron unit-root test for OCDO, Bartlett bandwidth 14:

Z_t = -9,04637 (p-value = 0,0000)

Test regression (OLS, dependent variable OCDO, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,0174773     0,0204530    0,8545   0,3928
  OCDO(-1)    0,0557225     0,104245     0,5345   0,5930

Sample variance of residual       0,0392823
Estimated long-run error variance 0,0370978
```

SDR

```
Augmented Dickey-Fuller test for SDR
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 94
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)SDR
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,936089
  στατιστική ελέγχου: tau_c(1) = -6,21002
  ασυμπτωτική p-τιμή 3,682e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,030

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SDR
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0795
  στατιστική ελέγχου: tau_ct(1) = -10,4537
  p-τιμή 4,419e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
```

```
Phillips-Perron unit-root test for SDR, Bartlett bandwidth 14:

Z_t = -10,4466 (p-value = 0,0000)

Test regression (OLS, dependent variable SDR, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------------
  const       0,00655556   0,00655165     1,001    0,3170
  SDR(-1)    -0,0758767    0,102667      -0,7391   0,4599

Sample variance of residual       0,00402391
Estimated long-run error variance 0,00466285
```

SGRO

```
Augmented Dickey-Fuller test for SGRO
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 93
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)SGRO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,25249
  στατιστική ελέγχου: tau_c(1) = -5,94921
  ασυμπτωτική p-τιμή 1,586e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,004
  υστερήσεις πρώτων διαφορών: F(2, 89) = 0,178 [0,8369]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)SGRO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,33856
  στατιστική ελέγχου: tau_ct(1) = -6,11523
  ασυμπτωτική p-τιμή 6,034e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
  υστερήσεις πρώτων διαφορών: F(2, 88) = 0,432 [0,6503]
```

```
Phillips-Perron unit-root test for SGRO, Bartlett bandwidth 14:

Z_t = -11,0044 (p-value = 0,0000)

Test regression (OLS, dependent variable SGRO, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,00928823   0,00573722     1,619   0,1055
  SGRO(-1)   -0,150769     0,103833      -1,452   0,1465

Sample variance of residual       0,00304352
Estimated long-run error variance 0,00369847
```

SMDS

```
Augmented Dickey-Fuller test for SMDS
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMDS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,19755
  στατιστική ελέγχου: tau_c(1) = -11,5777
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,027

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMDS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,20602
  στατιστική ελέγχου: tau_ct(1) = -11,6331
  p-τιμή 1,977e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,023
```

```
Phillips-Perron unit-root test for SMDS, Bartlett bandwidth 14:

Z_t = -13,0455 (p-value = 0,0001)

Test regression (OLS, dependent variable SMDS, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,0166176    0,00845820     1,965   0,0495 **
  SMDS(-1)   -0,197548     0,103436      -1,910   0,0562 *

Sample variance of residual       0,00652766
Estimated long-run error variance 0,00308376
```

EZJ

```
Augmented Dickey-Fuller test for EZJ
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 94
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)EZJ
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,810913
  στατιστική ελέγχου: tau_c(1) = -5,40928
  ασυμπτωτική p-τιμή 2,757e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)EZJ
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00051
  στατιστική ελέγχου: tau_ct(1) = -9,44613
  p-τιμή 1,226e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,002
```

```
Phillips-Perron unit-root test for EZJ, Bartlett bandwidth 14:

Z_t = -9,77305 (p-value = 0,0000)

Test regression (OLS, dependent variable EZJ, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const      0,00970511    0,00986256    0,9840   0,3251
  EZJ(-1)    0,0111112     0,105714      0,1051   0,9163

Sample variance of residual       0,00909413
Estimated long-run error variance 0,0144564
```

FRES

```
Augmented Dickey-Fuller test for FRES
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)FRES
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0428
  στατιστική ελέγχου: tau_c(1) = -10,1435
  p-τιμή 2,319e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)FRES
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,04395
  στατιστική ελέγχου: tau_ct(1) = -10,0888
  p-τιμή 1,382e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,007
```

```
Phillips-Perron unit-root test for FRES, Bartlett bandwidth 14:

Z_t = -10,1686 (p-value = 0,0000)

Test regression (OLS, dependent variable FRES, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
```

```
  ------------------------------------------------------
  const      -0,00603295    0,0133015    -0,4536   0,6501
  FRES(-1)   -0,0428007     0,102805     -0,4163   0,6772

Sample variance of residual       0,016786
Estimated long-run error variance 0,0152471
```

GVC

```
Augmented Dickey-Fuller test for GVC
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)GVC
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,05075
  στατιστική ελέγχου: tau_c(1) = -9,83435
  p-τιμή 7,293e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)GVC
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,05098
  στατιστική ελέγχου: tau_ct(1) = -9,79848
  p-τιμή 3,61e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,010
```

```
Phillips-Perron unit-root test for GVC, Bartlett bandwidth 14:

Z_t = -9,88608 (p-value = 0,0000)

Test regression (OLS, dependent variable GVC, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ------------------------------------------------------
  const       0,0224156    0,00833118     2,691    0,0071 ***
  GVC(-1)    -0,0507534    0,106845      -0,4750   0,6348

Sample variance of residual       0,00602519
Estimated long-run error variance 0,00458531
```

HLMA

```
Augmented Dickey-Fuller test for HLMA
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 85
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 10 υστερήσεων για (1-L)HLMA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -2,41993
  στατιστική ελέγχου: tau_c(1) = -3,95077
  ασυμπτωτική p-τιμή 0,001697
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,030
  υστερήσεις πρώτων διαφορών: F(10, 73) = 1,449 [0,1764]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 10 υστερήσεων για (1-L)HLMA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -2,42492
  στατιστική ελέγχου: tau_ct(1) = -3,83328
  ασυμπτωτική p-τιμή 0,01486
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,030
  υστερήσεις πρώτων διαφορών: F(10, 72) = 1,399 [0,1981]
```

```
Phillips-Perron unit-root test for HLMA, Bartlett bandwidth 14:

Z_t = -13,8688 (p-value = 0,0001)

Test regression (OLS, dependent variable HLMA, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,0165789    0,00576458     2,876   0,0040 ***
  HLMA(-1)   -0,160072     0,104707      -1,529   0,1263

Sample variance of residual       0,00292544
Estimated long-run error variance 0,000873412
```

ITV

```
Augmented Dickey-Fuller test for ITV
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ITV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,899035
  στατιστική ελέγχου: tau_c(1) = -8,75064
  p-τιμή 7,69e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)ITV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,926605
  στατιστική ελέγχου: tau_ct(1) = -8,93331
  p-τιμή 8,029e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,004
```

```
Phillips-Perron unit-root test for ITV, Bartlett bandwidth 14:

Z_t = -8,8084 (p-value = 0,0000)

Test regression (OLS, dependent variable ITV, T = 95):

            συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      0,00752485    0,00795193    0,9463   0,3440
  ITV(-1)    0,100965      0,102739      0,9827   0,3257

Sample variance of residual       0,00591427
Estimated long-run error variance 0,00641278
```

JE

```
Augmented Dickey-Fuller test for JE
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 53
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)JE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,30148
  στατιστική ελέγχου: tau_c(1) = -9,57671
  p-τιμή 1,364e-010
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,015

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)JE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,32207
  στατιστική ελέγχου: tau_ct(1) = -9,82768
  p-τιμή 5,727e-010
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for JE, Bartlett bandwidth 14:

Z_t = -10,138 (p-value = 0,0000)

Test regression (OLS, dependent variable JE, T = 53):
```

```
            συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,0260985     0,0149227     1,749   0,0803 *
  JE(-1)     -0,301481      0,135901     -2,218   0,0265 **

Sample variance of residual       0,0113677
Estimated long-run error variance 0,00780989
```

KGF

```
Augmented Dickey-Fuller test for KGF
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)KGF
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,985292
  στατιστική ελέγχου: tau_c(1) = -9,4765
  p-τιμή 2,523e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)KGF
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00771
  στατιστική ελέγχου: tau_ct(1) = -9,65332
  p-τιμή 5,931e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,001
```

```
Phillips-Perron unit-root test for KGF, Bartlett bandwidth 14:

Z_t = -9,75127 (p-value = 0,0000)

Test regression (OLS, dependent variable KGF, T = 95):

            συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const      0,000715652   0,00631466    0,1133   0,9098
  KGF(-1)    0,0147077     0,103972      0,1415   0,8875

Sample variance of residual       0,00378625
Estimated long-run error variance 0,00214457
```

PPB

```
Augmented Dickey-Fuller test for PPB
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)PPB
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06518
  στατιστική ελέγχου: tau_c(1) = -10,081
  p-τιμή 1,805e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)PPB
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,09758
  στατιστική ελέγχου: tau_ct(1) = -10,4141
  p-τιμή 4,982e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005
```

```
Phillips-Perron unit-root test for PPB, Bartlett bandwidth 14:

Z_t = -10,2415 (p-value = 0,0000)

Test regression (OLS, dependent variable PPB, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -----------------------------------------------------
  const       0,0100893    0,00732922     1,377    0,1686
  PPB(-1)    -0,0651776    0,105662      -0,6169   0,5373

Sample variance of residual       0,00497636
Estimated long-run error variance 0,00717536
```

PSON

```
Augmented Dickey-Fuller test for PSON
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)PSON
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,981835
  στατιστική ελέγχου: tau_c(1) = -9,4046
  p-τιμή 2,116e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)PSON
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,984017
  στατιστική ελέγχου: tau_ct(1) = -9,38917
  p-τιμή 1,503e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,005
```

```
Phillips-Perron unit-root test for PSON, Bartlett bandwidth 14:

Z_t = -9,81626 (p-value = 0,0000)

Test regression (OLS, dependent variable PSON, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const      -0,00212535   0,00856754    -0,2481   0,8041
  PSON(-1)    0,0181646    0,104399       0,1740   0,8619

Sample variance of residual       0,0069709
Estimated long-run error variance 0,00344661
```

RRS

```
Augmented Dickey-Fuller test for RRS
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RRS
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,0199
  στατιστική ελέγχου: tau_c(1) = -9,65961
  p-τιμή 4,179e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RRS
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01974
  στατιστική ελέγχου: tau_ct(1) = -9,60746
  p-τιμή 6,953e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,005
```

```
Phillips-Perron unit-root test for RRS, Bartlett bandwidth 14:

Z_t = -10,21 (p-value = 0,0000)

Test regression (OLS, dependent variable RRS, T = 95):
```

	συντελεστής	τυπ. σφάλμα	z	p-τιμή
const	-0,000874487	0,0113280	-0,07720	0,9385
RRS(-1)	-0,0198979	0,105584	-0,1885	0,8505

```
Sample variance of residual       0,0121781
Estimated long-run error variance 0,00575025
```

RTO

```
Augmented Dickey-Fuller test for RTO
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 91
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)RTO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,14992
  στατιστική ελέγχου: tau_c(1) = -4,97503
  ασυμπτωτική p-τιμή 2,296e-005
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
  υστερήσεις πρώτων διαφορών: F(4, 85) = 0,497 [0,7377]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 4 υστερήσεων για (1-L)RTO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,2787
  στατιστική ελέγχου: tau_ct(1) = -5,09803
  ασυμπτωτική p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003
  υστερήσεις πρώτων διαφορών: F(4, 84) = 0,797 [0,5302]
```

```
Phillips-Perron unit-root test for RTO, Bartlett bandwidth 14:

Z_t = -8,55221 (p-value = 0,0000)

Test regression (OLS, dependent variable RTO, T = 95):
```

	συντελεστής	τυπ. σφάλμα	z	p-τιμή	
const	0,0109249	0,00622903	1,754	0,0795	*
RTO(-1)	0,116002	0,102752	1,129	0,2589	

```
Sample variance of residual       0,00353587
Estimated long-run error variance 0,00241309
```

RSA

```
Augmented Dickey-Fuller test for RSA
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 89
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)RSA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,25189
  στατιστική ελέγχου: tau_c(1) = -3,40097
  ασυμπτωτική p-τιμή 0,01096
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,023
  υστερήσεις πρώτων διαφορών: F(6, 81) = 1,619 [0,1523]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 6 υστερήσεων για (1-L)RSA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,4504
  στατιστική ελέγχου: tau_ct(1) = -3,60049
  ασυμπτωτική p-τιμή 0,02971
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,023
  υστερήσεις πρώτων διαφορών: F(6, 80) = 1,732 [0,1241]


Phillips-Perron unit-root test for RSA, Bartlett bandwidth 14:

Z_t = -10,5483 (p-value = 0,0000)

Test regression (OLS, dependent variable RSA, T = 95):

             συντελεστής    τυπ. σφάλμα      z       p-τιμή
  ---------------------------------------------------------
  const      -0,000275956   0,00619162    -0,04457   0,9645
  RSA(-1)    -0,0758996     0,104707      -0,7249    0,4685

Sample variance of residual       0,00364186
Estimated long-run error variance 0,00242998
```

SGE

```
Augmented Dickey-Fuller test for SGE
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SGE
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,01751
  στατιστική ελέγχου: tau_c(1) = -9,78737
  p-τιμή 6,235e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SGE
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,02289
  στατιστική ελέγχου: tau_ct(1) = -9,80379
  p-τιμή 3,546e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,002
```

```
Phillips-Perron unit-root test for SGE, Bartlett bandwidth 14:

Z_t = -10,1557 (p-value = 0,0000)

Test regression (OLS, dependent variable SGE, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00794312   0,00626406     1,268    0,2048
  SGE(-1)    -0,0175137    0,103962      -0,1685   0,8662

Sample variance of residual       0,00366099
Estimated long-run error variance 0,00208047
```

SMIN

```
Augmented Dickey-Fuller test for SMIN
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMIN
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,12523
  στατιστική ελέγχου: tau_c(1) = -10,6793
  p-τιμή 2,741e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,027

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SMIN
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,12609
  στατιστική ελέγχου: tau_ct(1) = -10,6075
  p-τιμή 2,798e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,027
```

```
Phillips-Perron unit-root test for SMIN, Bartlett bandwidth 14:

Z_t = -10,6512 (p-value = 0,0000)

Test regression (OLS, dependent variable SMIN, T = 95):
```

	συντελεστής	τυπ. σφάλμα	z	p-τιμή
const	0,00172302	0,00661391	0,2605	0,7945
SMIN(-1)	-0,125227	0,105366	-1,189	0,2346

Sample variance of residual 0,00414994
Estimated long-run error variance 0,00465096

STJ

Augmented Dickey-Fuller test for STJ
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

έλεγχος με σταθερό όρο
συμπεριλαμβανομένου 0 υστερήσεων για (1-L)STJ
υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
εκτιμώμενη τιμή του (a - 1): -1,20137
στατιστική ελέγχου: tau_c(1) = -11,8601
p-τιμή 0,0001
συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,016

με σταθερό όρο και τάση
συμπεριλαμβανομένου 0 υστερήσεων για (1-L)STJ
υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
εκτιμώμενη τιμή του (a - 1): -1,21852
στατιστική ελέγχου: tau_ct(1) = -12,0663
p-τιμή 8,087e-015
συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,010

Phillips-Perron unit-root test for STJ, Bartlett bandwidth 14:

Z_t = -11,8076 (p-value = 0,0001)

Test regression (OLS, dependent variable STJ, T = 95):

	συντελεστής	τυπ. σφάλμα	z	p-τιμή	
const	0,0176524	0,00677683	2,605	0,0092	***
STJ(-1)	-0,201374	0,101295	-1,988	0,0468	**

Sample variance of residual 0,00415661
Estimated long-run error variance 0,00426845

UU

```
Augmented Dickey-Fuller test for UU
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)UU
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,11197
  στατιστική ελέγχου: tau_c(1) = -10,864
  p-τιμή 7,189e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)UU
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,12788
  στατιστική ελέγχου: tau_ct(1) = -10,9626
  p-τιμή 1,032e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for UU, Bartlett bandwidth 14:

Z_t = -11,0682 (p-value = 0,0000)

Test regression (OLS, dependent variable UU, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ---------------------------------------------------------
  const       0,00150178   0,00525509     0,2858   0,7750
  UU(-1)     -0,111967     0,102353      -1,094    0,2740

Sample variance of residual       0,00261915
Estimated long-run error variance 0,00205548
```

ADM

```
Augmented Dickey-Fuller test for ADM
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 88
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)ADM
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,3619
  στατιστική ελέγχου: tau_c(1) = -4,18232
  ασυμπτωτική p-τιμή 0,0007022
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,011
  υστερήσεις πρώτων διαφορών: F(7, 79) = 0,912 [0,5020]
```

```
  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 7 υστερήσεων για (1-L)ADM
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,48
  στατιστική ελέγχου: tau_ct(1) = -4,37793
  ασυμπτωτική p-τιμή 0,002315
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009
  υστερήσεις πρώτων διαφορών: F(7, 78) = 1,042 [0,4093]
```

```
Phillips-Perron unit-root test for ADM, Bartlett bandwidth 14:

Z_t = -8,80898 (p-value = 0,0000)

Test regression (OLS, dependent variable ADM, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const      0,00175452    0,00751608    0,2334   0,8154
  ADM(-1)    0,0939088     0,103413      0,9081   0,3638

Sample variance of residual       0,00536146
Estimated long-run error variance 0,00311404
```

BDEV

```
Augmented Dickey-Fuller test for BDEV
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BDEV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,973269
  στατιστική ελέγχου: tau_c(1) = -9,40191
  p-τιμή 2,103e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,021

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)BDEV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00143
  στατιστική ελέγχου: tau_ct(1) = -9,73311
  p-τιμή 4,509e-012
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,014
```

```
Phillips-Perron unit-root test for BDEV, Bartlett bandwidth 14:

Z_t = -9,47023 (p-value = 0,0000)
```

```
Test regression (OLS, dependent variable BDEV, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,0183581    0,00896930    2,047    0,0407 **
  BDEV(-1)    0,0267313    0,103518      0,2582   0,7962

Sample variance of residual       0,00728283
Estimated long-run error variance 0,00854482
```

BKG

```
Augmented Dickey-Fuller test for BKG
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 93
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 2 υστερήσεων για (1-L)BKG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -1,17482
  στατιστική ελέγχου: tau_c(1) = -5,56196
  ασυμπτωτική p-τιμή 1,259e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,006
  υστερήσεις πρώτων διαφορών: F(2, 89) = 1,142 [0,3238]

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 14 υστερήσεων για (1-L)BKG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -2,52037
  στατιστική ελέγχου: tau_ct(1) = -4,48615
  ασυμπτωτική p-τιμή 0,001535
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
  υστερήσεις πρώτων διαφορών: F(14, 64) = 2,525 [0,0062]
```

```
Phillips-Perron unit-root test for BKG, Bartlett bandwidth 14:

Z_t = -11,0075 (p-value = 0,0000)

Test regression (OLS, dependent variable BKG, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,0166395    0,00744321     2,236   0,0254 **
  BKG(-1)    -0,139728     0,103766      -1,347   0,1781

Sample variance of residual       0,00502134
Estimated long-run error variance 0,00474162
```

DLG

```
Phillips-Perron unit-root test for DLG, Bartlett bandwidth 14:

Z_t = -9,72161 (p-value = 0,0000)

Test regression (OLS, dependent variable DLG, T = 71):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ---------------------------------------------------------
  const       0,00826681   0,00623697     1,325   0,1850
  DLG(-1)    -0,149173     0,119008      -1,253   0,2100

Sample variance of residual       0,00270139
Estimated long-run error variance 0,0024107
```

MCRO

```
Augmented Dickey-Fuller test for MCRO
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MCRO
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,09201
  στατιστική ελέγχου: tau_c(1) = -10,6237
  p-τιμή 2,072e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)MCRO
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,10658
  στατιστική ελέγχου: tau_ct(1) = -10,742
  p-τιμή 1,9e-013
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,000
```

```
Phillips-Perron unit-root test for MCRO, Bartlett bandwidth 14:

Z_t = -10,5985 (p-value = 0,0000)

Test regression (OLS, dependent variable MCRO, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  ----------------------------------------------------------
  const       0,0152184     0,0101903     1,493    0,1353
  MCRO(-1)   -0,0920056     0,102790     -0,8951   0,3707

Sample variance of residual       0,00969815
Estimated long-run error variance 0,0101158
```

RMV

```
Augmented Dickey-Fuller test for RMV
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RMV
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,21125
  στατιστική ελέγχου: tau_c(1) = -11,6522
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,008

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RMV
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,23503
  στατιστική ελέγχου: tau_ct(1) = -11,9432
  p-τιμή 1,028e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for RMV, Bartlett bandwidth 14:

Z_t = -11,7242 (p-value = 0,0001)

Test regression (OLS, dependent variable RMV, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  -----------------------------------------------------
  const       0,0221104    0,00749700     2,949   0,0032 ***
  RMV(-1)    -0,211255     0,103951      -2,032   0,0421 **

Sample variance of residual       0,00494564
Estimated long-run error variance 0,00451802
```

RMG

```
Augmented Dickey-Fuller test for RMG
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 58
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)RMG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,851023
  στατιστική ελέγχου: tau_c(1) = -3,96342
  ασυμπτωτική p-τιμή 0,001619
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003

  με σταθερό όρο και τάση
  συμπεριλαμβανομένης μίας υστέρησης του (1-L)RMG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  εκτιμώμενη τιμή του (a - 1): -0,849822
  στατιστική ελέγχου: tau_ct(1) = -3,91897
  ασυμπτωτική p-τιμή 0,01134
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,003
```

```
Phillips-Perron unit-root test for RMG, Bartlett bandwidth 14:

Z_t = -8,20489 (p-value = 0,0000)

Test regression (OLS, dependent variable RMG, T = 59):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const      -0,00821782    0,0110769    -0,7419   0,4582
  RMG(-1)    -0,130600      0,141757     -0,9213   0,3569

Sample variance of residual       0,00723881
Estimated long-run error variance 0,0040596
```

SVT

```
Augmented Dickey-Fuller test for SVT
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SVT
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,19739
  στατιστική ελέγχου: tau_c(1) = -11,8555
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,013

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SVT
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,21391
  στατιστική ελέγχου: tau_ct(1) = -11,9865
  p-τιμή 9,434e-015
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,015
```

```
Phillips-Perron unit-root test for SVT, Bartlett bandwidth 14:

Z_t = -12,5912 (p-value = 0,0001)
```

```
Test regression (OLS, dependent variable SVT, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00344997   0,00465236     0,7416   0,4584
  SVT(-1)    -0,197390     0,100998      -1,954    0,0507 *

Sample variance of residual       0,00204096
Estimated long-run error variance 0,00132706
```

TW

```
Augmented Dickey-Fuller test for TW
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TW
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,934666
  στατιστική ελέγχου: tau_c(1) = -8,98448
  p-τιμή 9,782e-009
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,006

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TW
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -0,988027
  στατιστική ελέγχου: tau_ct(1) = -9,49092
  p-τιμή 1,046e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,009
```

```
Phillips-Perron unit-root test for TW, Bartlett bandwidth 14:

Z_t = -9,08274 (p-value = 0,0000)

Test regression (OLS, dependent variable TW, T = 95):

             συντελεστής   τυπ. σφάλμα     z      p-τιμή
  ------------------------------------------------------
  const       0,0176033    0,00775235    2,271    0,0232 **
  TW(-1)      0,0653339    0,104031      0,6280   0,5300

Sample variance of residual       0,00532418
Estimated long-run error variance 0,00616385
```

WG

```
Augmented Dickey-Fuller test for WG
testing down from 14 lags, criterion AIC
```

```
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,20199
  στατιστική ελέγχου: tau_c(1) = -11,8446
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,012

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)WG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,20952
  στατιστική ελέγχου: tau_ct(1) = -11,8575
  p-τιμή 1,223e-014
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: 0,012
```

```
Phillips-Perron unit-root test for WG, Bartlett bandwidth 14:

Z_t = -12,371 (p-value = 0,0001)

Test regression (OLS, dependent variable WG, T = 95):
```

	συντελεστής	τυπ. σφάλμα	z	p-τιμή	
const	0,00523809	0,00855998	0,6119	0,5406	
WG(-1)	-0,201988	0,101480	-1,990	0,0465	**

```
Sample variance of residual       0,00694142
Estimated long-run error variance 0,0049253
```

RDSA

```
Augmented Dickey-Fuller test for RDSA
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RDSA
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,16436
  στατιστική ελέγχου: tau_c(1) = -11,4009
  p-τιμή 0,0001
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,011

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)RDSA
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,16559
  στατιστική ελέγχου: tau_ct(1) = -11,3588
  p-τιμή 3,742e-014
```

```
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,012
```

```
Phillips-Perron unit-root test for RDSA, Bartlett bandwidth 14:

Z_t = -11,7324 (p-value = 0,0001)

Test regression (OLS, dependent variable RDSA, T = 95):

             συντελεστής   τυπ. σφάλμα      z      p-τιμή
  -------------------------------------------------------
  const       0,00245084   0,00602917     0,4065   0,6844
  RDSA(-1)   -0,164362     0,102129      -1,609    0,1075

Sample variance of residual       0,003448
Estimated long-run error variance 0,00260226
```

SKG

```
Augmented Dickey-Fuller test for SKG
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 95
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SKG
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00555
  στατιστική ελέγχου: tau_c(1) = -9,43824
  p-τιμή 2,294e-008
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)SKG
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,00523
  στατιστική ελέγχου: tau_ct(1) = -9,37793
  p-τιμή 1,564e-011
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,001
```

```
Phillips-Perron unit-root test for SKG, Bartlett bandwidth 14:

Z_t = -9,4241 (p-value = 0,0000)

Test regression (OLS, dependent variable SKG, T = 95):

             συντελεστής   τυπ. σφάλμα      z       p-τιμή
  --------------------------------------------------------
  const       0,0143999     0,0115722     1,244     0,2134
  SKG(-1)    -0,00555090    0,106540     -0,05210   0,9584
```

```
Sample variance of residual       0,0124232
Estimated long-run error variance 0,0101954
```

TUI

```
Augmented Dickey-Fuller test for TUI
testing down from 14 lags, criterion AIC
μέγεθος δείγματος 44
μηδενική υπόθεση μοναδιαίας ρίζας: a = 1

  έλεγχος με σταθερό όρο
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TUI
  υπόδειγμα: (1-L)y = b0 + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06014
  στατιστική ελέγχου: tau_c(1) = -6,88066
  p-τιμή 4,868e-007
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,009

  με σταθερό όρο και τάση
  συμπεριλαμβανομένου 0 υστερήσεων για (1-L)TUI
  υπόδειγμα: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  εκτιμώμενη τιμή του (a - 1): -1,06009
  στατιστική ελέγχου: tau_ct(1) = -6,79829
  p-τιμή 4,085e-006
  συντελεστής αυτοσυσχέτισης 1ης τάξης για e: -0,010
```

```
Phillips-Perron unit-root test for TUI, Bartlett bandwidth 14:

Z_t = -7,06869 (p-value = 0,0000)

Test regression (OLS, dependent variable TUI, T = 44):
```

	συντελεστής	τυπ. σφάλμα	z	p-τιμή
const	0,00422202	0,0107299	0,3935	0,6940
TUI(-1)	-0,0601368	0,154075	-0,3903	0,6963

```
Sample variance of residual       0,00505004
Estimated long-run error variance 0,00323846
```