INTERNATIONAL HELLENIC UNIVERSITY

Liquidity and Asset Pricing for the Greek Stock Market

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SCHOOL OF SCIENCE & TECHNOLOGY

A thesis submitted for the degree of

Master of Science (MSc) in ICT Systems

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THESSALONIKI – GREECE

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DISCLAIMER

This dissertation is submitted in part candidacy for the degree of Master of Science in ICT Systems, from the School of Science and Technology of the International Hellenic University, Thessaloniki, Greece. The views expressed in the dissertation are those of the author entirely and no endorsement of these views is implied by the said University or its staff.

This work has not been submitted either in whole or in part, for any other degree at this or any other university.

Signed: ....

Name: …..Konstantinos Maraslis..........

Date: ....

Abstract

This dissertation was written as a part of the MSc in ICT Systems at the International Hellenic University. Its scope is to investigate whether or not, the announcement that Mr. Papakonstantinou made on Monday, the 19th of October, 2009 and the overall financial crisis, have significantly affected some fundamental variables related to Greek Stock Exchange. The announcement was in fact an admission that the Greek deficit rate was not 6% of Greek GDP that was believed by then, but approximately 12%.

The method that is followed is mostly, hypothesis testing with various samples. The findings denote that the aforementioned announcement had indeed significant impact on some variables. As far as the overall financial crisis is concerned, its impact is undoubtedly severe according to the outcomes. The findings are extensively explained at the 4th chapter while at the end of the 3rd one there is some further testing due to some previous, unexpected results.

At this point, I would really like to thank my supervisor, Prof. Vassilis Polimenis for his perpetual assistance, without which, this dissertation would not have this form.

Konstantinos Maraslis

7/11/2011

To my brother and my parents…

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Chapter 1

Introduction

1. Introduction

It is now well known that Greece is not a financially healthy country and that its prosperity mostly depends on the "generosity" of the European Union (EU) members. The overall financial crisis has quite a few "countries - victims" up to the time that those lines were being written. However, Greece is one of the most outstanding examples and unfortunately, in a bad way. Not only is it under the supervision of the International Monetary Fund (IMF), but this supervision seems to be a failure, as well**.** Debts are constantly increasing as the deficit rate keeps staying away from what could call, healthy. But this unhealthy (deficit) rate is a result of some very important parameters. One of those is set under investigation.

Back in 2009, and more specifically on Monday, the 19th of October, 2009, the Finance Minister of the newly elected government of Greece, Giorgos Papakonstantinou, gave a presentation at a meeting of the euro area's sixteen finance ministers in Luxembourg about Greece's financial situation. It was then that he announced the new, revised Greek deficit figures. Up to then, predictions lied in the area of 3,5% to 4% of Gross Domestic Product (GDP). However, the new figures that Papakonstantinou announced, were talking about a deficit rate that would exceed 10% of Greek GDP and could even reach 12%.

That announcement led to numerous reactions from just about everyone involved, directly or indirectly. Jean – Claude Juncker, Prime Minister of Luxembourg and leader of the group of euro-area finance ministers, commented on this announcement immediately, underlying how impressed he was by the difference between the old and the new figures and mentioning that if it was something that would happen again, it would put all Eurostat's data at risk of credibility (EU Observer (1)).

Apart from all the "political" statements from almost all around the world, Greek journalists and reporters kept wondering not only how such a deficit rate occurred, but also why Greek Prime Minister decided to make such a disclosure when the country was just about to borrow money from the markets (it goes without saying that this announcement raised the spreads significantly).

While all those were in progress, Eurostat made an announcement expressing “a reservation on the data reported by Greece due to significant uncertainties over the figures notified by the Greek statistical authorities”. Later at the same announcement, there were some innuendos about manipulation of economic data (EU Observer (2)).

A lot of articles followed Papakonstantinou’s announcement when all of a sudden, Goldman Sachs came into play when it was revealed that with their help, Greece has managed to disguise the scale of its debts over several years with the use of different kind of swaps (Times, Guardian, Forbes). Of course that was not something illegal and that was probably the reason that both Goldman Sachs and the Greek Government defended themselves (BBC (1), Bloomberg).

After the “scandal” involving Goldman Sachs, the media did not deal a lot with the announcement (of the Greek Finance Minister) and its direct effects since the financial crisis was already a global phenomenon and apart from Greece, who was already much more affected by the recession and therefore had even newer problems to deal with), other, more important EU members had also major problems, as well. Meanwhile, the Finance Minister of Greece had changed and Evaggelos Venizelos had replaced Papakonstantinou. It was not until very recently, considering the time that those lines were being written, that the whole issue regarding the revised deficit rates and whether it was manipulated or not, became again the center of discussion.

Fortunately or unfortunately, it was then mostly a discussion among the Greek media since world media’s lights were already spotting newer issues. The progress in this particular case was that, Zoe Georganta, professor at the University of Macedonia in northern Greece and then-employee of the Hellenic Statistical Authority (ELSTAT), accused publicly the Greek government for artificial enlargement of the country’s deficit rates back in 2009, via a popular Greek newspaper (Enet (1), Enet (2)). As she said that could have happened either in order for the government to justify harsh measures against the country or to make the improvement in 2010 look even bigger.

Papakonstantinou, who was (and still is) serving as minister for the environment at that time, denied the accusations and said that "Unfortunately for all of us, Greece's deficit in 2009 was finally 15,4% of GDP, as officially announced by ELSTAT and Eurostat". Even Amadeu Altafaj, spokesperson for the Economic and Monetary Affairs' commissioner - Olli Rehn, supported Greece when he said that Greek statistics are trustworthy and conform with the requirements of the EU (AthensNews, NewPost, ToVima).

In spite of Papakonstantinou's denial and Amadeu Altafaj's statement, Zoe Georganta, who was not an employee of ELSTAT anymore, kept on with the accusations but there is no official decision about whether or not the deficit rates were indeed artificially inflated, although a preliminary investigation was ordered (EKathimerini (1), EKathimerini (2)). Unfortunately, the dramatic situation of Greek's deficit level still holds (BBC (2)).

1.1. Scope – Problem Definition

Although there was so much fuss about whether or not, Greek deficit rate was artificially enlarged, there is still no research made about whether or not the announcement of the former Finance Minister affected the Greek Stock Exchange and the behavior of the investors. This is exactly what this dissertation is about. *An investigation about the impact of the announcement on the Greek Stock Exchange and the investors' behavior*. In order for this to be done, a research is made about the effect of the announcement on some specific Stock Exchange – related variables.

The need for such a research came out of the fact that due to the announcement, Greece lost its credibility about its statistical data which in conjunction with the financial problems that the country needed to fight at that time, led to the admission that it is officially under heavy recession and later to the supervision of the International Monetary Fund (IMF). For that, it is important to test if the impact of the announcement was significant, because this could mean that it may constituted a kick-off for the Greek financial downhill.

The expected findings are not obvious at all since, as already mentioned, it was just an announcement and not some kind of financial report or something similar to this and due to that it is not easy to tell in advance if markets really absorbed it or not.

The variables and the whole procedure are described in the sections 3.1 and 3.2.

Chapter 2

Literature Review

2. Literature Review

As already mentioned in the previous section, up to now there is no research that investigates the impact that the announcement of Greece's former Finance Minister, Giorgos Papakonstantinou, had either on the Greek Stock Exchange or on investors' behavior in Greece. Therefore, in this section there will be a review of the past research not on exactly the same topic but on the impact that various announcements or (mainly) disclosures, had on the local Stock Exchange or on investors behavior of other countries.

As far as the impact that an announcement may have on some variables like the Price and the Volume, Bamber L.S. and Cheon Y. S. (1995) have certainly a lot to offer. Their research is not only about investigating the frequency with which earnings announcements generate differential price and volume reactions but it also assesses whether or not those reactions have any kind of correlation with announcement-specific characteristics. In fact, the primary objective of this research is to investigate the extent to which accounting earnings announcements can cause significant price change but minimal change in trading, or vice versa (Bamber and Cheon, 1995, p.417-422).

The study examines market reactions to earnings for fiscal quarters between 1986 and 1988, inclusive, which are announced between 1986 and 1989 and also meet some specific criteria in terms of availability. These criteria yielded a sample of 8,180 quarterly earnings announcements by 1,079 firms (Bamber and Cheon, 1995, p.422).

In order for this study to be performed, the authors apply the so-called contingency table analysis. What they do in particular, is to classify the reaction that each earning announcement causes, into a price reaction decile and a trading volume reaction decile. Reactions for which the magnitudes of the volume and price change are not much different (the absolute value of the difference between the price and volume reaction deciles is less than or equal to two), are considered to be “Similar”. If the absolute value of the difference between the price and volume reaction deciles is five or more, then those reactions are defined as “Different”. The remaining reactions (those for which the absolute value of the difference between the price and volume deciles is greater than two and at the same time less than five) are classified as “Indeterminate” ones. After that classification there is another sub-classification that takes place. The "Different" reactions are further sub-classified into the "Large Volume-Small Price reaction" and the "Small Volume-Large Price reaction" according to the magnitude of the absolute price of the previously mentioned difference. After the categorization, null hypotheses come into view. Initially, there are two hypotheses that take place. The first is that price and volume reactions are independent and the second one is that price and volume reactions are closely related (Bamber and Cheon, 1995, p.424-439).

After performing some hypothesis tests, among which are also the aforementioned ones, the study ended up with the result that trading volumes reactions and price reactions are not as relative to each other as it was believed. In fact they are almost independent. They also go on to say that those reactions depend on the charachteristics of the individual announcement (Bamber and Cheon, 1995, p.439-440). In addition, Kandel E. and Pearson N. D. (1995, p.868-870) report that trading volume around earnings announcements is, on average, abnormally high even in the case of announcements that stimulate negligible return response.

Cready W. M. and Hurtt D. N. (2002) also investigate which of the metrics Return and Trading Activity, maximizes the possibility that the presence or absence of a response, is correctly detected by a researcher. Prior research on event study methods usually focus on identifying which of several alternative volume or return metrics (Brown and Warner, 1980) is most possible to lead to a correct rejection of the null hypothesis of no investor response to information events. This study on the other hand, compares both return and volume-based metrics in earnings announcement periods.

The study employs a "grand sample" of 49,274 earnings announcements between the 1st of January 1983 and the 31st of December 1992. This sample consists only of earnings announcements that meet specific criteria in terms of their availability (Cready and Hurtt, 2002, p.898). By using a framework similar to Brown and Warner (1980), that "grand sample" is then split into more, relative small sub-samples and finally there is empirical estimation of each metric's sample-size-specific rejection rate. Although there is evidence that the investors' responses do not seem to be stimulated by most of the earnings announcements (Bamber et al., 2000, p.20), by assuming that the null hypothesis (that the mean investor response to earnings announcements is zero) is false for the population of earnings announcements, "this analysis yields insight into the relative power of tests based on returns vis-a-vis volume in detecting investor responses to earnings announcements" (Cready and Hurtt, 2002, p.893).

The findings of this study are pretty straightforward. Firstly, there is evidence provided that volume-based metrics, especially the ones expressed in numbers of transactions, provide more powerful tests of investor response to public disclosures than the return-based metrics do. Secondly, according to the outcomes of the study, supplementing return-based measures with trading-based measures, increases the power of tests to detect the response of the investors (the converse is not generally true). This is why it is suggested that after a return based analysis, before concluding that investors do not respond to a public disclosure, researchers should always confirm the nonresponse inference with trading-based measures (Cready and Hurtt, 2002, p.891). Finally, according to the findings, when using trading-based measures to test investor response to earnings announcements, it is more likely to correctly reject the null hypothesis of no investor response than it is when using tests based on returns (Cready and Hurtt, 2002, p.906).

Another study that grapples with the way that investors react to events (announcements in particular), is a study that was written by Kadiyala P. and Rau P. R. (2004) But before reviewing their study, it is essential that we demonstrate the two basic models of behavioral finance literature. According to the first model, investors tend to overreact to information, which leads to a pattern of long term return reversals when firms announce corporate events such as new issues of stock. According to the second model, investors have a tendency to underreact to information, leading to long-term return continuations when firms announce corporate events such as open-market share repurchases or cash-financed tender offers.

In this study, it is determined which behavioral explanation fits the long-run abnormal evidence. In order for this to be done, both investor reaction to the information conveyed by the event and information available prior to the event in considered. Specifically, the sample consists of cash-financed acquisitions/tender offers, firms announcing stock-financed acquisitions, or open-market share repurchases between January 1980 and December 1994. The sample is classified as stock or cash-financed based on whether the ratio of the value of the common stock portion of the deal to the effective value of the deal is 100% or 0%, respectively. Then acquisitions that are financed by a mixture of stock and cash are removed from the sample. For each type of corporate event, firms that previously announced events of other types are not eliminated since each type of event is viewed as an independent observation. Finally, reported earnings and analysts' estimates of earnings from the Institutional Brokers Estimate System (IBES) database are obtained.

After the sample has been defined and obtained, it is time for the testable hypotheses to be set, as well. The three hypotheses under testing, can be summarized as follows:

1) If investors underreact to information, the sample that announces the event after the release of positive information should be underperformed by the sample that consists of firms that announce a corporate event after the release of negative information.
2) If investors do overreact to information, the sample that announces the corporate event after the release of negative information should be underperformed by the sample of firms that announce a corporate event after the release of positive information.

3) If investors are unbiased in their response to information, the sample of firms that announce a corporate event after the release of positive information should neither underreact nor outperform the sample that announces the event after the release of negative information (Kadiyala and Rau, 2004, p.361-363).

Fama E. F. (1998) argues that behavioral models cannot explain the long-run abnormal return evidence because according to his study, investors' overreaction to some events and underreaction to others, implies that investors are unbiased as far as their reaction to information is concerned. However, in this study, it is shown that investor reaction to new information is not randomly split between apparent overreaction and apparent underreaction. In fact, according to the article, investors seem to interact to both information that conveyed by the event and to prior information. That leads to the different patterns: "return continuations and return reversals, documented in long-horizon returns". As far as the overreaction hypothesis is concerned, no support was found no matter what the testing technique was. As mentioned in the study "the evidence is most consistent with the hypothesis that long-run abnormal returns reflect investors' tendency to underreact, first to short-term information available prior to the event and subsequently to information conveyed by the event itself. There is no evidence that the overreaction model can explain abnormal long-run returns to any of our corporate events" (Kadiyala and Rau, 2004, p.358, 384).

Another very important article, was one of those that set the framework of studying about the way that investor's behavior is influenced by information and due to that, although it is too old, it worth's to be mentioned even in brief (Winsen, 1976). It is an article that was published back in 1976 and is a study that makes use of the efficient market hypothesis in its semi-strong form. The definitions of efficient market and its semi-strong form are given below:

“A market in which prices always "fully reflect" available information is called "efficient".”

(Fama, 1970, p.383)

“The semi-strong form of the efficient market hypothesis includes all the historical prices and all the information about the stock prices (like disclosures, quotes, announcements and press releases), that is available to any market participant. All the above information is reflected on every share’s current price. In semi-strong form tests, the concern is whether prices efficiently adjust to other information that is obviously publicly available.”

(Kaparis, 2007, p.26)

(Fama, 1970, p.383)

It is worth mentioning that “in an efficient market, the fundamental value of a security fluctuates randomly” (Roll, 1984, p.1127).

Under this hypothesis, fluctuations that occur in a stock price can be received as indications of the flow of publicly available information into the stock market about that particular stock. This study investigates whether investor behavior is associated with such a flow of information, or not.

By using data from New York Stock Exchange and processing them using a linear mathematical model, the study came to the result that investor behavior is indeed associated with the aforementioned flow of information and also confirmed the outcome of a previous study (Lease et al., 1974), that “typical investor is not well-diversified and naively optimistic”.

Closing this section about studies regarding the market or investor reaction to various kinds of information, we can make a reference to a study that was published in 2005 and was written by Randal R. Rucker, Walter N. Thurman and Jonathan K. Yoder (Rucker et al., 2005). We are not going to extensively refer to this article because it focuses on lumber sector. However, its contribution is not trivial mostly due to the unusual scope of the study. The authors do not only try to investigate if markets and investors do react when news come to the surface but they also investigate the how rapid the absorption is, in every kind of disclosure.

A Distributional Event Response Model (DERM) was used to process the data that the authors retrieved from The Chicago Mercantile Exchange (Lumber Futures price data for the period from January 1986 to April 1998). Using DERM, they analyzed the effects of three different types of information releases: (a) regular, periodic events in the form of housing start announcements; (b) aperiodic policy decisions related to U.S.- Canada lumber trade disputes; and (c) irregular and unprecedented information releases in the form of court rulings related primarily to the Endangered Species Act (ESA). Thus, they present evidence that “regular periodic announcements tend to be incorporated into lumber futures prices more rapidly than events whose contents are multidimensional and whose announcement dates are not known in advance”. Specifically, according to the findings, housing start events tend to be absorbed more quickly than trade events and the last ones are absorbed more quickly than ESA events (Rucker et al., 2005, p.482, 484, 497).

2.1. Elements of Originality

All the above studies tried to investigate the impact that some kind of disclosures have on the Stock Exchange Market. Nevertheless, none of those have been made, based on data from the Greek Stock Exchange Market and also none of those investigated the impact of a “simple” announcement. Instead, they focused on some kind of official financial reports or disclosures which did not necessarily come from a government but also from a company. Those elements of discrimination are rudiments of originality along, of course, with the method that is applied which unavoidably deviates from the above ones, although hypothesis tests are commonly used in some cases.

Chapter 3

Contribution

3. Contribution

3.1 Procedure Outline

So, let us start investigating if there has been an influence on the Greek Stock Exchange (GSE) by the fact that the Greek government admitted that the real deficit figures were far from the predicted ones. First of all, it is important that an outline of the procedure that is going to be followed is given, in order for the reader to be able to understand why such a process takes place and what are the prerequisites for the next step of the analysis.

In order for us to decide if there was some kind of impact on the Greek Stock Exchange by the admission of the bloated deficit rates by the Greek government, we are going to investigate if some specific variables (that are going to be presented afterwards), related to the Greek Stock Exchange, were affected. Those variables represent some fundamental financial factors related to the Greek Stock Exchange, for a large time period, during which the admission of the revised deficit figures took place. The first step will be to separate the sample of every variable into two groups: the one that consists of data that is related to the pre-announcement period and the one that consists of data that is related to the post-announcement period.

On those two groups, we are going to apply some methods that belong to the so called "Descriptive Statistics" in order to discover the properties that our variables are governed by. Specifically, we are going to examine if those variables follow a Normal Distribution or not and based on the results of this examination, we are going to apply the appropriate tests that serve our goal.

Those tests are going to examine whether those two groups of data of the same variable, differ "significantly" with each other, or not. Of course the term "significantly" is too vague and subjective. In addition, there are many ways to express – and for that, to examine - what "significant differentiation" means. This is why some less subjective mathematical methods take place at that point. Those methods can test if a *hypothesis* is correct or incorrect with specific, widely accepted ways that do not leave much room for doubt.

Those tests can be separated into two main categories: the parametric and the non-parametric ones. The difference between those two categories is that the tests that belong to the first (parametric ones) can only be applied on samples that meet some specific prerequisites, depending on the test we want to perform, whereas the test that belong to the non-parametric ones can be applied on every kind of samples. Most of the parametric tests have the normality of the samples as their main (or only) condition and this is also the case for the tests we are going to perform. Of course, the tests are not always equally efficient with each other. Those that belong to the category of the parametric ones, usually have more accurate results as they generally have less *Type II Error (it is explained later on).*

But what those tests really test? As mentioned earlier they test whether a hypothesis is valid or not, using mathematical algorithms. Usually they try to decide on the validation of an equation that is called *null hypothesis* and it is denoted as H_0. When the null-hypothesis is an equation, let's say H_0: E_1=E_2 (in case for example we want to check if it is safe to claim that two quantities are equal) then the alternative hypothesis – usually denoted as H_1 – can be either H_1: $E_1 \neq E_2$ or H_1: E_1 < (or >) E_2. In the first case (H_1: $E_1 \neq E_2$), the test is called "two-tailed" (Groebner et al., 2011, p.368-369) whereas in the other case (H_1: E_1 < (or >) E_2) it is called "one-tailed". In our case, the null hypothesis will usually regard the equation between the means, the medians or the variances of two samples of the same variable and these are going to be two-tailed tests. Based on the results of those tests, we are going to decide if the admission of the expanded deficit figures, affected drastically some distinct variables of Greek Stock Exchange and thus the Stock Exchange itself.

Type II Error

Every time we have a null and an alternative hypothesis to check (let's say that H_0: $T_1 = T_2$ and H_1: $T_1 \neq T_2$), the tests will not give a positive result only if T_1 and T_2 are exactly the same. If that was the case, then we would not have to run complex mathematical algorithms in order to decide if we should accept the null hypothesis or not. We could simply calculate T_1 and T_2 and check the equality by ourselves. The null hypothesis can be proven true even if T_1 and T_2 are not equal with each other but they do not differ significantly. But due to the fact that "significantly" is subjective, as already mentioned, we assign the decision making process to an objective mathematical algorithm that can tell us if it correct to claim that T_1 and T_2 are equal, or more accurately if they do not differ significantly. In order for an algorithm to come up with a result, it will not only take T_1 and T_2 into consideration, but the whole sample as well. Having said all that, it is obvious that there is a chance that we decide either to reject the null hypothesis even if we should have accepted it, or to accept the null hypothesis even if that is practically incorrect. In both cases, we will have made an error. The first kind of error (rejecting the null hypothesis even if we should have accepted it) is called Type I Error and the case is denoted as H_1/H_0, while the second kind of error (accepting the null hypothesis even if that is practically incorrect) is called Type II Error and the case is denoted as $H_0/H_{1.}$

The probability of not committing a Type II Error is called *power* of a hypothesis test. When we perform a parametric hypothesis test, it is less possible for us to commit a Type II Error (than it would be in case we would perform a non-parametric one) and thus we say that the parametric tests are more powerful than their non-parametric counterparts.

(Currell and Dowman, 2009, p.253)

(Walters, 2007, p.30,48)

3.2. Variables Presentation

Before we proceed with the tests, we should describe the data we are going to be based on, the way that the data is going to be handled and the reasons that this kind of processing was chosen. As already mentioned, in order for us to decide if there was some kind of impact on the Greek Stock Exchange by the admission of the bloated deficit rates by the Greek government, we are going to investigate if some specific variables, related to the Greek Stock Exchange, were affected. Those variables are the following:

Closing Price

Represents the Closing Price of the Greek Stock Exchange General Index on the current day.

Return

Represents the proportion of change of the Closing Price and is calculated by the following mathematical formula:

$$\text{Return for Day n} = \frac{\text{Closing Price}_{\text{n}} - \text{Closing Price}_{\text{n}-1}}{\text{Closing Price}_{\text{n}-1}}$$

Where *Closing Price*$_n$ is the closing price of the day n and *Closing Price*$_{n-1}$ is the closing price of the day n-1 which is one day before day n.

Volume in Shares

Represents the total number of shares traded on Greek Stock Exchange General Index on the current day. If no data is sent by the exchange for a day, the variable will reflect the last data received from the exchange.

Volume in Euros

Represents the total amount traded in the index's currency. This value consists of all trade prices for each security that belongs to the index, multiplied by the number of shares relating to each price. This value is then summed for each security and then totaled for the index.

High-Low Spread

Represents the difference between the highest and the lowest price, the index reached during the current trading day.

Velocity

We could say that this Variable represents, in a way, the proportion of the whole value of the index that is traded on the current day. It is calculated by the following mathematical formula:

$$\text{Velocity} = \frac{\text{Domestic Market Turnover}}{\text{Domestic Market Capitalization}}$$

where Domestic Market Turnover represents the total value of the shares traded on the current day (which is equal to “Volume (Euros)” in our case because we are dealing with indexes and not just shares or securities) and Domestic Market Capitalization represents the value of all the shares, traded or not, that consist the Greek Stock Exchange Market, on the current day.

All of the above variables represent data collected on a daily basis and for the period from 7/2/2008 up to 27/6/2011. The data for the days from 19/10/2009 up to 23/10/2009 have been intentionally skipped and there were two reasons behind that.

The first reason lies in the fact that the announcement, part of which was the admission of Greece’s deficit, took place on Monday, the 19th of October, 2009, at a meeting of the euro area's sixteen finance ministers in Luxembourg (EU Observer (1)). The days that followed that momentous statement were extremely “embarrassed” and volatile and as such, not characteristic of the post-announcement period. Due to that, it was considered appropriate that the whole week (actually, the working days out of it) should be skipped. At this point, it is worth mentioning that the 19th of October, 1987 (which was Monday as well) was a day that not only investors but almost each and every citizen of the world would like to forget. Known as the Black Monday, it was the day that stock markets around the world crashed, shedding a huge value in a very short time. The crash began in Hong Kong and spread west to Europe, hitting the United States after other markets had already declined by a significant margin (Investopedia).

But as mentioned before, there was a second reason as well. That was the release of new figures by the European Union's statistics office – Eurostat – on Thursday, the 22nd of October, 2009, which provided fresh information on the deficit levels of the countries of the European Union for the year 2008 and, as mentioned before (at 3. Problem Definition), pointed towards Greek political manipulation of the country's economic data (EU Observer (2)). It goes without saying that this insinuation was enough to make the following days a bit frustrating for the investors and ultimately, not representative for the post-announcement period, as well.

Due to the way that the sample has been restrained, the sample regarding the pre-announcement period consists of 418 observations while the one regarding the post-announcement period consists of 100 observations. This is important because there are tests that need an efficiently large sample in order to be performed. A “Large Sample” is a highly vague entity in the world of Statistics but a sample of 100 or more observations is considered large for all kinds of tests while there are tests that will give accurate results with a sample consisted of only 30 or even 10 observations. Furthermore, part of the bibliography supports that there is little need for normality tests of samples with more than 30 observations due to the so called “Central Limit Theorem”. Although some are cautious about this theorem (Ngurah Agung, 2009), it is generally accepted and therefore it is going to be used.

3.3. Testing the Impact of the Announcement

In this section, we are going to investigate if there is a significant impact on our variables due to the announcement about the revised, bloated figures regarding the Greek deficit rates. Two different approaches will be applied. This is appropriate due to the existence of the Central Limit Theorem which is going to be described later on. According to this theorem, all of our variables can be considered as normal ones (i.e. they follow a Normal Distribution) and hence a parametric test is the most appropriate for them. On the other hand, the tests of normality that are going to be performed, do not always confirm the normality of them all. Thus, there will be two different testing procedures. One based on the results of the normality tests and one based on the Central Limit Theorem.

3.3.1. Normality Tests

The first step of our analysis should undoubtedly be the so called, Normality Tests. Although checking for the normality of a variable is not always a trustworthy procedure, those tests will let us know if the variables we are supposed to work on, follow a normal distribution or not. This piece of information is very important because, as already mentioned, based on this information we are going to decide what kind of further tests are we going to perform. In case our variables do follow a normal distribution, we can apply some parametric tests on them and in case they do not follow a normal distribution, we can apply some non-parametric ones.

There are many normality tests available and since it is impossible to perform them all, we will only perform the most reliable ones, which are also the most popular and they are the following:

1. Kolmogorov – Smirnov test

This test is used to decide if a sample comes from a hypothesized continuous distribution. It is based on the empirical cumulative distribution function (ECDF). Assume that we have a random sample $x_1, \ldots, x_n$ from some distribution with CDF F(x). The empirical CDF is denoted by

$$F_n(x) = \frac{1}{n} \cdot [Number\ of\ Observations \leq x]$$

Definition

The Kolmogorov-Smirnov statistic (D) is based on the largest vertical difference between the theoretical and the empirical cumulative distribution function:

$$D = \max_{1 \leq i \leq n}(F(x_i) - \frac{i-1}{n}, \frac{i}{n} - F(x_i))$$

Hypothesis Testing

The null and the alternative hypotheses are:

- H_0: the data follow the specified distribution;
- H_1: the data do not follow the specified distribution.

The hypothesis regarding the distributional form is rejected at the chosen significance level (α) if the test statistic, D, is greater than the critical value obtained from a table. The fixed values of α (0.01, 0.05 etc.) are generally used to evaluate the null hypothesis (H_0) at various significance levels. A value of 0.05 is typically used for most applications, however, in some critical industries, a lower α value may be applied.

The standard tables of critical values used for this test are only valid when testing whether a data set is from a completely specified distribution. If one or more distribution parameters are estimated, the results will be conservative: the actual significance level will be smaller than that given by the standard tables and the probability that the fit will be rejected in error will be lower.

<u>P-Value</u>

The P-value, in contrast to fixed *α* values, is calculated based on the test statistic, and denotes the threshold value of the significance level in the sense that the null hypothesis (H_0) will be accepted for all values of less than the P-value.

The P-value can be useful, in particular, when the null hypothesis is rejected at all predefined significance levels, and you need to know at which level it could be accepted.

(Marques de Sá, 2007, p.201)

2. Anderson – Darling test

The Anderson-Darling procedure is a general test to compare the fit of an observed cumulative distribution function to an expected cumulative distribution function. This test gives more weight to the tails than the Kolmogorov-Smirnov test.

Definition

The Anderson-Darling statistic (A^2) is defined as:

$$A^2 = -n - \frac{1}{n}\sum_{i=1}^{n}(2i-1)\cdot[lnF(X_i) + \ln(1 - F(X_{n-i+1}))]$$

Hypothesis Testing

The null and the alternative hypotheses are:

- H_0: the data follow the specified distribution;
- H_1: the data do not follow the specified distribution.

The hypothesis regarding the distributional form is rejected at the chosen significance level (α) if the test statistic, A^2, is greater than the critical value obtained from a table. The fixed values of α (0.01, 0.05 etc.) are generally used to evaluate the null hypothesis (H_0) at various significance levels. A value of 0.05 is typically used for most applications, however, in some critical industries, a lower α value may be applied.

In general, critical values of the Anderson-Darling test statistic depend on the specific distribution being tested. However, tables of critical values for many distributions (except several the most widely used ones) are not easy to find.

The Anderson-Darling test implemented in EasyFit (the program we are going to use for that test) uses the same critical values for all distributions. These values are calculated using the approximation formula, and depend on the sample size only. This kind of test (compared to the "original" A-D test) is less likely to reject the good fit, and can be successfully used to compare the goodness of fit of several fitted distributions.

(EasyFit®, Help Document)

3. <u>Chi – Squared test</u>

The Chi-Squared test is used to determine if a sample comes from a population with a specific distribution. This test is applied to binned data, so the value of the test statistic depends on how the data is binned. Please note that this test is available for continuous sample data only.

Although there is no optimal choice for the number of bins (k), there are several formulas which can be used to calculate this number based on the sample size (N). For example, EasyFit (the program we are going to use for that test) employs the following empirical formula:

$$k = 1 + \log_2 N$$

The data can be grouped into intervals of equal probability or equal width. The first approach is generally more acceptable since it handles peaked data much better. Each bin should contain at least 5 or more data points, so certain adjacent bins sometimes need to be joined together for this condition to be satisfied.

<u>Definition</u>

The Chi-Squared statistic is defined as:

$$X^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

where O_i is the observed frequency for bin i and E_i is the expected frequency for bin i calculated by:

$$E_i = F(x_2) - F(x_1)$$

where F is the cumulative distribution function (CDF) of the probability distribution being tested and x_1, x_2 are the limits for bin i.

<u>Hypothesis Testing</u>

The null and the alternative hypotheses are:

- H_0: the data follow the specified distribution;
- H_1: the data do not follow the specified distribution.

The hypothesis regarding the distributional form is rejected at the chosen significance level (α) if the test statistic is greater than the critical value defined as:

$$X^2_{1-a,k-1}$$

meaning the Chi-Squared inverse CDF with k-1 degrees of freedom and a significance level of α. Though the number of degrees of freedom can be calculated as k-c-1 (where c is the number of estimated parameters), EasyFit (the program we are going to use for that test) calculates it as k-1 since this kind of test is least likely to reject the fit in error.

The fixed values of α (0.01, 0.05 etc.) are generally used to evaluate the null hypothesis (H_0) at various significance levels. A value of 0.05 is typically used for most applications, however, in some critical industries, a lower α value may be applied.

P-Value

The P-value, in contrast to fixed α values, is calculated based on the test statistic, and denotes the threshold value of the significance level in the sense that the null hypothesis (H_0) will be accepted for all values of α less than the P-value.

The P-value can be useful, in particular, when the null hypothesis is rejected at all predefined significance levels, and you need to know at which level it could be accepted.

EasyFit displays the P-values based on the Chi-Squared test statistics (X^2) calculated for each fitted distribution.

(Ramachandran and Tsokos, 2009, p.388, 395)

4. Jarque – Bera test

Its reliability is debatable (Ngurah Agung, 2009, p.34) and it consists of a statistic for testing whether the series is normally distributed. The test statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution. The statistic is computed as:

$$\text{Jarque} - \text{Bera} = \frac{N}{6} \cdot \left(S^2 + \frac{(K-3)^2}{4}\right)$$

Where S is the skewness, and K is the kurtosis.

Under the null hypothesis of a normal distribution, the Jarque-Bera statistic is distributed as X^2 with 2 degrees of freedom. The reported Probability is the probability that a Jarque - Bera statistic exceeds (in absolute value) the observed value under the null hypothesis. A probability value less than the chosen significance level, leads to the rejection of the null hypothesis of a Normal Distribution.

(EViews®, Help Document)

5. Shapiro – Wilk test

This test, calculates a W statistic that tests whether a random sample, x_1, x_2, ..., x_n comes from (specifically) a normal distribution. Small values of W are evidence of departure from normality and percentage points for the W statistic, obtained via Monte Carlo simulations. This test has done very well in comparison studies with other goodness of fit tests.

The W statistic is calculated as follows:

$$W = \frac{\left(\sum_{i=1}^{n} a_i x_{(i)}\right)^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

where the $x_{(i)}$ are the ordered sample values ($x_{(1)}$ is the smallest) and the a_i are constants generated from the means, variances and covariances of the order statistics of a sample of size n from a normal distribution

(Shapiro and Wilk, 1965)

6. Skewness test (Skewness / Standard Error of Skewness lies in the interval [-2,2]

This test is self-explanatory. We calculate the fraction:

$$\frac{\text{Skewness}}{\text{Standard Error of Skewness}}$$

And if the outcome lies in the interval from -2 to 2, then we accept the hypothesis that the variable under investigation follows a Normal Distribution.

(Mahaira and Mpora, 1998)

7. Visual tests (Q-Q Plots, P-P Plots e.t.c)

Q-Q Plot

The quantile-quantile (Q-Q) plot is a graph of the input (observed) data values plotted against the theoretical (fitted) distribution quantiles. Both axes of this graph are in units of the input data set.

The quantile-quantile graphs are produced by plotting the observed data values x_i (i = 1, ... , n) against the X-axis, and the following values against the Y-axis:

$$F^{-1}(F_n(x_i) - \frac{0.5}{n})$$

where:

- $F^{-1}(x)$ is the inverse cumulative distribution function (ICDF);
- $F_n(x)$ is the empirical CDF;
- n is the sample size.

The Q-Q plot will be approximately linear if the specified theoretical distribution is the correct model. EasyFit displays the reference diagonal line along which the graph points should fall.

P-P Plot

The probability-probability (P-P) plot is a graph of the empirical CDF values plotted against the theoretical CDF values. It is used to determine how well a specific distribution fits to the observed data. This plot will be approximately linear if the specified theoretical distribution is the correct model. EasyFit displays the reference diagonal line along which the graph points should fall.

This graph can also be used to determine where the data do and don't follow the theoretical distribution.

(EasyFit®, Help Document)

8. <u>More than 30 observations (Central Limit Theorem)</u>

   This is a theorem with a lot of applications that can save a researcher from a lot of normality tests but unfortunately sometimes its validity is debatable and subjective.

Central Limit Theorem

Let $\{X_n\}$ be a sequence of mutually independent and identically distributed random variables with means m and variances σ^2. Let

$$Y = \sum_{j=1}^{n} X_j$$

and let the normalized random variable Z be defined as

$$Z = \frac{Y - nm}{\sigma\sqrt{n}}$$

Then the probability distribution function of Z, $F_z(z)$ converges to N(0,1) as $n \rightarrow \infty$ for every fixed z.

That leads us to the following corollary:

Let $X_1, X_2, \ldots, X_n$ be a sample from a population having mean μ and standard deviation σ. For n large ($n \geq 30$), the sum

$$X_1 + X_2 + \ldots + X_n$$

will approximately have a normal distribution with mean nμ and standard deviation $\sigma\sqrt{n}$.

(Ross, 2010, p.304)

The corollary is very important because it mentions that if a variable can be considered the sum of some other variables, then we can accept that this variable follows a Normal Distribution no matter what is the distribution that the variables that consist it, follow. Furthermore, it is generally accepted that most of the variables that can be met in nature or our everyday life (like the ones we investigate) can be considered a sum of other "simpler" variables. Thus, we can imply that they follow a Normal Distribution. That means that we can also apply some parametric tests on them without further investigation about their distribution. This is what is going to be done but those tests will not be the only ones that are going to be undertaken. For every variable that the normality tests indicate that it does not follow a Normal Distribution, the appropriate non-parametric test will also be performed.

In order for the above tests to be performed, the sample for every variable (since we are going to perform normality tests for all of our variables) has to be split in two groups, the pre-announcement and the post-announcement one. On both of those groups we are going to apply the normality tests and if for both of the samples that belong to the same variable, it is safe not to reject the hypothesis that they follow a normal distribution, then, as already mentioned, this variable will be further analyzed with parametric tests, as opposed to the variables that fail the normality tests that will be analyzed with non-parametric tests. Performing more than one tests is essential because every test has its very own algorithm and the results do not always match. In such cases, it is up to the analyst to decide which test to "believe" in order to continue.

We will start examining the variables one by one. Not all tests are going to be performed by the same statistic or econometric program (it is not even possible since very few are the programs that can handle all of them) because not all programs are said to be equally specialized to all of them. There are some small differences from algorithm to algorithm like for example in the case of Kolmogorov – Smirnov test that SPSS and EasyFit, provide us with different statistics. Thus, every test is chosen to be run by a program that can most efficiently use the available data. The first three tests of the above list (i.e. Kolmogorov - Smirnov test, Anderson – Darling test, Chi – Square test) will be performed by the program EasyFit, the fifth and the sixth (i.e. Shapiro – Wilk test and the one that is based on skewness) by SPSS and the forth one (i.e. Jarque – Bera test) will be performed by EViews. The seventh one (i.e. Visual tests) is pretty standard and can be performed by every program and the last one (based on the Central Limit Theorem) is self-explanatory and does not need and further calculations.

By examining the variables in the order that they were earlier presented we have the following:

Closing Price

The whole sample is divided into two groups. The observations regarding the period before the announcement of the revised Greek deficit, consist the variable "Closing Price A" and those regarding the period after the announcement, consist the variable "Closing Price B". *Firstly, only the variable "Closing Price A" will be analyzed*.

Closing Price A:

- **Kolmogorov – Smirnov test**
- **Anderson – Darling test**
- **Chi – Squared test**

After importing the data and performing the appropriate test, we get the following results:

Kolmogorov-Smirnov					
Sample Size Statistic P-Value Rank	418 0,13364 5,6589E-7 41				
α	0,2	0,1	0,05	0,02	0,01
Critical Value	0,05248	0,05982	0,06642	0,07425	0,07968
Reject?	Yes	Yes	Yes	Yes	Yes
Anderson-Darling					
Sample Size Statistic Rank	418 12,841 41				
α	0,2	0,1	0,05	0,02	0,01
Critical Value	1,3749	1,9286	2,5018	3,2892	3,9074
Reject?	Yes	Yes	Yes	Yes	Yes
Chi-Squared					
Deg. of freedom Statistic P-Value Rank	8 88,672 8,8818E-16 38				
α	0,2	0,1	0,05	0,02	0,01
Critical Value	11,03	13,362	15,507	18,168	20,09
Reject?	Yes	Yes	Yes	Yes	Yes

Table 1 Kolmogorov-Smirnov, Anderson-Darling and Chi-Squared test for "Closing Price A"

Kolmogorov – Smirnov test:

Kolmogorov – Smirnov test is a hypothesis test with null hypothesis:

H_0: Variable follows a Normal Distribution

With the alternative hypothesis:

H_1: Variable does not follow a Normal Distribution.

According to the description of the test that has already been provided, the outcome of the hypothesis test is a probability value (p-value), which represents the probability to make a mistake if we finally accept the null hypothesis (that is the so-called Type II error according to description provided above). We do not reject the null hypothesis when p-value is greater than the significance level "a". The significance level that is usually used is 0,05 and this is also the value we are going to be based on. Thus, since the p-value is less than 0,05 (5,6589E-7 which is equal to $5{,}6589*10^{-7}$ =0,00000056589) , we do reject the null hypothesis that the variable "Closing Price A" follows a normal distribution. The outcome table provides the results for other common prices of "a", as well.

Anderson – Darling test:

Anderson – Darling test is a hypothesis test with the same null and alternative hypotheses as Kolmogorov – Smirnov test (i.e.: H_0: Variable follows a Normal Distribution, H_1: Variable does not follow a Normal Distribution). According to the procedure already provided, the outcome of this test is the statistic A^2 (referred as "Statistic"). This statistic compared to the critical value related to the significance level of our choice helps as decide if we are going to reject the null hypothesis or not. If the statistic A^2 is greater than the corresponding critical value (which is obtained with the help of statistic tables), then the null hypothesis is rejected. If not, then it is not rejected. In our case, the Statistic is equal to 12,841 which is greater than 2,5018 (the critical value that corresponds to the significance level 0,05) which means that the null hypothesis that the variable "Closing Price A" follows a normal distribution, is rejected.

<u>Chi – Squared test:</u>

Like both of the previous tests, Chi – Squared test is a hypothesis test that has a null hypothesis H_0: Variable follows a Normal Distribution and an alternative hypothesis H_1: Variable does not follow a Normal Distribution. The outcome of this test is a statistic (X^2) and there is a p-value that is calculated, based on this statistic. Exactly like the Kolmogorov – Smirnov test, this p-value represents the probability to make a mistake if we finally accept the null hypothesis (Type II error). In order for us to accept the null hypothesis, the p-value has to be greater than "a", which is the significance level of our test. As we can see, the given table informs us that the p-value is 8,8818E-16 = $8{,}8818*10^{-16}$ which is a lot less than 0,05 (the significance level we have decided to use for all the tests). That means that we have no reason to accept the null hypothesis that the variable "Closing Price A" follows a normal distribution.

- **Jarque – Bera test**

After importing our data and performing the test, the econometric program EViews provides the following results:

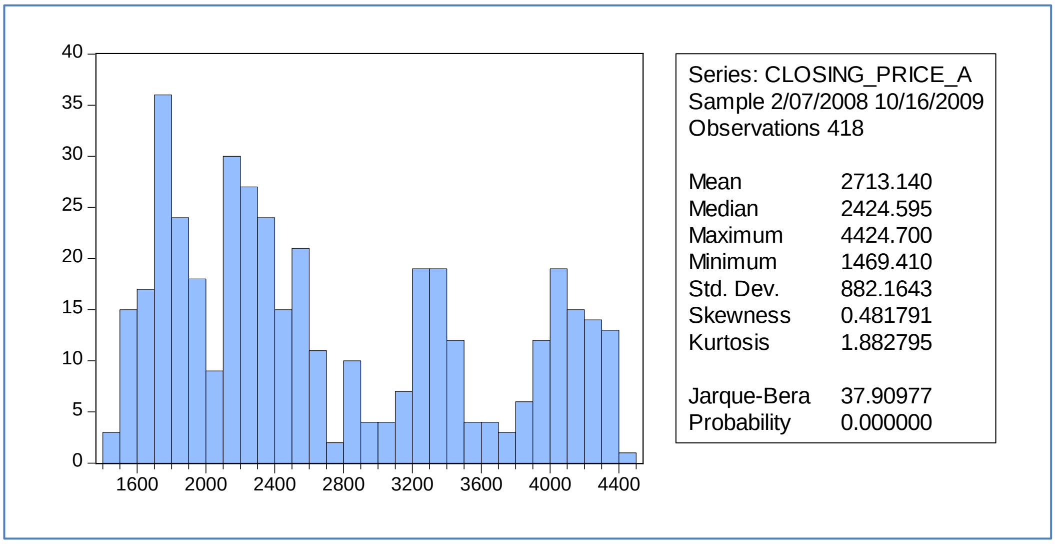

Figure 1 Jarque-Bera test for "Closing Price A"

The value tagged as “Jarque – Bera” is the value of the Jarque – Bera statistic, based on which, we have a “Probability”. This is nothing more than the equivalent of the p-value from the previous tests. Once more, the null hypothesis H_0: Variable follows a Normal Distribution (the alternative hypothesis is H_1: Variable does not follow a Normal Distribution) is not rejected if “Probability” is greater than the significance level of our choice (for us 0,05) because it represents the Type II error, as was also the case in the previous tests. Since Probability is 0,00 (practically it is not zero but it is a price that is rounded to zero because of the accuracy that EViews uses) which is less than 0,05, we once more reject the null hypothesis that the variable “Closing Price A” follows a normal distribution.

- **Shapiro – Wilk test**

This test will be performed by SPSS. After importing the data and running the test with the appropriate commands, we get the following results:

Test of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
Closing_Price_A	.910	418	.000

Table 2 Shapiro-Wilk test for “Closing Price A”

As was the case with the previous tests, a “Statistic” is calculated (in our case it is equal to 0,910) and then, based on that, we get a “Sig.” value which is the exact equivalent to p-value from the previous tests. As this value is not greater than our significance level (which is 0,05 in our case), we reject the null hypothesis H_0: Variable “Closing Price A” follows a Normal Distribution and thus accept the alternative hypothesis H_1: Variable “Closing Price A” does not follow a Normal Distribution.

After all those normality tests, we are sure that we our distribution is far from normal but for completion reasons we will also perform all the remaining tests.

- **Skewness test**

This is probably the most inconspicuous test of all we have performed or we are about to perform. What we are going to compute, is the skewness of our variable and the standard error of it (of the skewness). If the fraction:

$$\frac{\text{Skewness}}{\text{Standard Error of Skewness}}$$

is a number that lies in the interval from -2 to 2, then we are going to accept the null hypothesis that the variable "Closing Price A" follows a Normal Distribution. If not, then we are going to accept the alternative hypothesis which is that the variable "Closing Price A" does not follow a Normal Distribution.

Statistics

Closing_Price_A

N	Valid	418
	Missing	0
Mean		2709.4657
Std. Error of Mean		42.96659
Median		2424.5950
Mode		2830.01
Std. Deviation		878.45399
Variance		771681.415
Skewness		.486
Std. Error of Skewness		.119
Range		2955.29
Sum		1132556.67
Percentiles	25	1921.6525
	50	2424.5950
	75	3387.4025

Table 3 Skewness test for "Closing Price A"

As we can see from the above table, the skewness of our variable is 0,486 and the standard error of skewness is 0,119 which give as a fraction:

$$\frac{\text{Skewness}}{\text{Standard Error of Skewness}} = \frac{0{,}486}{0{,}119} = 4{,}084$$

which of course does not lie in the interval [-2,2] and thus we reject the null hypothesis.

- **Visual tests**

Those tests are the most subjective ones but this is why they can help us decide if we are going to treat a variable as one that follows a Normal Distribution or not, when the rest of the tests "disagree" with each other. There are lots of tests or graphs that belong to this category. The most useful out of those are the so called Q-Q Plot and T-T Plot and the histogram which can be much more helpful if it has the curve of the normal distribution on it. All those visual tests are presented below in the order they were just mentioned.

Quantile – Quantile Plot (Q-Q Plot)

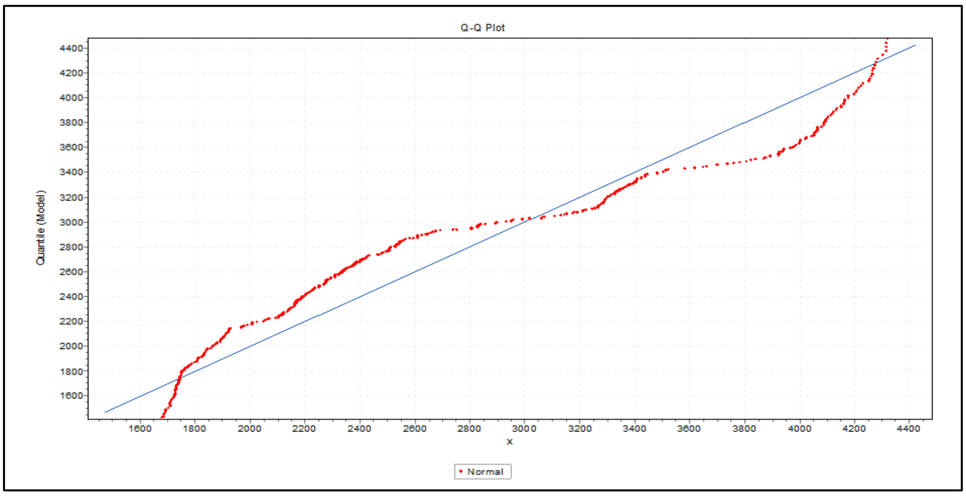

Figure 2 Q-Q Plot for "Closing Price A"

The above graph is the Q – Q Plot for the Normal Distribution. Based to the description of the graph's building procedure that has already been given, the closest the dots are to the diagonal line (which is the function f(x) = x), the more possible it is that the variable under investigation follows a Normal Distribution. Generally, we tend to accept that the variable follows a normal distribution when most of the dots lie in a relatively small zone around the diagonal line. And due to the fact that "relative small" implies subjectivity, this test is marked as highly subjective. Maybe a little influenced by the previous, less subjective tests, we come up with the conclusion that our observations (the dots) do not fit properly enough to the diagonal line. Thus, we cannot accept that our variable follows a normal distribution.

Probability – Probability Plot or Percentile – Percentile Plot (P – P Plot)

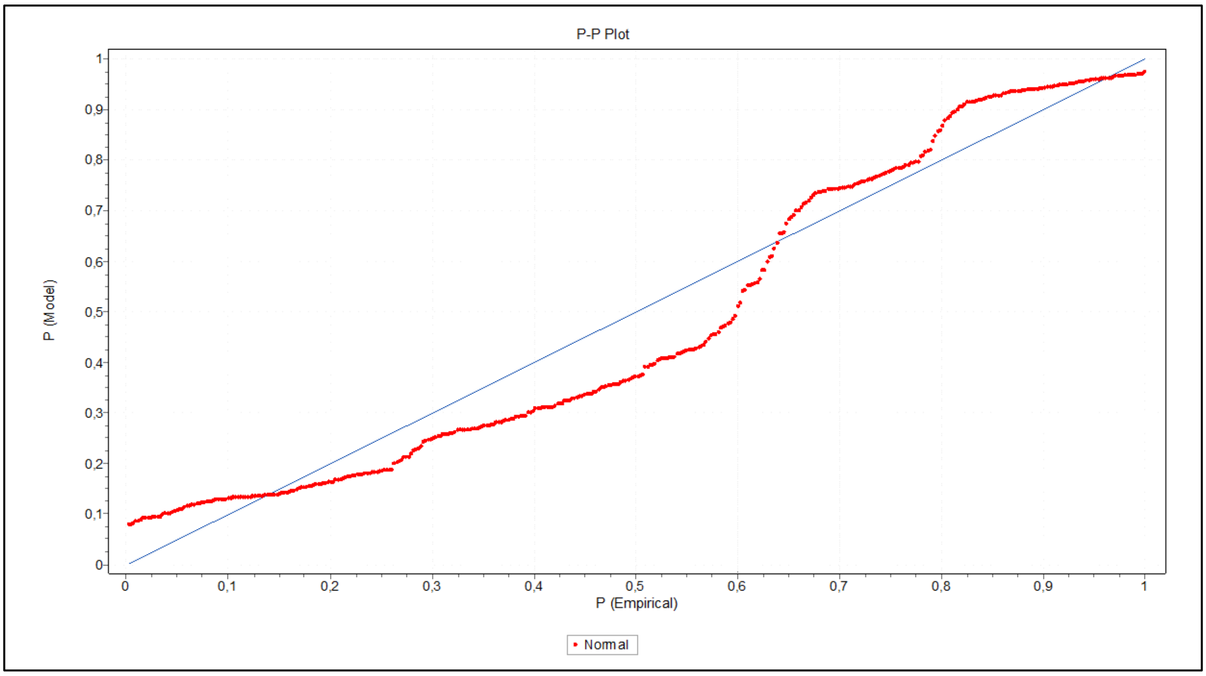

Figure 3 P-P Plot for "Closing Price A"

Although the axes, this time represent different entities (see description above) the main method about interpreting the outcome is the same. If the dots form a curve that is approximately linear and close to the diagonal, then we should tend to accept that it is about a variable that follows a normal distribution. In our case, the curve does not seem linear as there are quite a few areas that it is away enough from the diagonal and this is a good reason for us not to accept the normality of the variable "Closing Price A".

The next visual test, although subjective (as everyone in this category), is very useful in case of "disagreement" among the previous ones because it is easily interpretable and gives a much better view of the distribution of the variables it is built on.

Histogram with the curve of Normal Distribution

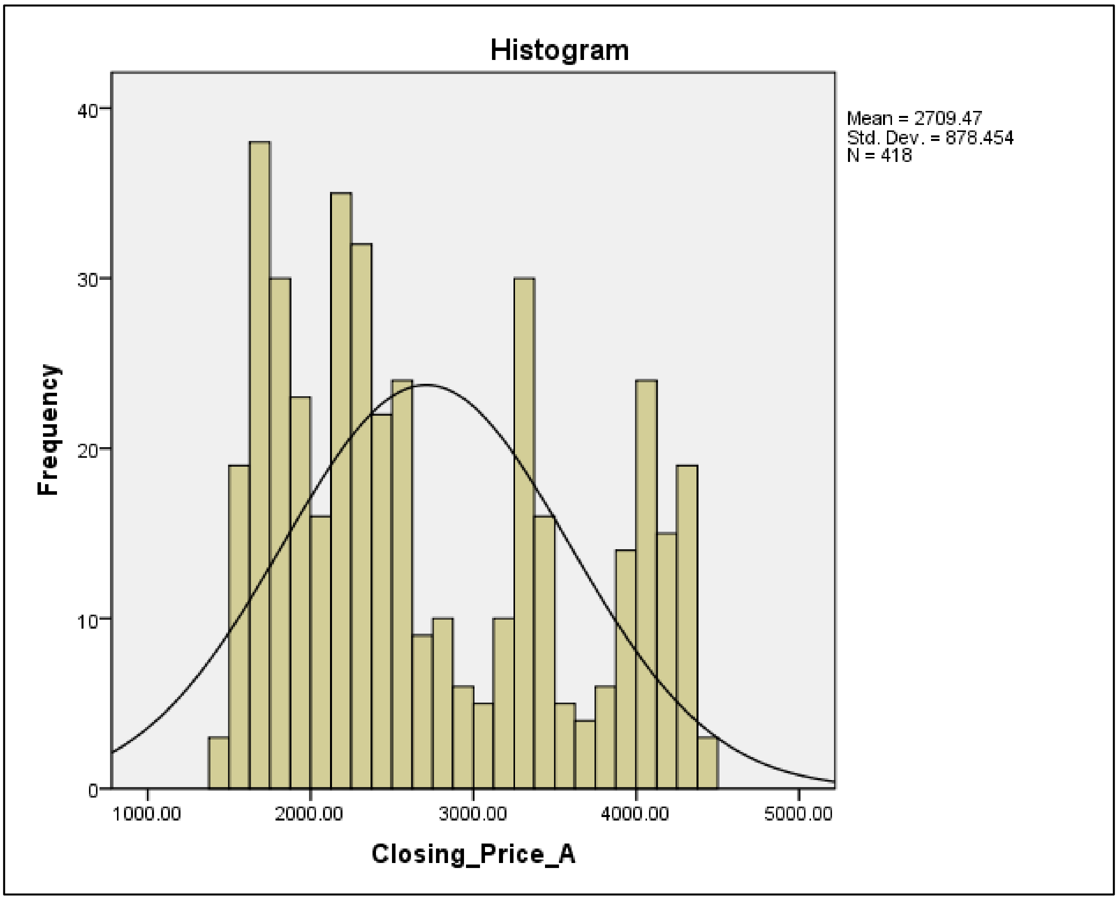

Figure 4 Histogram (including the curve of the Normal Distribution) for "Closing Price A"

This is the Histogram of "Closing Price A" with the curve of the Normal distribution on it. It is obvious that this variable does not follow a Normal Distribution as its Histogram seems a lot different from the Histogram of a Normal Variable. Therefore, we cannot accept that this variable follows a Normal Distribution.

The same procedure should be followed for the remaining variables. Since the interpretation of the outputs has already been explained, the remaining variables will be examined in short.

Volume in Shares

Once more, the whole sample is divided into two groups. The observations regarding the period before the announcement of the revised Greek deficit, consist the variable “Volume Shares A” and those regarding the period after the announcement, consist the variable “Volume Shares B”. Firstly, only the variable “Volume Shares A” will be analyzed.

Volume Shares A:

- **Kolmogorov – Smirnov test**
- **Anderson – Darling test**
- **Chi – Squared test**

Kolmogorov-Smirnov					
Sample Size Statistic P-Value Rank	418 0,16832 8,1936E-11 35				
☐	0,2	0,1	0,05	0,02	0,01
Critical Value	0,05248	0,05982	0,06642	0,07425	0,07968
Reject?	Yes	Yes	Yes	Yes	Yes
Anderson-Darling					
Sample Size Statistic Rank	418 31,081 37				
☐	0,2	0,1	0,05	0,02	0,01
Critical Value	1,3749	1,9286	2,5018	3,2892	3,9074
Reject?	Yes	Yes	Yes	Yes	Yes
Chi-Squared					
Deg. of freedom Statistic P-Value Rank	8 179,2 0 36				
☐	0,2	0,1	0,05	0,02	0,01
Critical Value	11,03	13,362	15,507	18,168	20,09
Reject?	Yes	Yes	Yes	Yes	Yes

Table 4 Kolmogorov-Smirnov, Anderson-Darling and Chi-Squared test for “Volume Shares A”

<u>Kolmogorov – Smirnov test:</u>

Variable “Volume Shares A” does not follow a Normal Distribution since p-value ($8{,}1936*10^{-11}$) is not greater than the significance level which is 0,05.

Anderson – Darling test:

Variable "Volume Shares A" does not follow a Normal Distribution since the statistic (31,081) is greater than the critical value (2,5018) that corresponds to the significance level (0,05).

Chi – Squared test:

Variable "Volume Shares A" does not follow a Normal Distribution since p-value (0) is less than the significance level which is 0,05.

- **Jarque – Bera test**

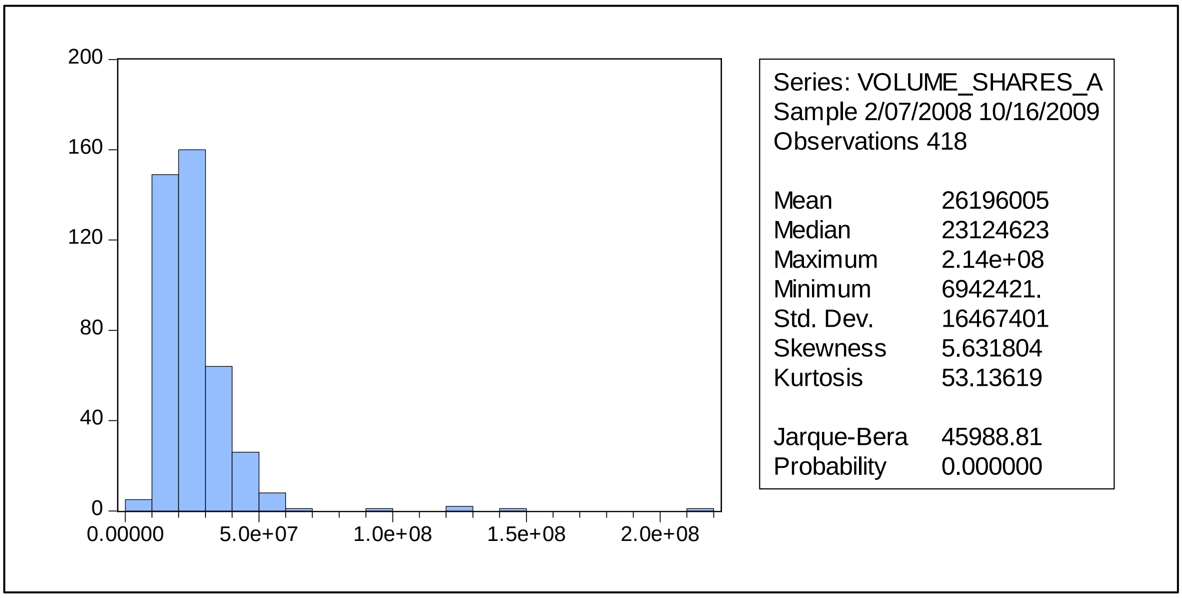

Figure 5 Jarque-Bera test for "Volume Shares A"

We cannot accept the hypothesis that the variable "Volume Shares A" follows a Normal Distribution because "Probability" (0) is less than 0,05 which is our significance level.

- **Shapiro – Wilk test**

Since the results of the test are the following

Test of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
Volume_Shares_A	.602	418	.000

a. Lilliefors Significance Correction

Table 5 Shapiro-Wilk test for "Volume Shares A"

We cannot accept the null hypothesis that the variable Volume Shares A follows a Normal Distribution because the "Sig." price, which is so small that is rounded to zero, is less than 0,05 which is our significance level.

- **Skewness test**

Statistics

Volume_Shares_A

N	Valid	418
	Missing	0
Mean		26196004.5144
Std. Error of Mean		805446.91945
Median		23124623.0000
Mode		6942421.00[a]
Std. Deviation		16467401.17135
Variance		2.712E14
Skewness		5.652
Std. Error of Skewness		.119
Sum		1.09E10
Percentiles	25	17814354.5000
	50	23124623.0000
	75	29815720.0000

a. Multiple modes exist. The smallest value is shown

Table 6 Skewness test for "Volume Shares A"

From the results we can see in the above figure, we can compute the fraction:

$$\frac{\text{Skewness}}{\text{Standard Error of Skewness}} = \frac{5{,}652}{0{,}119} = 47{,}496$$

Since the value of this fraction does not lie in the interval [-2, 2], we reject the null hypothesis that the variable "Volume Shares A" follows a Normal Distribution.

- **Visual tests**

Quantile – Quantile Plot (Q-Q Plot)

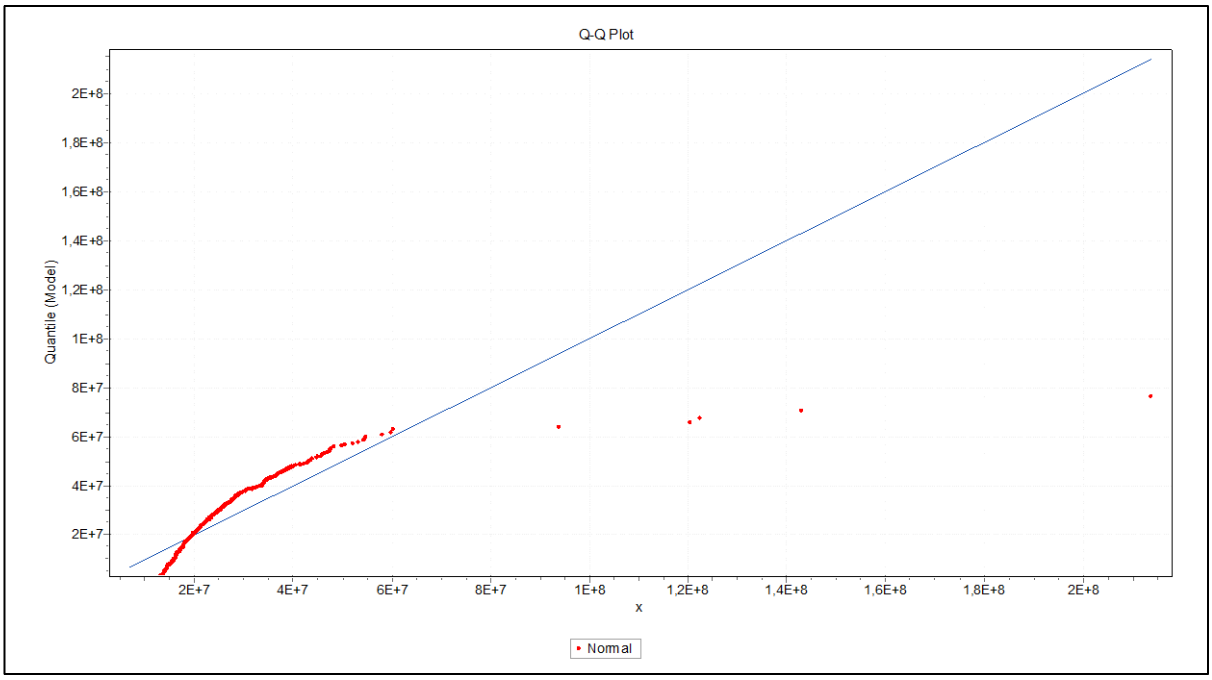

Figure 6 Q-Q Plot for "Volume-Shares A"

There is no doubt that the above graph depicts a Q – Q Plot of a non – normal variable since the dots do not belong to a small zone around the diagonal. That means that we reject the hypothesis that the variable "Volume Shares A" follows a Normal Distribution.

Probability – Probability Plot or Percentile – Percentile Plot (P – P Plot)

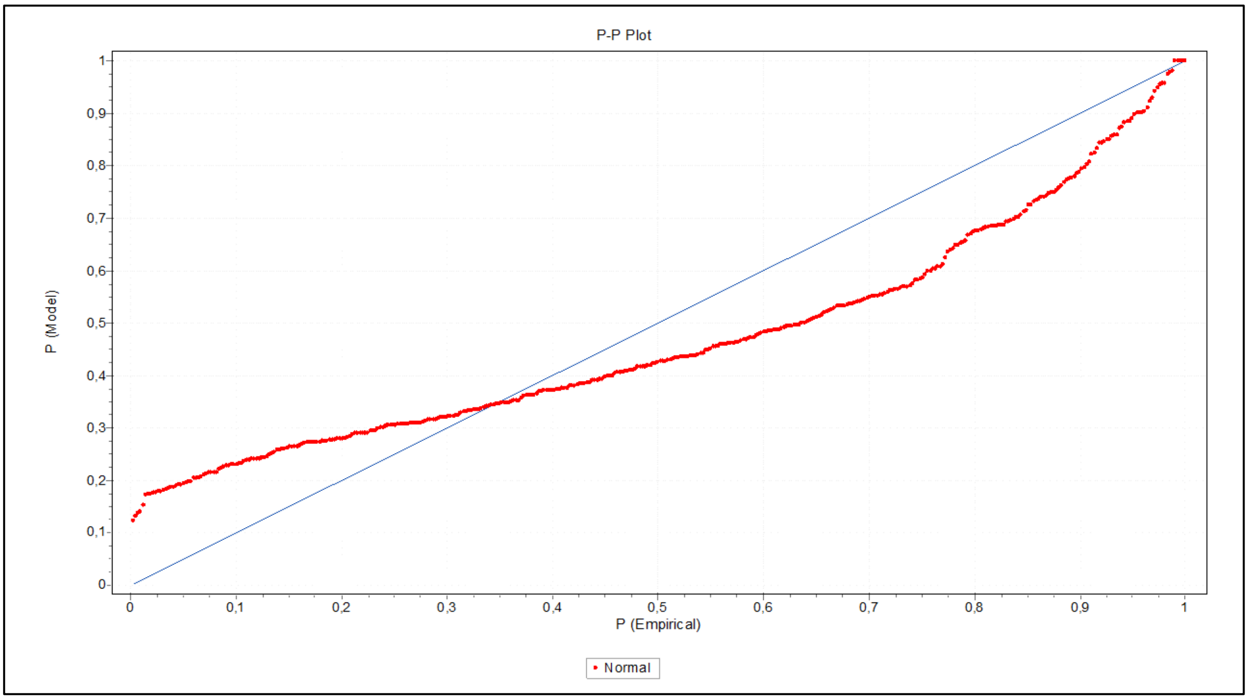

Figure 7 P-P Plot for "Volume Shares A"

The results derived from the Q – Q Plot can be confirmed also from the P – P Plot. It is clear that our variable fails to follow a Normal Distribution.

Histogram with the curve of Normal Distribution

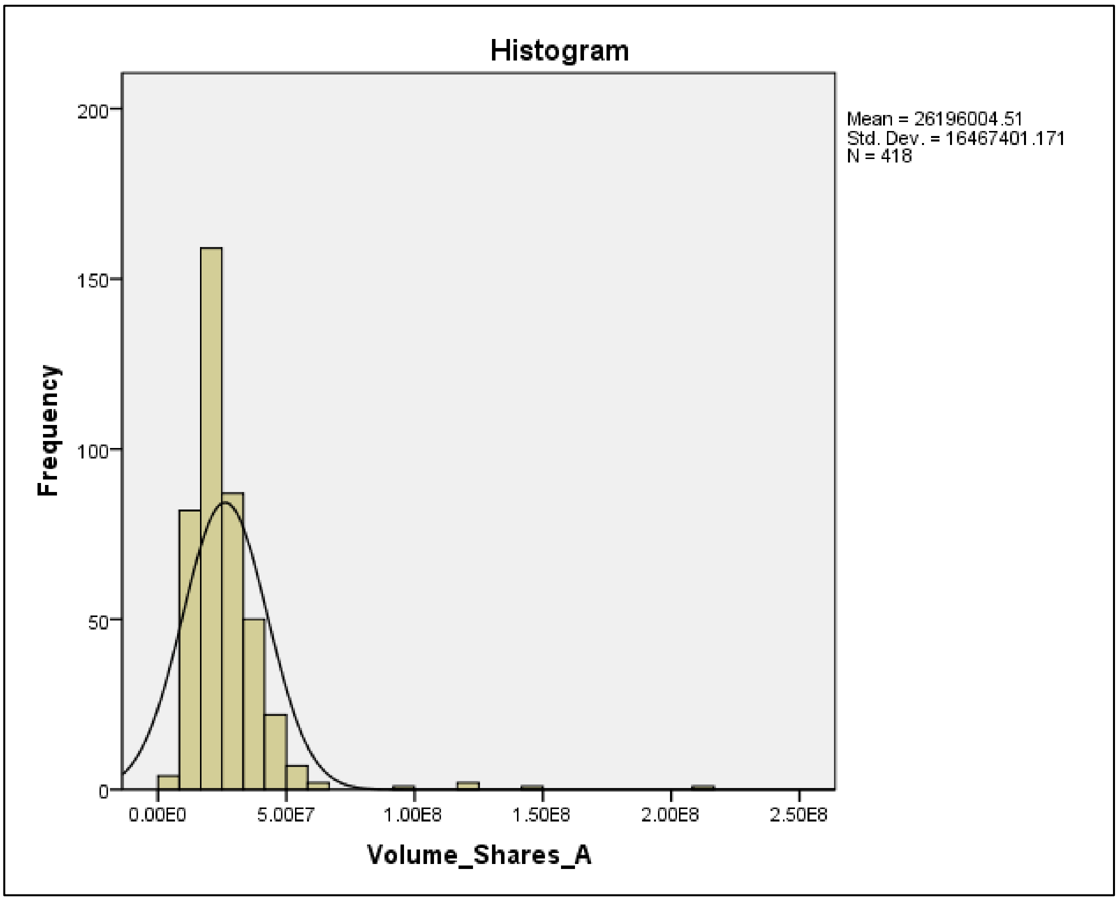

Figure 8 Histogram (including the curve of the Normal Distribution) for "Volume Shares A"

As easily observed from the histogram, on the one hand we have observations that exceed by far the maximum height of a Normal Distribution and on the other hand we have some too small observations that make our distribution differ a lot from a Normal one. It is possible for those observations to be *outliers* that have occurred either by mistake or due to some extreme circumstances during the days they correspond to. But since they are not by mistake, they cannot be changed or skipped in order to make our Distribution in order to seem more like a Normal one.

Following exactly the same procedure for all the other variables which only consist of observation that belong to the pre-announcement period we have the following table:

Test / Variable	Skewness test	Kolmogorov-Smirnov	Shapiro-Wilk	Jarque-Bera	Anderson-Darling	Chi - Squared	Visual tests	Verdict
Closing Price A	NO	NO	NO	NO	NO	NO	NO	Non-Normal
Volume Shares A	NO	NO	NO	NO	NO	NO	NO	Non-Normal
Volume Euros A	NO	NO	NO	NO	NO	NO	NO	Non-Normal
High – Low A	NO	NO	NO	NO	NO	NO	NO	Non-Normal
Velocity A	NO	NO	NO	NO	NO	NO	NO	Non-Normal
Return A	YES	YES	YES	NO	YES	NO	YES	Normal

Table 7 Cumulative results of the Normality tests for the first sample of all variables

In every cell there is the answer to the question: "if we perform the test that lies in the title of the corresponding column to the variable that lies in the title of the corresponding row, will we conclude that this variable follows a Normal Distribution"? For example, the "YES" cell that lies in the row "Return A" and in the column under the tab "Kolmogorov – Smirnov" denotes that according to the Kolmogorov – Smirnov test, the variable "Return A" follows a Normal Distribution.

By performing the same tests as up to that point and by interpreting the results the same way, we have the following results for the second group of observations (the ones that correspond to the period after the announcement):

Test / Variable	Skewness test	Kolmogorov-Smirnov	Shapiro-Wilk	Jarque-Bera	Anderson-Darling	Chi - Squared	Visual tests	Verdict
Closing Price B	NO	NO	NO	NO	YES	YES	NO	Non-Normal
Volume Shares B	NO	YES	NO	NO	YES	YES	YES	Normal
Volume Euros B	NO	YES	NO	NO	YES	YES	YES	Normal
High – Low B	NO	YES	NO	NO	YES	NO	NO	Non-Normal
Velocity B	NO	YES	NO	NO	YES	YES	YES	Normal
Return B	YES	YES	YES	YES	YES	YES	YES	Normal

Table 8 Cumulative results of the Normality tests for the second sample of all variables

From the union of the two previous tables we have a pooled table that summarizes the outcomes and the kind of test we are going to use for each (ungrouped) variable in order to test if the announcement regarding the revised Greek deficit, had a significant impact on them:

Variable	Normality Status	Kind of Future Test
Closing Price A	Non - Normal	**Non – Parametric**
Closing Price B	Non - Normal	
Volume Shares A	Non - Normal	**Non – Parametric**
Volume Shares B	Normal	
Volume Euros A	Non - Normal	**Non – Parametric**
Volume Euros B	Normal	
High – Low A	Non - Normal	**Non – Parametric**
High – Low B	Non - Normal	
Velocity A	Non - Normal	**Non – Parametric**
Velocity B	Normal	
Return A	Normal	**Parametric**
Return B	Normal	

Table 9 Normality test outcome and type of further testing for all our variables

It is worth pointing out that in order for us to apply a parametric test on a sample that is divided into two groups, *both* of those groups should follow a Normal Distribution. The above table was completed based on that principle.

3.3.2. Performing the hypothesis tests based on the normality tests

All the previous normality tests were performed for only one reason; to decide which kind of test is the most appropriate for each variable. The non – parametric tests can be applied on any kind of data, no matter if a Normal Distribution is followed or not, or if there is a pattern in our data. Parametric tests on the other hand, are not that convenient. There are some prerequisites that need to be met (depending on the test) in order for those tests to be performed. In our case, where the two groups of each variable are independent, we will decide about the type of test(s) we are going to perform, based exclusively on the distribution that our samples follow.

If they follow a Normal Distribution then we are going to perform the most appropriate test for a sample that: a) follows a Normal Distribution, b) consists of two groups independent to each other, c) those groups represent the measured values of a characteristic before and after a critical point (in our case, the announcement). Apart from the first characteristic, which is not applicable to every one of our variables, all the others are properties of our variables/samples. The most appropriate test for that kind of variables/samples is the so-called *two sample t-test.*

Two Sample t-test

The two-sample t-test is used to determine if two population means are equal. A common application of this is to test if a new process or treatment is superior to a current process or treatment. The variances of the two samples may be assumed to be equal or unequal.

Definition

The two sample t test for unpaired data is defined as:

H_0: $\mu_1=\mu_2$

H_1: $\mu_1\neq\mu_2$ (two-tailed), $\mu_1<\mu_2$ or $\mu_1>\mu_2$ (one-tailed)

Test Statistic

$$T = \frac{\overline{Y}_1 - \overline{Y}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}}$$

where N1 and N2 are the sample sizes, $\overline{Y}_1$ and $\overline{Y}_2$ are the sample means and s_1^2 and s_2^2 are the sample variances. If equal variances assumed, then the formula reduces to:

$$T = \frac{\overline{Y}_1 - \overline{Y}_2}{s_p\sqrt{\frac{1}{N_1} + \frac{1}{N_2}}}$$

where

$$s_p^2 = \frac{(N_1 - 1)s_1^2 + (N_2 - 1)s_2^2}{N_1 + N_2 - 2}$$

Critical Region

Reject the null hypothesis that the two means are equal if:

$$T < -t_{(a/2,\, u)} \text{ or } T > t_{(a/2,\, u)}$$

where $t_{(a/2,\, u)}$ is the critical value of the t distribution with u degrees of freedom where

$$u = \frac{(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2})^2}{\frac{(\frac{s_1^2}{N_1})^2}{N_1 - 1} + \frac{(\frac{s_2^2}{N_2})^2}{N_2 - 1}}$$

If equal variances are assumed, then $u = N_1 + N_2 - 2$. Equivalently, we reject the null hypothesis if the "Sig (2-tailed)" value is less than our significance level (for the two tailed test) or if the "Sig (1-tailed)" value which is equal to Sig (2-tailed)/2 is less than our significance level.

(Walpole et al., 2006, p.364)

If one of our samples do not follow the Normal Distribution, then based on the same rationale as before, we have to perform the most appropriate test for a sample that: a) does not follow a Normal Distribution, b) consists of two groups independent to each other, c) those groups represent the measured values of a characteristic before and after a critical point (in our case, the announcement). The most appropriate test for that kind of variables/samples is the *Mann – Whitney U test,* also known as Mann – Whitney Wilcoxon test or Wilcoxon Rank Sum test.

Mann – Whitney test for large samples (n_1>10 and n_2>10)

We test

$$H_0: m_1 = m_2 \ vs \ H_1: \begin{cases} m_1 > m_2, & upper\ tailed\ test \\ m_1 < m_2, & lower\ tailed\ test \\ m_1 \neq m_2, & two-tailed\ test \end{cases}$$

where m_1 and m_2 are the medians of sample1 and sample2, respectively.

We combine the two samples into a single sample of size n_1 + n_2, keeping track of each observation's original population. We then arrange the n_1 + n_2 observations in ascending order and assign ranks. We sum the ranks of observations from population II and we call it R.

$$W = R - \frac{1}{2}n_2(n_2 + 1)$$

and

$$Z = \frac{W - \frac{n_1 n_2}{2}}{\sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}}$$

Rejecting region:

$$\begin{cases} Z > Z_a, & upper\ tail\ RR \\ Z < -Z_a, & lower\ tail\ RR \\ |Z| > Z_{a/2}, & two\ tail\ RR \end{cases}$$

Equivalently to $|Z| > Z_{a/2}$ we reject the null hypothesis if "Asymp. Sig. (2-tailed)" value is less than our significance level.

(Marques de Sá, 2007, p.220)

We will now take the variables one by one and will apply the appropriate test to each of them.

Closing Price

The variables "Closing Price A" and "Closing Price B" are Non-Normal and thus the non-parametric Mann-Whitney U test will be applied on the variable "Closing Price". The values of "Closing Price A" and "Closing Price B" will not be examined in pairs (and this is why the size of the samples is not required to be equal) so they will not be introduced to SPSS as two separate variables but instead, only one variable will be introduced with all the observations in it. In order for us (and SPSS) to be aware of the observations that belong to the period before and after the announcement, we introduce a new variable that extends from the very first day of “Closing Price A” to the last day of “Closing Price B” (except of course from the week that is excluded) and takes only two prices as values: price “1” if the observation of that day belongs to the pre-announcement period and price “2” if the observation of that day belongs to the post-announcement period. This variable will be used by SPSS as a grouping variable.

After importing the variable “Closing Price” and the grouping variable, we run the appropriate commands and we are given the following results:

Ranks

	Grouping_Variable	N	Mean Rank	Sum of Ranks
Closing_Price	1	418	272.51	113909.50
	2	100	205.12	20511.50
	Total	518		

Table 10 Preliminary table with some basic figures about both samples of “Closing Price”

Test Statistics[a]

	Closing_Price
Mann-Whitney U	15461.500
Wilcoxon W	20511.500
Z	-4.045
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Grouping_Variable

Table 11 Mann-Whitney test for “Closing Price”

As already mentioned, the Mann – Whitney U test is a test that compares if two groups of a variable have the same distribution (i.e. the same median). Based on the differences of those two distributions/medians, we decide if the critical action that caused the grouping of our sample, has significantly changed the value of the variable under investigation.

The first of those tables informs us about some details regarding our groups. The group that consists of all the observations for which the variable "Grouping Variable" has price "1" (the observations that belong to the pre-announcement period), has 418 observations in total and those observations have mean rank equal to 272,51 and sum of ranks equal to 113909,5. That means that if we rearrange all the observations of the variable "Closing Price" in ascending order and add all the ranks that correspond to the observations of the "pre-announcement" group, we will get a total sum of 113909,5. If we now divide that number by 418 (the number of the observations – we compute the mean that way) we will get a mean rank equal to 272,51. Similarly, if we do the same for the ranks that correspond to the observations of the "post-announcement" group, we will get a total sum of 20511,5 and a mean rank equal to 205,12.

Although we understand that the announcement has caused some changes to the closing prices of the Greek Stock Exchange, we should statistically check if this "empirical" hypothesis is indeed correct. This is why we should consult the second table which depicts the results of the hypothesis test. From this test we mainly need the value of "Asymp. Sig. (2-tailed)" which represents the probability for us to make a mistake if we reject the null hypothesis. Since this probability is practically equal to zero which is a price less than 0,05 (our level of significance), we do not hesitate to reject the null hypothesis regarding the equality of the medians or the distributions. The U statistic is calculated as described earlier and it is equal to 15461,5.

By rejecting the null hypothesis, we are inclined to believe that the announcement regarding the Greek deficit rate, has caused significant change to the closing prices.

Volume in Shares

Since the variables "Volume Shares A" and "Volume Shares B" do not *both* follow a normal distribution, we have to perform a non-parametric test and as before, the most appropriate test for this occasion is the Mann-Whitney U test. We follow exactly the same procedure as the one we followed for the variable "Closing Price" for inserting the data on SPSS and using an extra auxiliary variable (the "Grouping variable") in order for us to be able to tell which observations belong to "Volume Shares A" and which belong to "Volume Shares B". The results of the test are the following:

Ranks

	Grouping_Variable	N	Mean Rank	Sum of Ranks
Volume_Shares	1	418	245.94	102802.00
	2	100	316.19	31619.00
	Total	518		

Table 12 Preliminary table with some basic figures about both samples of "Volume in Shares"

Test Statistics[a]

	Volume_Shares
Mann-Whitney U	15231.000
Wilcoxon W	102802.000
Z	-4.216
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Grouping_Variable

Table 13 Mann-Whitney test for "Volume in Shares"

From the first table of the results, we receive the information about the means rank for both of our groups (Group "1" represents the observations that correspond to the period before the announcement about the revised Greek deficit figures and Group "2" represents the ones that correspond to the period after the announcement about the revised Greek deficit figures). As we see, the mean rank of the first group is 245,94 and the group consists of 418 observations while the mean rank of the second group is 316,19 and this group consists of 100 observations.

Based on the second table, we can come to the conclusion that there is a considerable difference between the distributions/medians of the two groups, due to the announcement. We conclude that by the fact that the "Asymp. Sig. (2-tailed)" value (0) is a value less than 0,05 which is our significance level.

Volume in Euros

Due to the fact that the variables "Volume Euros A" and "Volume Euros B" do not both follow a normal distribution, we should once more perform the Mann-Whitney U test. The outcome of this test is the following:

Ranks

	Grouping_Variable	N	Mean Rank	Sum of Ranks
Volume_Euro	1	418	256.96	107410.00
	2	100	270.11	27011.00
	Total	518		

Table 14 Preliminary table with some basic figures about both samples of "Volume in Euros"

Test Statistics[a]

	Volume_Euro
Mann-Whitney U	19839.000
Wilcoxon W	107410.000
Z	-.789
Asymp. Sig. (2-tailed)	.430

a. Grouping Variable: Grouping_Variable

Table 15 Mann-Whitney test for "Volume in Euros"

By consulting the first table we can see that the mean ranks do not significantly differ to each other. In particular, the mean rank for the first group (which is defined as in the previous variables) is 256,96 and the mean rank for the second group is 270,11. This small difference makes us believe that the announcement may did not have such a great impact on the variable "Volume Euros". Of course, we should investigate that in a more scientific and objective way and thus we should reclaim the second table.

This time, the "Asymp. Sig. (2-tailed)" is equal to 0,430 and since the significance level is 0,05 (which is less), we can safely claim that the announcement under investigation, did not have notable impact on the daily traded volume when this is measured in euros.

High – Low Spread

As was the case with the previous variances, not both groups of the variable ("High Low A" and "High Low B") follow a Normal Distribution. This is why the most suitable test to be applied is the Mann-Whitney test. The results of the test when this is performed by SPSS, are the following:

Ranks

	Grouping_Variable	N	Mean Rank	Sum of Ranks
High_Low	1	418	254.17	106244.00
	2	100	281.77	28177.00
	Total	518		

Table 16 Preliminary table with some basic figures about both samples of "High – Low Spread"

Test Statistics[a]

	High_Low
Mann-Whitney U	18673.000
Wilcoxon W	106244.000
Z	-1.656
Asymp. Sig. (2-tailed)	.098

a. Grouping Variable: Grouping_Variable

Table 17 Mann-Whitney test for "High – Low Spread"

Similarly to the previous variable (Volume in Euros), the variation between the mean ranks of the two groups does not seem very large (proportionally to the quantities of the variable) and we once more anticipate that the results of the Mann-Whitney test will confirm our suspicions.

Indeed, "Asymp. Sig. (2-tailed)" value (0,098) which is equivalent to the p-value at the previous tests, is greater than our level of significance which is 0,05. That leads us to reject the null hypothesis and conclude that the announcement concerning the bloated Greek deficit figures, did not cause significant cuts or increments to the High-Low Spread.

Velocity

We should again perform a non-parametric test for this variable, due to the fact that the variables “Velocity A” and “Velocity B” do not both follow a Normal Distribution. According to the explanations given at the beginning of this section, the appropriate hypothesis test for this variable is the Mann-Whitney test. The results of this test are the following:

Ranks

	Grouping_Variable	N	Mean Rank	Sum of Ranks
Velocity	1	418	247.57	103483.00
	2	100	309.38	30938.00
	Total	518		

Table 18 Preliminary table with some basic figures about both samples of “Velocity”

Test Statistics[a]

	Velocity
Mann-Whitney U	15912.000
Wilcoxon W	103483.000
Z	-3.710
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Grouping_Variable

Table 19 Mann-Whitney test for “Velocity”

The value of “Asymp. Sig. (2-tailed)” is a number rounded to zero and since this number is less than 0,05 (our significance level) we are inclined to believe that the difference between the two groups (Group “1” for the pre-announcement period and Group “2” for the post-announcement period) are significant. We already had signs of this notable difference because of the considerable difference in the mean ranks of the two groups that are given in the first table.

Return

The variable "Return" is the only variable that consists of two groups, both of which follow a Normal Distribution. In this case we should perform the parametric equivalent of Mann-Whitney test which is the t-test and is identical to the ANOVA test when we investigate a variable that consists of only *two* groups (Park, 2009, p.5). After running the appropriate commands on SPSS, we have the following results:

Group Statistics

	Grouping_Variable	N	Mean	Std. Deviation	Std. Error Mean
Return	1	418	-.000776283939	.0226426257241	.0011074870253
	2	100	-.003164123891	.0237375023482	.0023737502348

Table 20 Preliminary table with some basic figures about both samples of "Return"

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
Return	Equal variances assumed	1.085	.298
	Equal variances not assumed		

Table 21 Levene's test for "Return" as part of the t-test

Independent Samples Test

		t-test for Equality of Means						
							95% Confidence Interval of the Difference	
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Return	Equal variances assumed	.938	516	.348	.0023878399	.0025444347	-.0026108854	.0073865653
	Equal variances not assumed	.912	145.157	.363	.0023878399	.0026193926	-.0027892363	.0075649162

Table 22 t-test for "Return"

At the first table we have some general information about the variables "Return A" and "Return B" (Group "1" represents the variable "Return A" and Group "2" represents the variable "Return B"). Specifically, we are informed about the number of observations each group has, the mean, the standard deviation and the standard error mean of them.

The next two tables are given into one by SPSS but that table was very big and it is presented into two pieces. The first of those two includes the results of a hypothesis test we have not seen yet. It is the so called Levene's test (Marques de Sá, 2007, p.149) and it tests the hypotheses:

H_0: $\sigma^2_A=\sigma^2_B$ and H_1: $\sigma^2_A\neq\sigma^2_B$

Where σ^2_A is the Variance of "Return A" and σ^2_B is the Variance of "Return B".

Moving to the third table, we can see that there are two rows providing the same kind of information regarding our main test which is the (two sample) t-test and tests the following hypotheses:

H_0: $\mu_1=\mu_2$ and H_1:$\mu_1\neq\mu_2$

where μ_1 and μ_2 is the mean value of the variable "Return A" and "Return B" respectively.

As was the case with the previous hypothesis tests, t-test is summarized in the computation of a statistic (t-statistic) and based on that, we get the value "Sig. (2-tailed)" which is compared to the used significance level. The outcome of this comparison is the one that makes us decide if we are going to accept the null hypothesis or not. The reason behind the fact that there are two rows of data in the third table, is that the values that are included to those rows are computed with two different ways, depending on the validity of the null hypothesis of the Levene's test. Thus, based on the second table we are going to make a decision about the validity of the H_0: $\sigma^2_A=\sigma^2_B$ and then, according to the decision we have made, we are going to check the validity of the H_0: $\mu_1=\mu_2$ by looking at the row of the third table that corresponds to the decision we took earlier.

At the second table, if "Sig." value is greater than our significance level which, in our case, is 0,05 then we accept the null hypothesis about the equality of the variances. As we can see, the "Sig." value is 0,298 which is greater than 0,05 and thus we accept the null hypothesis H_0: $\sigma^2_A=\sigma^2_B$. Since we have accepted the equality of variances, we now look at the row of the third table that corresponds to that acceptance which is of course the middle one ("Equal variances assumed"). The figure we are going to focus on, is the "Sig. (2-tailed)" value which is 0,348 (greater than 0,05). That means we cannot reject the null hypothesis regarding the equality of means.

We could also come to this conclusion only by investigating the "95% Confidence Interval of the Difference" which is connected with the significant level with the formula (1 – Significance Level)*100% (Potter, 1994). This interval is practically the [-0,0026108854, -0,0073865653] which means that there is a 95% probability that the figure μ_1-μ_2 will lie into this interval. Since this interval is very "close" to zero and *includes* it, that means that μ_1 and μ_2 are not significantly different and thus the null hypothesis H_0: $\mu_1=\mu_2$ is expected to be accepted.

Now that all variables have been investigated, an aggregate table can be created; a table that includes all the outcomes of the last section:

Variable	Significant Change due to the Announcement
Closing Price	Yes
Volume in Shares	Yes
Volume in Euros	No
High – Low Spread	No
Velocity	Yes
Return	No

Table 23 Cumulative table with basic outcomes of the hypothesis tests for all variables

What we should now investigate, is the kind of influence that the announcement had on every variable that has been proven to have significantly changed. Those variables are “Closing Price”, “Volume in Shares” and “Velocity” (as the above table denotes) and on all of them, the Mann – Whitney test has been applied.

Based on the description of the algorithm of the Mann - Whitney test in paragraph 3.3.2., for every one of those variables, we are going to check which one of the two following alternatives is true (the description also includes a third alternative but this is always true in our case because we only further investigate the variables for which we have already rejected the null hypothesis about the equality of medians):

$$\begin{cases} Z > Z_a, & upper\ tail\ Reject\ Region\ \rightarrow\ m_1 < m_2 \\ Z < -Z_a, & lower\ tail\ Reject\ Region\ \rightarrow\ m_1 > m_2 \end{cases}$$

where Z is given in every table with the results of a Mann-Whitney test and Z_a for a=0,05 is equal to 1,64 (there are specific statistic tables that help us compute that).

As we can see at the following table:

Test Statistics[a]

	Closing_Price	Volume_Shares	Velocity
Mann-Whitney U	15461.500	15231.000	15912.000
Wilcoxon W	20511.500	102802.000	103483.000
Z	-4.045	-4.216	-3.710
Asymp. Sig. (2-tailed)	.000	.000	.000

a. Grouping Variable: Grouping_Variable

Table 24 Cumulative table with Mann-Whitney test for all “Non-Normal” variables

for all of our variables under testing, the Z price is always less than $-Z_a$ = -1,64 which means that the median has decreased for all of them. What we conclude by that is the fact that the announcement had a negative impact to all of them and hence the Greek Stock Exchange.

That transforms the table regarding the impact due to the announcement, as follows:

Variable	Significant Change due to the Announcement
Closing Price	Yes (Decreased)
Volume in Shares	Yes (Decreased)
Volume in Euros	No
High – Low Spread	No
Velocity	Yes (Decreased)
Return	No

Table 25 Cumulative table with extended outcomes of the hypothesis tests for all variables

3.3.3. Performing the t-test for all variables based on the Central Limit Theorem

As already mentioned in this chapter, we can accept that our variables follow a Normal Distribution, due to the Central Limit Theorem. Based on that, the most appropriate test that needs to be applied on all of our variables is the t-test which is a parametric one. This test is more powerful than its non-parametric counterpart, Mann – Whitney test (i.e. the probability of not committing a Type II Error) and this is why it is also going to be performed.

Having already explained the methodology in the previous paragraph for the variable "Return", we are now going to undertake the same test for all the other variables (we will include the "Return" variable for completeness reasons). A pooled table with the results of the t-test for all the variables is presented below:

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Closing_Price	Equal variances assumed	177.979	.000	5.663	516	.000	504.49923	89.09324	329.46915	679.52931
	Equal variances not assumed			10.156	506.616	.000	504.49923	49.67266	406.90946	602.08900
Volume_Shares	Equal variances assumed	.710	.400	-1.820	516	.069	-3143697.325	1726912.806	-6536341.921	248947.2701
	Equal variances not assumed			-2.363	228.595	.019	-3143697.325	1330234.824	-5764786.449	-522608.2014
Volume_Euro	Equal variances assumed	2.681	.102	.412	516	.681	7148210.773	17357102.66	-26951067.63	41247489.17
	Equal variances not assumed			.626	340.705	.531	7148210.773	11411689.03	-15298024.59	29594446.13
High_Low	Equal variances assumed	2.708	.100	-.350	516	.727	-1.45127	4.14764	-9.59961	6.69708
	Equal variances not assumed			-.410	187.918	.682	-1.45127	3.53800	-8.43056	5.52803
Velocity	Equal variances assumed	.096	.756	-1.725	516	.085	-.0003233626	.0001874883	-.0006916971	.0000449717
	Equal variances not assumed			-2.115	203.759	.036	-.0003233626	.0001528795	-.0006247915	-.0000219338
Return	Equal variances assumed	1.085	.298	.938	516	.348	.0023878399	.0025444347	-.0026108854	.0073865653
	Equal variances not assumed			.912	145.157	.363	.0023878399	.0026193926	-.0027892363	.0075649162

Table 26 Cumulative table with t-test for all variables

For every variable, we firstly check the "Sig." value that lies in the column under the title "Levene's Test for Equality of Variances". If this value is greater than our significance level "α" (which is 0,05 in our case), we do not reject the null hypothesis about the equality of variances between the first (pre-announcement) and the second (post-announcement) group of our variable. In our case, we cannot reject the null hypothesis for all of our variables, apart from the "Closing Price" one.

Depending on the acceptance, or not, of the equality of variances, we then check the corresponding "Sig (2-tailed)" value that lies in the column under the title "t-test for Equality of Means". Once more, we do not reject the null hypothesis about the equality of means, if this value is greater than 0,05. Following this method, the outcome is that the only mean value that has significantly changed due to the announcement about the revised Greek deficit rate is the one that corresponds to the variable "Closing Price".

We now want to check if the mean value has increased or decreased (applicable only on the variables for which we have not accepted the null hypothesis about the equality of the means). In other words, we want to test if the announcement had a positive or negative impact on the closing prices of the Greek Stock Exchange. In order to do that, we take a look at the exact price of t-statistic (the value under the cell "t") that corresponds to the equality, or non-equality of variances. If this value is greater (or less) than zero, then we perform another hypothesis test that tests the following hypotheses:

H_0: $\mu_1=\mu_2$ and H_1: $\mu_1>\mu_2$ (or H_1: $\mu_1<\mu_2$).

We now reject the null hypothesis if the price:

$$\frac{\text{Sig.}\,(2-\text{tailed})}{2}$$

is less than 0,05.

Based on that reasoning, we have that the variable "Closing Price", which is the only one that has been found to have significantly changed, has decreased due to the announcement. We concurred to that result because t-statistic is equal to 10,156 (greater than zero) which leads us to an alternative hypothesis: H_1: $\mu_1>\mu_2$. This hypothesis finally gets accepted since:

$$\frac{\text{Sig. (2 - tailed)}}{2} = \frac{0}{2} = 0$$

which is less than 0,05.

Gathering all the final results of the tests from this paragraph, we can form the next table:

Variable	Significant Change due to the Announcement
Closing Price	Yes (Decreased)
Volume in Shares	Yes (Decreased)
Volume in Euros	No
High – Low Spread	No
Velocity	Yes (Decreased)
Return	No

Table 27 Cumulative table with extended outcomes of t-tests for all variables

and by gathering the final results of all the tests up to now we have the following table:

	Test Based on the Normality Tests' Results	t-Test
	Significant Change	
Closing Price	Yes (Decreased)	Yes (Decreased)
Volume in Shares	Yes (Decreased)	No
Volume in Euros	No	No
High-Low Spread	No	No
Velocity	Yes (Decreased)	No
Return	No	No

Table 28 Cumulative table with extended outcomes for all kinds of hypothesis tests for all variables

Having already seen the exact impact of the announcement on some variables regarding the Greek Stock Exchange and before we further interpret them, it would be very useful for us to test the impact due to the whole financial crisis on the same variables. This is the objective of the next section.

3.4. Testing the impact of the overall financial crisis

In order for us to test the impact of the financial crisis on the aforementioned variables we will follow exactly the same method as the one that has been followed up to that point. Of course there will be a differentiation between the samples we used at the previous sections and the ones that we are going to use now.

When we wanted to test the impact due to the announcement about the revised and unfortunately bloated Greek deficit figures, we had a sample of only 100 observations for the post – announcement period. The sample was intentionally that large because if it was even larger, it would also include a period heavily influenced by the overall financial crisis and thus the results could be interpreted fairly because not only the announcement would have interceded. The sample that will be used now, consists of 418 observations, exactly as many as the ones that constitute the pre – announcement (or even more accurately, the pre-crisis) period since the sample that corresponds to the period before the announcement/crisis will remain the same. Once more, the samples are large enough to give accurate test results for every kind of test.

We will start by performing all the appropriate normality tests. The whole procedure will be presented in short as it is exactly the same as up to now.

3.4.1. Normality tests

Following the same methodology as before, we have the following results:

Variable \ Test	Skewness test	Kolmogorov-Smirnov	Shapiro-Wilk	Jarque-Bera	Anderson-Darling	Chi - Squared	Visual tests	Verdict
Closing Price B	NO	NO	NO	NO	NO	NO	NO	Non-Normal
Volume Shares B	NO	NO	NO	NO	NO	NO	NO	Non-Normal
Volume Euros B	NO	NO	NO	NO	NO	NO	NO	Non-Normal
High – Low B	NO	NO	NO	NO	NO	NO	NO	Non-Normal
Velocity B	NO	NO	NO	NO	NO	NO	NO	Non-Normal
Return B	NO	YES	NO	NO	YES	YES	YES	Normal

Table 29 Cumulative results of the Normality tests for the second sample of all variables

As we can see from the above table, the only sample that can be considered as one that follows a Normal Distribution is the "Return B" which represents the return values for 418 days after the announcement.

Since the samples that represent the pre-crisis period have remain unchanged, we do not have to test the normality of them again. Thus, based on the results we are already aware of, due to the previous tests, we can build the following table:

Variable	Normality Status	Kind of Future Test
Closing Price A	Non - Normal	**Non – Parametric**
Closing Price B	Non - Normal	
Volume Shares A	Non - Normal	**Non – Parametric**
Volume Shares B	Non - Normal	
Volume Euros A	Non - Normal	**Non – Parametric**
Volume Euros B	Non - Normal	
High – Low A	Non - Normal	**Non – Parametric**
High – Low B	Non - Normal	
Velocity A	Non - Normal	**Non – Parametric**
Velocity B	Non - Normal	
Return A	Normal	**Parametric**
Return B	Normal	

Table 30 Normality test outcome and type of further testing for all our variables

As we are informed by the above table, a parametric test will only be applied on variable “Return” as this is the only variable that consists of two normally distributed samples. Once more, the most suitable parametric tests for our kind of data is the t-test for the variable “Return” and the Mann – Whitney test for all the others.

Due to the Central Limit Theorem, we will again follow two different approaches. We will firstly take into consideration the results of the normality tests we just performed and then we will treat all of our variables as normal ones, exactly as the Central Limit Theorem ordains.

3.4.2. Performing the hypothesis tests based on the normality tests

By applying the Mann – Whitney test on every variable apart from the “Return” one on which the t-test is applied, we have the results that are depicted on the next three tables:

Test Statistics[a]

	Closing_Price	Volume_Shares	Volume_Euro	High_Low	Velocity
Mann-Whitney U	21393.000	77761.000	41524.000	55421.000	65493.000
Wilcoxon W	108964.000	165332.000	129095.000	142992.000	153064.000
Z	-18.897	-2.750	-13.130	-9.150	-6.264
Asymp. Sig. (2-tailed)	.000	.006	.000	.000	.000

a. Grouping Variable: Grouping_Variable

Table 31 Cumulative table with Mann-Whitney test for all “Non-Normal” variables

We firstly see the results of the Mann – Whitney test. Since all the “Asymp. Sig. (2-tailed)” values are less than 0,05 (our significance level), we can conclude that the null hypothesis about the equality of the medians between the two samples of every variable, is rejected. Furthermore, since the Z price for every variable is less than -1,64 (that is $-Z_a$ for a=0,05) we cannot reject the hypothesis H_1: $m_1 > m_2$ for all the variables (m_1 and m_2 are the medians of the pre-announcement and post-announcement samples, respectively).

Then the t-test follows with two tables:

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
Return	Equal variances assumed	.065	.798
	Equal variances not assumed		

Table 32 Levene's test for "Return" as part of the t-test

On the first of the two tables, we can find the results of the Levene's test for equality of variances. As we can see, we cannot reject the null hypothesis about the equality of variances because the "Sig." value (0,798) is greater than 0,05. This means that on the following table, we are going to use only the figures that lie in the row under the title "Equal variances assumed".

Independent Samples Test

		t-test for Equality of Means						
							95% Confidence Interval of the Difference	
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Return	Equal variances assumed	.655	834	.513	.0009998241	.0015266510	-.0019967056	.0039963539
	Equal variances not assumed	.655	831.706	.513	.0009998241	.0015266510	-.0019967176	.0039963659

Table 33 t-test for "Return"

Thus, judging from this row, we can see that "Sig. (2-tailed)" value (0,513) is greater than 0,05 which means that we cannot reject the null hypothesis about the equality of means. Surprisingly enough, we conclude that the daily returns have not significantly changed under the pressure of the financial crisis.

We can now gather all the final results from the tests of this section and build the following table:

Variable	Significant Change due to the Financial Crisis
Closing Price	Yes (Decreased)
Volume in Shares	Yes (Decreased)
Volume in Euros	Yes (Decreased)
High – Low Spread	Yes (Decreased)
Velocity	Yes (Decreased)
Return	No

Table 34 Cumulative table with extended outcomes of the hypothesis tests for all variables

3.4.3. Performing the t-test for all variables based on the Central Limit Theorem

In this section, all the variables are going to be treated as normal ones (i.e. ones that follow a Normal Distribution). Hence, the t-test will be applied on all of them.

The following table depicts the results from the t-test applied on all of our variances:

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Closing_Price	Equal variances assumed	471.281	.000	21.690	834	.000	1002.79419	46.23344	912.04662	1093.54175
	Equal variances not assumed			21.690	537.885	.000	1002.79419	46.23344	911.97396	1093.61442
Volume_Shares	Equal variances assumed	.971	.325	2.307	834	.021	2294741.830	994568.4573	342590.4331	4246893.227
	Equal variances not assumed			2.307	760.147	.021	2294741.830	994568.4573	342314.7527	4247168.907
Volume_Euro	Equal variances assumed	13.175	.000	9.249	834	.000	83498560.38	9027393.307	65779479.98	1.01218E8
	Equal variances not assumed			9.249	570.232	.000	83498560.38	9027393.307	65767560.52	1.01230E8
High_Low	Equal variances assumed	34.127	.000	8.599	834	.000	19.51292	2.26927	15.05877	23.96707
	Equal variances not assumed			8.599	719.260	.000	19.51292	2.26927	15.05773	23.96810
Velocity	Equal variances assumed	1.498	.221	4.823	834	.000	.0005039984	.0001045068	.0002988711	.0007091257
	Equal variances not assumed			4.823	732.342	.000	.0005039984	.0001045068	.0002988297	.0007091671
Return	Equal variances assumed	.065	.798	.655	834	.513	.0009998241	.0015266510	-.0019967056	.0039963539
	Equal variances not assumed			.655	831.706	.513	.0009998241	.0015266510	-.0019967176	.0039963659

Table 35 Cumulative table with t-test for all variables

Adopting the same rationale as in the previous cases and taking into account the circled numbers we can conclude that the financial crisis has changed significantly all of our variables, apart from the returns.

In order for us to decide if the financial crisis has affected those variables in a positive or negative way (although the answer seems obvious) we need to perform additional hypothesis tests. According to the method we have already used, for every variable out of those for which we have rejected the null hypothesis, we check the value of the t-statistic that corresponds to the equality, or non-equality of variances. If this value is greater (or less) than zero, then we perform another hypothesis test that tests the following hypotheses:

H_0: $\mu_1=\mu_2$ and H1: $\mu_1>\mu_2$ (or H_1: $\mu_1<\mu_2$).

We now reject the null hypothesis if the price:

$$\frac{\text{Sig.}\,(2-\text{tailed})}{2}$$

is less than 0,05.

For all of our variables (apart from the variable "Returns" for which we did not reject the null hypothesis), this fraction is indeed less than 0,05 which means that the financial crisis had a significant negative impact on all of those variables.

Based on all the final results from this section we can make the following table:

Variable	Significant Change due to the Financial Crisis
Closing Price	Yes (Decreased)
Volume in Shares	Yes (Decreased)
Volume in Euros	Yes (Decreased)
High – Low Spread	Yes (Decreased)
Velocity	Yes (Decreased)
Return	No

Table 36 Cumulative table with extended outcomes of t-tests for all variables

We can now build a pooled table that includes the final results from the whole section 3.5 (Table 37) or even from the whole chapter 3 up to now (Table 38). By doing that, we get the following very interesting and informative tables:

	Test Based on the Normality Tests' Results	t-Test
	Significant Change	
Closing Price	Yes (Decreased)	Yes (Decreased)
Volume in Shares	Yes (Decreased)	Yes (Decreased)
Volume in Euros	Yes (Decreased)	Yes (Decreased)
High-Low Spread	Yes (Decreased)	Yes (Decreased)
Velocity	Yes (Decreased)	Yes (Decreased)
Return	No	No

Table 37 Cumulative table with extended outcomes for all kinds of hypothesis tests for all variables

On this table we can see that no matter what is the hypothesis test that we use, we conclude that all of our variables are severely affected by the overall financial crisis, in a negative way, apart from the variable "Return" which seems not to have been significantly affected.

On the following cumulative table we have summarized the final results of the whole chapter.

	Test Based on the Normality Tests' Results	t-Test
Testing the Impact of the Announcement (Sample B = 100 Obs.)		
	Significant Change	
Closing Price	Yes (Decreased)	Yes (Decreased)
Volume in Shares	Yes (Decreased)	No
Volume in Euros	No	No
High-Low Spread	No	No
Velocity	Yes (Decreased)	No
Return	No	No
Testing the Impact of the Overall Financial Crisis (Sample B = 418 Obs.)		
	Significant Change	
Closing Price	Yes (Decreased)	Yes (Decreased)
Volume in Shares	Yes (Decreased)	Yes (Decreased)
Volume in Euros	Yes (Decreased)	Yes (Decreased)
High-Low Spread	Yes (Decreased)	Yes (Decreased)
Velocity	Yes (Decreased)	Yes (Decreased)
Return	No	No

Table 38 Cumulative results about the impact of both the announcement and the overall financial crisis

A first commend on that table could be the (obvious) fact that the announcement about the revised figures of the Greek deficit rates did not affect our variables a lot in contrast to the overall financial crisis that influenced our variables in a massive way.

Further interpretation of the results will take place in the final chapter.

3.5. Further analysis due to some unexpected results

The announcement itself does not seem to have caused many significant changes to the investigated indexes, when Sample B consists of 100 observations. Due to the fact that the impact was expected to be even greater, some further tests are going to be performed in order for the accuracy of the up to now tests to be ascertained. For that reason, we will restrain our second sample even more (20 observations).

We will firstly perform a Mann – Whitney hypothesis test and a t-test (where applicable) for those samples in order to check for the direct impact of the announcement, on the very first days. Secondly, we will perform two tests - F-test and Bartlett's test - in order to test the equality of standard deviations and variances, respectively. The Mann – Whitney hypothesis tests will be applied on all of our variables while the tests regarding the standard deviations and the variances, will be applied only on the variables "Return" and "High – Low Spread" as these are the two variables that demonstrated unexpected behavior as long as their variance/standard deviation is concerned.

3.5.1. Mean/Median hypothesis tests

As already mentioned, we apply the Mann – Whitney test on all of our variables and the t-test only on those that can be applied and those are only the ones that follow a normal distribution. After making the appropriate tests, we found out that the only variable that consists of two samples that both follow a normal distribution, is the variable "Return". Therefore, the t-test can be only applied on that variable.

The results of the Mann – Whitney test for all the variables, are the following. Since the Mann – Whitney test is a non-parametric one, it can be applied on every variable, even if it consists of two "normal" samples, like "Return".

Test Statistics[a]

	Closing_Price	Volume_Shares	Volume_Euro	High_Low	Velocity	Return
Mann-Whitney U	3614.500	2943.000	3332.000	3840.000	3469.000	3294.000
Wilcoxon W	91185.500	90514.000	90903.000	91411.000	91040.000	3504.000
Z	-1.023	-2.237	-1.533	-.615	-1.286	-1.602
Asymp. Sig. (2-tailed)	.307	.025	.125	.539	.199	.109

a. Grouping Variable: Grouping_Variable

Table 39 Cumulative table with Mann-Whitney test for all variables

As we can easily observe, the above table informs us that the only variable that seems to have been significantly affected by the announcement, during the very first days after it, is the variable "Volume in Shares". This variable was also one of the affected ones when sample B consisted of 100 observations and the test was once more the Mann – Whitney.

As far as the t-test for the "Return" variable is concerned, the results of the test are the following:

		Levene's Test for Equality of Variances	
		F	Sig.
Return	Equal variances assumed	.544	.461
	Equal variances not assumed		

Table 40 Levene's test for "Return" as part of the t-test

Independent Samples Test

		t-test for Equality of Means					
						95% Confidence Interval of the Difference	
		df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Return	Equal variances assumed	436	.210	.0064451084975	.0051331219844	-.0036436313547	.0165338483496
	Equal variances not assumed	22.362	.117	.0064451084975	.0039557731570	-.0017509723875	.0146411893824

Table 41 t-test for “Return”

From the first of the above tables, we have a conclusion regarding the equality of variances. The “Sig” value is greater than 0,05 which means that we can assume that the variances of our samples (“Return A” and “Return B”) do not differ significantly. Based on that assumption, we now look at the “Sig. (2-tailed)” value for the row that corresponds to equal variances. Since this value is greater than 0,05 we cannot reject the null hypothesis about the equality of mean values. That means that we can claim that the observations of the variable “Return” have not changed severely, shortly after the announcement, which also confirms all the up to now findings.

By joining those new results with the existing ones, we have the following table:

	Test Based on the Normality Tests' Results	t-Test
Testing the Direct Impact of the Announcement (Sample B = 20 Obs.)		
	Significant Change	
Closing Price	No	Not Applicable
Volume in Shares	Yes (Decreased)	Not Applicable
Volume in Euros	No	Not Applicable
High-Low Spread	No	Not Applicable
Velocity	No	Not Applicable
Return	No	No
Testing the Impact of the Announcement (Sample B = 100 Obs.)		
	Significant Change	
Closing Price	Yes (Decreased)	Yes (Decreased)
Volume in Shares	Yes (Decreased)	No
Volume in Euros	No	No
High-Low Spread	No	No
Velocity	Yes (Decreased)	No
Return	No	No
Testing the Impact of the Overall Financial Crisis (Sample B = 418 Obs.)		
	Significant Change	
Closing Price	Yes (Decreased)	Yes (Decreased)
Volume in Shares	Yes (Decreased)	Yes (Decreased)
Volume in Euros	Yes (Decreased)	Yes (Decreased)
High-Low Spread	Yes (Decreased)	Yes (Decreased)
Velocity	Yes (Decreased)	Yes (Decreased)
Return	No	No

Table 42 Table with all the results of the hypothesis tests regarding mean value or median

Further interpretation of the results of the above table, is provided at the final chapter.

3.5.2. Variance / Standard Deviation hypothesis tests

As already mentioned, the tests regarding the equality of Variances / Standard Deviations, will only be applied on the variables that demonstrated the most unexpected behavior, either in terms of variance and standard deviation or in terms of the outcome of the hypothesis test about the mean value or the median of our samples in conjunction with the variance and / or standard deviation. Judging from the tables 26 and 35, we firstly see that the variable “Return” does not seem to have changed significantly neither due to the effects of the announcement nor due to the impact of the overall financial crisis. Furthermore, it is highly impressive that the outcome of the hypothesis test about the equality of variances (Levene’s test) between “Return A” and “Return B”, is that after all, there are no severe changes observed. Almost the same applies for the “High – Low Spread”. The unexpected behavior of this variable lies on the fact that, not only the “High – Low Spread” variable does not seem to have changed a lot due to the announcement (Sample B consists of 100 observations), but also the Levene’s test outcome denotes that there was no significant change between the variance of the two samples. Those results are considered strange due to the fact that the High – Low Spread can be considered as a measurement of the uncertainty that characterizes a Stock Exchange Market.

Because of the aforementioned reasons, the variables that are going to be further investigated are the “Return” and the “High – Low Spread”. We will begin with the F-test (hypothesis test about the equality of standard deviations) and we will proceed with the Bartlett’s test (hypothesis test about the equality of variances).

F-test

F-test is used to test if the standard deviations of two populations are equal. This test can be a two-tailed test or a one-tailed test. The two-tailed version tests against the alternative that the standard deviations are not equal. The one-tailed version only tests in one direction, that is the standard deviation from the first population is either greater than or less than (but not both) the second population standard deviation . The choice is determined by the problem.

The F hypothesis test is defined as:

H_0: $\sigma_1 = \sigma_2$

H_1: $\sigma_1 < \sigma_2$ for a lower one – tailed test

$\sigma_1 > \sigma_2$ for an upper one-tailed test

$\sigma_1 \neq \sigma_2$ for a two – tailed test

Test Statistic: $F = s_1^2/s_2^2$

where s_1^2 and s_2^2 are the sample variances. The more this ratio deviates from 1, the stronger the evidence for unequal population variances.

Significance Level: α

Critical Region: The hypothesis that the two standard deviations are equal is rejected if:

$F > F_{(\alpha,\ N1-1,\ N2-1)}$ for an upper one-tailed test

$F < F_{(1-\alpha,\ N1-1,\ N2-1)}$ for a lower one-tailed test

$F < F_{(1-\alpha/2,\ N1-1,\ N2-1)}$
or
$F > F_{(\alpha/2,\ N1-1,\ N2-1)}$
} for a two-tailed test

where $F_{(\alpha,k-1,N-k)}$ is the critical value of the F distribution with ν_1 and ν_2 degrees of freedom and a significance level of α.

In the above formulas for the critical regions, F_α is the upper critical value from the *F* distribution and $F_{1-\alpha}$ is the lower critical value from the F distribution.

(Engineering Statistics Handbook (1))

- *Sample A consists of 418 observations, Sample B consists of 20 observations*

F-test		
	Return	**High-Low**
s_1^2 (418 Obs.)	0,000512688	1506,195973
s_2^2 (20 Obs.)	0,000288432	678,4885421
s_1^2/s_2^2	1,777500453	2,219928384
Critical Value	2,133	2,133
Verdict	$\sigma 1 = \sigma 2$	$\sigma_1 \neq \sigma_2$

Table 43 F-test for "Return" and "High-Low Spread" (Sample B = 20 Observations)

- *Sample A consists of 418 observations, Sample B consists of 100 observations*

F-test		
	Return	**High-Low**
s_1^2 (418 Obs.)	0,00000026284899	1506,19597289881000
s_2^2 (100 Obs.)	0,00000031749733	891,42326071717100
s_1^2/s_2^2	0,82787777169899	1,68965298447231
Critical Value	1,35	1,35
Verdict	$\sigma 1=\sigma 2$	$\sigma_1 \neq \sigma_2$

Table 44 F-test for “Return” and “High-Low Spread” (Sample B = 100 Observations)

- *Sample A consists of 418 observations, Sample B consists of 100 observations*

F-test		
	Return	**High-Low**
s_1^2 (418 Obs.)	0,0000002628495	2268626,3087765900000
s_2^2 (418 Obs.)	0,0000002130089	417828,4600837480000
s_1^2/s_2^2	1,2339837602905	5,4295638653286
Critical Value	Not provided by statistical tables but it is very close to 1,23	Not provided by statistical tables but it is very close to 1,23
Verdict	$\sigma 1 \approx \sigma 2$	$\sigma_1 \neq \sigma_2$

Table 45 F-test for “Return” and “High-Low Spread” (Sample B = 418 Observations)

Bartlett’s test

Bartlett's test is used to test if k samples have equal variances. Equal variances across samples, is called homogeneity of variances. Bartlett's test is sensitive to departures from normality. Thus, if our samples come from non-normal distributions, then Bartlett's test may simply be testing for non-normality. The Levene’s test is an alternative to the Bartlett’s test that is less sensitive to departures from normality.

The Bartlett’s test is defined as:

$H_0: \sigma_1 = \sigma_2 = \ldots = \sigma_\kappa$

$H_1: \sigma_i \neq \sigma_j$ for at least one pair (I,j)

Test Statistic:

The Bartlett test statistic is designed to test for equality of variances across groups against the alternative that variances are unequal for at least two groups and is computed as follows:

$$T = \frac{(N-k)\ln s_p^2 - \sum_{i=1}^{k}(N_i - 1)\ln s_i^2}{1 + (1/(3(k-1)))((\sum_{i=1}^{k}\frac{1}{N_i - 1}) - 1/(N-k))}$$

In the above, s_i^2 is the variance of the i[th] group, N is the total sample size, N_i is the sample size of the *i*th group, k is the number of groups, and s_p^2 is the pooled variance. The pooled variance is a weighted average of the group variances and is defined as:

$$s_p^2 = \sum_{i=1}^{k}(N_i - 1)s_i^2/(N-k)$$

Significance Level: α

Critical Region: The variances are judged to be unequal if,

$$T > X^2_{(a,k-1)}$$

where $X^2_{(a,k-1)}$ is the upper critical value of the chi-square distribution with k - 1 degrees of freedom and a significance level of α.

In the above formulas for the critical regions, X^2_a is the upper critical value from the chi-square distribution and X^2_{1-a} is the lower critical value from the chi-square distribution.

(Engineering Statistics Handbook (2))

- *Sample A consists of 418 observations, Sample B consists of 20 observations*

	Return	High-Low
N	438	
N1	418	
N2	20	
k	2	
s_1^2 (418 Obs.)	0,000512688	1506,195973
s_2^2 (20 Obs.)	0,000288432	678,4885421
s_p^2	0,000502916	1470,126154
T	2,555470949	4,601384059
critical value	3,841	3,841
Verdict	**equal variances**	**unequal variances**

Table 46 Bartlett's test for "Return" and "High-Low Spread" (Sample B = 20 Observations)

- *Sample A consists of 418 observations, Sample B consists of 100 observations*

	Return	High-Low
N	518	
N1	418	
N2	100	
k	2	
s_1^2 (418 Obs.)	0,0000002628490	1506,1959728988100
s_2^2 (100 Obs.)	0,0000003174973	891,4232607171710
s_p^2	0,0000002733	1388,2453943988
T	1,4863871316	9,8532661192
critical value	3,841	3,841
Verdict	**equal variances**	**unequal variances**

Table 47 Bartlett's test for "Return" and "High-Low Spread" (Sample B = 100 Observations)

- *Sample A consists of 418 observations, Sample B consists of 418 observations*

	Return	High-Low
N	836	
N1	418	
N2	418	
k	2	
s_1^2 (418 Obs.)	0,000512688	1506,195973
s_2^2 (418 Obs.)	0,000461529	646,3965192
s_p^2	0,000487109	1076,296246
T	1,152738899	72,47846725
critical value	3,841	3,841
Verdict	**equal variances**	**unequal variances**

Table 48 Bartlett's test for "Return" and "High-Low Spread" (Sample B = 418 Observations)

As we can easily conclude by the above tables, the results of the F-tests and the Bartlett's tests are almost the same. That is not a surprise though, since the standard deviation of a variable, is the square root of its variance. Of course, in reality this would not always be true but in our case, it is. It is considered useful, for the sake of completeness, that both of those methods are demonstrated.

In more details, the unexpected result of the Levene's test about the equality of variances for the variable "Return" when sample B consists of 100 observations, seem to be confirmed by both the F-test and the Bartlett's test. In order for us to invest once more if the announcement itself caused a significant change in our variable's variance or standard deviation, we considered an even smaller "Return B" sample that consists of just 20 observations. Even then, we see that the announcement was not enough to cause an important alteration of the variance or standard deviation. Furthermore, the results of the Levene's test are confirmed even in the case that the second sample consists of 418 observations. No matter how strange it may look, the fact that both the announcement and the overall financial crisis did not manage to alter significantly, not only the mean value or the median between the two samples of "Return" but also the variance and the standard deviation, it is now totally confirmed.

As far as the "High – Low Spread" variable is concerned, the situation is not that similar to the "Return" variable. Although the results among the Levene's test, the F-test and the Bartlett's test do not differ when the second sample consists of 418 observations, this is not the case when it consists of 100 observations. In that case, according to the Levene's test, the variance of "High – Low Spread" has not significantly changed due to the announcement. On the other hand, the two new tests performed (F-test and Bartlett's test) are unbridable. They both depict a significant change for both the variance and the standard deviation of the variable and this also applies on the occasion where the second sample consists of 20 observations. This outcome (unequal variances and standard deviations) can now be considered more rational than the one provided by the Levene's test (equal variances) because as already mentioned the "High – Low Spread" can be used as a measurement of the uncertainty that prevails the (Stock Exchange) Market. As such, its mean value and/or the median is expected to have been significantly changed due to the overall financial crisis (as it did), but it is also expected that the announcement would have at least changed its variance and/or standard deviation. This is why, in this particular case, we tend to consult the F-test's and the Bartlett's test's outcomes instead of the ones of the Levene's test. Of course, this does not cause any further changes to the up-to-now analysis.

Further interpretation of the results will take place at the final chapter.

Chapter 4

Conclusions

4. Conclusions

Interpreting results is a procedure that requires extensive knowledge about the field as many parameters need to be taken into consideration. In our case, we are going to focus on the most important findings (basically from those that can be found in Table 42) and then try to provide an explanation about the reasons that led to those.

Initially, we are going to evaluate the direct impact of the announcement about the Greek deficit rates. As we can see at Table 42, the t-test is not applicable to most of our variables. That happened firstly because normality tests showed that not both samples follow a normal distribution and secondly because the second sample of all variables is not large enough (more than 30 observations) in order for it to be considered as normal due to the Central Limit Theorem. Therefore, all the upcoming interpretation of the results will be based mostly on the ones that come out of the Mann – Whitney tests.

Thus, based on this hypothesis test, we can see that almost none of the variables under investigation was significantly changed. That happened probably because of two reasons. The first reason could be that the second sample consists of only a few observations (20) and therefore it is too small to reflect the impact of the announcement; even the direct one. The only variable that seems to have changed significantly is the "Volume in Shares". Taking into account that the second sample is too small and that all the other variables have not been changed significantly, we could surmise that this specific outcome is just an "outlier", a kind of paradox that owes its existence to the algorithm that is used by the hypothesis test or to the magnitude of the second sample. However, if we wanted to give an explanation about that phenomenon, we could say that it occurred because some investors decided to withdraw when they listened to the announcement while some others who had enough confidence about the progress of the Greek economy, found the opportunity to fulfill their investing ambitions at the right (according to Warren Buffett) moment: “when others are fearful”.

Moving on to the results that correspond to the overall impact of the announcement (Sample B = 100 Observations), we are going to provide an explanation for almost all of them. Starting from the “Closing Price” we can say that there seems to be a decrease in the level of the index. That is reasonable due to the lowering of the expectations about future growth prospects, which was caused because of the increased deficit figures. It is strange however, that this drop of “Closing Price” does not cause significant drop of “Return”. This is caused because the observations of “Return” are very small prices as they are expressed by the formula

$$\text{Return for Day n} = \frac{\text{Closing Price}_\text{n} - \text{Closing Price}_{\text{n}-1}}{\text{Closing Price}_{\text{n}-1}}$$

Due to that, even significant fluctuations at the “Closing Price” do not necessarily cause significant fluctuations at “Return”. As far as the Volume variables are concerned, it seems relatively surprising that we detect a significant drop in the share volume while the null hypothesis about the volume in euros is maintained. This initially puzzling effect may have a statistical as well as an economical explanation. The statistical one can be that there might not be a significant change at “Volume in Shares” as the t-test, which, as a parametrical test, is more powerful than Mann – Whitney test, denotes that. On the other hand, the application of the t-test on the Volume variables is based on the Central Limit Theorem which has a debatable proof in practice. The economical explanation is that the announcement imparted huge uncertainty in the Greek economy and this was translated into huge uncertainty in the sustainable profitability for Greek enterprises and their valuations. Such uncertainty has been much more pronounced for small companies and in a setting with decision making under uncertainty it is known that a country may be led to a market breakdown in the sense that most players refuse to participate. Thus, most traders switched to trading larger capitalization companies where information about cash flows was more trustworthy and valuations could be more easily educated. The switch to larger capitalization companies compensated for the relative loss of share volume, keeping volume in euros almost constant. The behavior of "Velocity" could be explained statistically in the same way as "Volume in Shares", although the drop of its price according to the Mann – Whitney test, could have been partially caused by the drop in Volume (according to the same test). Finally, "High – Low Spread" does not demonstrate a strange behavior that needs to be further interpreted. Neither the behavior of the other variables nor the announcement itself, should necessarily lead to a significant change of this variable.

As far as the interpretation of the results of the last part of Table 42 is concerned, it is more than obvious that the overall financial crisis had a severe impact on most of the essential variables related to the Greek Stock Exchange. The reason that the crisis altered most of the variables is obvious (the interpretation of the behavior of "Return" is the same as in the case where the second sample consisted of 100 observations). What is not obvious is the decrease of "High – Low Spread". Someone would probably expect either no significant change or an increase of that spread, since "High – Low Spread" can be considered as a measurement of the existing uncertainty in the market and proportional to that. However, in our case, the reason for this drop is the magnitude of the impact. It seems that the financial crisis had a repercussion which was so massive that made investors very fearful. That made a great proportion of them either to withdraw or to participate in a very conservative way. That fact led to very limited daily fluctuations which unavoidably led to the decrease of the spread between the minimum and the maximum price throughout the day.

Although, the interpretation of such kind of results is sometimes subjective*, it is more than obvious that the overall financial crisis had a severe negative impact on almost all of the market – related variables. As far as the impact of the announcement itself is concerned, the verification or denial of which is the basic objective of this research, it seems that there was such an impact but not on all of the variables and also not to the same extend.* That is a very important finding, especially if we take into consideration that the announcement took place when Greece was about to borrow money from other EU members and the conspiracy theories that want the later Greek Prime

Minister, George Papandreou, to have come in contact with Dominique Strauss-Kahn even before the national elections, in order to ask the financial surveillance of the International Monetary Fund (Kathimerini). Although it is very hard for someone to tell where does the impact of the announcement end and where the one of the financial crisis begin, it is a fact that this announcement took place in a very critical point of the modern economical history of Greece and was the sparking that lit the fire of uncertainty against the country, its statistics and finally its potentials. As far as some major questions are concerned, like “what went wrong” or “what should be done in order for Greece to come out of the financial crisis”, everyone can have their opinion. However, it can be arrogant to judge on so important issues via a research like this, when experienced, prestigious economists and politicians cannot agree with each other. Let us all hope for the best.

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Appendix

Tables

Figures