Testing for Bubble(s) in NASDAQ and DJI indexes in 1990-2003

Master's Thesis

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Study Number: 20202047

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Date: 12/14/2022

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ABSTRACT

The primary goal of this paper is to investigate if there was a bubble in Nasdaq Composite index between 1990 and 2003. To do this, two major different tests are applied. The GSADF test, which can date-stamp the dates with explosiveness and identify if a bubble existed throughout the study period is the first test. In addition to the GSADF, another method that is used to detect the explosiveness is the variance bounds test. Some other tests were also applied in order to have a better understanding about the period with explosiveness in the study period. These tests, includes the chow break test, the abnormal return test, and the variance ratio test, which in themselves are not designed to detect bubbles.

Introduction

In the 1990s, the Internet was becoming a popular trend, and many technology companies, such as AltaVista and Cyberian Outpost as well as several other firms, began to provide services involving technology, more specifically businesses that offered a service for users of the internet. During this time period, there was also a rise in the number of businesses that offered services for users of the internet. This trend continued for the next several years.

In the later part of the 1990s, when there was this rapid increase in the use of the internet which had existed but was very timidly known only to some and had not become as widely known as today where basically every home has internet connection and everyone seem to be a computer literate and make use of the internet in one way or the other either by shopping, studying, working, the list is inexhaustible. This was not the case two decades ago were, there seem to be that excitement about the internet which led to an increase in the number of start-ups and IPOs that were created at the time with the numbers soaring over a short period. Investing in such stocks too became a trend and many are those who bought such stocks just because they had something to do with the internet. As many of these online companies were created, there was also a noticeable growth in the few existing companies at the time which were involved in the use of the internet such as Microsoft, Amazon.

It should be emphasized that a significant number of the start-up companies that emerged at that time did not make it to the long run and, as a result, closed their doors when the market fell. Even if the company had nothing to do with the internet, they thrived for some time and numerous companies adopted this and gained from it. It was a common thing at the time to have a domain with the (dot-com) attached to it, and even if the company had nothing to do with the internet, they thrived for some time.

Regardless of the fact that these extremely speculative dotcom enterprises showed virtually no possibility for success, several traders made significant investments across these businesses. At the beginning of the year 2000, investors came to the realization that many of these firms had business strategies that were not feasible, which led to the bursting of the bubble.

One of the characteristics of the dot-com bubble was the heavy investment in advertisement, most companies at that time heavily invested in advertisement, with the belief at the time that creating awareness of the company will increase market shares, growth in the company but forgetting that the performance of the firm was equally very important given that no one will want keep their money or invest in a company that does not have optimal performance.

Priceline.com is a prime example of a firm that thrived during the dot-com boom. The firm was founded by Jay Walker, a businessman with an answer to a genuine issue (daily empty seats on 500,000 flights). Using this company, those interested could purchase their tickets at their discretion meaning that instead of having a standard price per ticket, buyers could rather state their own price and get the tickets sold to them as per their demand. Buyers saved money on tickets, airlines cleared out unsold stock, market inefficiencies were eliminated, and Priceline reaped a share as a facilitator, and everyone was happy. After launching in April 1998, Priceline had immediate success as a dot-com, expanding from 50 to over 300 people and selling over 100,000 flight tickets during the company's first seven months of existence. The average daily ticket sales had surpassed one thousand by the end of 1999.

Commenting on the state of the market on December 5, 1996, Alan Greenspan, the serving chairman of the Federal Reserve Board at the time, used the phrase "irrational exuberance" to describe the situation, this phrase has become common since then, such that when heard of, one thinks of a booming situation where there is a lot of trade taking place and with or without reason there some sort of euphoria in the market. (Phillip et al., 2011) in their review paper claim that this statement by Alan Greenspan had some immediate market impacts and it also, had long term effects on the market participants and scientists perceptions about financial market and herding behavior. After Alan Greenspan made the comment during his address at a dinner party, the following day saw substantial drops in stock prices across the market. The comment made by Greenspan was not enough to prevent an increase in market prices in the long run, which can be explained by Robert Shiller’s explanation about how a bubble is formed and what causes people to follow each other and investing in stocks which they do not have clear ideas and information about the business they are inventing in and what the main reason for sudden surge in the internet stocks is.

(Lamont and Thaler, 2003) points out that “during the Nasdaq bubble of the late 1990s, approximately $7 trillion of wealth was created and then destroyed.” In other words, a considerable number of market participants who followed the trend but did not go short prior

to the unexpected collapse in March 2000 incurred a significant financial loss because of this market meltdown. Therefore, it is crucial to study different characteristics of bubbles, including how a bubble originates, how to spot a bubble, what psychological factors generate a bubble, and how market participants react while an asset price irrationally increase and when the bubble bursts. This paper focus is on the econometrics aspect of bubble and does not cover other aspects.

This paper aims at answering the following questions through the use of econometrics methods. (1) if there was a bubble in Nasdaq Composite (IXIC) index in the period between 1990-2001, (2) if there was a bubble in Dow Jones Industrial Average (DJI). Thus, the two major tests used for answering these two questions above are GSADF and variance bound tests . The results of these two tests can be compared to see whether their results confirm each other or not. Three other tests are applied on the data series including chow test, abnormal returns and variance ratio tests are not specifically designed for detecting bubbles. They are supplementary tests and later in this paper further discussion will be made about them and what their results can show. All these two tests for detecting a bubble and three other supplementary tests are carried out for the other Dow Jones Industrial Average (DJI) as well. Therefore, the test results of DJI can indicate if there was a bubble in the same time period. Indeed, this paper does not aim to test if Nasdaq bubble (in case our test results show there was any bubble in Nasdaq) spilled over Dow Jones. I understand that by carting out these tests on both indexes and possibly finding a coincidence I cannot state that there is a causation relation between bubble in Nasdaq and bubble in Dow Jones. It is more a coincidence test which means that there were any bubble(s) in both Nasdaq and Dow Jones at the same time, but this test does not prove any causal relation. To do this, other tests should be developed.

None of the test in this paper are causation test. However, if there is any coincidence occurs, we can assume that perhaps this coincidence could be not accidental and this could be an interesting topic to do further research on it, but in this paper I don’t test any causal relation between the tech bubble and the possible bubble in Dow Jones. Finding explosiveness in the Dow Jones in the same time period does not confirm that the bubble in Nasdaq spilled over Dow Jones. It is only an indirect test and based on that, we can probably say the bubble in Nasdaq had a spillover effect on other parts of the market such as Dow Jones which is an index with non-tech companies.

1.0 LITERATURE REVIEW

Many people now use the term "bubble" to refer to a broad variety of distinct concepts. It seems that some individuals are referring to any significant change in pricing as bubble. Others consider this to indicate substantial price shifts that indeed correlate to low or maybe negative anticipated excess returns rather than a violation of the terminal condition; nonetheless, these expected returns are in some way separated from the rest of the economy. (see Cochrane, 2005, p. 404).

However, Eugene Fama has a different point of view from Robert Shiller regarding the existence of bubbles in asset prices. He believes that what some other scientists call a bubble in asset prices is only a short and temporary increase in the asset price. Eugene Fama, the father of the efficient market hypothesis in his Nobel prize lecture in 2014 defines bubble as " an irrational strong price increase that implies a predictable strong decline" (Fama, 2014). In other words, there can be some anomalies in the market such as big increases in the prices of an asset price or even for a group of stocks, but eventually they will return to the price before the beginning of the big hike in the prices. Therefore, in his terminology there is no such word as bubble.

It is not uncommon to have heard about financial bubbles given that shares of stocks began being sold to the general public in the last four hundred years and counting. Share prices have often reached unrealistic heights before plummeting back down. This procedure has often been gone with trickery, as unethical insiders have attempted to gain an advantage at the cost of inexperienced traders. Fergusen in his book Ascent of Money categorizes this repetitive pattern is categorized into five categories as follows (see Fergusen, 2008, p.121-122) :

" 1. Displacement: Some change in economic circumstances creates new and profitable opportunities for certain companies.

2. Euphoria or overtrading: A feedback process sets in whereby rising expected profits lead to rapid growth in share prices.

3. Mania or bubble: The prospect of easy capital gains attracts first-time investors and swindlers eager to mulct them of their money.

4. Distress: The insiders discern that expected profits cannot possibly justify the now exorbitant price of the shares and begin to take profits by selling.

5. Revulsion or discredit: As share prices fall, the outsiders all stampede for the exits, causing the bubble to burst altogether."

Three other characteristics are typical in stock market bubbles: It is still a disputable topic as to whether there is such a thing called bubble or not. Nevertheless, Fergusen (2008) in his book (the Ascent of Money, 2008, p.122) talks about three conditions under which a bubble component can be built in an economy, stocks and housing market etc which can be seen below.

Firstly, asymmetric information which refers to insiders who have higher positions in the management of firms with bubble stock prices are much more knowledgeable than outsiders, which is a violation of the strong form of the efficient market hypothesis. These insiders can exploit the market by applying their information. Indeed, there are such asymmetries in business all the time, but in a bubble, the insiders have the opportunity to take unfair advantage of other investors who do not have access to the same information.

The function of international capital flows is the second major subject. When money moves freely across nations, bubbles are more prone to develop. The experienced investor, located in a significant financial hub, may not have the inside information of the actual insider. But compared to the uninformed novice trader, he is considerably more likely to get his deal done and purchase soon and exit well before the bubble collapses. Or, at the very least, a portion of the euphoric behavior is less irrational than others. In a bubble, it is possible to find market participants who act rationally.

Finally, without money, it will be difficult for a bubble to be formed, in that when there is enough cash available in circulation, actors in the market are able to carry out trading transactions. When there is a trade and an increase in the number of trading activities, there is the possibility for the bubble component to be formed in that asset indiscriminately of what is being traded and the reasons why they are being traded. For instance, the availability of cheap credit can boost trading in that money is readily available and cheap so investors can borrow to do business. It is known to many that one of the reasons why there was the housing bubble in 2008 was due to the fact that there were cheap interest rates which ended up fueling that bubble. So cheap credit availability can be considered the most important driver of a bubble.

In a similar way Robert Shiller in the second edition of his book Irrational Exuberance defines a bubble in a much more psychological manner which best suits a behavioral finance sphere. It describes the environment and conditions that can create a bubble. He describes the environment and conditions that can create a bubble and goes ahead to state that a bubble is "a situation in which news of price increases spurs investor enthusiasm, in a sort of psychological epidemic." (Shiller, 2005, p.15). This psychological epidemic can be reinforced by the narratives in the market by the traders who are advocating buying stocks to earn profit with the belief that asset prices are going to surge in the future. Consequently, this new wave will absorb some other market participants in the market to invest, although they are skeptical of the real value of their investments due to their less risk averse nature and jealousy of others who have already invested and gained a great return from their investments.

However, Eugene Fama does not agree with Robert Shiller about the existence of any bubble in asset prices and he believes that what some other scientists call a bubble in asset prices is only a short and temporary increase in the asset price. Eugene Fama, the father of the efficient market hypothesis in his Nobel prize lecture in 2014 defines bubble as " an irrational strong price increase that implies a predictable strong decline" (Fama, 2014).

Many scholars have come up with different definitions and explanations for bubbles. (Craine, 1993) states that "bubbles are deviations in the stock's price from the fundamental value". "A rational bubble reflects a self-con- firming belief that an asset's price depends on a variable (or a combination of variables) that is intrinsically irrelevant-that is, not part of market fundamentals-or on truly relevant variables in a way that involves parameters that are not part of market fundamentals" (Diba and Grossman, 1988).

If there is no rational bubble in existence at time t, and $t \geq 0$, then there will be no rational bubble in existence at time t+1, and there will be no rational bubble at any point in the future (Diba and Grossman, 1987). Since a bubble cannot form if it was not existed before, it can be concluded that any bubble that now exists must have always been there (Diba and Grossman, 1988).

The topic bubble which still remains a debate, with earlier research works like that of (Fama, 1970) where he brought about the EMH, the idea of a bubble seems to be a contradiction to this theory. In another study (Fama, 1991) rebuts this argument that dividend yields can be

used as evidence for detecting bubbles. Furthermore, he elaborates on this by mentioning that "to judge whether the forecast power of dividend yields is the result of rational variation in expected returns or irrational bubbles, other information must be used." He believes that having all these information together still is not an sufficient document to prove whether the market is efficient.

(Fama,1970) states that a market is efficient when asset prices are already impounded by the available information. Thus, asset prices "at any time "fully reflect" the available information such as news in the market . In other words, no investor can gain any abnormal returns (alpha) systematically and persistently by the use of technical analysis, chartism and/or fundamental analysis and there is no way to beat the market. To clarify more the efficient market theory and what informationally efficient means exactly, for instance when bad news hits the market and the market implies that the price of that security should fall from its current price to a lower price. As a result of this, in a non efficient market some traders might overreact to this news and want to sell their stocks at a lower price. However, in an efficient market the price will fall to a lower price and traders do not have time to overreact to the bad event. Therefore, based on the efficient market hypothesis theory it is not possible for bubbles to be found in stock prices given that for bubbles to exist in a stock price, there has to be that deviation from their fundamental values and at such periods there is usually an increase in the prices of the stocks and an increase in sales volume because every market participant wants to take advantage and make some profits, but based on the EMH all the information is readily incorporated in the stock prices so no one can actually take advantage of any given situation in the market. The Efficient Market hypothesis has been researched many times; however, it is still a controversial topic and many researchers are for and against this hypothesis. Despite Eugene Famaand his belief about the EMH, many scientists believe the market is not efficient and to some extent traders can achieve abnormal returns. Dimson and Mussavian (1988) states that "the efficient markets hypothesis does not rule out small abnormal returns, before fees and expenses." Therefore, investors have a good reason to analyze the news and information in the market with the hope of predicting the market and achieving some abnormal returns out of it. Even (Fama, 1991) states that "market efficiency per se is not testable. It must be tested jointly with some model equilibrium, an asset-pricing model."

Efficient market theory can have different interpretations. (Lamont and Thaler, 2003) states that based on EMH, it is not easy to earn abnormal returns and prices are just representing the

intrinsic value. If the stock prices of certain companies are significantly different from their fundamental value, then such companies will either collect an excessive amount of capital or an inadequate amount of capital. Most of the tests for finding bubbles try to find the deviation of the asset price from the fundamental value of that asset price. As concerns the fundamental value of a stock, there are diverse opinions with (Craine, 1993) who gives a specific definition of fundamental value and states that " the fundamental value of a stock is the sum of the expected discounted dividend sequence.". Therefore, in any case where the prices of a stock moves away from the fundamental value we can conclude that there is a bubble but at the same time we have a shortcoming which is; how do we determine the fundamental value of a stock? Some profound scholars have expressed thoughts about the difficulty in finding the fundamental value of a stock such as (Craine, 1993) who mentions that, identifying the bubble should be an easy job. However, since it is difficult to determine the intrinsic value, detecting the deviation of stock prices from its dividend is not a simple task. In a similar view, (Lamont and Thaler, 2003) supports that actually determining the fundamental value of stock is not easy, so testing whether prices may drift from their intrinsic value is not possible in light with their study. Therefore, (Lamont and Thaler, 2003) came up with a solution for that and they suggest that instead of intrinsic value, the relative valuation should be tested. Using closed-end funds which are traded at a big discounts or premia is a method suggested by (Lamont and Thaler, 2003) to find if the assets are mispriced.

In other matters we can relate the efficient market hypothesis to another theory "random walk" of which (see Burton, 2019, p. 24) states plainly that "random walk is one in which future steps or directions cannot be predicted on the basis of past action" and when this theory is applied on security prices Burton further conclude that "short-run changes in stock prices cannot be predicted." Consequently, it can be said that, based on the random walk theory stock prices are not predictable. (Burton, 2019, p.25) goes further to relate investors in the market who act rationally to a blindfolded monkey throwing darts at the stock listings could select a portfolio that would do just as well as one selected by the experts. Hence, from his example it can be said that no matter how smart an investor is or how experienced they are, they perform better than other market participants because no one has better information than the others since prices in the market simply follow a random walk. So if prices also follow a random walk we can equally say that the prices are efficient since no one can with any special skills whatsoever or with any special information outperform the market by gaining super normal profits as per the efficient market theory.

(Kortian, 1995) “Simply stated, a rational bubble is present whenever an asset price deviates progressively more quickly from the path dictated by its economic fundamentals. The growth of rational bubbles reflects the presence of arbitrary and self confirming expectations about future increases in an asset's price.” In a similar way, (Blanchard and Watson,1982) also states that behavior and expectations that are rational do not always entail that the asset prices should match its intrinsic value. In addition to this, he claims that a rational bubble exists anytime the price of an asset deviates gradually more rapidly from the path that is indicated by the economic fundamentals. Thus, a characteristic of a market would be the practice of an investor purchasing an item only with the assumption that they might be able to resell the asset at a better price to another trader who is eager to acquire the asset for the same purpose. (Shiller, 2015). Irrational exuberance. In Irrational exuberance. Princeton university press. Because of this sharp increase, prices are beginning to diverge from their intrinsic values, which is fostering the creation of a rational bubble. Inasmuch as these expectations keep holding, stock prices will continue to hike. The bubble continues to expand to the point when market participants views shift and investors begin to worry that the price surge is not permanent. This happens when the bubble reaches a certain point. At this stage, any piece of negative information might set up a panic, which ultimately results in the bubble bursting.

On the contrary, at least some traders and investors allow external or non-fundamental elements, such as fads, trends, rumors, and "noise," to impact their emotions and expectations (Kortian, 1995).

When many of the scientists and market experts comment on the different market crashes such as what happened in housing prices in 2008, technology stocks in 2000, meme stocks such as GME in 2021 or other market crashes all over the world. They claim that at least one of the reasons for these market crises is that the prices were too high for some time before the market crash. One of the reasons for having irrational high prices for a time period is that some irrational investors drive prices up too much. In these kinds of situations it is assumed that arbitrageurs enter the market to earn some profit by shorting the high-priced stocks. As a result of this the prices will get back to its rational valuation before the time irrational investors pump up the prices. (Lamont and Thaler, 2003) clarify that the arbitrageurs do not do this necessarily because “there can be cases of mispricing in which arbitrageurs are unwilling to establish positions because of fundamental risk or noise trader risk”. They

further states that throughout the mania dot-com bubble, many market participants believed that Internet stocks were were traded for prices that were higher than the fundamental price; however, only a small minority of them were inclined to take a short position, and the number of investors who took short positions were insufficient to reduce the price to rational valuations.

(Blanchard and Watson,1982) states that despite behaviorists, investors and economists can have quite different perspectives on how to value assets. The broad opinion among economists is that, given the presumption of that market participants behave rationally, the stock price should be fair, that is, it can only be based on knowledge of the asset's present and potential future returns. Deviations from this fundamental market value are considered to be literal proof of irrationality. In contrast, market players often think that fundamentals merely account for a portion of what drives asset values. When other participants believe that external factors have an impact on the price, "crowd psychology" becomes a significant factor in pricing.

Some researchers compare the situation when the market prices surge irrationally with a Ponzi scheme. (Shiller, 2015, p.155). states that it is a “type of naturally occurring Ponzi process” which is fueled by investors' expectation and confidence due to stock prices increase in the recent past. As a direct result of this, the prices continue to rise at an increasing rate, which eventually leads to prices that are irrational.

This paper aims to figure out if there was a bubble in the Nasdaq Composite index (IXIC) which mostly have internet stocks in the period between 1990-2001. It is claimed by many market participants, and media that market prices were driven up by irrational investors and collapsing bubbles have been detected in the asset price of Nasdaq Composite (IXIC). (Blanchard and Watson,1982) states that “a bubble on the price of any asset will usually affect the prices of other assets, even if they are not subject to bubbles”. Consequently, it is highly possible that other major indices were affected by this market condition. Nasdaq Composite includes companies that are mostly technology related such as Amazon, Microsoft, and Apple. To test that if market situation and the surge in prices had any effect on the other indices, choosing a non-tech index can help us to make a better comparison. Dow Jones Industrial Average (DJI) is an index including thirty non-technology firms such as Walmart and Coca Cola and by testing it we can figure out if the assumption that bubbles in an asset price can affect other asset prices as well. However, despite the stand of (Blanchard

and Watson, 1982) about bubbles in prices affecting other stocks, we do not in anyway in this piece of work plan to find the causation and if in case we detect a bubble in both indices, it would most probably be a coincident because we do not plan to do any test that's shows the bubble in NASDAQ caused a bubble in DJI.

Without testing bubbles we are not able to figure out if bubbles actually exist or not. Thus, it is necessary to apply some econometrics tests which are most classical in testing bubbles. There are some tests such as West's two-step test, variance bounds test and unit root test for detecting bubbles. The fundamental goal of the specification test proposed by (West, 1987) is to estimate the model's parameters using two distinct methods. One approach that generates reliable estimates both with and without bubbles. One other method that delivers reliable estimates solely in the event f there are no bubbles present. We can determine if there is a bubble by comparing the two sets of estimates. In the absence of bubbles, the two sets of parameters are considered to be equivalent. The two parameter are distinct from one another if there is a bubble. As well as the two-step tests developed by West, and the variance bounds tests have the same objective: to detect "anything other than intrinsic values.

The case for securities is that if share prices are not more explosive than dividends, we can conclude that rational bubbles are not existent (Diba and Grossman, 1988). The reason for this conclusion is that they would provide an explosive element to stock prices. (Evans, 1991) has another point of view contrary to that expressed by (Diba and Grossman, 1988), he found that if applying cointegration and unit root tests is good enough to detect recursive bubbles. He figured out that these techniques cannot find bubbles because "the residuals from the cointegrating regression largely reflect the presence of periodically collapsing bubbles." Among these tests the latest and modified version of unit root test which is General Sup Augmented Dickey Fuller test (GSADF) is a powerful method to detect multiple bubbles and is able to datestamp bubbles. For instance, (Blanchard and Watson,1982) found some weaknesses in variance bound test and claimed that certain bubbles cannot be identified by applying variance bound test. It further states that other possibilities, such as irrationality, might lead to a breach of these bounds; hence, our findings need to be interpreted taking this into consideration these irrationalities. There are some empirical tests for finding rational bubbles using simple stationarity checks suggested by scientists such as Diba and Grossman (1984, 1988), (Hamilton and Whiteman, 1995). The use of observable fundamentals and the analysis of stationarity of stock prices is the way to test for rational bubbles suggested by

these scientists. Most of these tests have to be done with strict restrictions. (Hamilton and White, 1995) states that external factors which are not empirically testable increase the prices. Therefore, restrictions on the dynamics of the fundamental driving factors can be loosened. Thus, the analysis of test results will be given a better interpretation of the existence of rational bubbles in asset prices.

Taking into consideration the period from which this thesis draws its data (1990-2001) what is obvious is that the price of these two indices are erratic.

2.0 Methodology

When determining a research method, it is important to make a deliberate choice for what is considered reality and how we validate what we know. The answers to these two questions set up the frame of research, methodology, results, and interpreting results.

2.1 Ontology

To determine the research approach in this thesis, two dimensions need to be considered. First, ontology is about the study of reality in the sense of how we understand and relate to reality. Any research needs to be intentional with respect to two primary choices in ontology, namely, subjectivity and objectivity. A subjective approach is cognizant of the viewer of reality and accepts different perspectives, and as a result, different realities. An objective approach, on the other hand, starts with the premise that reality exists irrespective of viewers and their points of view. With objectivity, reality exists in a concrete way that is independent of who views it and how. Each of these approaches has its application in research. Since the current thesis studies concrete and objective matters, an objective ontology is chosen, as it is a natural fit. (see O'Gorman and MacIntosh, 2015, p.55-58)

2.2 Epistomology

The second aspect of the research approach that needs to be decided is about epistemology. Epistemology is about the question of how we develop valid knowledge. There are several approaches to epistemology varying with respect to how knowledge is verified. Two common yet extreme epistemological paradigms are positivism and interpretivism. Positivism focuses

on facts, underlying causality, and formulating testable hypotheses. In contrast, interpretivism is mainly about meanings, understanding, and forming induction from data. In this thesis, a positivist approach is taken because a positivist epistemological approach is a natural fit for the quantitative nature of this thesis. (see O'Gorman and MacIntosh, 2015, p.58-60)

Many scholars came up with different definitions and explanations for bubbles. (Craine,1993) states that "bubbles are deviations in the stock's price from the fundamental value". A rational bubble is characterized by the self-confirming assumption that the price of an asset depends on a variable (or a set of variables) that is intrinsically irrelevant- that is, not a component of market fundamentals, or on truly relevant variables in a way that involves parameters that are not a component of market fundamentals (Diba and Grossman, 1988).

The Generalized Sup Augmented Dickey Fuller is applied in this paper which "involves the recursive implementation of a right-side unit root test and a sup test, both of which are easy to use in practical applications, and some new limit theory for mildly explosive processes" (Phillip et al., 2011). This test is more powerful to capture the explosiveness in the data series. This method works well for identifying bubbles that burst multiple times. Using this method allows us date-stamp the beginning and end of the explosive behavior through using forward recursive regression method (Phillip et al., 2015).

Another method applied in this paper is variance bounds test (Shiller, 1983) which aims to test if the volatility of the index can be attributed to volatility of the fundamentals. Therefore, we can calculate the fair value that the index should have had based on future dividends based and final selling price. Then we need to figure out if this fair value is bigger than the actual price or not. If the actual price is more volatile than the projected fair value, we can conclude that there is speculative variance to the index movement and the volatility is not fully explained by fundamentals. To compare two variances, we can calculate them using return and fair value changes. Then, we can calculate the ratio of those variances using one tailed f-test to figure out if the variance of returns is substantially greater than fundamental values. Then, if we can find such a result the speculative component is confirmed.

Chow break test is one of the supplementary tests applied in this paper which aim that if there is any structural break in the in the data set. The other supplementary test is test for abnormal

returns which is an event test. This test is developed to figure out if there are any abnormal returns in the event period.

2.3 Econometric Method for Bubble detection

However, since we cannot conclude on whether there exist rational bubbles or not by basing our judgements only on theoritical assumptions and principles, therefore, the application of some econometric methods have to be employed to ascertain the validity of the claim. Regardless of the visible fluctuations in the market and the daily changes in volume of sale and stock prices, news reports, comments on online trading platforms, and general euphoria and excitement in the market during the period between mid-1995 to late 2000 regarding the herding in order to invest in technology companies, it is not enough evidence of a bubble.

A conclusion about what must have been happening in the market goes beyond anything that has been observed, or felt in the market even though there have been numerous assertions of "getting the smart money". This is because a conclusion concerning what must have been happening in the market is derived from an economics and finance perspective.

Consequently, the existence of a bubble component in stock prices goes beyond what the senses can detect. In so doing, for me to make any claims concerning the presence of bubbles in these indexes (DJI and IXIC), they must be supported by a corresponding test or a series of statistical tests that prove existence; otherwise, they will remain mere assertions.
Because of this, the significance of econometric tests for bubbles cannot be overstated. The reason for this is because, in the absence of these tests, we are unable to verify the existence of bubble components in any stock price.

Indiscriminately of what we see and the analysis of the market the movement in the volume of sale, the hikes in the prices, increases, doubling and tripling of the number of start-ups and IPOs, the general euphoria in the market, the willingness to trade and so on. We cannot depend on these to say that there is a bubble in such a market reason why we use econometric methods to be able to test if actually there is a bubble without which we cannot conclude on the existence or not of a bubble.

Before going into the details, the econometric method employed in this paper we are going to start by the simple definition of a bubble which is the deviation of the price from its fundamentals (Craine, 1993) and how that is solved econometrically,

2.3.1 Tests for Bubbles

A classical way of finding out the bubble component is by determining first what the price is, where the price of a stock is given by:

(1)

$$P_t = \sum_{i=0}^{\infty} \left(\frac{1}{1+r_f} \right)^i IE_t \left(D_{t+i} + U_{t+i} \right) + B_t$$

P_t = Price of the asset when the dividends have already been paid.

D_t = Dividends at time t

B_t= Bubble at time t

U_t = Fundamentals of the stock price which are not observed

Hence finding the market fundamentals we have

$P_t^f = P_t - B_t$ and where B_t satisfies the

(2) $E_t(B_{t+1}) = ¿) B_t$

When there are no bubble components present in a stock, that is, B_t= 0, how stationary the stock price is can only be defined by the dividends and the fundamental values meaning that, explosiveness in the stock prices will be explained by corresponding explosiveness in the dividends in cases where there are no bubbles.

2.3.2 West´s Two Estimation Techniques

In addition to the above, there is the method of (West,1987) who uses two ways in capturing a bubble in a stock and in each of the two ways he has different assumptions as seen below

In the first technique favors both the presence and the absence of a bubble where.

(3) $P_t = \theta\left(P_{t+1} + D_{t+1}\right) + u_t$

$$u_t = -\theta\left[\left(P_{t+1} + D_{t+1}\right) - E_t\left(P_{t+1} + D_{t+1}\right)\right]$$

D_t = Dividend paid at time t

In this this first method for finding a bubble as employed by (West, 1987), it will be able to give a result in both cases since the method is two sided.

However, the second method has a limited assumption which only focuses in a situation where there is no bubble in the stock price. So as to be able to obtain a consistent estimate we take into consideration the transversality conditions

$$\lim_{n \to \infty} \theta^n E_t P_{t+n} = 0$$

Therefore,

$$P_t = P_t^f$$

Consider the AR(1) model

(4) $D_t = \alpha D_{t-1} + v_t$

Therefore

$$P_t^f = \sum_{i=1}^{\infty} \theta^i E\left(D_{t+1} \middle| F_t\right) + \varepsilon_t = \frac{\theta\alpha}{1-\theta\alpha} D_t + \varepsilon_t$$

$$\varepsilon_t = \sum_{i=1}^{\infty} \theta^i \left[E\left(D_{t+i} \middle| \Omega_t\right) - E\left(D_{t+i} \middle| F_t\right.\right.¿¿$$

In a situation where we have a bubble component in a stock,

$$P_t = \frac{\theta}{1-\theta} D_t + \varepsilon_t + B_t$$

Then

(5) $P_t = \beta D_t + \omega_t$

Applying the ordinary list square having $\omega_t = \varepsilon_t + B_t$ and consistent estimate of

β only if $Cov(D_t, \omega_t) = Cov(D_t, B_t) = 0$

To find the value for β, we use both assumptions which implies that we will use both techniques in equation (3), (4) and (5) to obtain $\rightarrow \frac{\theta\hat{\alpha}\hat{}}{1-\theta\hat{\alpha}\hat{}}$

And in that way, we have the hypothesis as:

$H_0 : \beta = \frac{\theta\alpha}{1-\theta\alpha}$ No bubbles in the price

$H_1 \beta \neq \frac{\theta\alpha}{1-\theta\alpha}$ Bubbles in the price

The generalized method of moment and the instrumental variables are employed so as to get a consistent estimate for θ in the two step procedure by (West,1987).

2.3.3 The price-dividend ratio, bubbles, and Book to Market ratio

In recent times there has also been the development of new test can fit special conditions like that developed (by Caspi and Graham, 2017) where the use the log book-to-market ratio in testing for bubbles in the Israeli stock market, this method is suitable for stocks with irregular dividend or no dividend payments at all such as the case with the Israeli stock market. In this new mwthod, Caspi and Graham us the log to-book-market model of Vuolteenaho (1999, 2002) where

(6) $V_t - V_{t-1} = X_t - D_t$

Where: v_t = the book value at time t,

X_t = the earnings, and

D_t = the dividends

And the log book-to-market ratio is given by:

$\theta_t = b_t - m_t = ¿ \log (B_t / M_t)$

M_t = Market equity value at time t.

Caspi and Graham relates the above (15) to the GGM of Campbell and Shiller, (1988) where

$$\theta_t = k_t + E_t \sum_{J=1}^{\infty} P^j r_{1+j+1} - E_t \sum_{j=1}^{\infty} P^j \left(r^e{}_{1+j+1} - r^f{}_{1+j+1} \right) + ¿ b_t ¿ \quad (8)$$

Where $r_{t=}$ the log gross excess return at time t,

B_t = Bubble

k_t = Constant

$r^f{}_t$ = Log gross risk-free return

$r^e{}_t$ = Log returns

2.3.4 General Sup Augmented Dickey Fuller test (GSADF)

Furthermore, for the sake of the is piece of work, we are going to employ one of the classical econometric methods in testing for bubbles which was employed by (Philip et al., 2015) modified from the (Philip et al., 2011) and this new procedure has a higher ability to capture bubble components and date stamp such bubbles and it is also a rolling window test which can unlike the previous test for bubbles capture several bubbles.

Here we have the hypothesis stated as

$$H_o : y_1 = d_T + y_{t+1} + E_{t.}$$

Where $d_T = d\,T^{-\tau} with\, \tau > 0.5.$

Using the method by (Phillips and Magdalinos, 2007), we express the alternative hypothesis as a mildly explosive unit root

$$H_1 : y_t = \delta_T y_{t-1} + \varepsilon_t,$$

$Where\, \delta_r = 1 + cT^{-\theta} with\, c > 0 \wedge 0 < r < 1.$

Following a recursive estimate by employing the (Philip et al., 2011)*)* regression model where by

$$\Delta y_t = a_{r_1 r_2} + p_{r_1 r_2} y_{t-1} + \sum_{j=1}^{p-1} \gamma^1_{r1,r2} \Delta y_{t-1} + \varepsilon_t$$

And a t-statistics of

(9) $$ADF_{\lambda 1,\lambda 2} = \frac{\hat{P} r_1, r_2}{S.E.(\hat{P} r_1, r_2)'}$$

Utilizing the GSADF test with rolling window, which is built on the concept of continually applying ADF (9) to different sub samples of data. When the regression coefficient r_2 changes from r_1 to r_0, with r_0 being the window with the smallest size. The test gives room for changes to be made in the parameters, such that the starting value of r_1 may be altered, and it also has capacity for a great deal of additional sub samples.

We use the GSADF test statistics of (Philip et al., 2011) in other for us to test the null hypothesis of "no bubble" which is the supremum of the $ADF_{r1,r2}$

(10) $$GSADF(r_0) = \left[ADF_{r_1 r_2} \right].$$

$$r_2 \epsilon [r_0, 1]$$

$$r_1 \epsilon [0, r_2, r_0]$$

Therefore, the GSADF statistic is regarded to be the largest value of the ADF statistic in this double recursion over all feasible ranges of r_1 and r_2. When the value of the GSADF statistic is greater than the associated critical value, therefore, the null hypothesis will be rejected since it cannot account for the difference between the two.

In a situation where were reject the null hypothesis, the following criteria offers fair estimates for the bubble period lengths:

(11) $$\hat{r}_e = \inf_{r_2 \in [r_0, 1]} \left\{ r_2 : BSADF_{r_2}(r_0) ¿ sc \upsilon_{r_2}^{\beta_T} \right\}$$

(12) $$\hat{r}_f = \inf_{r_2 \in [\hat{r}_0 + \delta \log(T)/T, 1]} \left\{ r_2 : BSADF_{r_2}(r_0) ¿ sc \upsilon_{r_2}^{\beta_T} \right\}$$

r_e refers to the starting point of the bubble at the point where the GSADF test statistics exceeds the critical values, that is, lies above the critical value while on the other hand r_f denotes the ending or collapsing of the bubble when the GSADF statistics is beneath the critical value (Philip et al., 2015)

2.3.5 Variance bound test

This method was developed by (Shiller, 1983).

Ex-post fair value based on dividends and final selling price (31/12/2001):

(13) $$FV_t = \sum_{i=t}^{N} \frac{D_i}{(1+r_i)^i} + \frac{P_N}{(1+r_N)^N}$$

N - sample size (82 months for NASDAQ and 143 months for DJIA)

(14) $$f_t = \frac{FV_t}{FV_{t-1}} - 1$$

F-stat for equality of variances (one tailed because the condition is violated only if the variance of returns is higher than the variance of fair value changes

(15) $$VB = \frac{V(r_t)}{V(f_t)} \quad F¿)$$

Valuating the variance ratio between the returns and changes in the fair value and test it statistically

$H_0 : V(r_t) \leq V(f_t)$ variance bounds condition

$H_1 : V(r_t) > V(f_t)$ variance bounds are violated

3.0 Data and Results

In this thesis the daily data on price series and dividend series of two indexes, namely Nasdaq Composite Index (IXIC) and Dow Jones Industrial Average (DJIA) is used. The data used, which spanned from January 1990 to December 2001 and included a total of 3131 observations, came from Bloomberg. As per the dividend series for Nasdaq Composite is not available for the period of 1990 to 1995 and dividend series for Dow Jones Industrial Average does not provide a regular dividend series for the first two and half years. Thus, in this period I just test if there is any sign of explosiveness in the price series which alone can not be a scientific reason for detecting bubbles.

Each regression model used to calculate the GSADF has a trend, and the distribution of simulated critical values used to assess the GSADF statistics is a right distribution. The critical values are determined using Monte Carlo 2000 simulations. With the number of lags set to one, and the window size set to five and fifteen percent, the Akaike information criterion is used. Here, three different window sizes were applied which are fifteen percent, ten percent, and five percent. Smaller windows are able to capture more explosivesness. Thus, using three different window sizes allows us to compare the result of GSADF tests and figure out which one is more efficient.

Figure1: Nasdaq composite price and volume

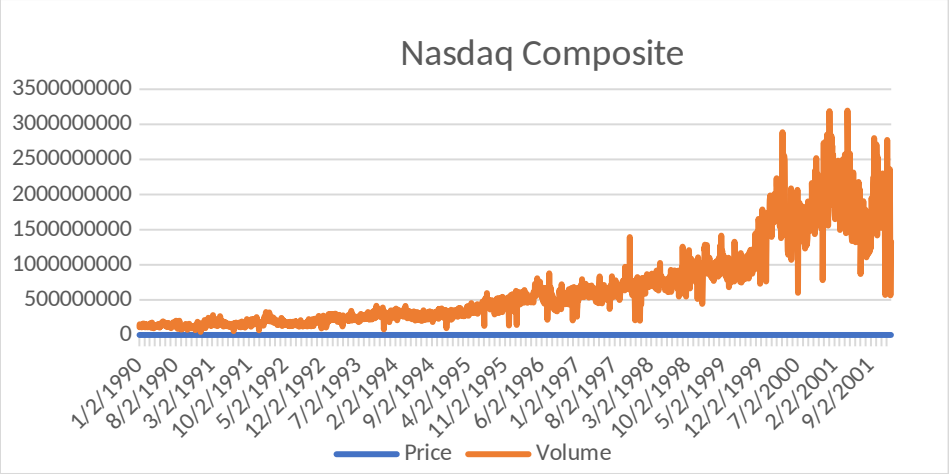

Figure 1 indicates a 24.8516% increase of Nasdaq Composite price in 1995 unlike 1994 when there is only 2.0537% increase in price compared to its last year 1993. 1995 can be

considered the beginning point of the surge in the price. The increasing trend of Nasdaq price kept continuing as we see the 18.7256%, 24.6058%, 20.3786%, 46.1164%, and 19.3976% increase in the annual price in 1996, 1997, 1998, 1999 , and 2000 respectively. Nasdaq reached its highest price which is 5048.62 on 10th of March 2000 and the lowest price in this period is 325.4 on October 16th of 1990.

The other important point to consider is that even after March 2000 when the bubble burst the volume kept increasing. The reason for this increase in volume is that market participants desired to get rid of their shares and sell it at any price which is lower than the time before the bubble burst. This way they intended to avoid more losses.

Figure 2: Dow Jones price and volume

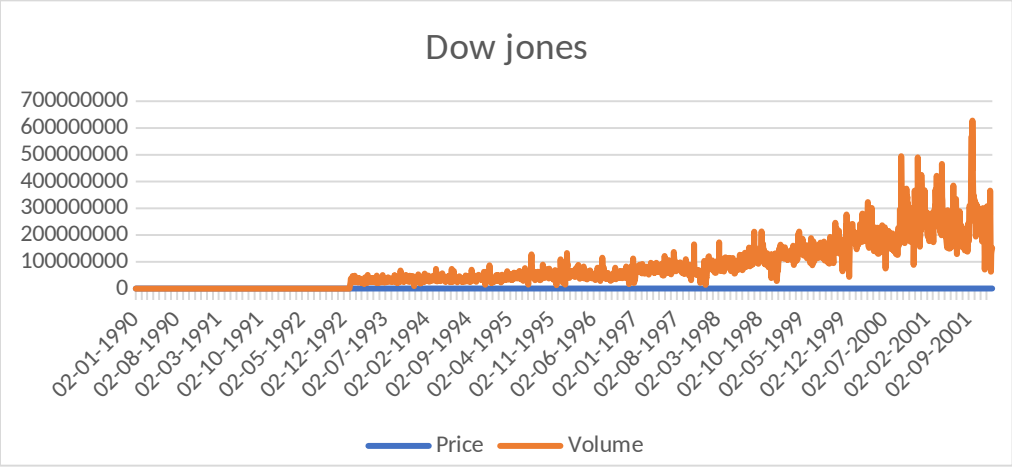

Figure 2 shows that the Dow Jones price has grown steadily in the study period. The maximum price of each year increased around 1% which shows that the price was not erratic. The Nasdaq price was ranging $32882 -$33255, $33256- $33632, $33633 – $34010, $34011-

$34387, $34388 – $34764, $34765 – $35138, $35139 – $35516, $35520-$35894, $35898-$36273, $36276- $36650, $36651- $37027, $37028 - $37253 respectively from 1990 to 2001. Despite the price, the traded volume increases drastically. The price of max price of Nasdaq rose 22.2482%, 31.7626%, 3.9055%, 19.6481%, 22.647%, 22.8476%, 44.0411%, and 21.2067% respectively from 1994 to 2001. The highest recorded volume is 627,654,700 and it belongs to 2001 which can be interpreted as market participants willingness to sell their shares due to the decrease in their share value when the market crashed.

3.1 Results based on GSADF test:

GSADF test is applied in this paper to find explosiveness in the price and dividend series for Dow Jones and Nasdaq. The results of employing GSADF test show explosiveness in the price and dividend series. Therefore, we can conclude that the null hypothesis of no bubble is rejected in the study period for this paper for both Dow Jones and Nasdaq.

Figure 3: Nasdaq Price series 0.15

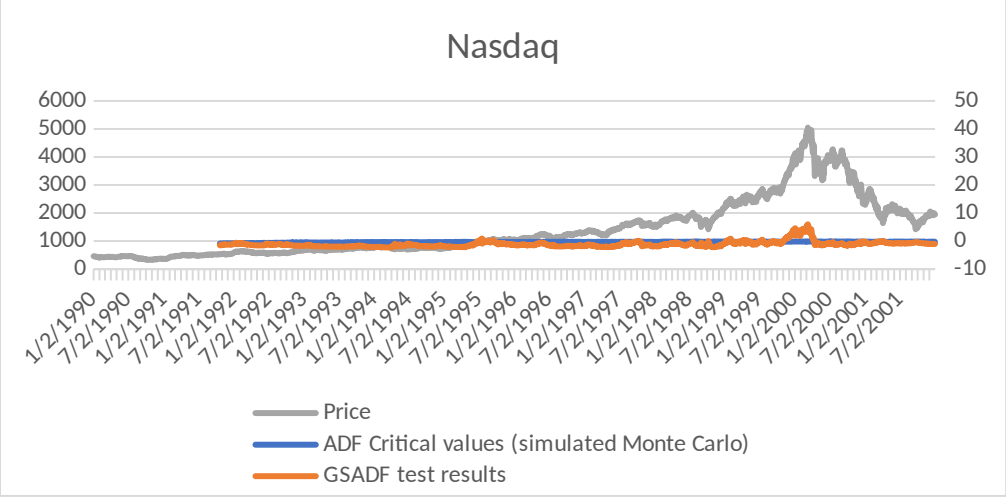

Figure 3 indicates the GSADF test results of the price series of Nasdaq with the window size 15% which shows explosiveness in the price series for 7 seven days in the period between 1st January 1992 and 17th January 1992, 52 days in the period between 20th June of 1995 and September 1995, 12 days between 22nd of september of 1997 and October 15th of 1997, 8th of October in 1998, 120 days in the period 6th January 1999 to 31th of December 1999, 74 days in 2000 in the period between 1st of January to 21st of December 21st, and 14 days in 2001 in the period between 2nd of February and 4th of September. The dates with explosiveness can be seen on Appendix 1.

Table 1: NASDAQ Prices

NASDAQ PRICES				
	r_0= 0.05		r_0= 0.15	
	t- statistic	Prob	t- statistic	Prob
GSADF	5.961730	0.0000	5.961730	0.0000
Critical Value 99%	2.029212		1.749051	
Critical Value 95%	1.629108		1.260229	
Critical Value 90%	1.403873		1.049810	

From table 1 it is noticeable that as the window size decreases from 0.15 to 0.05, critical values of test statistics increase. For example, when the window size decreases, the 99% asymptotic critical value of GSADF statistics rises from 1.749051 to 2.029212. Another point is that although the critical values are different for different windows size the probability is not changed. Thus, it is shown that with different windows size we can capture bubbles.

Table 2: Nasdaq Dividends

NASDAQ DIVIDENDS				
	r_0= 0.05		r_0= 0.15	
	t- statistic	Prob	t- statistic	Prob
GSADF	-5.771971	1.0000	-11.21327	1.0000
Critical Value 99%	2.015423		1.882081	
Critical Value 95%	1.614994		1.260638	
Critical Value 90%	1.406961		1.010600	

From table 2, it is noticeable that as the window size decreases from 0.15 to 0.05, critical values of test statistics increase. For example, when the window size decreases, the 95% asymptotic critical value of GSADF statistics rises from 1.260638 to 1.614994. The probability of 1 shows no evidence for bubble in the dividend series.

Figure 4: Nasdaq Dividend Series 0.15%

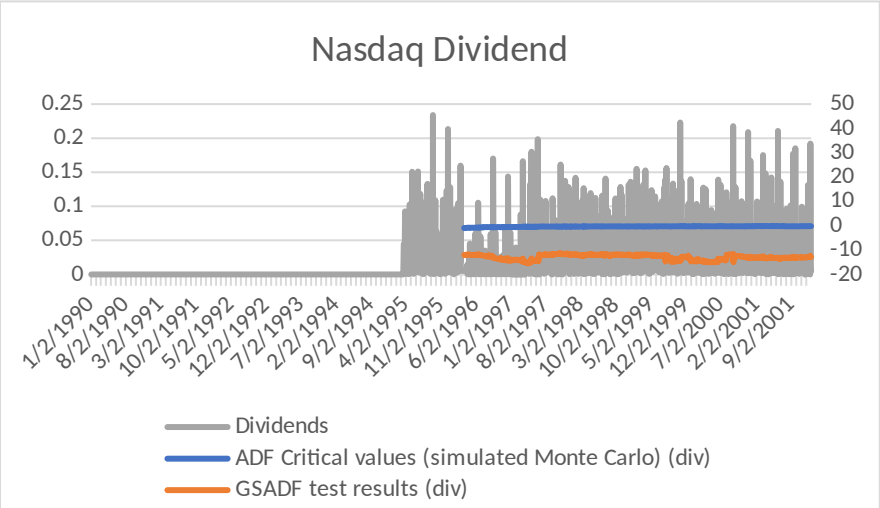

Figure 4: It indicates the GSADF test results of the Nasdaq index dividend series with windows size 0f 15%. The test results do not show any sign of explosiveness.

Figure 5: Nasdaq Price Series 5%

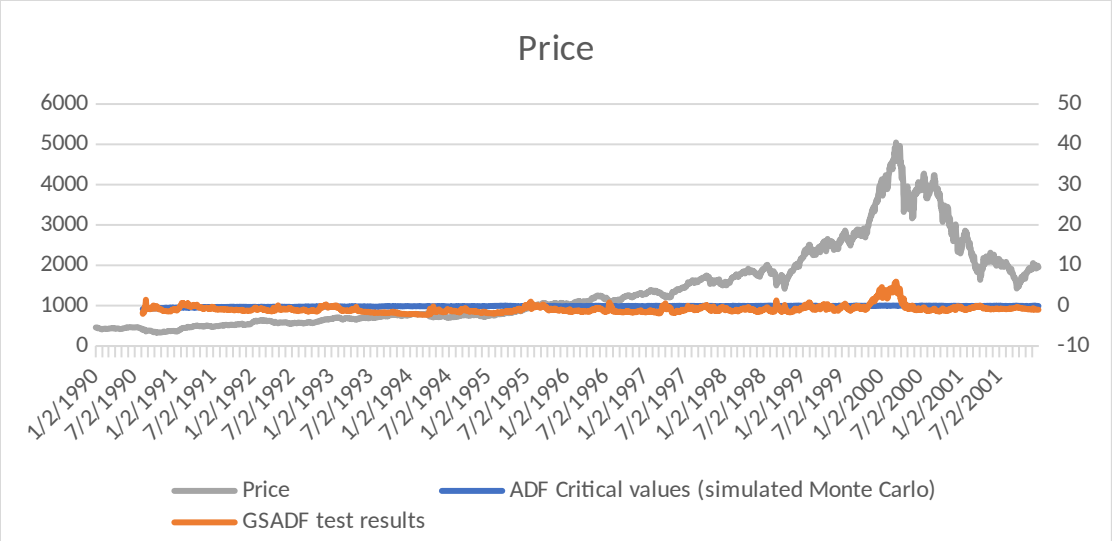

Figure 5 indicates the GSADF test results of the price series of Nasdaq with the window size 5% which shows explosiveness in the price series for 29 days in the period between 17th of August 1990 to 17th of October 1990, 71 day in the period between 24th of March 1991 and 3rd of July 1991, 24 days in the period between 21st of April 1992 and 31st of December 1992, 13 days in the period between 1st of January 1993 and January 26th 1993, 37 days in the period between June 20th of 1995 and 20th of September 1995, 4 days in the period between 15th of July 1996 and 24th of July 1996, 14 days in the period between 19th of May 1997 to 14th of October 1997, 8 days in the period between 28th of August 1998 and 8th of October 1998, 78 days in the period between 8th of January 1999 and 31th of December 1999, 78 days in the period between 3rd of 2000 and 23rd of May 2000, and only 3 days in the period between 3rd of April to 6th of April 2001. The dates with explosiveness can be seen on Appendix 2.

Figure 6: Nasdaq dividend series 5%

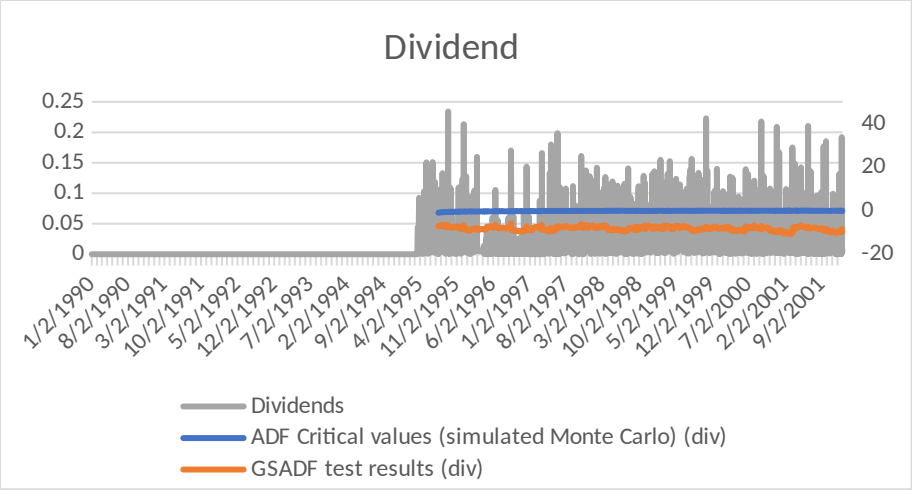

Figure 6 indicates the GSADF test results of the Nasdaq index dividend series with windows size 0f 5%. The test results do not show any evidence for explosiveness in the dividend series.

Figure 7: Dow Jones Price series 15%:

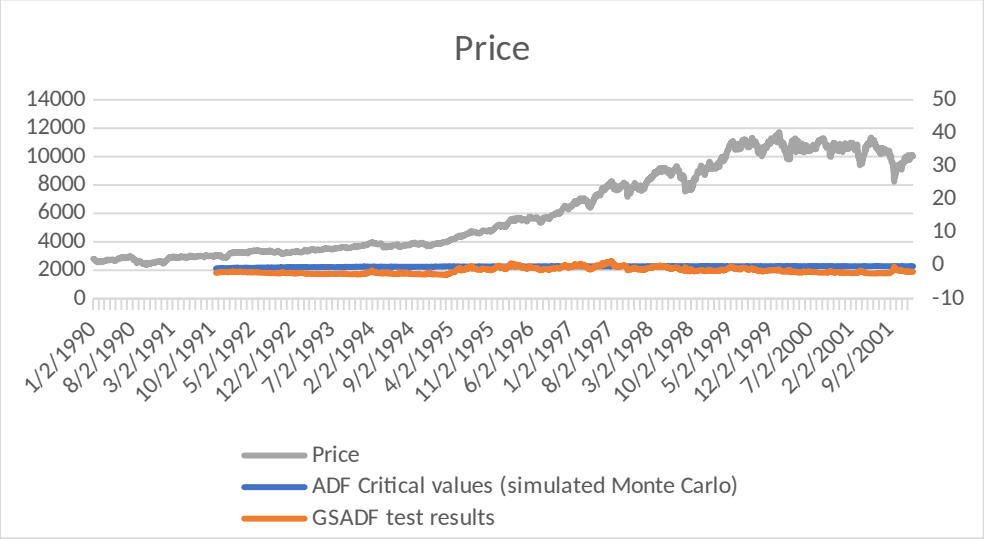

Figure 7 indicates the GSADF test results of the price series of Dow jones with the window size of 15% which shows signs explosiveness in the price series for 14 days in the period between 7th July 1995 and 15th of December, 68 days in the period between 30th of January 1996 and 30th of December 1996, 151 days in the period between 6th of January 1997 and

21st of October 1997, and 16 days in the period between March 20th of1998 and 13th of May 1998. The dates with explosiveness can be seen on Appendix 3.

Figure 8: Dow Jones dividend series 15%

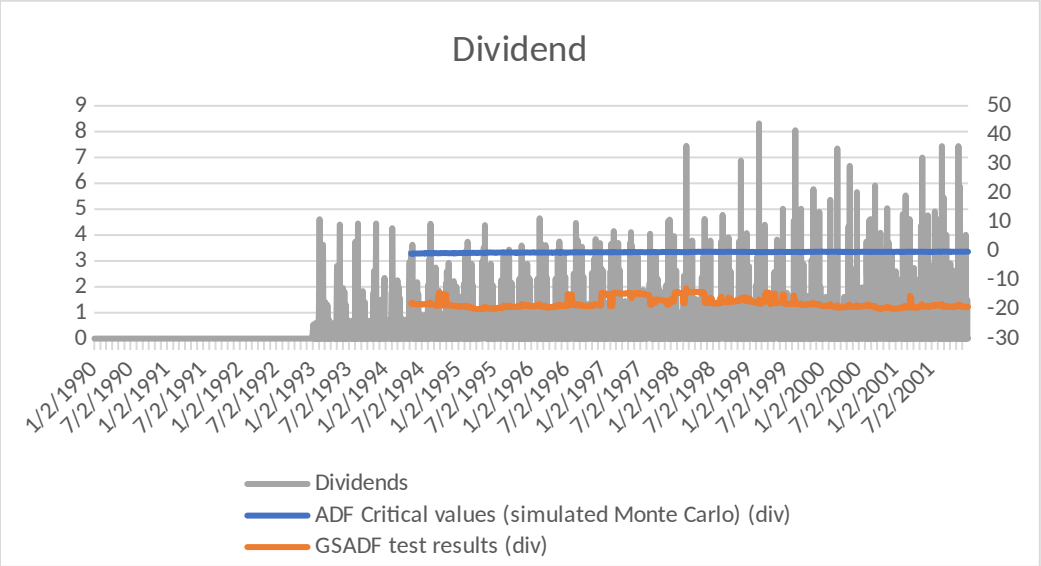

Figure 8 indicates the GSADF test results of the Dow Jones dividend series with windows size of 15%. The test results do not show any evidence for explosiveness in the dividend series.

Figure 9: Dow Jones Price series 5%

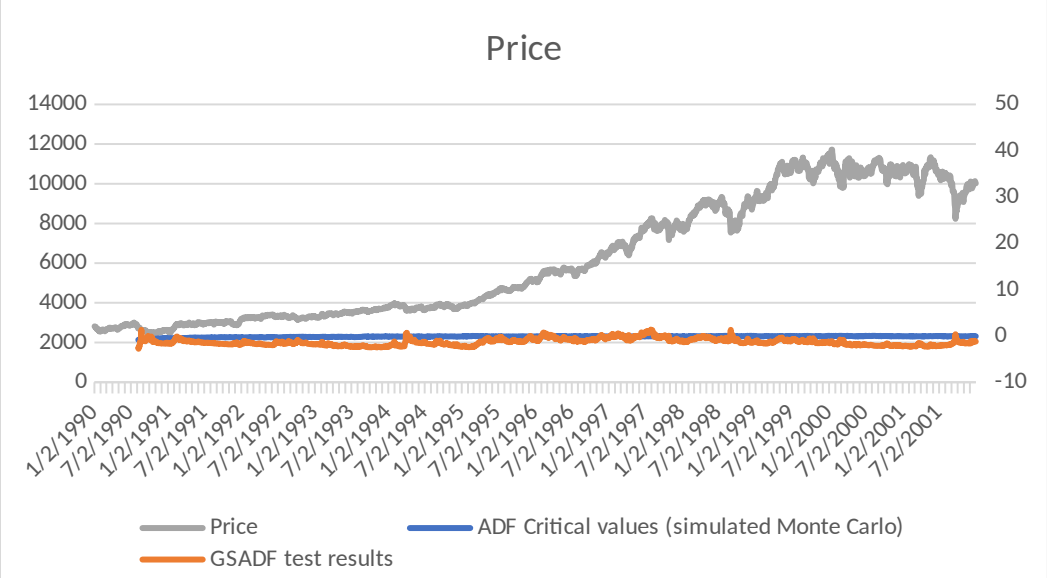

Figure 9 shows the GSADF test results of the price series of Dow Jones with the window size 5% which shows explosiveness in the price series for 22 days in the period between 21st of

August 1990 to 17th of October 1990, 7 days in the period between 11th of February 1991 an 6th of March 1991, 5 days in the period between 31st if March 1994 and 20th of April 1994, 3 days in the period between 12th of June 1995 and 13th of December 1995, 46 days in the period between 30th of January 1996 and 2nd of December 1996, 108 days in the period between 10th of January 1997 and 27th of October 1997, 13 days in the period between 14th of April 1998 and 10th of September 1998, 20th and 21th of September 2001. The dates with explosiveness can be seen on Appendix 4.

Figure 10: Dow Jones dividend series 5%

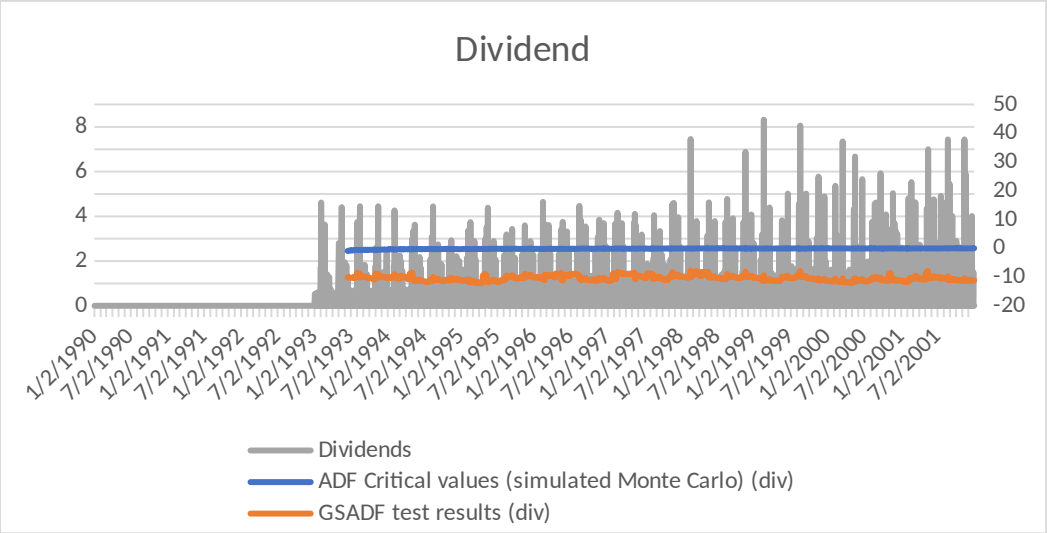

Figure 10 indicates the GSADF test results of the Dow Jones dividend series with windows size of 5%. The test results do not show any evidence for explosiveness in the dividend series.

Table 3: DJI Price

DJI PRICES				
	r_0= 0.05		r_0= 0.15	
	t- statistic	Prob	t- statistic	Prob
GSADF	1.374755	0.1100	1.374755	0.0350
Critical Value 99%	2.029212		1.749051	
Critical Value 95%	1.629108		1.260229	
Critical Value 90%	1.403873		1.049810	

it is noticeable in table 3 that when the window size decreases from 0.15 to 0.05, critical values of test statistics increase. For example, when the window size decreases, the 90% critical value of GSADF statistics increase from 1.260229 to 1.629108. The probability of 0.035 for the window size of 0.15 is good evidence of existence of bubble. However, with the window size of 0.05 is a very week evidence for explosiveness even with 90% critical values.

Table 4: DJI dividends

DOW JONES DIVIDENDS				
	r_0= 0.05		r_0= 0.15	
	t- statistic	Prob	t- statistic	Prob
GSADF		1.0000	-12.75219	1.0000
Critical Value 99%	2.011114		1.821422	
Critical Value 95%	1.601311		1.232276	
Critical Value 90%	1.398234		1.014238	

From table 4, it is noticeable that as the window size increase from 0.5 to 0.15, critical values of test statistics increase. But the case is different here where for example, when the window size increases, the 90% asymptotic critical value of GSADF statistics decreases from 1.398234 to 1.0114238. The probability of 1.0000 shows no evidence for bubble in the dividend series.

3.2) Variance Bounds test:

Table 5 : Dow Jones bound test for the whole period between 1990-2001

	Price	Forecasted fair value	F-stat	P-value
Return	0.00179580	0.00029406	6.11	0.00%

From table 5 which is the test results for the period between 1990 to 2001 it is noticeable that the variance for the price return is 0.00179580 which is higher than 0.00029406 which is variance of forecasted fair value meaning that price returns were more erratic than the forecasted fair value. It is very unlikely that the volatility in the Dow Jones price returns is due to fundamentals, showing that Dow Jones is sensitive to speculative pressure, since both the return and price of Dow Jones have p-values of zero. The bubble theory is confirmed by significant movements in Dow Jones speculative.

Table 6: Dow Jones variance bounds test results for each year

Returns				
	Price	Forecast fair value	F-stat	p-value
1990	0.0023040	0.0006143	3.75	1.91%
1991	0.0017775	0.0009148	1.94	14.29%
1992	0.0004985	0.0013472	0.37	94.31%
1993	0.0003169	0.0000019	163.45	0.00%
1994	0.0014084	0.0000007	1886.85	0.00%
1995	0.0006097	0.0000008	767.55	0.00%
1996	0.0008595	0.0000008	1132.06	0.00%
1997	0.0025953	0.0000007	3518.93	0.00%
1998	0.0039697	0.0000009	4532.39	0.00%
1999	0.0017196	0.0000008	2037.00	0.00%
2000	0.0023812	0.0000007	3607.65	0.00%
2001	0.0036779	0.0000008	4486.01	0.00%

Table 6 indicates that except the year 1991 and 1992 in the other years the change in the forecasted fair value is much higher than the actual price returns. For instance, in 1995 the variance of the price returns is 0.0023040 and is higher than the variance of forecasted fair value which is 0.0006143 meaning that the price returns are more volatile than changes in the forecasted fair value. However, in the years 1991 and 1992 the variance forecasted fair value is higher than the which means variance bounds test are not violated and therefore the no bubble hypothesis in these two years cannot be confirmed.

Figure 11: Dow Jones Variance Bounds Test

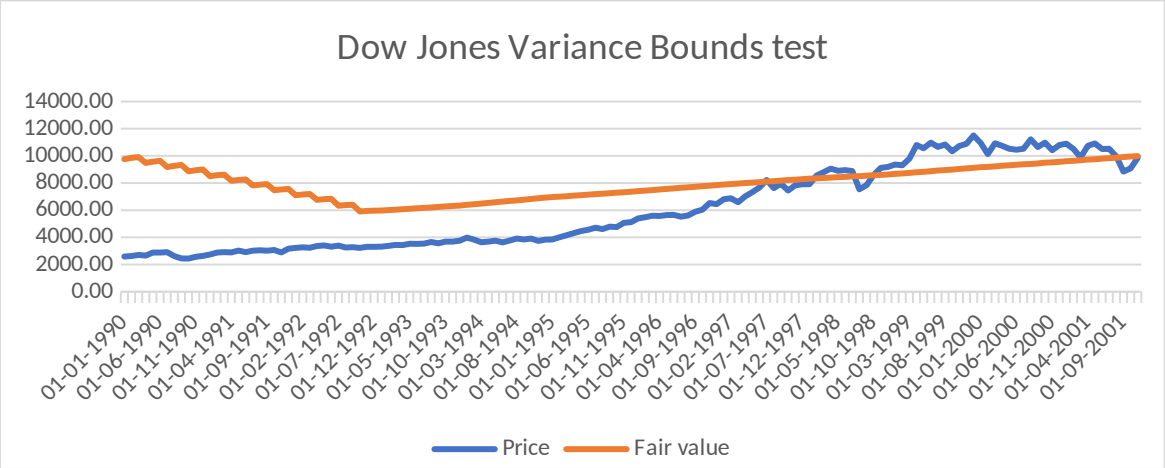

Figure 11 indicates that in at the certain period of time the price series of Dow Jones goes higher than the fair value which is assign that in these period prices were explosive.

Table 7: Nasdaq Composite variance bound test for the whole period between 1990-2001

	Price	Forecasted fair value	F-stat	p-value
Return	0.00849358	0.00000042	20309.78	0.00%

From table 7 it is noticeable that the price returns are more volatile, as can be seen by comparing their variance to that of variance of changes in forecasted fair value. The p-value of price returns of Nasdaq are zero which means that it is very unlikely that the volatility in the Nasdaq price is related to fundamentals indicating that Nasdaq is susceptible to speculative pressure. A lot of movements in Nasdaq speculative confirms the bubble hypothesis.

Table 8: Nasdaq Composite variance bound test results for each year

Return				
	Price	Forecasted fair value	F-stat	p-value
1995	0.00080273	0.00000326	246.33	0.00%
1996	0.00255698	0.00000001	176358.44	0.00%
1997	0.00366706	0.00000002	153495.08	0.00%
1998	0.00817599	0.00000001	774410.37	0.00%
1999	0.00706610	0.00000002	466210.56	0.00%
2000	0.01685699	0.00000001	2253316.57	0.00%
2001	0.01883912	0.00000001	2348398.09	0.00%

Table 9 shows a comparison between the variance of price returns and variance of changes in forecasted fair value in the period between 1995 and 2001shows that the variance of actual price returns is significantly higher than the variance of changes in forecasted fair value meaning that price returns are much more volatile. The p-values are almost zero which shows that there were bubbles in asset price of Nasdaq between 1995-2001.

Figure 12: Nasdaq Composite Variance Bounds test

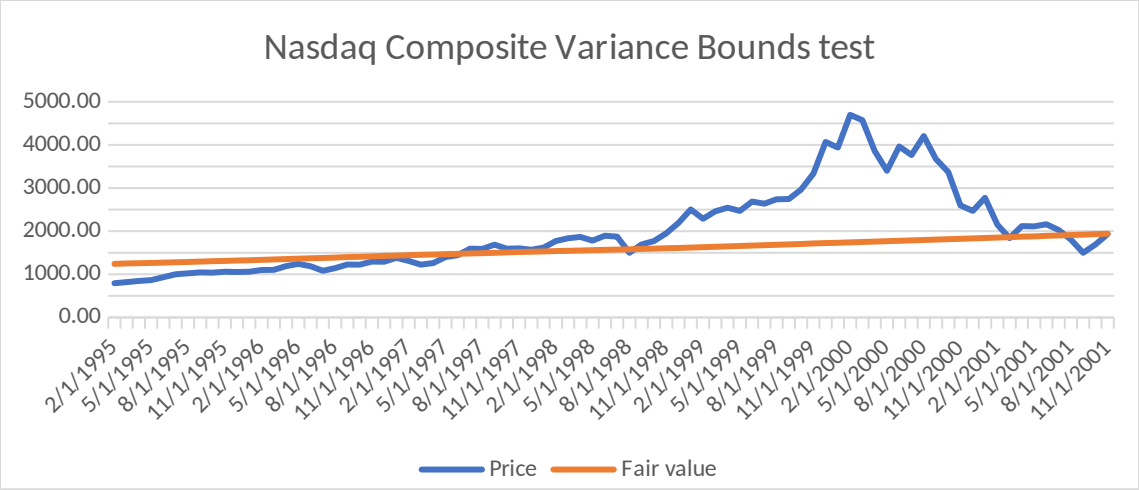

Figure 12 indicates that in at the certain period of time the price series of Nasdaq index goes higher than the fair value which is assign that in these period prices were explosive.

3.3 Variance ratio Test:

Regarding GSADF test that rejects the null hypothesis of no bubbles, I apply variance ratio test for random walk which is able to test if random walk assumption is actually violated or not. The main assumption is that future stock returns are not influenced by current or past stock returns. The other parts of these results can be seen in appendix 5.

Table 10: variance ratio test

	Dow Jones Industrial Average				Nasdaq Composite			
K	2-day return	4-day return	8-day return	16-day return	2-day return	4-day return	8-day return	16-day return
P-Value	4.41%	39.53%	14.72%	15.67%	0.69%	26.16%	48.78%	25.29%

Table 10indicates the result of variance ratio test which was developed by (Lo and Mackinlay, 1988) that both indexes 2-day price returns do not follow the random walk model. However, the computed 4-day, 8-day, and 16-day return follow random walk hypothesis which means market is efficient.

3.4 Test Abnormal returns:

The time periods that came before the beginning date of the bubble were utilized as the estimate periods in both indices, while the time periods that comprised the bubble were considered to be the event period. The Standard & Poor's 500 Index is the benchmark for both indices and the reason for using it was simply because many of the stocks listed in Nasdaq Composite and Dow Jones are listed in S&P 500 and it can be seen as the best representative of both indices. As a result of this, they are highly correlated. With regards to the findings, the results from the abnormal return test shows statistical significance indicating that there were days with abnormal returns in both two indices, and the t-statistics show that those abnormal returns were significant. These findings indicate that there were days with abnormal returns when testing the significance of the abnormal returns.

In the event window of the Dow Jones, which is 249 observations, 24 days were identified to have abnormal returns that were significant, resulting in a cumulative abnormal return of

0.003975248; in the event window of the Nasdaq, which is 262 observations, 96 days were discovered to have abnormal returns that were significant, resulting in a cumulative abnormal return of 0.075874.

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Although other external factors may also be playing a role for existence of abnormal returns in these two indices, these abnormal returns may be explained by the presence of bubbles in these firms since in this paper the focus in bubbles.

Table 11: Event study test for abnormal returns for both DJI and IXIC

Event Study		
	Dow Jones	Nasdaq Composite
Intercept	0.000059	0.000297
Slope (Beta)	0.986439473	0.882318

Standard Error	0.002473729	0.005008
R-Square	0.89602413	0.736649

In order to test for abnormal returns, the data from the estimate period were calculated. Table 11 shows the findings, along with the t-statistics, significance, and cumulative abnormal return of the even period.

3.5 Chow test:

The variance bounds and GSADF tests indicate that there were several bubbles during the study period. For both the Nasdaq as well as Dow Jones, the Chow break test which examines the presence of any structural breaks in the period of study. The null hypothesis of chow test is $H_0 \rightarrow \beta_1 = \beta_2$. The test was done by using simple OLS regression and computing p-values afterwards.

Table 12: Chow break test for DJI and IXIC

Chow break test		
	Nasdaq Composite	Dow Jones
F-Statistics	57.92147	1.406959056
Degree of Freedom	(2,3023)	(2,3125)
P-value	0.0000	0.245041919

From table 12 which shows the test statistics from the chow break test, we can conclude that there was indeed a structural break in both indices.

Conclusion:

Two different econometrics tests were applied in this paper to identify the possible bubbles in the two major indexes Nasdaq Composite and Dow Jones Industrial Average. GSADF test results for both Nasdaq and Dow Jones confirms the existence of explosiveness in the data set. The GSADF test also date stamps the days when there was evidence of exuberance in the data series. Considering the result of GSADF test for the price series of Dow Jones with the window size of 0.15, it is noticeable that the bubble started in 1995 and continued until 1998. However, applying a smaller window size of 0.05 allows us to confirm the existence of exuberance in 2001. GSADF test results for Nasdaq price series with window size of 0.15 indicates that there are some observations with explosiveness in 1992, 1995, 1997, 1998, 1999, and 2000. However, if we use a smaller window of 0.05, we are able to detect more accurately and confirm existence of exuberance in the years of 1990, 1991, 1993, 1996, and 2001 beside the ones we already detected using of window size of 0.15.

In years such as 1995,1996,1997, and 1998 bubbles occurred in both indexes. We could say that this is a pure coincidence since I did not do any causality test which shows that one leads to another.

The result of variance bounds test shows that between the period 1995 and 2001 there are evidence of explosiveness in both Nasdaq and Dow Jones. It is important to say that since the dividend data for Nasdaq in the period between 1990 to 1995 was not available, I could not compute the variance bounds test for this period. Therefore, in this period of time there is no any data to compare with Dow Jones.

Therefore, it can be concluded that there are many days with explosiveness in the time period between 1990 to 2001 in Nasdaq Composite index is positive. Both GSADF and Variance bounds test confirm this conclusion. Also, it can be concluded that at the same time period there are many days with explosiveness in Dow Jones index. It is noticeable that there some

coincidence between the result of these two indexes. However, we cannot conclude for sure about the spilling over effect of Nasdaq bubble on Dow Jones.

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Appendixes:

Apendix 1

Date	ADF Critical values (simulated Monte Carlo)	GSADF test results	Price	Explosiveness significant
1/9/1992	-0.744745525	-0.624184	619.8	Explosiveness
1/13/1992	-0.732567345	-0.72077	617.63	Explosiveness
1/14/1992	-0.71397564	-0.57937	625.75	Explosiveness
1/15/1992	-0.711343877	-0.536736	630.82	Explosiveness
1/16/1992	-0.726253181	-0.660345	627.34	Explosiveness
1/17/1992	-0.707780771	-0.667089	626.85	Explosiveness
2/12/1992	-0.683807856	-0.636389	644.92	Explosiveness
6/20/1995	-0.355228011	-0.254007	929.84	Explosiveness
6/21/1995	-0.362451448	-0.344608	929.19	Explosiveness
6/22/1995	-0.339728605	-0.031672	940.09	Explosiveness
6/23/1995	-0.342239023	-0.158869	938.95	Explosiveness
7/5/1995	-0.379704002	-0.262767	941.82	Explosiveness
7/6/1995	-0.37350927	-0.035575	952.93	Explosiveness
7/7/1995	-0.374690732	0.322987	969.75	Explosiveness
7/10/1995	-0.374476946	0.379458	976.63	Explosiveness
7/11/1995	-0.375964231	0.091537	970.22	Explosiveness
7/12/1995	-0.356415691	0.691722	988.63	Explosiveness
7/13/1995	-0.346208333	0.700606	994.15	Explosiveness
7/14/1995	-0.368978794	0.780878	999.33	Explosiveness

7/17/1995	-0.345770222	0.907005	1005.89	Explosiveness
7/18/1995	-0.364737745	0.232736	988.53	Explosiveness
7/24/1995	-0.346580959	-0.13002	978.57	Explosiveness
7/25/1995	-0.335190846	0.099738	993.76	Explosiveness
7/26/1995	-0.332546915	0.144915	1000.17	Explosiveness
7/27/1995	-0.337804724	0.34865	1010.66	Explosiveness
7/28/1995	-0.364594326	0.109643	1005.28	Explosiveness
7/31/1995	-0.360976758	-0.011095	1001.21	Explosiveness
8/1/1995	-0.349375992	-0.290491	991.11	Explosiveness
8/4/1995	-0.33546869	-0.29077	991.11	Explosiveness
8/7/1995	-0.322811317	-0.265171	995.22	Explosiveness
8/8/1995	-0.320318482	-0.266839	997.12	Explosiveness
8/9/1995	-0.34650374	-0.123018	1005.04	Explosiveness
8/10/1995	-0.346608765	-0.284459	1000.61	Explosiveness
8/11/1995	-0.347764711	-0.206137	1004.11	Explosiveness
8/14/1995	-0.342847433	-0.06459	1012.44	Explosiveness
8/15/1995	-0.351634635	-0.132177	1012.37	Explosiveness
8/16/1995	-0.340574617	0.148027	1025.75	Explosiveness
8/17/1995	-0.307926625	0.132339	1029.25	Explosiveness
8/18/1995	-0.298491639	0.130294	1031.28	Explosiveness
8/21/1995	-0.291062342	-0.190873	1019.7	Explosiveness
8/22/1995	-0.303781446	-0.02483	1025.29	Explosiveness
8/23/1995	-0.295744367	-0.0149	1028.19	Explosiveness
8/24/1995	-0.286652201	-0.217102	1020.93	Explosiveness
8/25/1995	-0.287867244	-0.23108	1019.98	Explosiveness
8/31/1995	-0.317567917	-0.305228	1020.11	Explosiveness
9/5/1995	-0.29329206	-0.019845	1039.3	Explosiveness
9/6/1995	-0.317796778	-0.026775	1044.27	Explosiveness
9/7/1995	-0.305614057	0.069757	1051.08	Explosiveness
9/8/1995	-0.292494523	0.203015	1060.03	Explosiveness
9/11/1995	-0.31666531	0.274531	1066.56	Explosiveness
9/12/1995	-0.310407159	0.176933	1065	Explosiveness
9/13/1995	-0.313627516	0.209694	1067.4	Explosiveness
9/14/1995	-0.318878819	0.157775	1066.96	Explosiveness
9/15/1995	-0.321959449	-0.227681	1051.1	Explosiveness
9/18/1995	-0.27646633	-0.196676	1050.18	Explosiveness
9/19/1995	-0.301328642	-0.014544	1060.31	Explosiveness
9/20/1995	-0.304849745	0.012458	1065.09	Explosiveness
9/21/1995	-0.293506108	-0.164883	1058.51	Explosiveness
9/22/1995	-0.287726475	-0.265326	1053.39	Explosiveness
9/22/1997	-0.216563684	-0.210896	1689.45	Explosiveness
9/23/1997	-0.209843927	-0.149072	1697.36	Explosiveness
10/2/1997	-0.236929223	-0.188057	1702.41	Explosiveness
10/3/1997	-0.205356883	-0.072096	1715.87	Explosiveness
10/6/1997	-0.203012641	-0.041095	1721.91	Explosiveness
10/7/1997	-0.182766929	0.114243	1737.27	Explosiveness
10/8/1997	-0.188989134	0.12362	1741.77	Explosiveness
10/9/1997	-0.218142344	0.149507	1745.85	Explosiveness

10/10/1997	-0.217578451	0.040776	1739.03	Explosiveness
10/13/1997	-0.202633004	0.077694	1742.12	Explosiveness
10/14/1997	-0.237793655	-0.056389	1732.79	Explosiveness
10/15/1997	-0.24083386	-0.166635	1723.37	Explosiveness
10/8/1998	-0.244093734	0.007482	1419.12	Explosiveness
1/6/1999	-0.182950315	-0.16043	2320.86	Explosiveness
1/7/1999	-0.188704944	-0.16327	2326.09	Explosiveness
1/8/1999	-0.208814249	-0.043599	2344.41	Explosiveness
1/11/1999	-0.190893216	0.229641	2384.59	Explosiveness
1/15/1999	-0.184312326	-0.086204	2348.2	Explosiveness
1/18/1999	-0.196241273	-0.117954	2348.2	Explosiveness
1/19/1999	-0.212283797	0.297327	2408.17	Explosiveness
1/20/1999	-0.20169543	0.315542	2415.49	Explosiveness
1/25/1999	-0.200424339	-0.081866	2369.31	Explosiveness
1/26/1999	-0.208351768	0.325295	2433.41	Explosiveness
1/27/1999	-0.185589472	0.108622	2407.14	Explosiveness
1/28/1999	-0.189064527	0.632208	2477.34	Explosiveness
1/29/1999	-0.212238142	0.797619	2505.89	Explosiveness
2/1/1999	-0.240355642	0.800406	2510.09	Explosiveness
2/2/1999	-0.220064284	0.397146	2463.42	Explosiveness
2/3/1999	-0.239234089	0.637503	2493.41	Explosiveness
2/4/1999	-0.241417882	0.10372	2410.07	Explosiveness
2/8/1999	-0.22358373	-0.076657	2404.92	Explosiveness
2/11/1999	-0.26313536	-0.054505	2405.55	Explosiveness
3/16/1999	-0.250182475	-0.232152	2439.27	Explosiveness
3/18/1999	-0.239605679	-0.119808	2462.96	Explosiveness
3/29/1999	-0.217034707	-0.101488	2492.84	Explosiveness
3/30/1999	-0.21611828	-0.186921	2480.29	Explosiveness
4/1/1999	-0.210127083	-0.139393	2493.37	Explosiveness
4/2/1999	-0.210750562	-0.150962	2493.37	Explosiveness
4/5/1999	-0.207929665	0.21836	2560.06	Explosiveness
4/6/1999	-0.225298527	0.223231	2563.17	Explosiveness
4/7/1999	-0.23288237	0.093004	2544.43	Explosiveness
4/8/1999	-0.228612091	0.253062	2573.39	Explosiveness
4/9/1999	-0.251205499	0.359826	2593.05	Explosiveness
4/12/1999	-0.219097987	0.380595	2598.81	Explosiveness
4/13/1999	-0.239130467	0.268549	2583.5	Explosiveness
4/14/1999	-0.262491763	-0.212298	2507.28	Explosiveness
4/15/1999	-0.233061249	-0.143713	2521.77	Explosiveness
4/22/1999	-0.218458658	-0.106143	2561.61	Explosiveness
4/23/1999	-0.230163592	0.026894	2590.69	Explosiveness
4/26/1999	-0.208246889	0.358996	2652.05	Explosiveness
4/27/1999	-0.221746809	0.060874	2602.41	Explosiveness
5/12/1999	-0.243017665	-0.101313	2606.54	Explosiveness
7/1/1999	-0.244173426	-0.164887	2706.18	Explosiveness
7/2/1999	-0.226108393	-0.005294	2741.02	Explosiveness
7/5/1999	-0.220442438	-0.017083	2741.02	Explosiveness
7/6/1999	-0.229761383	-0.050109	2736.78	Explosiveness

7/7/1999	-0.224748178	-0.030319	2743.04	Explosiveness
7/8/1999	-0.215810485	0.102005	2771.86	Explosiveness
7/9/1999	-0.236906244	0.198333	2793.07	Explosiveness
7/12/1999	-0.221788382	0.171369	2790.44	Explosiveness
7/13/1999	-0.217638347	0.09511	2778.23	Explosiveness
7/14/1999	-0.208366975	0.285176	2818.13	Explosiveness
7/15/1999	-0.218919939	0.383385	2839.37	Explosiveness
7/16/1999	-0.218807694	0.503447	2864.48	Explosiveness
7/19/1999	-0.23649634	0.300157	2830.29	Explosiveness
7/21/1999	-0.233162606	-0.099835	2761.77	Explosiveness
9/9/1999	-0.215222647	-0.207428	2852.02	Explosiveness
9/10/1999	-0.200030548	-0.065272	2887.06	Explosiveness
9/14/1999	-0.189934215	-0.174879	2868.29	Explosiveness
9/20/1999	-0.171902428	-0.153478	2886.15	Explosiveness
10/29/1999	-0.237518163	-0.222679	2966.43	Explosiveness
11/2/1999	-0.24246473	-0.180309	2981.63	Explosiveness
11/3/1999	-0.244999036	0.000784	3028.51	Explosiveness
11/4/1999	-0.257223588	0.106552	3055.95	Explosiveness
11/5/1999	-0.256546551	0.296219	3102.29	Explosiveness
11/8/1999	-0.244725785	0.471496	3143.97	Explosiveness
11/9/1999	-0.231599405	0.368448	3125.04	Explosiveness
11/10/1999	-0.228191273	0.496086	3155.96	Explosiveness
11/11/1999	-0.216276365	0.674417	3197.29	Explosiveness
11/12/1999	-0.197854585	0.773523	3221.15	Explosiveness
11/15/1999	-0.216903765	0.748919	3219.54	Explosiveness
11/16/1999	-0.226524138	1.098688	3295.52	Explosiveness
11/17/1999	-0.217309563	0.944095	3269.39	Explosiveness
11/18/1999	-0.223593502	1.310333	3347.11	Explosiveness
11/19/1999	-0.22947289	1.405467	3369.25	Explosiveness
11/22/1999	-0.245358751	1.507198	3392.56	Explosiveness
11/23/1999	-0.211723151	1.213188	3342.87	Explosiveness
11/24/1999	-0.196409815	1.587464	3420.5	Explosiveness
11/25/1999	-0.172238625	1.563292	3420.5	Explosiveness
11/26/1999	-0.190127665	1.68606	3447.81	Explosiveness
11/29/1999	-0.183133294	1.515769	3421.37	Explosiveness
11/30/1999	-0.195565538	1.034912	3336.16	Explosiveness
12/1/1999	-0.203697379	1.102467	3353.71	Explosiveness
12/2/1999	-0.210438196	1.565509	3452.78	Explosiveness
12/3/1999	-0.211556834	1.896353	3520.63	Explosiveness
12/6/1999	-0.204997998	2.00865	3546.01	Explosiveness
12/7/1999	-0.196727252	2.206696	3586.92	Explosiveness
12/8/1999	-0.187576448	2.171429	3586.08	Explosiveness
12/9/1999	-0.207113052	2.187186	3594.17	Explosiveness
12/10/1999	-0.208809613	2.303521	3620.23	Explosiveness
12/13/1999	-0.219914693	2.486752	3658.15	Explosiveness
12/14/1999	-0.212910758	1.942631	3571.66	Explosiveness
12/15/1999	-0.21758859	2.184489	3621.95	Explosiveness
12/16/1999	-0.221785248	2.659339	3715.06	Explosiveness

12/17/1999	-0.22258935	2.84394	3753.06	Explosiveness
12/20/1999	-0.190142354	2.987953	3783.87	Explosiveness
12/21/1999	-0.190103398	3.680967	3911.15	Explosiveness
12/22/1999	-0.193212097	3.797544	3937.3	Explosiveness
12/23/1999	-0.182715682	3.95143	3969.44	Explosiveness
12/24/1999	-0.178956571	3.898657	3969.44	Explosiveness
12/27/1999	-0.191137946	3.885162	3975.38	Explosiveness
12/28/1999	-0.173059581	3.813063	3972.11	Explosiveness
12/29/1999	-0.190518757	4.191521	4041.46	Explosiveness
12/30/1999	-0.182232202	4.106173	4036.87	Explosiveness
12/31/1999	-0.191976096	4.258948	4069.31	Explosiveness
1/3/2000	-0.147193052	4.595508	4131.15	Explosiveness
1/4/2000	-0.17944135	2.930184	3901.69	Explosiveness
1/5/2000	-0.163710985	2.756941	3877.54	Explosiveness
1/6/2000	-0.147586575	1.877987	3727.13	Explosiveness
1/7/2000	-0.163388608	2.579841	3882.62	Explosiveness
1/10/2000	-0.146282342	3.384172	4049.67	Explosiveness
1/11/2000	-0.151977695	2.587453	3921.19	Explosiveness
1/12/2000	-0.158143391	2.178544	3850.02	Explosiveness
1/13/2000	-0.168281374	2.665326	3957.21	Explosiveness
1/14/2000	-0.186963691	3.172217	4064.27	Explosiveness
1/17/2000	-0.18442525	3.13171	4064.27	Explosiveness
1/18/2000	-0.170532562	3.446141	4130.81	Explosiveness
1/19/2000	-0.165453149	3.515751	4151.29	Explosiveness
1/20/2000	-0.176031022	3.682375	4189.51	Explosiveness
1/21/2000	-0.167219949	3.891518	4235.4	Explosiveness
1/24/2000	-0.174457372	3.016143	4096.08	Explosiveness
1/25/2000	-0.172308179	3.344111	4167.41	Explosiveness
1/26/2000	-0.155309218	2.765916	4069.91	Explosiveness
1/27/2000	-0.15137733	2.577715	4039.56	Explosiveness
1/28/2000	-0.166872618	1.779199	3887.07	Explosiveness
1/31/2000	-0.16514625	1.988112	3940.35	Explosiveness
2/1/2000	-0.181235178	2.454132	4051.98	Explosiveness
2/2/2000	-0.168174309	2.528036	4073.96	Explosiveness
2/3/2000	-0.164167327	3.129621	4210.98	Explosiveness
2/4/2000	-0.171543815	3.25862	4244.14	Explosiveness
2/7/2000	-0.181384	3.609186	4321.77	Explosiveness
2/8/2000	-0.186722553	4.106836	4427.54	Explosiveness
2/9/2000	-0.19508789	3.693658	4363.24	Explosiveness
2/10/2000	-0.201154909	4.270017	4485.63	Explosiveness
2/11/2000	-0.211922674	3.704285	4395.45	Explosiveness
2/14/2000	-0.182782175	3.778859	4418.55	Explosiveness
2/15/2000	-0.187615152	3.744097	4420.77	Explosiveness
2/16/2000	-0.18925263	3.734217	4427.65	Explosiveness
2/17/2000	-0.179853789	4.293474	4548.92	Explosiveness
2/18/2000	-0.18580764	3.641478	4411.74	Explosiveness
2/21/2000	-0.187894357	3.428579	4411.74	Explosiveness
2/22/2000	-0.183542043	3.239748	4382.12	Explosiveness

2/23/2000	-0.165884954	4.139695	4550.33	Explosiveness
2/24/2000	-0.151310262	4.264662	4617.65	Explosiveness
2/25/2000	-0.170124461	4.067907	4590.5	Explosiveness
2/28/2000	-0.155959417	3.95309	4577.85	Explosiveness
2/29/2000	-0.133673439	4.640112	4696.69	Explosiveness
3/1/2000	-0.154969698	4.881355	4784.08	Explosiveness
3/2/2000	-0.146223452	4.657535	4754.51	Explosiveness
3/3/2000	-0.142010961	5.577182	4914.79	Explosiveness
3/6/2000	-0.173389793	5.487802	4904.85	Explosiveness
3/7/2000	-0.14981819	5.083429	4847.84	Explosiveness
3/8/2000	-0.142868761	5.288176	4897.17	Explosiveness
3/9/2000	-0.142579324	5.96173	5046.86	Explosiveness
3/10/2000	-0.179956659	5.920437	5048.62	Explosiveness
3/13/2000	-0.163982714	5.001567	4907.24	Explosiveness
3/14/2000	-0.167686582	3.675212	4706.63	Explosiveness
3/15/2000	-0.165627139	3.042597	4582.62	Explosiveness
3/16/2000	-0.161537791	3.568128	4717.39	Explosiveness
3/17/2000	-0.186757918	3.885002	4798.13	Explosiveness
3/20/2000	-0.176319264	2.930546	4610	Explosiveness
3/21/2000	-0.196913078	3.312209	4711.68	Explosiveness
3/22/2000	-0.189177014	3.910374	4864.75	Explosiveness
3/23/2000	-0.186998908	4.204875	4940.61	Explosiveness
3/24/2000	-0.187006554	4.259956	4963.03	Explosiveness
3/27/2000	-0.17543899	4.189098	4958.56	Explosiveness
3/28/2000	-0.156746488	3.544273	4833.89	Explosiveness
3/29/2000	-0.157794145	2.653169	4644.67	Explosiveness
3/30/2000	-0.143365786	1.582848	4457.89	Explosiveness
3/31/2000	-0.142383971	2.060965	4572.83	Explosiveness
4/3/2000	-0.17860818	0.905314	4223.68	Explosiveness
4/4/2000	-0.133159334	0.550387	4148.89	Explosiveness
4/5/2000	-0.16410264	0.604971	4169.22	Explosiveness
4/6/2000	-0.159714897	0.862958	4267.56	Explosiveness
4/7/2000	-0.169966357	1.323393	4446.45	Explosiveness
4/10/2000	-0.152370694	0.619501	4188.2	Explosiveness
4/11/2000	-0.176181683	0.127052	4055.9	Explosiveness
12/20/2000	-0.174335873	-0.127842	2332.78	Explosiveness
12/21/2000	-0.195868657	-0.154881	2340.12	Explosiveness
1/2/2001	-0.245947435	-0.195321	2291.86	Explosiveness
3/12/2001	-0.228238873	-0.160085	1923.38	Explosiveness
3/16/2001	-0.234756295	-0.158606	1890.91	Explosiveness
3/20/2001	-0.223101499	-0.13188	1857.44	Explosiveness
3/21/2001	-0.228958829	-0.099963	1830.23	Explosiveness
3/28/2001	-0.234686569	-0.188397	1854.13	Explosiveness
3/29/2001	-0.237215387	-0.148322	1820.57	Explosiveness
3/30/2001	-0.236622661	-0.186212	1840.26	Explosiveness
4/2/2001	-0.246860359	-0.112441	1782.97	Explosiveness
4/3/2001	-0.233198424	0.039485	1673	Explosiveness
4/4/2001	-0.231825818	0.081104	1638.8	Explosiveness

4/5/2001	-0.231236961	-0.15677	1785	Explosiveness
4/6/2001	-0.233615263	-0.073558	1720.36	Explosiveness
4/9/2001	-0.247501218	-0.120308	1745.71	Explosiveness

Appendix 2

Date	ADF Critical values (simulated Monte Carlo)	GSADF test results	Price	Explosiveness significant
8/17/1990	-0.78072863	-0.430373	393.49	Explosiveness
8/20/1990	-0.798729929	-0.339634	388.59	Explosiveness
8/21/1990	-0.801259197	0.453525	379.68	Explosiveness
8/22/1990	-0.799988945	0.512095	374.84	Explosiveness
8/23/1990	-0.809053079	1.46228	360.22	Explosiveness
8/24/1990	-0.781448919	0.425917	367.33	Explosiveness
8/28/1990	-0.734514296	-0.658764	382.86	Explosiveness
8/29/1990	-0.751200582	-0.603624	381.78	Explosiveness
8/30/1990	-0.781756176	-0.49264	378.68	Explosiveness
8/31/1990	-0.761755903	-0.71843	381.21	Explosiveness
9/3/1990	-0.75836969	-0.70991	381.21	Explosiveness
9/6/1990	-0.708134978	-0.675726	378.78	Explosiveness
9/20/1990	-0.692721179	-0.510608	364.43	Explosiveness
9/21/1990	-0.658341832	-0.547119	362.25	Explosiveness
9/24/1990	-0.690750437	-0.178682	352.16	Explosiveness
9/25/1990	-0.648759801	-0.455348	354.78	Explosiveness
9/26/1990	-0.641237771	-0.232611	350.03	Explosiveness
9/27/1990	-0.669361129	0.046563	341.19	Explosiveness
9/28/1990	-0.630786717	-0.266979	344.51	Explosiveness
10/3/1990	-0.640860401	-0.587863	351.45	Explosiveness
10/4/1990	-0.645650045	-0.615314	349.89	Explosiveness
10/5/1990	-0.659387117	-0.573695	347.36	Explosiveness
10/9/1990	-0.650986429	-0.354274	339.11	Explosiveness
10/10/1990	-0.65714654	-0.278495	333.25	Explosiveness
10/11/1990	-0.668435763	-0.092842	325.61	Explosiveness
10/12/1990	-0.674340257	-0.312658	327.55	Explosiveness
10/15/1990	-0.721800576	-0.431675	329.54	Explosiveness
10/16/1990	-0.696536044	-0.283376	325.44	Explosiveness
10/17/1990	-0.704208166	-0.426902	326.78	Explosiveness
1/24/1991	-0.543482334	-0.439034	391.33	Explosiveness

1/25/1991	-0.532695279	-0.440077	394.28	Explosiveness
1/28/1991	-0.522703752	-0.394392	396.8	Explosiveness
1/29/1991	-0.504422378	-0.289175	400.61	Explosiveness
1/30/1991	-0.515703124	-0.032525	408.53	Explosiveness
1/31/1991	-0.483821402	0.059556	414.2	Explosiveness
2/1/1991	-0.484964606	0.090414	417.69	Explosiveness
2/4/1991	-0.491904048	0.330697	424.8	Explosiveness
2/5/1991	-0.484207936	0.509133	432.2	Explosiveness
2/6/1991	-0.462935533	0.661971	439.24	Explosiveness
2/7/1991	-0.463493135	0.24281	435.01	Explosiveness
2/8/1991	-0.467477691	0.376085	436.98	Explosiveness
2/11/1991	-0.47480236	0.637059	444.1	Explosiveness
2/12/1991	-0.467578601	0.446257	443.98	Explosiveness
2/13/1991	-0.43645095	0.586956	447.97	Explosiveness
2/14/1991	-0.460671253	0.271822	444.31	Explosiveness
2/15/1991	-0.448701074	0.496953	448.71	Explosiveness
2/18/1991	-0.440354719	0.368741	448.71	Explosiveness
2/19/1991	-0.466822271	0.383516	450.32	Explosiveness
2/20/1991	-0.467496099	0.105369	446.02	Explosiveness
2/21/1991	-0.483064109	0.139957	446.38	Explosiveness
2/22/1991	-0.461679489	0.198988	448.95	Explosiveness
2/25/1991	-0.475056249	0.207701	451.09	Explosiveness
2/26/1991	-0.510499651	-0.001785	447.71	Explosiveness
2/27/1991	-0.507088136	0.136046	450.82	Explosiveness
2/28/1991	-0.474816155	0.141876	453.05	Explosiveness
3/1/1991	-0.521570897	0.213411	456.73	Explosiveness
3/4/1991	-0.529057847	0.290859	461.13	Explosiveness
3/5/1991	-0.531115507	0.634896	473.05	Explosiveness
3/6/1991	-0.530163996	0.465709	473.8	Explosiveness
3/7/1991	-0.537002927	0.479615	475.74	Explosiveness
3/8/1991	-0.506220989	0.368476	475.11	Explosiveness
3/11/1991	-0.518302417	-0.013035	467.15	Explosiveness
3/12/1991	-0.516155505	-0.183886	461.4	Explosiveness
3/13/1991	-0.492274108	0.10572	468.18	Explosiveness
3/14/1991	-0.500930688	-0.011307	467.79	Explosiveness
3/15/1991	-0.499100973	-0.091379	466.29	Explosiveness
3/18/1991	-0.471963917	-0.105697	466.27	Explosiveness
3/19/1991	-0.490591226	-0.244767	462.81	Explosiveness
3/20/1991	-0.463232284	-0.129561	466.09	Explosiveness
3/21/1991	-0.48217779	-0.230349	464.6	Explosiveness
3/22/1991	-0.456143751	-0.254105	464.15	Explosiveness
3/25/1991	-0.468245382	-0.148819	468.49	Explosiveness
3/26/1991	-0.448693347	0.063789	478.57	Explosiveness
3/27/1991	-0.493473719	0.045077	482.37	Explosiveness
3/28/1991	-0.489490059	-0.028814	482.3	Explosiveness
3/29/1991	-0.47165079	-0.05733	482.3	Explosiveness
4/1/1991	-0.464848917	-0.133521	480.86	Explosiveness
4/2/1991	-0.454500617	0.196606	491.2	Explosiveness

4/3/1991	-0.452545951	0.180862	495.05	Explosiveness
4/4/1991	-0.435685699	0.190689	497.57	Explosiveness
4/5/1991	-0.460036702	0.06526	495.79	Explosiveness
4/8/1991	-0.479809501	0.048722	495.65	Explosiveness
4/9/1991	-0.415251731	-0.089624	492.46	Explosiveness
4/10/1991	-0.438230644	-0.139242	490.76	Explosiveness
4/11/1991	-0.48766421	0.12531	499.31	Explosiveness
4/12/1991	-0.463448706	0.083362	501.62	Explosiveness
4/15/1991	-0.467981399	0.003513	500.84	Explosiveness
4/16/1991	-0.434375425	0.176002	506.75	Explosiveness
4/17/1991	-0.401727037	0.226815	511.31	Explosiveness
4/18/1991	-0.420829635	-0.004443	506.62	Explosiveness
4/19/1991	-0.426478351	-0.169817	501.19	Explosiveness
4/22/1991	-0.45116755	-0.355286	494.38	Explosiveness
4/23/1991	-0.410701269	-0.256559	496.08	Explosiveness
4/24/1991	-0.398476856	-0.227493	498.45	Explosiveness
4/25/1991	-0.428761402	-0.330991	496.03	Explosiveness
4/26/1991	-0.392995668	-0.365194	494.64	Explosiveness
6/24/1991	-0.369329505	-0.273285	475.23	Explosiveness
6/25/1991	-0.366995688	-0.27697	473.3	Explosiveness
6/26/1991	-0.374472802	-0.300872	473.08	Explosiveness
7/3/1991	-0.35200083	-0.341237	474.32	Explosiveness
4/21/1992	-0.339769151	-0.315301	575.05	Explosiveness
4/24/1992	-0.352377415	-0.304293	572.89	Explosiveness
4/27/1992	-0.359488752	-0.134271	566.94	Explosiveness
4/28/1992	-0.328718539	0.060234	560.33	Explosiveness
4/29/1992	-0.323945213	-0.315343	569.94	Explosiveness
11/11/1992	-0.223095447	-0.085758	634.92	Explosiveness
11/12/1992	-0.227036735	-0.157403	634.37	Explosiveness
11/13/1992	-0.198959465	-0.073409	637.16	Explosiveness
11/20/1992	-0.211399106	-0.08502	642.6	Explosiveness
11/24/1992	-0.24108844	-0.049774	645.94	Explosiveness
11/25/1992	-0.253630878	0.002126	648.33	Explosiveness
11/26/1992	-0.239878757	-0.044534	648.33	Explosiveness
11/27/1992	-0.234386609	-0.043189	649.49	Explosiveness
11/30/1992	-0.23499665	0.037796	652.73	Explosiveness
12/1/1992	-0.240491949	0.038059	653.95	Explosiveness
12/2/1992	-0.224721714	-0.048855	652.91	Explosiveness
12/3/1992	-0.22150572	0.035319	656.36	Explosiveness
12/4/1992	-0.229697588	0.184674	661.6	Explosiveness
12/7/1992	-0.226716029	0.322224	666.53	Explosiveness
12/8/1992	-0.23282388	0.285533	667.12	Explosiveness
12/9/1992	-0.200793404	0.102719	663.92	Explosiveness
12/10/1992	-0.250781058	-0.126048	658.93	Explosiveness
12/30/1992	-0.259530175	-0.231286	671.85	Explosiveness
12/31/1992	-0.232350313	-0.119766	676.95	Explosiveness
1/1/1993	-0.237996637	-0.158413	676.95	Explosiveness
1/6/1993	-0.262604291	-0.137851	681.85	Explosiveness

1/11/1993	-0.2589978	-0.236732	682.4	Explosiveness
1/13/1993	-0.25741654	-0.194277	686.78	Explosiveness
1/14/1993	-0.265835374	0.015761	695.7	Explosiveness
1/15/1993	-0.260746746	0.014398	697.15	Explosiveness
1/18/1993	-0.259679313	-0.001318	698.13	Explosiveness
1/19/1993	-0.26901842	-0.084975	696.81	Explosiveness
1/20/1993	-0.252437645	-0.108147	697.44	Explosiveness
1/21/1993	-0.236620429	-0.05503	700.77	Explosiveness
1/22/1993	-0.244595078	-0.072871	701.63	Explosiveness
1/25/1993	-0.243713207	0.03545	706.95	Explosiveness
1/26/1993	-0.232139695	-0.00465	707.16	Explosiveness
6/20/1995	-0.171950956	-0.041274	929.84	Explosiveness
6/21/1995	-0.159738294	-0.133616	929.19	Explosiveness
6/22/1995	-0.14558254	0.174564	940.09	Explosiveness
6/23/1995	-0.125018698	0.047892	938.95	Explosiveness
7/6/1995	-0.093177456	0.054718	952.93	Explosiveness
7/7/1995	-0.101883601	0.411706	969.75	Explosiveness
7/10/1995	-0.107362352	0.470057	976.63	Explosiveness
7/11/1995	-0.119621617	0.17695	970.22	Explosiveness
7/12/1995	-0.101395229	0.770615	988.63	Explosiveness
7/13/1995	-0.138604449	0.782724	994.15	Explosiveness
7/14/1995	-0.168649676	0.859901	999.33	Explosiveness
7/17/1995	-0.174525474	0.983097	1005.89	Explosiveness
7/18/1995	-0.149236121	0.297623	988.53	Explosiveness
7/24/1995	-0.140325751	-0.119382	978.57	Explosiveness
7/25/1995	-0.149842394	0.107899	993.76	Explosiveness
7/26/1995	-0.116555334	0.153192	1000.17	Explosiveness
7/27/1995	-0.131132827	0.35273	1010.66	Explosiveness
7/28/1995	-0.103253128	0.113012	1005.28	Explosiveness
7/31/1995	-0.124124774	-0.011095	1001.21	Explosiveness
8/9/1995	-0.149698731	-0.123018	1005.04	Explosiveness
8/14/1995	-0.149890816	-0.06459	1012.44	Explosiveness
8/15/1995	-0.16878521	-0.132177	1012.37	Explosiveness
8/16/1995	-0.160755451	0.148027	1025.75	Explosiveness
8/17/1995	-0.156943625	0.132339	1029.25	Explosiveness
8/18/1995	-0.125434798	0.130294	1031.28	Explosiveness
8/22/1995	-0.143401488	-0.02483	1025.29	Explosiveness
8/23/1995	-0.129477022	-0.0149	1028.19	Explosiveness
9/5/1995	-0.125191541	-0.019845	1039.3	Explosiveness
9/6/1995	-0.114898558	-0.026775	1044.27	Explosiveness
9/7/1995	-0.153261738	0.069757	1051.08	Explosiveness
9/8/1995	-0.12864958	0.203015	1060.03	Explosiveness
9/11/1995	-0.108713233	0.274531	1066.56	Explosiveness
9/12/1995	-0.11585256	0.176933	1065	Explosiveness
9/13/1995	-0.116223936	0.209694	1067.4	Explosiveness
9/14/1995	-0.110158115	0.157775	1066.96	Explosiveness
9/19/1995	-0.107771651	-0.014544	1060.31	Explosiveness
9/20/1995	-0.122190392	0.012458	1065.09	Explosiveness

7/15/1996	-0.087302198	0.686469	1060.38	Explosiveness
7/16/1996	-0.098328869	0.782137	1053.49	Explosiveness
7/23/1996	-0.111165413	0.065344	1049.05	Explosiveness
7/24/1996	-0.107663261	0.117324	1042.36	Explosiveness
3/19/1997	-0.06915682	0.014733	1249.29	Explosiveness
3/24/1997	-0.126484418	0.023536	1242.64	Explosiveness
3/31/1997	-0.109244684	0.179281	1221.7	Explosiveness
4/1/1997	-0.064479759	0.232025	1216.93	Explosiveness
4/2/1997	-0.068393731	0.558574	1201	Explosiveness
4/3/1997	-0.078866183	0.123924	1213.76	Explosiveness
7/16/1997	-0.114224148	-0.021273	1580.63	Explosiveness
10/6/1997	-0.044604046	-0.041095	1721.91	Explosiveness
10/7/1997	-0.056129224	0.114243	1737.27	Explosiveness
10/8/1997	-0.071936302	0.12362	1741.77	Explosiveness
10/9/1997	-0.061071523	0.149507	1745.85	Explosiveness
10/10/1997	-0.108624333	0.040776	1739.03	Explosiveness
10/13/1997	-0.083028787	0.077694	1742.12	Explosiveness
10/14/1997	-0.083345621	-0.056389	1732.79	Explosiveness
8/28/1998	-0.006281923	0.142491	1639.68	Explosiveness
8/31/1998	-0.038870923	1.289866	1499.25	Explosiveness
9/1/1998	-0.038991269	0.291739	1575.09	Explosiveness
9/2/1998	-0.061431753	-0.000459	1592.85	Explosiveness
9/3/1998	-0.052825496	0.167081	1571.86	Explosiveness
9/4/1998	-0.067479101	0.157141	1566.52	Explosiveness
9/7/1998	-0.059125119	0.091194	1566.52	Explosiveness
10/8/1998	-0.111552215	0.181555	1419.12	Explosiveness
1/8/1999	-0.05993143	-0.029013	2344.41	Explosiveness
1/11/1999	-0.074321477	0.229641	2384.59	Explosiveness
1/19/1999	-0.078476839	0.297327	2408.17	Explosiveness
1/20/1999	-0.09204522	0.315542	2415.49	Explosiveness
1/26/1999	-0.057302442	0.325295	2433.41	Explosiveness
1/27/1999	-0.071118506	0.108622	2407.14	Explosiveness
1/28/1999	-0.067032695	0.632208	2477.34	Explosiveness
1/29/1999	-0.081161266	0.797619	2505.89	Explosiveness
2/1/1999	-0.091137199	0.800406	2510.09	Explosiveness
2/2/1999	-0.091456136	0.397146	2463.42	Explosiveness
2/3/1999	-0.081540197	0.637503	2493.41	Explosiveness
2/4/1999	-0.091416394	0.10372	2410.07	Explosiveness
2/8/1999	-0.113237766	-0.076657	2404.92	Explosiveness
4/5/1999	-0.053189903	0.21836	2560.06	Explosiveness
4/6/1999	-0.044934651	0.223231	2563.17	Explosiveness
4/7/1999	-0.050546249	0.093004	2544.43	Explosiveness
4/8/1999	-0.056582859	0.253062	2573.39	Explosiveness
4/9/1999	-0.034157371	0.359826	2593.05	Explosiveness
4/12/1999	-0.0550871	0.380595	2598.81	Explosiveness
4/13/1999	-0.082022523	0.268549	2583.5	Explosiveness
4/23/1999	-0.062725368	0.026894	2590.69	Explosiveness
4/26/1999	-0.061207009	0.358996	2652.05	Explosiveness

4/27/1999	-0.06244688	0.060874	2602.41	Explosiveness
5/12/1999	-0.118025754	-0.101313	2606.54	Explosiveness
7/2/1999	-0.049303074	-0.005294	2741.02	Explosiveness
7/5/1999	-0.031102578	-0.017083	2741.02	Explosiveness
7/7/1999	-0.039856623	-0.030319	2743.04	Explosiveness
7/8/1999	-0.068160673	0.102005	2771.86	Explosiveness
7/9/1999	-0.040242521	0.198333	2793.07	Explosiveness
7/12/1999	-0.085918329	0.171369	2790.44	Explosiveness
7/13/1999	-0.0865528	0.09511	2778.23	Explosiveness
7/14/1999	-0.06039907	0.285176	2818.13	Explosiveness
7/15/1999	-0.039923193	0.383385	2839.37	Explosiveness
7/16/1999	-0.067479372	0.503447	2864.48	Explosiveness
7/19/1999	-0.103734717	0.300157	2830.29	Explosiveness
11/3/1999	-0.051535692	0.000784	3028.51	Explosiveness
11/4/1999	-0.059831035	0.106552	3055.95	Explosiveness
11/5/1999	-0.053130457	0.296219	3102.29	Explosiveness
11/8/1999	-0.07061966	0.471496	3143.97	Explosiveness
11/9/1999	-0.081680079	0.368448	3125.04	Explosiveness
11/10/1999	-0.073627631	0.496086	3155.96	Explosiveness
11/11/1999	-0.076602578	0.674417	3197.29	Explosiveness
11/12/1999	-0.045600613	0.773523	3221.15	Explosiveness
11/15/1999	-0.103363828	0.748919	3219.54	Explosiveness
11/16/1999	-0.063635824	1.098688	3295.52	Explosiveness
11/17/1999	-0.050665008	0.944095	3269.39	Explosiveness
11/18/1999	-0.057010317	1.310333	3347.11	Explosiveness
11/19/1999	-0.054028343	1.405467	3369.25	Explosiveness
11/22/1999	-0.05460611	1.507198	3392.56	Explosiveness
11/23/1999	-0.06020927	1.213188	3342.87	Explosiveness
11/24/1999	-0.054712747	1.587464	3420.5	Explosiveness
11/25/1999	-0.080792075	1.563292	3420.5	Explosiveness
11/26/1999	-0.062984015	1.68606	3447.81	Explosiveness
11/29/1999	-0.052415708	1.515769	3421.37	Explosiveness
11/30/1999	-0.05814614	1.034912	3336.16	Explosiveness
12/1/1999	-0.039176707	1.102467	3353.71	Explosiveness
12/2/1999	-0.056478671	1.565509	3452.78	Explosiveness
12/3/1999	-0.058952478	1.896353	3520.63	Explosiveness
12/6/1999	-0.069215975	2.00865	3546.01	Explosiveness
12/7/1999	-0.052355965	2.206696	3586.92	Explosiveness
12/8/1999	-0.079049343	2.171429	3586.08	Explosiveness
12/9/1999	-0.08510463	2.187186	3594.17	Explosiveness
12/10/1999	-0.054968525	2.303521	3620.23	Explosiveness
12/13/1999	-0.047806405	2.486752	3658.15	Explosiveness
12/14/1999	-0.051773945	1.942631	3571.66	Explosiveness
12/15/1999	-0.053258329	2.184489	3621.95	Explosiveness
12/16/1999	-0.053389505	2.659339	3715.06	Explosiveness
12/17/1999	-0.056000264	2.84394	3753.06	Explosiveness
12/20/1999	-0.042790202	2.987953	3783.87	Explosiveness
12/21/1999	-0.012094142	3.680967	3911.15	Explosiveness

12/22/1999	-0.016679168	3.797544	3937.3	Explosiveness
12/23/1999	-0.050637054	3.95143	3969.44	Explosiveness
12/24/1999	-0.009141296	3.898657	3969.44	Explosiveness
12/27/1999	0.00327152	3.885162	3975.38	Explosiveness
12/28/1999	-0.000676315	3.813063	3972.11	Explosiveness
12/29/1999	0.011029645	4.191521	4041.46	Explosiveness
12/30/1999	-0.005099154	4.106173	4036.87	Explosiveness
12/31/1999	0.005542822	4.258948	4069.31	Explosiveness
1/3/2000	0.001704115	4.595508	4131.15	Explosiveness
1/4/2000	-0.001771866	2.930184	3901.69	Explosiveness
1/5/2000	0.018367561	2.756941	3877.54	Explosiveness
1/6/2000	-0.024039797	1.877987	3727.13	Explosiveness
1/7/2000	-0.011042115	2.579841	3882.62	Explosiveness
1/10/2000	-0.029135165	3.384172	4049.67	Explosiveness
1/11/2000	-0.022554107	2.587453	3921.19	Explosiveness
1/12/2000	0.013167739	2.178544	3850.02	Explosiveness
1/13/2000	-0.00348387	2.665326	3957.21	Explosiveness
1/14/2000	0.011369776	3.172217	4064.27	Explosiveness
1/17/2000	-0.009648142	3.13171	4064.27	Explosiveness
1/18/2000	-0.012647164	3.446141	4130.81	Explosiveness
1/19/2000	0.023429065	3.515751	4151.29	Explosiveness
1/20/2000	-0.003877862	3.682375	4189.51	Explosiveness
1/21/2000	-0.024227893	3.891518	4235.4	Explosiveness
1/24/2000	-0.034035929	3.016143	4096.08	Explosiveness
1/25/2000	-0.002547984	3.344111	4167.41	Explosiveness
1/26/2000	-0.020380956	2.765916	4069.91	Explosiveness
1/27/2000	-0.023330555	2.577715	4039.56	Explosiveness
1/28/2000	-0.032634222	1.779199	3887.07	Explosiveness
1/31/2000	-0.021776025	1.988112	3940.35	Explosiveness
2/1/2000	0.022553662	2.454132	4051.98	Explosiveness
2/2/2000	-0.001537717	2.528036	4073.96	Explosiveness
2/3/2000	-0.007981186	3.129621	4210.98	Explosiveness
2/4/2000	-0.007155396	3.25862	4244.14	Explosiveness
2/7/2000	-0.018043318	3.609186	4321.77	Explosiveness
2/8/2000	-0.029637164	4.106836	4427.54	Explosiveness
2/9/2000	-0.05674149	3.693658	4363.24	Explosiveness
2/10/2000	-0.059864292	4.270017	4485.63	Explosiveness
2/11/2000	-0.041351869	3.704285	4395.45	Explosiveness
2/14/2000	-0.052307737	3.778859	4418.55	Explosiveness
2/15/2000	-0.07321117	3.744097	4420.77	Explosiveness
2/16/2000	-0.043422101	3.734217	4427.65	Explosiveness
2/17/2000	-0.028975227	4.293474	4548.92	Explosiveness
2/18/2000	0.008388681	3.641478	4411.74	Explosiveness
2/21/2000	-0.000807377	3.428579	4411.74	Explosiveness
2/22/2000	-0.000131674	3.239748	4382.12	Explosiveness
2/23/2000	0.004883147	4.139695	4550.33	Explosiveness
2/24/2000	0.008793108	4.264662	4617.65	Explosiveness
2/25/2000	0.029094444	4.067907	4590.5	Explosiveness

2/28/2000	0.000924785	3.95309	4577.85	Explosiveness
2/29/2000	0.020948452	4.640112	4696.69	Explosiveness
3/1/2000	0.017869052	4.881355	4784.08	Explosiveness
3/2/2000	0.005046857	4.657535	4754.51	Explosiveness
3/3/2000	0.019328312	5.577182	4914.79	Explosiveness
3/6/2000	-0.004472032	5.487802	4904.85	Explosiveness
3/7/2000	-0.004560577	5.083429	4847.84	Explosiveness
3/8/2000	-0.015996044	5.288176	4897.17	Explosiveness
3/9/2000	-0.021051532	5.96173	5046.86	Explosiveness
3/10/2000	-0.049103669	5.920437	5048.62	Explosiveness
3/13/2000	-0.015063445	5.001567	4907.24	Explosiveness
3/14/2000	-0.003154011	3.675212	4706.63	Explosiveness
3/15/2000	-0.019033118	3.042597	4582.62	Explosiveness
3/16/2000	-0.004717755	3.568128	4717.39	Explosiveness
3/17/2000	-0.017993637	3.885002	4798.13	Explosiveness
3/20/2000	-0.040966161	2.930546	4610	Explosiveness
3/21/2000	-0.023254178	3.312209	4711.68	Explosiveness
3/22/2000	-0.048141649	3.910374	4864.75	Explosiveness
3/23/2000	-0.044917105	4.204875	4940.61	Explosiveness
3/24/2000	-0.046227714	4.259956	4963.03	Explosiveness
3/27/2000	-0.04220922	4.189098	4958.56	Explosiveness
3/28/2000	-0.010676288	3.544273	4833.89	Explosiveness
3/29/2000	0.00397343	2.653169	4644.67	Explosiveness
3/30/2000	-0.022817224	1.582848	4457.89	Explosiveness
3/31/2000	-0.00925833	2.060965	4572.83	Explosiveness
4/3/2000	-0.001689007	0.905314	4223.68	Explosiveness
4/4/2000	-0.018108784	0.550387	4148.89	Explosiveness
4/5/2000	0.004050419	0.604971	4169.22	Explosiveness
4/6/2000	-0.017214403	0.862958	4267.56	Explosiveness
4/7/2000	-0.044944265	1.323393	4446.45	Explosiveness
4/10/2000	-0.052827965	0.619501	4188.2	Explosiveness
4/11/2000	-0.014166161	0.127052	4055.9	Explosiveness
4/12/2000	-0.028646549	0.049231	3769.63	Explosiveness
4/13/2000	-0.025558794	0.384759	3676.78	Explosiveness
4/14/2000	-0.019468977	1.776199	3321.29	Explosiveness
4/17/2000	-0.018865071	0.466239	3539.16	Explosiveness
4/24/2000	-0.021185181	0.257145	3482.48	Explosiveness
5/23/2000	-0.094040028	0.020846	3164.55	Explosiveness
4/3/2001	-0.100212725	0.039485	1673	Explosiveness
4/4/2001	-0.116670086	0.081104	1638.8	Explosiveness
4/6/2001	-0.096077285	-0.073558	1720.36	Explosiveness

Aappendix 3

Date	ADF Critical values (simulated Monte Carlo)	GSADF test results	Price	Explosiveness significant
7/14/1995	-0.368978794	-0.364684	4708.82	Explosiveness
12/15/1995	-0.314004368	-0.30275	5176.73	Explosiveness
12/8/1995	-0.306352071	-0.295131	5156.86	Explosiveness
12/4/1995	-0.306403585	-0.29431	5139.52	Explosiveness
5/9/1997	-0.291335025	-0.287704	7169.53	Explosiveness
1/27/1997	-0.295226205	-0.286334	6660.69	Explosiveness
3/29/1996	-0.282043132	-0.28103	5587.14	Explosiveness
12/7/1995	-0.324153953	-0.265492	5159.39	Explosiveness
2/29/1996	-0.280063164	-0.26235	5485.62	Explosiveness
1/6/1997	-0.309015972	-0.261869	6567.17	Explosiveness
12/14/1995	-0.294878561	-0.260447	5182.15	Explosiveness
12/25/1996	-0.334177769	-0.257221	6522.84	Explosiveness
5/22/1996	-0.277373563	-0.25229	5778	Explosiveness
12/12/1995	-0.311289063	-0.248712	5174.92	Explosiveness
12/5/1996	-0.252406258	-0.24721	6437.1	Explosiveness
3/4/1997	-0.288320382	-0.245577	6852.72	Explosiveness
12/24/1996	-0.303122998	-0.241312	6522.84	Explosiveness
5/19/1997	-0.268594294	-0.240058	7228.87	Explosiveness
6/5/1997	-0.256800411	-0.230316	7305.28	Explosiveness
5/22/1997	-0.266531526	-0.226172	7258.13	Explosiveness
12/30/1996	-0.295740167	-0.225816	6549.37	Explosiveness
5/5/1998	-0.234164113	-0.222665	9147.56	Explosiveness
7/13/1995	-0.346208333	-0.220415	4727.48	Explosiveness
12/3/1996	-0.250679631	-0.214258	6442.69	Explosiveness
3/20/1998	-0.238000518	-0.21361	8906.42	Explosiveness
9/5/1997	-0.249121829	-0.211247	7822.4	Explosiveness
10/21/1997	-0.249299133	-0.209172	8060.43	Explosiveness
4/3/1998	-0.213124074	-0.209059	8983.4	Explosiveness
12/26/1996	-0.301514932	-0.2037	6546.68	Explosiveness
5/1/1998	-0.243296755	-0.201634	9147.06	Explosiveness
7/17/1995	-0.345770222	-0.20149	4736.29	Explosiveness
8/15/1997	-0.243609786	-0.201095	7694.65	Explosiveness
9/8/1997	-0.251567768	-0.198996	7835.18	Explosiveness
6/3/1997	-0.248548843	-0.197128	7312.15	Explosiveness
9/17/1997	-0.252992066	-0.196714	7886.43	Explosiveness
2/5/1997	-0.273168012	-0.196402	6746.89	Explosiveness
5/13/1998	-0.244180823	-0.196341	9211.83	Explosiveness
4/2/1998	-0.226581764	-0.193706	8986.64	Explosiveness
7/12/1995	-0.356415691	-0.190756	4727.28	Explosiveness
12/9/1996	-0.295660865	-0.190042	6463.93	Explosiveness
1/7/1997	-0.316900836	-0.188566	6600.65	Explosiveness
12/10/1996	-0.279404196	-0.185839	6473.25	Explosiveness
12/11/1995	-0.310919142	-0.185198	5184.32	Explosiveness

1/24/1997	-0.288728792	-0.183345	6696.48	Explosiveness
12/27/1996	-0.305982818	-0.180193	6560.9	Explosiveness
9/9/1997	-0.268161327	-0.179923	7851.9	Explosiveness
2/2/1996	-0.298191455	-0.174906	5373.99	Explosiveness
4/16/1998	-0.225435438	-0.174292	9076.56	Explosiveness
9/16/1997	-0.247771609	-0.169449	7895.92	Explosiveness
3/14/1997	-0.248527976	-0.169064	6935.46	Explosiveness
2/28/1997	-0.28339733	-0.16616	6877.73	Explosiveness
9/19/1997	-0.250764037	-0.163507	7917.26	Explosiveness
11/19/1996	-0.242682087	-0.160246	6397.59	Explosiveness
8/27/1997	-0.266617114	-0.145171	7787.33	Explosiveness
8/26/1997	-0.254674408	-0.143922	7782.22	Explosiveness
5/4/1998	-0.219665721	-0.143742	9192.65	Explosiveness
9/18/1997	-0.280007724	-0.143155	7922.72	Explosiveness
4/6/1998	-0.243212275	-0.142838	9033.22	Explosiveness
3/17/1997	-0.260593797	-0.141308	6955.48	Explosiveness
5/21/1997	-0.268582585	-0.139888	7290.68	Explosiveness
11/21/1996	-0.259653602	-0.138311	6418.46	Explosiveness
1/9/1997	-0.284641964	-0.137589	6625.67	Explosiveness
5/30/1997	-0.233436715	-0.135984	7331.04	Explosiveness
10/15/1997	-0.24083386	-0.133689	8057.97	Explosiveness
12/5/1995	-0.302385676	-0.131966	5177.45	Explosiveness
5/29/1997	-0.250476879	-0.129243	7330.18	Explosiveness
4/23/1998	-0.245877748	-0.129213	9143.32	Explosiveness
5/6/1997	-0.285907374	-0.127281	7225.32	Explosiveness
4/1/1996	-0.322806672	-0.126846	5637.72	Explosiveness
10/10/1997	-0.217578451	-0.122622	8045.2	Explosiveness
3/13/1996	-0.282067151	-0.122469	5568.71	Explosiveness
5/5/1997	-0.283405636	-0.121101	7214.48	Explosiveness
9/4/1997	-0.266357286	-0.120513	7867.23	Explosiveness
2/6/1997	-0.28355163	-0.120167	6773.06	Explosiveness
3/28/1996	-0.314594721	-0.110268	5630.85	Explosiveness
3/27/1996	-0.304596222	-0.108299	5626.88	Explosiveness
9/29/1997	-0.204313022	-0.107121	7991.42	Explosiveness
5/13/1997	-0.278803906	-0.100777	7274.2	Explosiveness
2/20/1996	-0.273629183	-0.099787	5458.52	Explosiveness
1/29/1997	-0.263347416	-0.098588	6740.73	Explosiveness
4/20/1998	-0.241228671	-0.097639	9141.83	Explosiveness
4/14/1998	-0.237031791	-0.096393	9110.19	Explosiveness
3/15/1996	-0.255623634	-0.095787	5584.97	Explosiveness
9/23/1997	-0.209843927	-0.093753	7970.06	Explosiveness
5/20/1997	-0.275004486	-0.091462	7303.46	Explosiveness
10/1/1997	-0.202927184	-0.088994	8015.49	Explosiveness
11/20/1996	-0.236565267	-0.086604	6430.02	Explosiveness
10/13/1997	-0.202633004	-0.085711	8072.22	Explosiveness
2/28/1996	-0.285147342	-0.085341	5506.21	Explosiveness
1/30/1996	-0.32032189	-0.083365	5381.21	Explosiveness
10/9/1997	-0.218142344	-0.082738	8061.41	Explosiveness

5/14/1997	-0.27701531	-0.081374	7286.15	Explosiveness
10/2/1997	-0.236929223	-0.078291	8027.52	Explosiveness
2/10/1997	-0.284631127	-0.076783	6806.54	Explosiveness
9/2/1997	-0.258770772	-0.075469	7879.78	Explosiveness
3/14/1996	-0.258290388	-0.074763	5586.06	Explosiveness
12/13/1995	-0.297330213	-0.073303	5216.47	Explosiveness
10/3/1997	-0.205356883	-0.069377	8038.57	Explosiveness
4/22/1998	-0.243248386	-0.065564	9176.71	Explosiveness
3/3/1997	-0.295949748	-0.062015	6918.91	Explosiveness
9/3/1997	-0.240923533	-0.05919	7894.64	Explosiveness
5/28/1997	-0.265605827	-0.054977	7357.22	Explosiveness
10/14/1997	-0.237793655	-0.053791	8096.28	Explosiveness
5/26/1997	-0.262348295	-0.052956	7345.9	Explosiveness
2/5/1996	-0.306528238	-0.051488	5407.58	Explosiveness
3/12/1996	-0.294653185	-0.047347	5583.89	Explosiveness
4/17/1998	-0.222901249	-0.045521	9167.49	Explosiveness
12/6/1995	-0.309590532	-0.044519	5199.13	Explosiveness
4/21/1998	-0.249550363	-0.041193	9184.93	Explosiveness
3/11/1996	-0.277701062	-0.040823	5581	Explosiveness
1/31/1996	-0.30735877	-0.040785	5395.3	Explosiveness
4/5/1996	-0.316195999	-0.035069	5682.88	Explosiveness
3/6/1997	-0.275261895	-0.035056	6944.7	Explosiveness
3/21/1996	-0.255978226	-0.034093	5626.88	Explosiveness
9/22/1997	-0.216563684	-0.032847	7996.83	Explosiveness
5/12/1997	-0.280368591	-0.031799	7292.74	Explosiveness
2/27/1997	-0.280625398	-0.031631	6925.07	Explosiveness
5/23/1997	-0.271371885	-0.031547	7345.9	Explosiveness
4/15/1998	-0.258952457	-0.0254	9162.26	Explosiveness
4/2/1996	-0.303226821	-0.023552	5671.68	Explosiveness
4/4/1996	-0.311003295	-0.018025	5682.88	Explosiveness
2/1/1996	-0.285182323	-0.017439	5405.05	Explosiveness
3/22/1996	-0.252665963	-0.015139	5636.63	Explosiveness
10/8/1997	-0.188989134	-0.009633	8095.05	Explosiveness
3/1/1996	-0.274781217	-0.007935	5536.56	Explosiveness
3/5/1997	-0.271967958	-0.007658	6945.85	Explosiveness
8/18/1997	-0.21843859	-0.006778	7803.36	Explosiveness
3/25/1996	-0.29920795	-0.005676	5643.86	Explosiveness
2/3/1997	-0.283218108	-0.002984	6806.16	Explosiveness
1/23/1997	-0.276641923	-0.002449	6755.74	Explosiveness
11/28/1996	-0.250341149	0.009473	6499.34	Explosiveness
11/22/1996	-0.230451556	0.011111	6471.76	Explosiveness
8/25/1997	-0.271223993	0.017341	7859.57	Explosiveness
5/15/1997	-0.270471522	0.017756	7333.54	Explosiveness
11/27/1996	-0.263869017	0.020809	6499.34	Explosiveness
5/27/1997	-0.27253406	0.023336	7383.4	Explosiveness
4/3/1996	-0.32179507	0.024751	5689.74	Explosiveness
1/31/1997	-0.299889431	0.028776	6813.08	Explosiveness
10/6/1997	-0.203012641	0.03085	8100.21	Explosiveness

6/6/1997	-0.255264554	0.031729	7435.77	Explosiveness
1/13/1997	-0.286104813	0.031833	6709.18	Explosiveness
1/10/1997	-0.285307445	0.041503	6703.79	Explosiveness
12/2/1996	-0.236487428	0.046111	6521.7	Explosiveness
1/15/1997	-0.281427952	0.046442	6726.88	Explosiveness
2/20/1997	-0.286127285	0.059789	6927.38	Explosiveness
2/4/1997	-0.266926627	0.061721	6833.48	Explosiveness
2/11/1997	-0.288848625	0.062464	6858.11	Explosiveness
11/29/1996	-0.227618243	0.063983	6521.7	Explosiveness
2/21/1997	-0.283430974	0.074367	6931.61	Explosiveness
3/26/1996	-0.281167283	0.076175	5670.59	Explosiveness
2/7/1997	-0.298507513	0.078238	6855.8	Explosiveness
1/30/1997	-0.26914267	0.085159	6823.86	Explosiveness
8/22/1997	-0.256141838	0.085779	7887.9	Explosiveness
3/20/1996	-0.274358213	0.095676	5655.42	Explosiveness
3/7/1997	-0.26811592	0.097586	7000.88	Explosiveness
6/9/1997	-0.259935014	0.097664	7478.49	Explosiveness
8/21/1997	-0.253254214	0.110405	7893.94	Explosiveness
2/21/1996	-0.289880412	0.113112	5515.97	Explosiveness
2/19/1996	-0.309671488	0.114209	5503.32	Explosiveness
2/27/1996	-0.275282703	0.116913	5549.2	Explosiveness
3/12/1997	-0.249702543	0.120141	7039.36	Explosiveness
6/23/1997	-0.284003553	0.125628	7604.25	Explosiveness
11/26/1996	-0.260785505	0.130142	6528.41	Explosiveness
2/16/1996	-0.28853389	0.135629	5503.32	Explosiveness
2/26/1997	-0.311422081	0.143913	6983.18	Explosiveness
1/16/1997	-0.280202711	0.152995	6765.36	Explosiveness
2/6/1996	-0.30140057	0.154991	5459.61	Explosiveness
3/4/1996	-0.317045204	0.16317	5600.14	Explosiveness
10/7/1997	-0.182766929	0.164335	8178.31	Explosiveness
1/14/1997	-0.273173969	0.17111	6762.28	Explosiveness
3/19/1996	-0.271869476	0.171998	5669.51	Explosiveness
8/19/1997	-0.234891877	0.203491	7918.1	Explosiveness
11/25/1996	-0.243428757	0.215686	6547.79	Explosiveness
6/10/1997	-0.273898167	0.22207	7539.27	Explosiveness
2/26/1996	-0.28986173	0.222243	5565.1	Explosiveness
3/6/1996	-0.272875747	0.247893	5629.77	Explosiveness
3/18/1996	-0.264335069	0.251041	5683.6	Explosiveness
3/11/1997	-0.257093616	0.266718	7085.16	Explosiveness
2/24/1997	-0.311225618	0.269929	7008.19	Explosiveness
3/10/1997	-0.269925971	0.278455	7079.39	Explosiveness
3/7/1996	-0.258594109	0.279493	5641.69	Explosiveness
2/7/1996	-0.296226404	0.281547	5492.12	Explosiveness
6/11/1997	-0.283254808	0.287975	7575.82	Explosiveness
1/22/1997	-0.300130765	0.310186	6850.03	Explosiveness
2/17/1997	-0.265461126	0.311777	6988.95	Explosiveness
2/12/1997	-0.293952152	0.315655	6961.63	Explosiveness
2/14/1997	-0.278868794	0.322452	6988.95	Explosiveness

2/25/1997	-0.305199645	0.32428	7038.21	Explosiveness
8/13/1997	-0.221106534	0.324746	7928.32	Explosiveness
3/5/1996	-0.286185984	0.326252	5642.41	Explosiveness
1/17/1997	-0.270676969	0.327701	6833.09	Explosiveness
1/20/1997	-0.264389381	0.333312	6843.87	Explosiveness
8/14/1997	-0.232557781	0.339852	7942.02	Explosiveness
2/19/1997	-0.280722949	0.359621	7020.12	Explosiveness
6/26/1997	-0.262835484	0.369062	7654.24	Explosiveness
8/20/1997	-0.256071636	0.383805	8021.23	Explosiveness
2/15/1996	-0.289159159	0.386184	5551.37	Explosiveness
6/30/1997	-0.250411959	0.395239	7672.79	Explosiveness
8/12/1997	-0.23734404	0.411187	7960.84	Explosiveness
6/27/1997	-0.257367448	0.433583	7687.72	Explosiveness
1/21/1997	-0.281181294	0.438704	6883.89	Explosiveness
2/13/1997	-0.277655013	0.450526	7022.43	Explosiveness
2/9/1996	-0.299388749	0.463015	5541.62	Explosiveness
2/8/1996	-0.296304542	0.479804	5539.45	Explosiveness
2/22/1996	-0.285017743	0.484969	5608.45	Explosiveness
6/25/1997	-0.263011175	0.488121	7689.98	Explosiveness
7/1/1997	-0.231014846	0.498049	7722.32	Explosiveness
6/18/1997	-0.302726743	0.499003	7718.7	Explosiveness
2/18/1997	-0.276378667	0.531016	7067.46	Explosiveness
2/14/1996	-0.290532477	0.552628	5579.55	Explosiveness
2/23/1996	-0.278443447	0.561511	5630.49	Explosiveness
6/12/1997	-0.285320965	0.602755	7711.46	Explosiveness
6/24/1997	-0.278569806	0.603849	7758.06	Explosiveness
8/8/1997	-0.230495391	0.613051	8031.22	Explosiveness
7/18/1997	-0.251574945	0.617472	7890.46	Explosiveness
6/17/1997	-0.275523661	0.634102	7760.77	Explosiveness
7/21/1997	-0.250436585	0.63966	7906.72	Explosiveness
7/2/1997	-0.22664498	0.645353	7795.38	Explosiveness
6/19/1997	-0.273672997	0.648947	7777.06	Explosiveness
7/9/1997	-0.250719738	0.651842	7842.43	Explosiveness
8/11/1997	-0.235901316	0.667873	8062.11	Explosiveness
6/20/1997	-0.302139469	0.67325	7796.51	Explosiveness
6/16/1997	-0.267779052	0.684117	7772.08	Explosiveness
2/13/1996	-0.300478458	0.693782	5601.23	Explosiveness
7/7/1997	-0.254804459	0.716191	7858.48	Explosiveness
2/12/1996	-0.299043459	0.719645	5600.14	Explosiveness
6/13/1997	-0.275410099	0.741304	7782.03	Explosiveness
7/10/1997	-0.242533182	0.750939	7886.76	Explosiveness
7/14/1997	-0.249328393	0.798494	7922.98	Explosiveness
7/11/1997	-0.227149709	0.81504	7921.81	Explosiveness
7/4/1997	-0.222553695	0.834841	7895.8	Explosiveness
7/3/1997	-0.225765426	0.855485	7895.8	Explosiveness
7/15/1997	-0.225502487	0.920163	7975.7	Explosiveness
7/8/1997	-0.254785879	0.986096	7962.3	Explosiveness
7/17/1997	-0.24199987	0.987613	8020.76	Explosiveness

7/22/1997	-0.253270282	0.994787	8061.64	Explosiveness
8/7/1997	-0.246603216	1.041483	8188	Explosiveness
7/23/1997	-0.262261617	1.04372	8088.35	Explosiveness
7/16/1997	-0.212759971	1.058813	8038.88	Explosiveness
7/28/1997	-0.243748203	1.06426	8121.1	Explosiveness
7/25/1997	-0.263285451	1.0659	8113.44	Explosiveness
8/5/1997	-0.258993397	1.094351	8187.53	Explosiveness
7/24/1997	-0.288107665	1.09759	8116.92	Explosiveness
8/4/1997	-0.242235437	1.145895	8198.45	Explosiveness
8/1/1997	-0.24093775	1.156876	8194.04	Explosiveness
7/29/1997	-0.264975566	1.182928	8174.52	Explosiveness
8/6/1997	-0.249108806	1.25874	8259.3	Explosiveness
7/31/1997	-0.262038152	1.258918	8222.61	Explosiveness
7/30/1997	-0.270797173	1.374755	8254.89	Explosiveness

Appendix 4

Date	ADF Critical values (simulated Monte Carlo)	GSADF test results	Price	Explosiveness significant
8/21/1990	-0.801259197	-0.107117	2603.96	Explosiveness
8/22/1990	-0.799988945	0.453997	2560.15	Explosiveness
8/23/1990	-0.809053079	1.322489	2483.42	Explosiveness
8/24/1990	-0.781448919	0.471276	2532.92	Explosiveness
8/30/1990	-0.781756176	-0.766392	2593.32	Explosiveness
9/14/1990	-0.706380652	-0.635337	2564.11	Explosiveness
9/19/1990	-0.687843546	-0.66531	2557.43	Explosiveness
9/20/1990	-0.692721179	-0.448938	2518.32	Explosiveness
9/21/1990	-0.658341832	-0.444831	2512.38	Explosiveness
9/24/1990	-0.690750437	-0.07681	2452.97	Explosiveness
9/25/1990	-0.648759801	-0.363071	2485.64	Explosiveness
9/26/1990	-0.641237771	-0.228367	2459.65	Explosiveness
9/27/1990	-0.669361129	-0.049629	2427.48	Explosiveness
9/28/1990	-0.630786717	-0.286096	2452.48	Explosiveness
10/3/1990	-0.640860401	-0.640796	2489.36	Explosiveness
10/9/1990	-0.650986429	-0.552165	2445.54	Explosiveness
10/10/1990	-0.65714654	-0.37325	2407.92	Explosiveness
10/11/1990	-0.668435763	-0.152484	2365.1	Explosiveness
10/12/1990	-0.674340257	-0.414931	2398.02	Explosiveness
10/15/1990	-0.721800576	-0.55454	2416.34	Explosiveness
10/16/1990	-0.696536044	-0.398718	2381.19	Explosiveness
10/17/1990	-0.704208166	-0.472906	2387.87	Explosiveness
2/11/1991	-0.47480236	-0.310457	2902.23	Explosiveness
2/13/1991	-0.43645095	-0.344183	2909.16	Explosiveness
2/15/1991	-0.448701074	-0.128026	2934.65	Explosiveness

2/18/1991	-0.440354719	-0.15682	2934.65	Explosiveness
2/19/1991	-0.466822271	-0.244036	2932.18	Explosiveness
3/5/1991	-0.531115507	-0.435805	2972.52	Explosiveness
3/6/1991	-0.530163996	-0.491731	2973.27	Explosiveness
3/30/1994	-0.139494839	0.489282	3626.75	Explosiveness
3/31/1994	-0.153163344	0.207683	3635.96	Explosiveness
4/1/1994	-0.164625251	0.1259	3635.96	Explosiveness
4/4/1994	-0.175627944	0.681151	3593.35	Explosiveness
4/20/1994	-0.183222118	-0.136292	3598.71	Explosiveness
12/5/1995	-0.132194956	-0.131966	5177.45	Explosiveness
12/6/1995	-0.138680218	-0.044519	5199.13	Explosiveness
12/13/1995	-0.118552451	-0.073303	5216.47	Explosiveness
1/30/1996	-0.087749018	-0.083365	5381.21	Explosiveness
1/31/1996	-0.114095685	-0.040785	5395.3	Explosiveness
2/1/1996	-0.101975365	-0.017439	5405.05	Explosiveness
2/5/1996	-0.09990735	-0.051488	5407.58	Explosiveness
2/6/1996	-0.123406143	0.154991	5459.61	Explosiveness
2/7/1996	-0.118791032	0.281547	5492.12	Explosiveness
2/8/1996	-0.106703804	0.479804	5539.45	Explosiveness
2/9/1996	-0.09644088	0.463015	5541.62	Explosiveness
2/12/1996	-0.121368631	0.719645	5600.14	Explosiveness
2/13/1996	-0.120904078	0.693782	5601.23	Explosiveness
2/14/1996	-0.112974777	0.552628	5579.55	Explosiveness
2/15/1996	-0.116995339	0.386184	5551.37	Explosiveness
2/16/1996	-0.120210266	0.135629	5503.32	Explosiveness
2/19/1996	-0.120231142	0.114209	5503.32	Explosiveness
2/21/1996	-0.084529934	0.113112	5515.97	Explosiveness
2/22/1996	-0.104703953	0.484969	5608.45	Explosiveness
2/23/1996	-0.10991246	0.561511	5630.49	Explosiveness
2/26/1996	-0.142275217	0.222243	5565.1	Explosiveness
2/27/1996	-0.086682092	0.116913	5549.2	Explosiveness
2/28/1996	-0.096249993	-0.085341	5506.21	Explosiveness
3/1/1996	-0.090340039	-0.007935	5536.56	Explosiveness
3/4/1996	-0.080670773	0.16317	5600.14	Explosiveness
3/5/1996	-0.09204414	0.326252	5642.41	Explosiveness
3/6/1996	-0.110504191	0.247893	5629.77	Explosiveness
3/7/1996	-0.075850003	0.279493	5641.69	Explosiveness
3/11/1996	-0.120718397	-0.040823	5581	Explosiveness
3/12/1996	-0.120607536	-0.047347	5583.89	Explosiveness
3/14/1996	-0.114474605	-0.074763	5586.06	Explosiveness
3/15/1996	-0.119065123	-0.095787	5584.97	Explosiveness
3/18/1996	-0.128172816	0.251041	5683.6	Explosiveness
3/19/1996	-0.132754678	0.171998	5669.51	Explosiveness
3/20/1996	-0.151108041	0.095676	5655.42	Explosiveness
3/21/1996	-0.129078737	-0.034093	5626.88	Explosiveness
3/22/1996	-0.12174581	-0.015139	5636.63	Explosiveness
3/25/1996	-0.142791686	-0.005676	5643.86	Explosiveness
3/26/1996	-0.153065967	0.076175	5670.59	Explosiveness

4/2/1996	-0.094805668	-0.023552	5671.68	Explosiveness
4/3/1996	-0.108607508	0.024751	5689.74	Explosiveness
4/4/1996	-0.095987377	-0.018025	5682.88	Explosiveness
4/5/1996	-0.117508407	-0.035069	5682.88	Explosiveness
11/22/1996	-0.106701749	0.011111	6471.76	Explosiveness
11/25/1996	-0.10624661	0.215686	6547.79	Explosiveness
11/26/1996	-0.094092812	0.130142	6528.41	Explosiveness
11/27/1996	-0.12285937	0.020809	6499.34	Explosiveness
11/28/1996	-0.113848177	0.009473	6499.34	Explosiveness
11/29/1996	-0.121594791	0.063983	6521.7	Explosiveness
12/2/1996	-0.114187899	0.046111	6521.7	Explosiveness
1/10/1997	-0.062756944	0.041503	6703.79	Explosiveness
1/13/1997	-0.077253204	0.031833	6709.18	Explosiveness
1/14/1997	-0.056083818	0.17111	6762.28	Explosiveness
1/15/1997	-0.055900927	0.046442	6726.88	Explosiveness
1/16/1997	-0.066625411	0.152995	6765.36	Explosiveness
1/17/1997	-0.068699443	0.327701	6833.09	Explosiveness
1/20/1997	-0.047258012	0.333312	6843.87	Explosiveness
1/21/1997	-0.066997442	0.438704	6883.89	Explosiveness
1/22/1997	-0.100253692	0.310186	6850.03	Explosiveness
1/23/1997	-0.118440329	-0.002449	6755.74	Explosiveness
1/30/1997	-0.067696072	0.085159	6823.86	Explosiveness
1/31/1997	-0.068977318	0.028776	6813.08	Explosiveness
2/3/1997	-0.11753677	-0.002984	6806.16	Explosiveness
2/4/1997	-0.092286461	0.061721	6833.48	Explosiveness
2/7/1997	-0.078240736	0.078238	6855.8	Explosiveness
2/10/1997	-0.079764907	-0.076783	6806.54	Explosiveness
2/11/1997	-0.080461026	0.062464	6858.11	Explosiveness
2/12/1997	-0.030225058	0.315655	6961.63	Explosiveness
2/13/1997	-0.083170104	0.450526	7022.43	Explosiveness
2/14/1997	-0.065971522	0.322452	6988.95	Explosiveness
2/17/1997	-0.051444571	0.311777	6988.95	Explosiveness
2/18/1997	-0.064112251	0.531016	7067.46	Explosiveness
2/19/1997	-0.059657105	0.359621	7020.12	Explosiveness
2/20/1997	-0.039770154	0.059789	6927.38	Explosiveness
2/21/1997	-0.030492085	0.074367	6931.61	Explosiveness
2/24/1997	-0.079318594	0.269929	7008.19	Explosiveness
2/25/1997	-0.090096072	0.32428	7038.21	Explosiveness
2/26/1997	-0.065257691	0.143913	6983.18	Explosiveness
2/27/1997	-0.071746546	-0.031631	6925.07	Explosiveness
3/3/1997	-0.078921781	-0.062015	6918.91	Explosiveness
3/5/1997	-0.089545794	-0.007658	6945.85	Explosiveness
3/6/1997	-0.071137186	-0.035056	6944.7	Explosiveness
3/7/1997	-0.078990567	0.097586	7000.88	Explosiveness
3/10/1997	-0.084378981	0.278455	7079.39	Explosiveness
3/11/1997	-0.051977427	0.266718	7085.16	Explosiveness
3/12/1997	-0.0692759	0.120141	7039.36	Explosiveness
4/3/1997	-0.078866183	-0.007562	6477.35	Explosiveness

4/11/1997	-0.09891043	0.174531	6391.69	Explosiveness
5/12/1997	-0.093353878	-0.031799	7292.74	Explosiveness
5/15/1997	-0.083995433	0.017756	7333.54	Explosiveness
5/20/1997	-0.114861533	-0.091462	7303.46	Explosiveness
5/23/1997	-0.06345422	-0.031547	7345.9	Explosiveness
5/27/1997	-0.081689287	0.023336	7383.4	Explosiveness
5/28/1997	-0.081260232	-0.054977	7357.22	Explosiveness
6/6/1997	-0.066731387	0.031729	7435.77	Explosiveness
6/9/1997	-0.080880178	0.097664	7478.49	Explosiveness
6/10/1997	-0.075184571	0.22207	7539.27	Explosiveness
6/11/1997	-0.102715972	0.287975	7575.82	Explosiveness
6/12/1997	-0.074349033	0.602755	7711.46	Explosiveness
6/13/1997	-0.078802145	0.741304	7782.03	Explosiveness
6/16/1997	-0.061202286	0.684117	7772.08	Explosiveness
6/17/1997	-0.087375225	0.634102	7760.77	Explosiveness
6/18/1997	-0.065289332	0.499003	7718.7	Explosiveness
6/19/1997	-0.09764466	0.648947	7777.06	Explosiveness
6/20/1997	-0.112295341	0.67325	7796.51	Explosiveness
6/23/1997	-0.083805412	0.125628	7604.25	Explosiveness
6/24/1997	-0.072133167	0.603849	7758.06	Explosiveness
6/25/1997	-0.073448941	0.488121	7689.98	Explosiveness
6/26/1997	-0.095203948	0.369062	7654.24	Explosiveness
6/27/1997	-0.09201064	0.433583	7687.72	Explosiveness
6/30/1997	-0.097112546	0.395239	7672.79	Explosiveness
7/1/1997	-0.079561052	0.498049	7722.32	Explosiveness
7/2/1997	-0.063277237	0.645353	7795.38	Explosiveness
7/3/1997	-0.098341879	0.855485	7895.8	Explosiveness
7/4/1997	-0.072891356	0.834841	7895.8	Explosiveness
7/7/1997	-0.056716552	0.716191	7858.48	Explosiveness
7/8/1997	-0.047245581	0.986096	7962.3	Explosiveness
7/9/1997	-0.060038573	0.651842	7842.43	Explosiveness
7/10/1997	-0.067357479	0.750939	7886.76	Explosiveness
7/11/1997	-0.067590095	0.81504	7921.81	Explosiveness
7/14/1997	-0.078880315	0.798494	7922.98	Explosiveness
7/15/1997	-0.060337263	0.920163	7975.7	Explosiveness
7/16/1997	-0.114224148	1.058813	8038.88	Explosiveness
7/17/1997	-0.104137258	0.987613	8020.76	Explosiveness
7/18/1997	-0.093625651	0.617472	7890.46	Explosiveness
7/21/1997	-0.066214092	0.63966	7906.72	Explosiveness
7/22/1997	-0.086388016	0.994787	8061.64	Explosiveness
7/23/1997	-0.07441959	1.04372	8088.35	Explosiveness
7/24/1997	-0.056803736	1.09759	8116.92	Explosiveness
7/25/1997	-0.057919403	1.0659	8113.44	Explosiveness
7/28/1997	-0.083348218	1.06426	8121.1	Explosiveness
7/29/1997	-0.093675441	1.182928	8174.52	Explosiveness
7/30/1997	-0.103591638	1.374755	8254.89	Explosiveness
7/31/1997	-0.075031429	1.258918	8222.61	Explosiveness
8/1/1997	-0.069046627	1.156876	8194.04	Explosiveness

8/4/1997	-0.074910787	1.145895	8198.45	Explosiveness
8/5/1997	-0.081262199	1.094351	8187.53	Explosiveness
8/6/1997	-0.06110121	1.25874	8259.3	Explosiveness
8/7/1997	-0.079500351	1.041483	8188	Explosiveness
8/8/1997	-0.091750383	0.613051	8031.22	Explosiveness
8/11/1997	-0.054620771	0.667873	8062.11	Explosiveness
8/12/1997	-0.048853594	0.411187	7960.84	Explosiveness
8/13/1997	-0.059949666	0.324746	7928.32	Explosiveness
8/14/1997	-0.08173818	0.339852	7942.02	Explosiveness
8/18/1997	-0.100046516	-0.006778	7803.36	Explosiveness
8/19/1997	-0.089052585	0.203491	7918.1	Explosiveness
8/20/1997	-0.08731992	0.383805	8021.23	Explosiveness
8/21/1997	-0.091083298	0.110405	7893.94	Explosiveness
8/22/1997	-0.100853806	0.085779	7887.9	Explosiveness
8/25/1997	-0.108927655	0.017341	7859.57	Explosiveness
9/2/1997	-0.08587406	-0.075469	7879.78	Explosiveness
9/3/1997	-0.100216489	-0.05919	7894.64	Explosiveness
9/22/1997	-0.080143281	-0.032847	7996.83	Explosiveness
10/6/1997	-0.044604046	0.03085	8100.21	Explosiveness
10/7/1997	-0.056129224	0.164335	8178.31	Explosiveness
10/8/1997	-0.071936302	-0.009633	8095.05	Explosiveness
10/14/1997	-0.083345621	-0.053791	8096.28	Explosiveness
10/27/1997	-0.064415431	0.036318	7161.14	Explosiveness
4/14/1998	-0.09702495	-0.096393	9110.19	Explosiveness
4/15/1998	-0.095971102	-0.0254	9162.26	Explosiveness
4/17/1998	-0.078492615	-0.045521	9167.49	Explosiveness
4/21/1998	-0.078203699	-0.041193	9184.93	Explosiveness
4/22/1998	-0.088776552	-0.065564	9176.71	Explosiveness
8/28/1998	-0.006281923	0.03195	8051.68	Explosiveness
8/31/1998	-0.038870923	1.305356	7539.06	Explosiveness
9/1/1998	-0.038991269	0.114838	7827.42	Explosiveness
9/2/1998	-0.061431753	0.171941	7782.37	Explosiveness
9/3/1998	-0.052825496	0.369523	7682.22	Explosiveness
9/4/1998	-0.067479101	0.404412	7640.25	Explosiveness
9/7/1998	-0.059125119	0.325108	7640.25	Explosiveness
9/10/1998	-0.078112453	0.016737	7615.55	Explosiveness
9/20/2001	-0.055054613	0.125047	8376.21	Explosiveness
9/21/2001	-0.035940202	0.348274	8235.81	Explosiveness

Appendix 5

	Dow Jones Industrial Average	Nasdaq Composite

K	2-day return	4-day return	8-day return	16-day return	2-day return	4-day return	8-day return	16-day return
Variance	0.02%	0.04%	0.07%	0.14%	0.000492	0.000963	0.001888	0.003967
VR	0.030487	-0.00888	-0.05544	-0.07902	0.044035	0.021356	0.001618	0.052352
Variance of VR	0.00032	0.001119	0.002796	0.006192	0.00032	0.001119	0.002769	0.006192
STD	0.017877	0.033445	0.052881	0.07869	0.017877	0.033445	0.052881	0.07869
Z-Stats	1.70537	-0.26565	-1.04832	-1.00417	2.463218	0.638541	0.030605	0.665294
P-Value	4.41%	39.53%	14.72%	15.67%	0.69%	26.16%	48.78%	25.29%