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**EFFICIENT MARKET HYPOTHESIS:
NEW EVIDENCE FROM EURO AREA COUNTRIES**

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ABSTRACT

EFFICIENT MARKET HYPOTHESIS: NEW EVIDENCE FROM EURO AREA COUNTRIES

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The main purpose of this thesis is to analyze the Efficient Market Hypothesis for a group of European Monetary Union (EMU) countries by providing a new empirical framework through employing recently developed methodologies. In this respect, we have tested the stock exchange price indices of the EMU countries to detect their market efficiencies in weak and semi-strong forms by conducting linear and nonlinear panel unit root tests, and a panel causality test. In general, our results show that the stock markets of the selected EMU countries are weak and semi-strong form efficient, and thereby corroborate the findings of the previous studies in the literature.

Keywords: Efficient Market Hypothesis (EMH), European Monetary Union (EMU) Countries, Non Linear Models, Panel Unit Root, Panel Causality, Cross-sectional Dependency.

ÖZ

ETKİN PİYASALAR KURAMI: AVRUPA PARASAL BİRLİĞİ ÜLKELERİ İÇİN YENİ BİR YAKLAŞIM

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Bu tezin ana amacı Avrupa Parasal Birliği ülkelerinde Etkin Piyasalar Kuramını son yıllarda geliştirilmiş yöntemlerle incelemek ve yeni bir ampirik yaklaşım ortaya koymaktır. Bu bağlamda, ülkelerin hisse senedi piyasası fiyat endekslerinin zayıf ve yarı güçlü form etkinlikleri, doğrusal ve doğrusal olmayan panel birim kök testleri ve bir de panel nedensellik testiyle sınanmıştır. Araştırma sonucunda elde edilen bulgular, önceki çalışmaları destekler nitelikte olup, Avrupa Parasal Birliği ülkeleri hisse senedi piyasalarının zayıf ve yarı güçlü formda etkin olduğunu göstermektedir.

Anahtar Kelimeler: Etkin Piyasa Kuramı, Avrupa Parasal Birliği Ülkeleri, Doğrusal Olmayan Modeller, Panel Birim Kök Testi, Panel Nedensellik Testi, Yatay Kesit Bağımlılığı.

**To My Dear Parents,
Belkıs & Güray ERGÖR**

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ABBREVIATIONS

ADF	: Augmented Dickey Fuller
AEX	: Amsterdam Exchanges Index
ATX	: Austrian Traded Index
BEL 20	: Belgian 20 Price Index
CAC 40	: Compagnie des Agents de Change 40 Index
CPIc	: Consumer Price Index by Country
CPIe	: Consumer Price Index for Euro Area
DAX 30	: Deutscher Aktienindex
EMH	: Efficient Market Hypothesis
EMU	: European Monetary Union
FTSEMIB	: Milano Italia Borsa 30 Index
GOLD	: World Gold Price
HEX	: Helsinki Stock Exchange All Share Index
IBEX 35	: Spanish Association of Stock Exchanges
IFS	: International Financial Statistics
IP	: Industrial Production Index
IPS	: Im – Pesaran – Shin
ISEQ	: Irish Stock Exchange Equity Overall Index
KPSS	: Kwiatkowski – Phillips – Schmidt – Shin
KSS	: Kapetanios – Snell – Shin
LIR	: Long-Term Interest Rate
LLC	: Levin – Lin – Chu
LUXX	: Luxembourg Stock Exchange Index
M1	: Narrow money supply
OIL	: World Crude Oil Price
PP	: Phillips Perron
PSI 20	: Portuguese Stock Index 20
SI	: Stock Market Index
SIR	: Short-Term Interest Rate
Uc	: Unemployment Rate by Country
Ue	: Unemployment Rate for Euro Area
UO	: Ucar – Omay
VAR	: Vector Autoregressive
VECM	: Vector Error Correction Model

CHAPTER 1

1. INTRODUCTION

The primary role of financial markets is to transfer funds from lenders to borrowers efficiently. Market participants, individuals and firms, should be able to have access to the productive investment opportunities with available funds offering a higher rate of return than the borrowing rate that is determined in the market. Lenders having excess funds are willing to lend their funds at a higher rate, and borrowers who are in need of funds, are willing to borrow these funds to fulfill their needs. Financial markets satisfy this requirement by generating an environment for investors to lend and borrow the needed funds. Thus, all participants will be better off through the ease of transferring funds if efficient financial markets exist.

At this point, it might be enlightening to define the term “efficient market”. Efficient market is defined as a market in which security prices fully reflect all available and relevant information and where relevant information must be complete and simultaneously transmitted to all participants. *Efficient Market Hypothesis* (henceforth: *EMH*) states that security prices already incorporate and reflect all available relevant information at any point in time, so that if a market is efficient, it is impossible for one to earn excess returns on a continual basis by using past, current or new information. In other words, excess returns above the average cannot be earned and the market cannot be beaten all the time, except only by chance.

There are three forms of market efficiency: weak, semi-strong and strong. If the market prices reflect all past information including historical data, then no excess return can be earned by analyzing the *previous information*, and this type of a market is said to be *weak form* efficient. If investors in the market cannot earn excess returns

from trading rules based on any *publicly available information*, such as annual reports, dividend announcements, and macroeconomic figures; then the market is called *semi-strong form* efficient. Finally, if it is impossible to beat the market by using *any, publicly or privately provided information*, then the market is said to be *strong form* efficient.

The aim of this thesis is to test the EMH in its weak and semi-strong forms for a selected group of European Monetary Union (henceforth: EMU) countries. The study considers the time that the single currency –euro– is legally introduced and uses monthly data that spans the period from January 1999 to July 2013.

The first stage of this study is aimed at testing for weak form efficiency using the major stock exchange price indices of the selected EMU countries by conducting panel linear and nonlinear unit root tests. Although, with a few exceptions, most studies testing EMH conclude in favor of weak and semi-strong form efficiency, they all neglect the possibility of nonlinearities in conditional mean of the series in their analyses. However, the evidence is clear that many economic and financial time series follow nonlinear processes (Granger and Terasvirta, 1993; Franses and van Dijk, 2000). Therefore, possible nonlinearities in data generating process should explicitly be taken into account in analyzing financial time series in order to avoid spurious results (Hasanov and Omay, 2007). Recent studies also confirm that the stock price indices show nonlinear data generating processes (Narayan, 2005; Hasanov and Omay, 2007; Lim and Brooks, 2009; Munir and Mansur, 2009; Hasanov 2009).

While using panel data approach in unit root testing has its own merits like increasing the power of the conventional unit root tests, it also generates other extra problems that are not present in the univariate time series techniques, such as cross-sectional dependence. Cross-sectional dependence may arise due to spatial correlations, spill-over effects, economic distance, omitted global variables and common unobserved shocks and it may lead to biased estimates and misleading inference (Omay and Kan, 2010). Ignoring the cross-sectional dependence may

cause considerable size distortions in the analysis and may lead to over-rejections of the null hypothesis by causing substantial increases in the size of the linear panel unit root tests. Therefore, unlike previous studies that analyze the EMH, our study contributes to literature by considering the possibility of nonlinearities and cross-sectional dependence simultaneously. To this end, to detect the EMH in its weak form, we conduct the Ucar and Omay (2009) test in addition to the conventional linear panel unit root tests of Levin, Lin, and Chu (2002), Im, Pesaran, and Shin (2003), Fisher-ADF test (Maddala and Wu, 1999), and Hadri (2000).

In the second stage, semi-strong form of market efficiency is tested by running the panel Granger causality test developed by Emirmahmutoglu and Kose (2011) to explore the relationship between the stock prices and the main macroeconomic variables of the EMU countries. To our knowledge, this is the first study that applies this test to analyze the EMH in semi-strong form. The main advantage of the Emirmahmutoglu and Kose (2011) test over the other tests developed in the literature is that it does not require pretesting for unit roots and cointegration whose application causes the Granger causality tests to suffer from severe pretest biases.

The findings of the study which will be explained in detail in the upcoming chapters appear to be consistent with the previous empirical studies. At the end of the research, strong evidence in favor of weak form efficiency of the EMU countries was found. Results of linear and nonlinear panel unit root tests confirmed that stock price indices contain unit root and demonstrate random walk behavior. Findings of the panel causality tests indicate that none of the macroeconomic variables subject to this research shows causality running to the stock price indices, implying that EMU countries' stock exchanges are also efficient in semi-strong form. However, the topic is still open for further investigations. The evidence in favor of semi-strong form efficiency for EMU countries paves the way for testing strong form efficiency for further research.

In addition, previous studies may remain insufficient because of the fact that their works cover only the pre-debt crisis periods. This study, however, considers the post-debt crisis era as well and thereby captures the period where structural reforms and developments occurred due to financial and economic downturns. Therefore, this thesis appears to be an important indicator for the global economic and financial policy makers as well as the market participants in the sense that the reforms undertaken during the global and financial crisis can crucially affect the efficiency of the stock markets.

The rest of this thesis is structured as follows: Chapter 2 introduces the Efficient Market Hypothesis by emphasizing its importance for the economy and the financial system. This chapter also provides brief definitions of weak form, semi-strong form and strong form efficiencies. Chapter 3 surveys the literature by presenting previous empirical studies that have been conducted to test the Efficient Market Hypothesis. Chapter 4 presents the data and discusses the econometric methodologies used in this research. The results of the tests utilized are presented and discussed in Chapter 5. Finally, Chapter 6 is reserved for the concluding remarks and recommendations for further research.

CHAPTER 2

2. EFFICIENT MARKET HYPOTHESIS

This chapter aims to introduce efficient market hypothesis and is comprised as follows: First, a brief definition for the term “efficiency” will be provided; second the criteria for the market efficiency will be defined; later, the importance of market efficiency will be discussed, then the historical background of EMH will be presented and finally, three forms of EMH will be explained.

In economics, “*efficiency*” is explained as “*the use of resources so as to maximize the production of goods and services.*” It refers to the state in which all resources are optimally allocated and used to produce the maximum level of goods and services with the aim of serving each individual in the best way while minimizing the cost like money, time, and labor.

In business, “*efficiency*” is achieved by “*maximizing profits while minimizing losses and expenditures*” and/or by “*maximizing the level of output with the minimum use of input*”. It is often expressed as the expenses as a percentage of revenues or ratio of output over input. Meaning, lower the expense/revenue ratio, higher the output/input ratio, higher the efficiency.

It is also vital to know the term “efficiency” in the financial management context. In financial management, the term usually refers to “financial market efficiency”, and is used to express the random behavior of prices in money and capital markets. It is mainly related with comprising the available information and satisfying an equilibrium condition. Here, the term “*efficiency*” is used to describe a market in which “*prices fully reflect all available information*” (Fama, 1970) or “*all*

relevant information is impounded into the price of financial assets (Dimson and Mussavian, 1998).

2.1 Market Efficiency Criteria

Three criteria are required when market efficiency is considered. First is *operational* efficiency. Second is *allocation* efficiency and the last one is *informational* efficiency. In this section the definitions of these three criteria will be elaborated.

2.1.1 Operational Efficiency: The idea behind operational efficiency is to construct an environment that facilitates the overall operation of the market. Operational efficiency will be feasible by employing minimum cost resources, such as transaction costs, brokerage fees, and so on. An operationally efficient market enables its participants to execute transactions and receive trading services at fair prices. Markets are composed of different types of investors: *big investors* who have a huge trading volume such as mutual funds and *small investors* who have a relatively lower budget and trading volume. Obviously, the impact of trading costs on each investor's trading behavior will be different. High costs will limit small investors' ability to trade frequently or almost entirely and eventually cause the market to become inefficient. Therefore, trading costs such as transaction costs and brokerage fees are required to be low to encourage a higher trading volume and to achieve efficiency.

2.1.2 Allocation Efficiency: Allocation efficiency implies when all capital and other resources are allocated in a way that makes all the participants in the market better off. A market is said to be allocationally efficient if it allows the "Pareto optimal" allocation of resources. Pareto optimal efficiency asserts the economic condition in which no other alternative allocation exists that would benefit at least one individual while making another worse off. Allocation efficiency considers each participant's benefit to the greatest possible extent. It also requires all relevant

information to be publicly available and included in the prices of assets, the cost of services provided (i.e. transaction costs) for investors to be fairly priced, markets to be complete such that they include every type of asset to meet every participants' (both current and potential) needs. In such efficiency, only the projects having the highest profitability will exist in the market because all available capital and resources will be allocated to those projects for gaining the possible maximum benefits. In other words, capital allocation efficiency requires investing in securities offering the highest returns by using all available resources.

2.1.3 Informational (Pricing) Efficiency: Informational efficiency satisfies the state where the prices of each asset in the market fully and fairly reflect all available information, so that it is impossible for an investor to gain higher profits on a continual basis by using the available relevant information. For informational efficiency all securities must be fairly priced, they must behave randomly and be unpredictable, and there must be no persistent arbitrage opportunities. At this point, it would be better to clarify the arbitrage opportunity. An arbitrage opportunity exists when two identical assets having the same value are priced differently in the market so that a certain riskless profit can be gained by buying the one at a lower price while selling the other at a higher price. The logic behind this type of efficiency is that, if prices do not contain all the relevant information, then any information that is not already included in the prices can be useful in predicting the future prices. And if there is a possibility for an investor to reach such an information that is not available in the current prices by paying a certain amount of fee (information cost), then it is possible that the investors who are capable of paying the fee can predict the future prices and gain high abnormal returns by using the information that is not available for other investors in the market. If such a case occurs permanently, then investors who are unable to reach the unavailable information and compensate for the cost will start to cut down their trading volume and eventually exit the market. And this will cause the market to operate inefficiently. Thus, to talk about efficiency, it should be impossible to gain abnormal returns and beat the market consistently by using and analyzing any information.

2.2 Why Do Efficient Markets Matter?

The main goal of financial management is to maximize the current value of stocks of a company and shareholder's wealth. Shareholders seek for capital gains and invest in a security to increase their current level of wealth. Managers, on the other hand, act on the behalf of shareholders and are charged to make decisions in the best interest of the company and thus, in the best interest of shareholders. Otherwise they are subject to loosing their jobs and professional reputation. Since the pleasure of shareholders depend on the value of their wealth, and the value of their wealth is directly related to the market value of the stock they own, investing in "true" stocks and making decisions to maximize the market value of company stocks appear as the crucial goal for shareholders and managers.

Making financial decisions and managing funds require hot trail of the developments in global financial markets and a successful analysis of the financial facts together with a great extent of financial knowledge and managerial skills. Moreover, individuals need to satisfy their needs and desires in a world with scarce resources in order to survive and they do it through consuming goods and services which will bring them the maximum utility.

There exists a circulation between the use of real and financial assets in an integrated world economy. Real assets are tangible assets, such as land, buildings, and machines, which are used to produce goods and services and determine the net wealth of the overall economy. Financial assets such as stocks, bonds, derivative securities, on the other hand, represent the claims of ownership on real assets or income generated by real assets. This circulation needs to proceed in an economy to meet the needs of the participants.

It should be kept in mind that market efficiency has a considerable role in preserving the hierarchical structure of the economy, thus, this phenomenon leads to a well established financial management system.

2.3 The Historical Evolution towards the Efficient Market Hypothesis

The concept of “efficient market hypothesis” roots back to early twentieth century. In 1900, Louis Bachelier who did his PhD on applied mathematics at Sorbonne University, published his dissertation thesis in which he firstly modeled a stochastic process –called Brownian motion- by studying stock options. In his dissertation, he captured the fact of informational efficiency in markets, and this provided the motivation of his dissertation research. In the study, he claimed that prices already contain all the information in the market and that price changes occur spontaneously irrespective of events. So changes in price cannot be attributed to past, present and future events. A “likelihood” in price movements exists and this can be studied mathematically. He put his motivation to the words as following (Bachalier; 1900):

“past, present and even discounted future events are reflected in market price, but often show no apparent relation to price changes... if the market, in effect, does not predict its fluctuations, it does assess them as being more or less likely, and this likelihood can be evaluated mathematically.”

After Bachelier, many other studies carried out by Cowles (1933, 1944), and Working (1934) and Kendall (1953) examined stock and commodity price series. At the end of their research, the researchers found no serial correlation and concluded that prices show random behavior and they are unpredictable.

In his research paper about this topic, in which he collected and compiled all previous studies published about random walk behavior of stock prices, Cootner (1964) stated that:

“If any substantial group of buyers thought prices were too low, their buying would force up the prices. The reverse would be true for sellers. Except for appreciation due to earnings retention, the conditional expectation of tomorrow’s price, given today’s price, is today’s price. In such a world, the only price changes that would occur are

those that result from new information. Since there is no reason to expect that information to be non-random in appearance, the period-to-period price changes of a stock should be random movements, statistically independent of one another."

Although a lot of studies related to questioning stock price behaviors had been conducted, the concept of "*efficient market*" was never discovered until Samuelson (1965). Instead, the random behavior of stock prices was attributed to "fair game", which remained "*insufficient to lead random walk*" of stock prices (Fama 1970). Samuelson (1965), firstly, presented a formal economic argument for "*efficient market*" and explained market efficiency by using martingale process instead of random walk model.

Even though, the previous research mentioned above form the basis of Efficient Market Hypothesis, Fama (1970) is the first researcher who has firstly investigated Efficient Market Hypothesis in a widely comprehensive manner. In his study, he has presented a review of previous literature about stock price behavior by providing both theoretical and empirical framework on market efficiency and analyzed the distribution and serial correlation of stock returns. Based on comprehensive research, he concluded that "*the evidence in support of the efficient markets model is extensive and (somewhat uniquely in economics) contradictory evidence is sparse*" but "*much remains to be done*".

The widely known formal definition of "*efficient market*" is also provided by Fama (1970) by the following words: "*A market in which prices always "fully reflect" all available information is called "efficient".*"

However, this definition was to be extended by Rubinstein (1975) and Latham (1999) and "no transaction" requirement for efficiency was added to it (Copeland et al.; 2005: 355). Thus according to Rubinstein (1975) and Latham (1999):

“The market is said to be efficient with regard to an information event if the information causes no portfolio changes. It is possible that people might disagree about the implications of a piece of information so that some buy an asset and others sell in such a way that the market price is unaffected.”

The definition of the term is not limited to these. In another resource, the term “*efficient market*” is explained as follows (Sharpe et.al. 1999: 93, 95):

“A market is efficient with respect to a particular set of information if it is impossible to make abnormal profits (other than by chance) by using this set of information to formulate buying and selling decisions. The term “efficient capital market” is used to describe a market in which stock prices reflect all relevant and available information. In this sense, a market is said to be efficient if stock prices adjust rapidly and correctly to new information. New information is just that: new, meaning a surprise, as anything that is not a surprise is predictable and should have been anticipated before the fact.”

A market can be efficient under the following circumstances:

- All participants must be rational and seek to maximize their expected utility.
- All participants must be price takers. In other words, they must not be capable to affect market price.
- Informational efficiency must exist; that is no information cost, complete and simultaneous arrive of information to all participants
- Strong and developed market structure must be strongly developed.
- Transaction costs must be low.

2.4 Forms of Efficient Market Hypothesis

In an economic and financial environment the efficient markets are classified in different forms in the context of the relevant information availability in the market. The most common classification is as follows:

1. Weak form efficiency: Information in past prices or returns is not useful.
2. Semi-strong form efficiency: Publicly available information is not useful.
3. Strong form efficiency: Any relevant information, whether publicly available or not, is not useful.

Each stronger form captures weaker form of market efficiency. Meaning, if a market is strong form efficient, then it also meets the conditions for weak-form and semi-strong form efficiencies (See Figure 1). In other words, semi-strong form efficiency implies weak-form efficiency and strong-form efficiency implies semi-strong form efficiency.

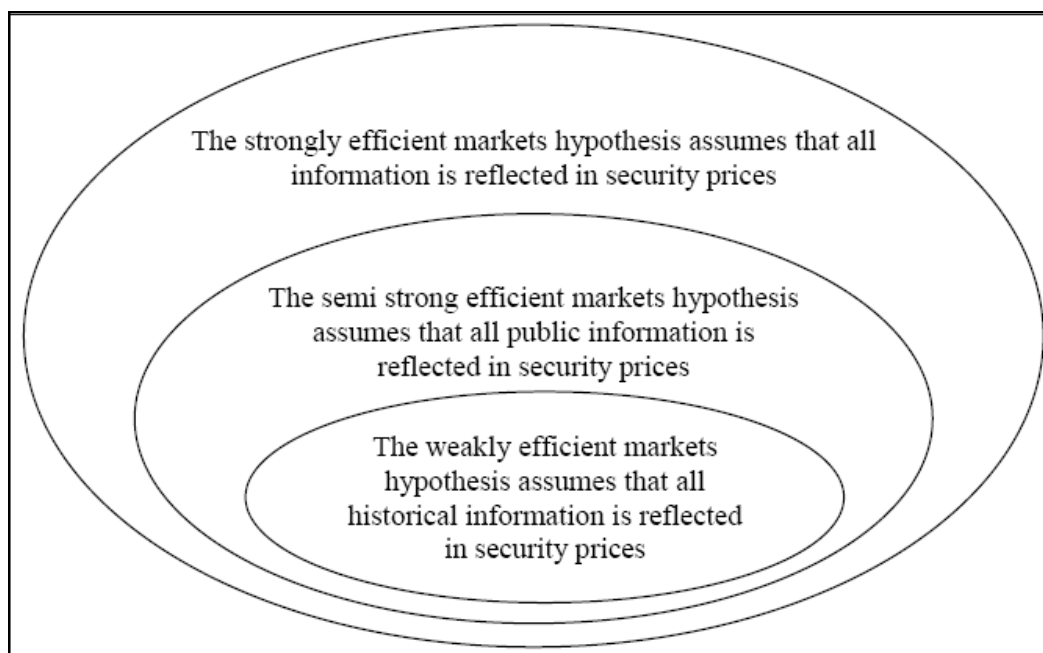


Figure 1 Relationship among Three Forms of Market Efficiency (Ross et al, 2002)

2.4.1 Weak Form Efficient Market Hypothesis

A market is said to satisfy weak-form efficiency if the security prices reflect the information of past prices. Weak form efficient market is the one having the weakest type of efficiency since the historical price data is the easiest kind of information to achieve.

Weak form market efficiency hypothesis states that stock prices are already incorporated with the information that can be derived by analyzing the market data such as historical prices, trading volume, and so on. The hypothesis asserts that it is impossible for investors to generate excess returns in the long run by examining the previous prices and making forecasts about future prices of stocks, except by chance, since stock prices show random walk behavior. Thus, the validity of the hypothesis implies that *technical analysis* is useless, which will be clarified below.

Technical analysis is defined as the sum of techniques that are used to predict the future behavior of stock prices by analyzing the past price movements. It attempts to search for predictable patterns to make higher profits. Defenders of technical analysis argue that in practice, stocks may not capture the newly arrived information immediately. Meaning, there is a likelihood of stocks to respond to newly arrived information in a sluggish way. And if the response of the stock price is slow enough, then the analyst will be able to determine a trend that can be exploited to generate abnormal returns during the adjustment period. The analysts believe that the price of a stock is likely to follow two kinds of trend patterns: *head-and-shoulders* and *trip-tops*. If stock price movements show a head-and-shoulder pattern, then the lower and higher prices can be identified and profit can be made by buying at low and selling at high. If triple-tops pattern is identified, then selling at the third top, the possible highest point before prices tend to go down, would be a good strategy to generate higher return (See Figure 2a and 2b).

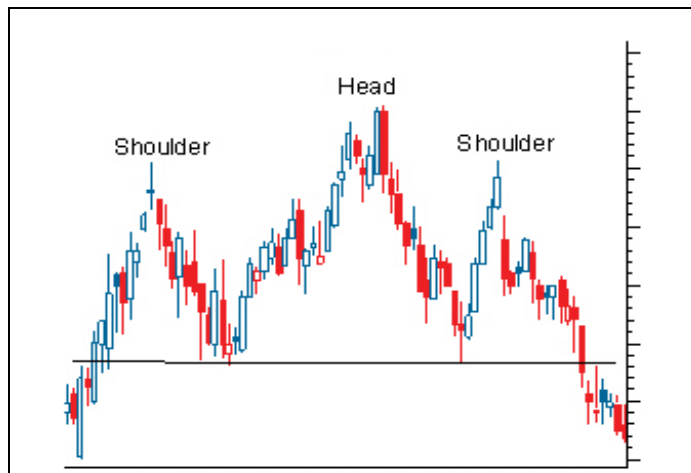


Figure 2.a. Head and Shoulders Pattern (*Source: www.investopedia.com*)

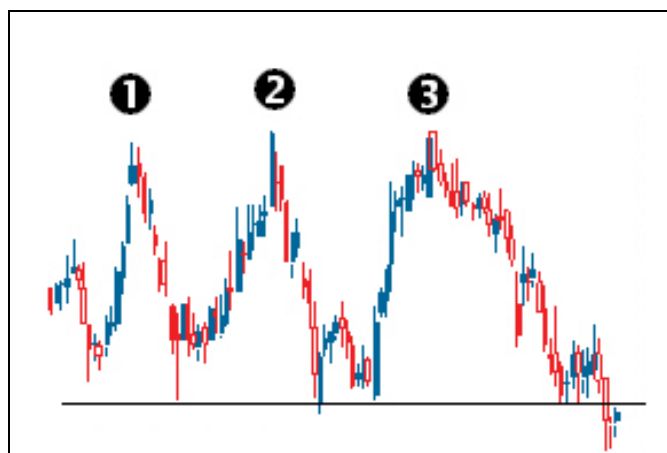


Figure 2.b. Triple Top Pattern (*Source: www.investopedia.com*)

However, weak form efficient market hypothesis denies what trend analysts believe and disregard the validity of technical analysis. According to the efficient market hypothesis, if it were possible to make excess profits simply by identifying a price pattern, then everyone would do it by accessing to historical prices at lower costs and thus, any profits would disappear eventually. As everyone in the market use the common information of historical prices or trading volumes of stocks, the stock prices will be driven to the levels where the expected rates of returns will be exactly proportionate with its risk. Thus, no excess returns will be generated.

2.4.2 Semi-Strong Form Efficient Market Hypothesis

A level ahead of weak-form efficiency is called semi-strong form market efficiency. Different from weak-form efficiency, in a semi-strong form efficient market stock prices are said to reflect all publicly available information in addition to historical price and trading volume information. The only requirement for a market to show semi-strong form efficiency is to be weak-form efficient.

Semi-strong form efficient market hypothesis asserts that stock prices already incorporate all publicly available information related with the company's performance, such as balance sheet, income statement, financial reports, patents held, dividend announcements, central bank announcements about interest rate and money supply, published macroeconomic data including growth rate, industrial production, inflation, exchange rates, unemployment rate, trade balance, retail sales, natural disasters, and so on. After the announcement of this information, participants react immediately and so do stock prices. Since stock prices already reflect all publicly available information, there is no possibility of ending up with excess returns.

Semi-strong form efficiency not only disregards technical analysis but also *fundamental analysis* which is a method for determining the proper price, in other words the intrinsic value, of a security by analyzing all relevant information which can be effective on securities value. For the purposes of determining the present value of stock, forecasting company's future performance, evaluating management and identifying the relevant risks, fundamental analysts study and examine all kinds of macroeconomic, financial and other company-related factors such as dividend and earnings announcements, company balance sheet, financial reports, financial ratios etc. The method mainly consists of three analyses namely economic, industry and company. At the end of the evaluation, appropriate trading strategy is recommended. For example, if the stock is *underpriced* "buy" strategy; if it is *overpriced* "sell" or "short sell" strategy is suggested to investors.

Efficient market hypothesis claims that fundamental analysis is futile as well as technical analysis for generating abnormal returns in the long run. If the publicly available information is already included in prices, then the estimated present value of the stock will be the same as its current market value, implying the nonexistence of excess return opportunity. Even if a difference exists in estimated intrinsic value and market value; again it will be very unlikely to beat the market consistently, because everyone in the market has access to the publicly available information and there will not be a considerable difference between the evaluations and trading strategies. *“Only analysts with a unique insight will be rewarded”* (Bodie et al., 2009: 351). In a semi-strong form efficient market, only the information which is not available to everyone will be useful.

In order to better visualize the issue, the following two figures illustrate stock price responses to newly arrived information are given. The first one shows the price responses of target companies before takeover attempts announcement. Since in most takeovers, the target company is paid a significant amount of premium over current market prices, this type of an announcement is perceived as being positive, causing the stock price to go up. As it is observed, the stock prices increase substantially, generating abnormal returns, on the day of announcement. Cumulative abnormal return jumps from 12% to about 25%. However, after the announcement, the returns seem to keep going closer in the following days, implying how fast the prices adjust to newly arrived information. The second graph shows the speed of adjustment of stock prices to the new information on a minute basis. The lines represent the average price movements of the stocks that are featured on CNBC. Top line belongs to the stocks with positive reports and bottom line belong to the stocks receive negative announcements. Prices of stocks with good news adjust to information within 5 minutes while the speed of adjustment of prices to negatively perceived information takes more than 10 minutes.

Notice that, in both figures, there seems insider trading. There are price run ups just before the announcements, as they are denoted with arrows. These may be due to leaking the already known information to outside before it occurs.

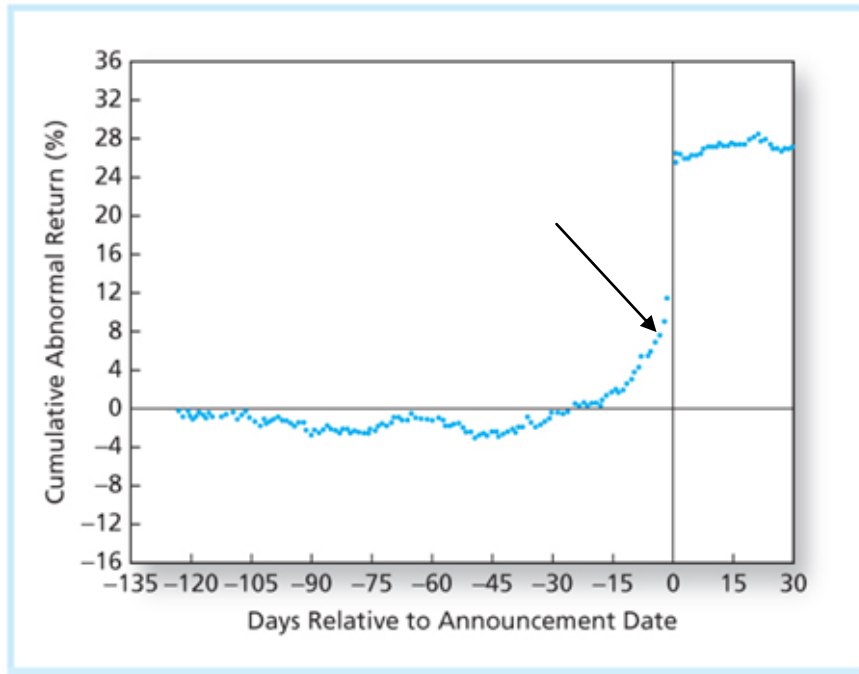


Figure 3.a. Cumulative Abnormal Returns before Take-Over Attempts: Target Companies
 (Source: Bodie et al. 2009: 346)

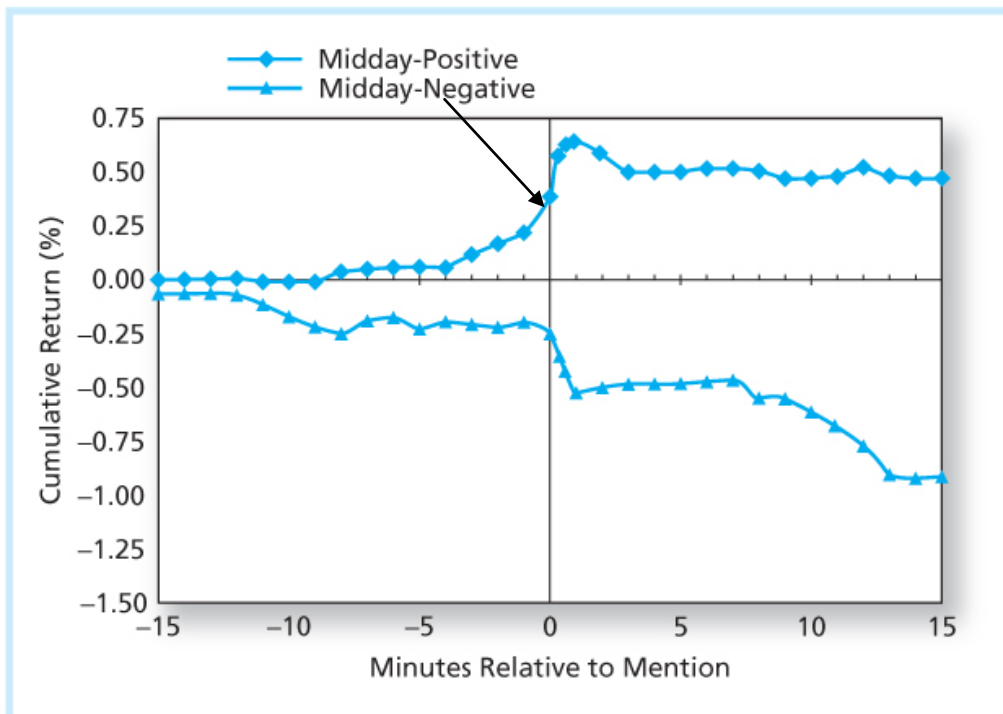


Figure 3.b. Stock Price Reaction to CNBC Reports
 (Source: Bodie et al. 2009: 347)

2.4.3 Strong Form Efficient Market Hypothesis

A market in which the stock prices are incorporated with all available information, including the *private information* as well as public information is called strong form efficient market. Here, the *private information* refers to any relevant information that is only access to the insiders of the company.

Thus, strong form efficient market hypothesis states that stock prices fully reflect all relevant available information, so that, even insiders cannot earn excess profits by using the data or information they know. It does not matter whether the information is accessible or inaccessible. Trying to take advantage of *special information* is completely fruitless.

However, this type of market efficiency is “*quite extreme*” and cannot be observed in real life. If any investor owns information that no one knows, then, no doubt, he or she will tend to turn it into an advantage for generating higher returns above the average.

Although, regulatory agencies like Securities and Exchange Commission (SEC) make and execute legal regulations for deterring insiders from using their private information while trading, it is really difficult to control and purge completely the insiders who make abnormal profits by using their privileges. Moreover, there are studies examining insider trading and providing evidence for inefficient markets in strong form. Thus, strong form market efficiency hypothesis does not seem to hold in practice. However, still many studies continue to being conducted for elaborating more on the issue.

2.5 How to test Efficient Market Hypothesis?

The studies done by academicians to test EMH and analyze the stock price changes fall into broad categories. As the theoretical background of EMH, three major theoretical models that are used to examine stock price behavior can be found in literature: *Fair game model*, *martingale and/or sub-martingale process*, and *random walk process*

Fair game model states that, given a large number of samples, the expected return on an asset is equal to its actual return on average. The model is mathematically expressed as follows:

$$\varepsilon_{j,t+1} = \frac{P_{j,t+1} - P_{jt}}{P_{jt}} - \frac{E(P_{j,t+1} | \eta_t) - P_{jt}}{P_{jt}} = \frac{P_{j,t+1} - E(P_{j,t+1} | \eta_t)}{P_{jt}} = 0 \quad (1)$$

where $P_{j,t+1}$ is the actual price of security j for next period, $E(P_{j,t+1} | \eta_t)$ is the predicted end-of-period price of security j given the current information structure, η_t , and $\varepsilon_{j,t+1}$ is the difference between actual and predicted returns.

Martingale and sub martingale are also fair game models. *Martingale* process is expressed as a stochastic process in which the conditional expectation of the future value of an asset is same as its current value, given the current and preceding values. Given a sequence of random variables, at a certain time period, martingale is the condition that the expected next value in the sequence is equal to the current observed value even all prior observed values are known. In other words, with a martingale, tomorrow's price of a stock is expected to be equal to today's price. Mathematical expression for a martingale process is presented as follows:

$$E(P_{j,t+1} | \eta_t) = P_{jt} \quad (2)$$

On the other hand, in *sub-martingale* case, next price of an asset is expected to be higher than current price. This implies that expected returns will be all positive and fair game will be observed. Because if all prices are expected to increase over time and if the market is efficient, then all portfolios will have positive returns, and the difference between returns of any two portfolios will be, no doubt, zero.

A *random walk* is a process where the current value of a variable is equal to its past value plus an error term which is called a white noise. A random walk model is mathematically represented as follows:

$$P_{jt} = P_{j,t-1} + \varepsilon_{jt} \quad (3)$$

where, P_{jt} and $P_{j,t-1}$ represent the current and previous stock prices, respectively, and ε_{jt} represents the white noise disturbance term with a zero mean and variance equal to one. The model states that, current price of an asset is stochastic and includes a value (ε_{jt}) that is independent of all previous information in addition to its past price. In a random walk process, all the parameters of a distribution such as mean, variance, skewness and kurtosis, must be same, and the successive drawings over time must be independent and belong to same distribution¹.

Fama (1970) asserted that the random walk model captures explains better the stochastic changes of the prices in economy and it is the most appropriate approach to be used in testing EMH. In his 1970 paper, he states that “*it is best to regard the random walk model as an extension of the general expected return or “fair game” efficient markets model in the sense of making a more detailed statement about the economic environment. The “fair game” model just says that the conditions of the market equilibrium can be stated in terms of expected returns, and thus it says a little about the details of the stochastic process generating returns. A*

¹ Copeland, Weston and Shastri (2005). “Financial Theory and Corporate Policy”, International 4th Edition, pg.368

random walk arises within the context of such a model when the environment is such that the evolution of investor tastes and the process generating new information combine to produce equilibria in which return distributions repeat themselves through time.”

In an efficient market, stock price changes are said to follow a *random walk*. As aforementioned above, *random walk hypothesis* implies that a stock price change in the past is unrelated to its price movement in the future. A market is said to be weak-form efficient if the stock prices reflect the information of past prices, meaning if the stock prices show random walk behavior. Therefore, talk about the weak form market efficiency, there should be no correlation between current and past changes of stock prices. In other words, stock prices should exhibit no serial dependency. They should be unpredictable and should not follow a pattern. Within this context, autocorrelation tests, runs tests, unit root tests, stationarity tests are the most commonly employed statistical methods to test the weak form efficiency in literature. Trading tests, like “buy and hold strategies”, are also used to detect whether the past returns are predictors of future returns (i.e. buying and holding the stock for short and long horizons, then comparing the returns for each horizon).

Once it is confirmed that the market is weak form efficient, further research is being done to test the semi-strong form efficiency. Event studies, regression and time series tests, and panel causality tests are the types of procedures used to test this type of market efficiency.

As to test the last form of EMH, strong form efficiency, the trading of the actors who are capable of achieving special information is investigated. Insiders, exchange specialists, analysts and institutional money managers are examples to those having monopolistic access to privately held information.

CHAPTER 3

3. EMPIRICAL LITERATURE ON EFFICIENT MARKET

HYPOTHESIS

Fama (1970) has presented a comprehensive review of the theory underlying the efficient market hypothesis. He in this paper, in addition to the theoretical background, has provided a review of the empirical studies for efficient market hypothesis. He has surveyed the studies that were conducted about weak form, semi-strong form and strong form efficiency tests and concluded that “with a few exceptions” the Efficient Market Hypothesis holds. Following Fama (1970), various studies have been done to test EMH. This chapter discusses the further and more recent empirical studies that are conducted to test EMH. Sections 3.1 and 3.2 present the studies that analyze the weak form and semi-strong form efficiency, respectively.

3.1 Empirical Evidence on Weak Form Market Efficiency

One can find vast empirical evidence on weak form market efficiency rooting back to 70s in the literature. However, this part will mainly cover the more recent evidence that were presented after 2000s. To make this section easier to follow, the studies below are listed in chronological order.

Kenourgios and Samitas (2005) examined daily spot and futures prices of copper traded at London Metal Exchange for the period of 1989-2000. In their study, they have used Augmented Dickey-Fuller (ADF) and Phillips- Perron (PP) unit root test to test EMH of the exchange. Based on their results, they have concluded that London Methal Exchange was not weak form efficient.

Gan et. al. (2005) have analyzed four stock exchanges: New Zealand Stock Exchange Index (NZSE), Australia Stock Exchange Index (ASX), Japan Nikkei Index and US New York Stock Exchange Index (NYSE). They have also employed ADF and PP tests to examine the unit root for series. The data have composed of daily, weekly and monthly closing prices, for the period 1990-2003. They have concluded that the markets subject to research were weak form efficient.

Çelik and Taş (2007) also have tested the EMH for twelve emerging stock exchange indices (Argentina, Brazil, Czech Republic, Egypt, Indonesia, Hungary, India, Israel, Korea, Mexico, Russia, and Turkey) by employing runs test, ADF, PP and Kwiatkowski – Phillips – Schmidt – Shin (KPSS) unit root tests and variance ratio tests. They have used the weekly data for the period of April 1998-April 2007. Their results have indicted that random walk behavior of stock prices were present for all markets, implying the evidence for weak form market efficiency.

Legoarde-Segot and Lucey (2008) have examined the daily prices for seven emerging Middle-Eastern North African (MENA) stock markets (Egypt, Morocco, Tunisia, Jordan, Lebanon, Israel and Turkey) between the period of 1994 and 2003. They have used KPSS test, individual variance ratio analysis, multiple variance ratio analysis, non-parametric variance ratio analysis. The KPSS and non-parametric variance ratio analyses results have revealed that markets are inefficient.

Another accomplishment in the field belongs to Torun and Kurt (2008) who have tested weak and semi-strong form efficiency of the stock exchanges for EMU countries by employing panel unit root tests and panel co-integration and causality tests. Their research covered the period of January 1999-December 2006, and they have used monthly data that included share price index, purchasing power index of euro, consumer price index and unemployment rate. They have employed LLC, IPS and ADF-F panel unit root tests to evaluate the presence of unit root in series; Holtz-Eakin, Newey and Rosen (1988) panel causality tests and Pedroni (1999, 2004) residual co-integration procedure to detect the causality and long term panel co-integration relationship between variables. The results have indicated that stock

market indexes of EMU countries have unit root and are exposed to random walk behavior. Also, causality from purchasing power index of euro and consumer price index to stock exchange index was found. Furthermore, a long term co-integration relationship between stock exchange indexes with other macroeconomic variables is detected. Based on these results, they have concluded that EMU countries stock exchanges are weak-form efficient but not semi-strong form efficient. Finally, they have suggested that “closer integration of the efficiency levels of EMU countries with low-form efficiency stock markets will bring a positive contribution to the sustainability of monetary union”.

Demireli et. al. (2010) have examined the weekly closing prices of S&P 500 Index for the period of 1991-2010, by employing Dickey Fuller (DF) and PP Tests. The results supported random walk model for the index, implying the presence of weak form market efficiency.

When all the above mentioned studies are examined, a common point observed is that all these studies have employed conventional linear unit root testing procedures. However, it has been proved and accepted that economic and financial time series may follow a nonlinear data generating processes. However, other studies that take the possibility of nonlinearity into consideration also exist in literature which will be covered in the following parts.

The study of Hasanov and Omay (2007) is one of those using nonlinear unit roots testing procedure in their research. In their study, they have tested the weak form market efficiency for stock price indices of eight transition markets, namely, Bulgarian, Chinese, Czech, Hungarian, Polish, Romanian, Russian and Slovakian. They have applied KSS nonlinear unit root test in addition to conventional ADF and PP unit root tests to detect whether the series contain unit root. Based on their ADF and PP tests results, they have concluded that, except for China and Russia, the stock markets are weak form efficient. However, KSS nonlinear unit root test results implied that the stock price series of Poland and Romania did not contain unit root as well as China and Russia.

Another study investigating weak form efficient market hypothesis by using nonlinear unit root tests belong to Omay and Karadagli (2010). Omay and Karadagli (2010) have examined the weak form efficiency for Bulgarian, Greek, Hungarian, Polish, Russian, Slovenian, Romanian, and Turkish stock markets for the period of January 2002- May 2010. They have both conduct linear and nonlinear unit root tests in their research. They have employed ADF, PP linear unit root tests, and nonlinear unit root tests of Kapetanios et al.(2003) (KSS test) and Ucar and Omay (2009) (UO test). According to ADF and PP tests results, they have concluded that all markets are weak form efficient. However, non linear panel unit root test results have supported the weak form market efficiency for all markets except for Russian, Polish and Romanian stock exchanges.

Karadagli and Donmez (2012) have also investigated the weak form efficiency of futures market for five Central and Eastern European Emerging Counties: Greece, Hungary, Poland, Russia, and Turkey. In addition to ADF and PP individual unit root tests, they have also employed IPS panel unit test. They have also run KSS and UO nonlinear individual and panel unit root tests as well. Their result have indicated that all futures markets were weak form efficient according to ADF and PP linear unit root tests, but Turkish and Polish futures markets were inefficient according to KSS test results. Moreover, linear panel unit root tests results have appeared to be in favor of weak form efficiency, while nonlinear panel unit root tests results have implied the markets were inefficient.

More recent studies in the area also exist. Chronologically speaking, Lim and Hooy (2013), have examined the nonlinear predictability of G7 stock markets. They have applied Brock-Dechert-Scheinkman (BDS) test on autoregression (AR)-filtered returns in rolling estimation windows. They have used daily index return for countries, Canada, France, Germany, Italy, Japan, the UK and the USA, covering sample period from 31 December 1979 and 29 June 2007. Their results have shown that there exists periods of nonlinear predictability of stock returns for all G7 countries.

The most recent and up-to-date study analyzing the weak form efficiency of stock indices by employing nonlinear panel unit root testing methodology has been carried out by Suresh et al (2013). In their paper, Suresh et al. (2013) have examined the stock indices of emerging BRICS countries. Their research period covers months between January, 2000 and December, 2010. They have applied UO nonlinear panel unit root test and concluded that the stock indices of the emerging BRICS countries are stationary, implying no weak form efficiency.

3.2 Empirical Evidence on Semi-Strong Form Market Efficiency

There are various empirical evidence on semi-strong form efficiency is in literature. In addition to the studies employing time series analyses, event studies in which the effects of company-specific announcements like dividends and earnings announcements on stock prices have been examined are also present. However, this section will mainly focus on the studies that have explored the relationship between stock indices and various macroeconomic variables by using different econometric methodologies.

As for the empirical evidence related with stock price-inflation relation, Nelson (1976), Miller et al. (1976), Fama and Schwert (1977), and Chen et al. (1986), Kool and Hafer (1988) are the earliest studies that have revealed a significant negative relationship between inflation and stock prices.

In 1981, based on previous studies, Fama (1981) analyzed the impact of inflation on stock return, and as a result suggested a conclusion called “proxy hypothesis”, which created a great motivation for the latter studies that test the relation between inflation and stock prices. *Proxy hypothesis* states that: if high inflation rates lead the low real growth rate of the economy and if high real stock returns anticipate high real growth rate, then inflation and stock returns move in opposite directions, therefore they are negatively correlated. This hypothesis’ importance for efficient market theory is that, if inflation and stock prices and/or returns are somehow related, then it could be possible to gain high returns by

following and analyzing the publicly available inflation announcements. If this happens, then the presence of semi-strong form market efficiency will be violated.

Studies of Geske and Roll (1983), Mandelker and Tandon (1985) and Kaul (1987) are the first studies that questioned Fama's claim. Their results appeared to be consistent with Fama's hypothesis and suggested that stock returns are significantly and negatively related with inflation.

Balduzzi (1995) brought up the Fama's (1981) "proxy hypothesis" argument and reinvestigated the relationship between stock returns and inflation by using quarterly data of industrial production growth, monetary base growth, 3-month T-bill rates, CPI inflation and return of equally weighted NYSE portfolio for periods 1954-1976 (as the sample period examined by Fama, 1981) and 1977-1990. He used vector autoregression, implied vector moving averages and variance-decomposition techniques for testing the proxy hypothesis. He found strong and negative correlation between inflation and stock returns in response to inflation and short term nominal interest rates shocks.

In late 1990's and early 2000's, except from Balduzzi (1995) many other studies (i.e. Lee (1992), Marshal (1992), Boudoukh and Richardson (1993), Boudoukh et al. (1994), Aarstol (2000), Choudry (2001), Carmichael and Samson (2003), Duman and Karamustafa (2004)) continued to be conducted with the aim of exploring Fama's argument. All these studies concluded in favor of Fama's hypothesis.

The existence of this considerable empirical evidence on the relationship between inflation and stock prices led researchers to conduct studies that question the impact of other macroeconomic variables on stock prices and returns. In this context, Geske and Roll (1983), Chen et. al (1986) and Fama (1990) appeared to be the earliest researches. In their works, these authors have studied the relationship between the industrial production index and stock prices and as a result have concluded that the two variables are positively related. Kasman (2006) has analyzed

the same relationship for Turkey covering the period 1986-2003 and found unidirectional causality running from industrial production index to stock prices.

Darrat (1990) has found that economic variables such as long-term bond rate, interest volatility, and industrial production are significantly related with stock prices, and negative relation between inflation and stock returns, implying evidence contradict with semi-strong form market efficiency for Canadian stock market.

On the other hand, Menike (2006) has analyzed the effects of macroeconomic variables on stock prices by using regression method. He has concluded that stock prices are negatively related with inflation and interest rates, and positively related with money supply. Ratanapakorn and Sharma (2007) have employed VECM and Granger causality tests to explore the relationship between stock prices and macroeconomic variables. Their findings were consistent with those of Menike (2006).

Hsing (2011) has chosen to apply EGARCH methodology to examine the relationship among stock prices, inflation, interest rates and money supply. His results confirmed the previous two researches mentioned above. Based on his findings, he claimed that stock prices are negatively associated with inflation and interest rates while they are positively related with money supply.

As aforementioned in the preceding section, Torun and Kurt (2008) have also tested semi-strong form efficiency of the stock exchanges for EMU countries by employing panel co-integration and causality tests. They have carried out Holtz-Eakin, Newey and Rosen (1988) panel causality tests and Pedroni (1999, 2004) residual co-integration procedure to detect the causality and long term panel co-integration relationship between variables. They have found causality running from purchasing power index of euro and consumer price index to stock exchange index, in addition to a long term co-integration relationship between stock exchange indexes with other macroeconomic variables. Finally, they have concluded that EMU countries stock exchanges are not semi-strong form efficient.

Caldas and Terra (2011), have reinvestigated the causality between stock returns and inflation, interest rates, and real activity by examining 15 developed (Austria, Belgium, Canada, Denmark, France, Germany, Greece, Italy, Japan, Netherlands, Norway, Spain, Sweden, United Kingdom, and the United States) and 16 developing countries (Brazil, Chile, China, Colombia, Czech Republic, Hungary, India, Israel, Malaysia, Mexico, Peru, Philippines, Poland, South Africa, South Korea, and Turkey). They employed vector autoregressive approach (VAR) and Granger causality tests. Their results show that no Granger causality exists for 11 of the 16 developing countries, while the evidence is mixed for the developed countries. For Brazil, Mexico and South Korea results indicate a positive relation between stock returns and real activity, and a negative relation between inflation and stock returns. For the developed countries, a very low relation was observed between inflation and stock returns, but some relation between real activity and inflation, real activity and stock returns.

Al-Khazali and Pyun (2004) have employed ADF and PP unit root tests, Johansen co-integration test, Vector Error Correction Model (VECM) and VAR method to examine the relationship between stock prices and inflation for Australia, Hong Kong, Indonesia, Japan, South Korea, Malaysia, the Philippines, Singapore, and Thailand. They have found a long-run relationship between stock prices and inflation.

Hussain et al. (2012) have analyzed the impact of macroeconomic variables on stock prices by using KPSS unit root test, Johansen Co-integration test, Vector Error Correction Model (VECM) and Granger Causality tests, and found a long-term relationship between these variables and stock prices. Interest rates and money supply appeared to be significantly and positively related with stock prices, while the industrial production index is found to have a significant but negative relation with stock prices. Also, money supply was found to be the cause of stock prices but no causality was found with industrial production index and interest rates.

Rasheed and Mustaq (2013) have examined the relationship between gold prices and stock returns of Karachi stock exchange by using monthly data for the period 1997-2011 and employing unit root, co-integration and granger causality tests. They have found a significant long-run and bidirectional causal relationship between the gold prices and stock returns and claimed that gold prices have an important role in determining the stock returns.

All in all, as one of the latest studies, Rahim (2013) has investigated the impact of interest rate, industrial production, exchange rate and inflation rate on stock returns on an industrial basis for Pakistan by using yearly data for the period of 2002-2009. While the results implied that stock returns were positively related with exchange rates and negatively related with inflation, no significant relationship occurred with interest rates and industrial production.

CHAPTER 4

4. DATA AND METHODOLOGY

This chapter provides information regarding the data and methodology used in this research. First, the data used to test EMH will be explained. Then, the methodologies employed during the research process will be introduced and discussed.

4.1 Data

This research uses *monthly* data to test the efficient market hypothesis over the period 1999:01-2013:07 for a group of eleven Euro area member states: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. The data used to test the efficient market hypothesis in its weak and semi-strong form is comprised of the eight main financial and macroeconomic indicators of the included Euro area member states. The aforementioned eight indicators include the stock market index (SI), unemployment rates for countries (Uc), unemployment rates for Euro area (Ue), long-term interest rate (LIR), short term interest rate (SIR), world gold price (GOLD), world crude oil price (OIL), consumer price index for countries (CPIc), consumer price index Euro area (CPIe), narrow money supply (M1), and industrial production index (IP). The analysis excludes the remaining Euro area member states, namely Cyprus, Greece, Estonia, Malta, Slovakia, and Slovenia; for which the necessary data were only available for a short period of time. The data used in the study were collected from the electronic databases of Euro Stat, OECD library and International Financial Statistics (IFS). All variables were put into natural logarithms before the analyses. The base year for all price indices and the industrial production index were 2005.

The *SI* are the share price indices that aim to represent share price movements of companies quoted on stock exchanges of EMU countries: ATX (Austria), BEL20 (Belgium), HEX (Finland), CAC40 (France), DAX30 (Germany), ISEQ (Ireland), FTSEMIB (Italy), LUXX (Luxembourg), AEX (Netherlands), PSI20 (Portugal), and IBEX35 (Spain). *Uc* and *Ue* represent seasonally adjusted harmonized unemployment rates that give the number of unemployed persons as a percentage of the labor force for countries and Euro area, respectively. *LIR* refers to the yield on 10-year government bonds obtained from each country's national bank records while *SIR* represents the 3-month "European Interbank Offered Rate" from the date the country joined the euro. *MI* is monetary aggregate that comprises currency in circulation and overnight deposits for Euro area. The *CPI* dataset measure the average changes in the prices of consumer goods and services purchased by household and shows the growth previous period. *IP* data is seasonally adjusted and covers industrial activities in mining, quarrying, manufacturing and electricity, gas and water for each country. *GOLD* and *OIL* are world prices of gold and crude oil represented by U.S. dollars per ounce and per barrel.

4.2 Methodology

In this thesis, the methodology based on random walk model is used to test the weak form efficiency of EMU stock markets. EMH asserts that price changes follow a "random walk". If stock prices follow a random walk, then stock prices are characterized by a unit root (Omay and Karadagli, 2010). Moreover, EMH also states that, since the stock price movements are unpredictable, there should be no causality between stock prices and any publicly available information. Therefore, panel unit root tests were run to test the weak form efficiency; and for the purpose of testing semi-strong form efficiency causality tests were employed. The following part explains the reasons behind executing panel study and provide brief information about the methodologies employed in the research.

Panel techniques for testing unit root have received a remarkable attention in the recent decades. Many classical unit root tests in a single time series setting suffer from low power compared to near unit root alternatives. One solution to this power problem is to use long-span data and enlarge the time range of the series. Using long-span data is considered to be the easiest way to overcome this problem and increase the power of unit root tests. However, this alternative is a very restrictive approach in cross-county comparisons since it can only be applied to counties where such long data series are available (Carvalho and Julio, 2012). Second proposed solution to the power problem is to expand the cross-section dimension of the database by including several countries and apply panel of several univariate time series techniques (Carvalho and Julio, 2012; He and Sandberg, 2006). In all panel unit root tests cross-section data is pooled for generating more powerful tests but this may lead to other problems such as contemporaneous correlation between observations.

Although, with a few exceptions, most studies testing EMH conclude in favor of weak and semi-strong form efficiency, they all neglect the possibility of nonlinearities in conditional mean of the series in their analyses. However, the evidence is clear that many economic and financial time series follow nonlinear processes (Granger and Terasvirta, 1993; Franses and van Dijk, 2000). Therefore, possible nonlinearities in data generating process should explicitly be taken into account in analyzing financial time series in order to avoid spurious results (Hasanov and Omay, 2007).

Unlike previous studies, our study contributes to literature by considering the possibility of nonlinearities and cross-sectional dependency, and conduct appropriate panel unit root and causality tests to detect the EMH in its weak and semi-strong forms. The following sections present the employed methodologies in sequence.

4.2.1 Linear Panel Unit Root Tests

The most commonly used linear panel unit root tests belong to Levin et al. (2002)-LLC, Im et al. (2003)-IPS, and Madala and Wu (1999)-Fisher-ADF test. In addition to these tests, a panel stationary test which is known as the Hadri test (Hadri 2000) is also used to detect the stationarity of a series in a panel study.

Suppose that the stochastic process, y_{it} , is generated by the first order autoregressive AR(1) process:

$$y_{it} = \rho_i y_{it-1} + X_{it} \delta_i + \varepsilon_{it}, \quad (4)$$

where $i=1,2,..N$, represents the cross-section series; $t=1,2,..T_i$, represents the time period; X_{it} represents the exogenous variables included in the study (with fixed effects or individual trends); ρ_i and ε_{it} represent autoregressive coefficient and mutually independent idiosyncratic disturbance term, respectively. If $|\rho_i| < 1$ then, y_{it} is stationary and contain no unit root. If $|\rho_i| = 1$ then, y_{it} has a unit root.

Two assumptions are made regarding the autoregressive coefficient ρ_i . In the first one, persistent parameters are assumed to be common for all cross-section series, implying $\rho_i = \rho$ for all i . In the second one, the coefficient ρ_i is assumed to change freely across cross-sections. LLC and Hadri tests use the first assumption while IPS and ADF-Fisher tests are based on the second assumption.

The Levin et al. (LLC) Test: Levin, Liu and Chu (2002) test assumes a common unit root process and is based on the following ADF model:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{\rho_i} \beta_{ij} \Delta y_{it-j} + X_{it} \delta_i + \varepsilon_{it}, \text{ where } \alpha = \rho - 1 \quad (5)$$

The model allows for individual (common) intercepts and heterogeneity across the cross-sections. Error term is assumed to be independent and identically distributed. Heteroscedasticity can exist across individuals. The test evaluates the null hypothesis where the series contain unit root against the alternative hypothesis that the series are stationary: $H_0: \alpha_i = 0$, $H_1: \alpha_i \neq 0$. LLC test is based on a modified t-statistic obtained from a pooled proxy regression equation where the estimate of the coefficient α is obtained and the test shows that α is normally distributed under the null hypothesis.

The Im et al. (IPS) Test: Im, Pesaran and Shin (2003) proposed a more flexible panel unit root testing model compared to the LLC test. IPS based their model on the same ADF specification as LLC did, but with the exception that individual unit root is assumed rather than common unit root. IPS model allows for the autoregressive coefficient ρ_i to vary across the N cross-section series of the panel. The model tests the null of $H_0: \alpha_i = 0$, for every i, against the alternative hypothesis which is expressed as:

$$H_1: \alpha_i = 0, \text{ for } i = 1, 2, \dots, N_1 \text{ and } \alpha_i < 0, \text{ for } i = N+1, N+2, \dots, N \quad (6)$$

They estimate separate ADF regressions and obtain t-statistics for each element of the panel. They take the average of those t-statistics and construct a standardized t-bar statistic. They show that a properly standardized t-bar statistic has an asymptotic standard normal distribution under the null hypothesis.

The Fisher-ADF Test: Madala and Wu (1999) and Choi (2001) proposed a panel unit root test that employs Fisher's (1932) results and derive testing procedures that include a combination of p-values from individual unit root tests.

The test is built on the IPS test. However, here the main idea is to combine the p- values obtained from individual unit root tests for each cross-section unit. Let π_i be the p-value from any individual unit root test for each cross-section i. If π_i for the cross-section I are uniformly distributed in (0,1), then under the null hypothesis of a unit root:

$$-2 \sum_{i=1}^N \log \pi_i \rightarrow \chi^2 2N \tag{7}$$

The Fisher-ADF test's superiority over IPS lies in it being non-parametric, exact and more reliable, since it also takes into account that each cross-section unit of the panel can have distinct sample sizes.

The Hadri Test: Hadri (2000) proposes a stationary test for panel data that is similar to the KPSS test. Hadri test is mainly based on the residuals obtained from the individual OLS regressions of variables on constant or on constant and trend. The test evaluates the null that the series in question is stationary or contains no unit root against the alternative non-stationarity or random walk. For this purpose, it forms Lagrange multiplier (LM) test statistic with the cumulative sum of residuals obtained from each individual regression.

Researchers should pay attention while employing this procedure since the test suffers from considerable size distortion due to autocorrelation in case of no unit root. Moreover, there is a possibility of over-rejecting the null hypothesis and giving results that contradict with those obtained from other alternative methods.

Although using panel data approach in unit root testing has its own merits like increasing the power of the conventional unit root tests, it also generates other extra problems that are not present in univariate time series techniques, such as cross-sectional dependence. Cross-sectional dependence may arise due to spatial correlations, spill-over effects, economic distance, omitted global variables and common unobserved shocks and it may lead to biased estimates and misleading inference (Omay and Kan, 2010). A serious shortcoming of aforementioned linear panel unit root tests is that, none of them takes into account the likely presence of the cross-sectional dependence between countries included in a study. Ignoring the cross-sectional dependence may cause considerable size distortions in the analysis and may lead to over-rejections of the null hypothesis by causing substantial increases in the size of the linear panel unit root tests.

While it is claimed that as the size of the panel increases and becomes large enough, the cross-section dependence stops to be a serious problem (Gonzalez et al., 2005), Pesaran (2004) argues that cross-section dependence can still exist in large panels. Therefore, it is not sufficient to enlarge the size of the panel to overcome the problem. Moreover, it is well known that conventional linear unit root tests suffer from low power problem if the true data generating process is nonlinear (Omay and Karadagli, 2010). As aforementioned at the beginning of this chapter, many economic and financial time series follow nonlinear processes (Granger and Terasvirta, 1993; Franses and van Dijk, 2000). Recent studies also confirm that the stock price indices show nonlinear data generating processes (Narayan, 2005; Hasanov and Omay, 2007; Lim and Brooks, 2009; Munir and Mansur, 2009; Hasanov 2009). The reasons behind the nonlinearity of the indices are mostly explained as the presence of market frictions and transaction costs (Hasanov, 2009).

Therefore, possible nonlinearities in data generating process should be taken into account in the analyses of economic and financial series (Hasanov and Omay, 2007). In order to deal with these low power and cross-sectional dependence problems, we used the sieve bootstrap methodology outlined in Ucar and Omay (2009) which is explained in the following part.

4.2.2 Nonlinear Panel Unit Root Tests

Ucar and Omay (2009) (henceforth: UO test) have developed unit root tests for nonlinear and heterogeneous panels by using the nonlinear time series framework of Kapetenois et al (2003) (henceforth: KSS test) and panel unit root testing framework of Im et al (2003). The derivation of the model is given as follows:

Let $y_{i,t}$ be panel exponential smooth transition autoregressive process of order one (PESTAR(1)) on the time domain $t = 1, 2, \dots, T$ for the cross-section units $i=1, 2, \dots, N$. Consider $y_{i,t}$ follows the data generating process (DGP) with fixed effect (heterogeneous intercept) parameter α_i :

$$\Delta y_{i,t} = \alpha_i + \phi_i y_{i,t} + \gamma_i y_{i,t-1} \left[1 - \exp(-\theta_i y_{i,t-d}^2) \right] + \varepsilon_{i,t} \quad (8)$$

where $d \geq 1$ is the delay parameter and $\theta_i > 0$ implies the speed of mean reversion for all i .

By referring to the previous literature, Ucar and Omay (2009) set $\phi_i = 0$ for all i and $d=1$, which gives specific PESTAR (1) model:

$$\Delta y_{i,t} = \alpha_i + \gamma_i y_{i,t-1} \left[1 - \exp(-\theta_i y_{i,t-d}^2) \right] + \varepsilon_{i,t} \quad (9)$$

Nonlinear panel data unit root test based on regression (9) is simply to test the null hypothesis $\theta_i = 1$ for all i against $\theta_i > 0$ for some i under the alternative. However, direct testing of the $\theta_i = 1$ is somewhat problematic because γ_i is not identified under the null. The problem can be solved by applying first-order Taylor

series expansion to the PESTAR(1) model around $\theta_i = 1$ for all i . Hence, the obtained auxiliary regression is given by:

$$\Delta y_{i,t} = \alpha_i + \delta_i y_{i,t}^3 + \varepsilon_{i,t} \quad (10)$$

where $\delta_i = \theta_i \gamma_i$.

The hypotheses for unit root testing based on regression (10) are set by Ucar and Omay (2009) as follows:

$$H_0 : \delta_i = 0, \text{ for all } i, \quad (\text{linear nonstationarity})$$

$$H_1 : \delta_i < 0, \text{ for some } i, \quad (\text{nonlinear stationarity})$$

The UO test is structured by standardizing the average of individual KSS statistics across the whole panel. The KSS test for the i^{th} individual is simply t-statistics for testing $\delta_i = 0$ in regression equation (10) is defined by:

$$t_{i,NL} = \frac{\Delta y_i' \mathbf{M}_\tau y_{i,-1}^3}{\hat{\sigma}_{i,NL} (y_{i,-1}' \mathbf{M}_\tau y_{i,-1})^{3/2}} \quad (11)$$

where $\hat{\sigma}_{i,NL}$ is the consistent estimator such that:

$$\hat{\sigma}_{i,NL}^2 = \Delta y_i' \mathbf{M}_\tau \Delta y_i / (T-1), \mathbf{M}_\tau = \mathbf{I}_T - \tau_T (\tau_T' \tau_T)^{-1} \tau_T'$$

Note that $\Delta y_i = (\Delta y_{i,1}, \Delta y_{i,2}, \dots, \Delta y_{i,T})$, $y_{i,-1}^3 = (y_{i,0}^3, y_{i,1}^3, \dots, y_{i,T-1}^3)$ and

$$\tau_T = (1, 1, \dots, 1)'$$

Moreover, when the invariance property and the existence of moments are satisfied, the usual normalization of \bar{t}_{NL} statistic occurs as:

$$\bar{Z}_{NL} = \frac{\sqrt{N} \left(\bar{t}_{NL} - E(t_{i,NL}) \right)}{\sqrt{Var(t_{i,NL})}} \xrightarrow{d} N(0,1) \quad (12)$$

Where, $\bar{t}_{NL} = \frac{1}{N} \sum_{i=1}^N t_{i,NL}$, $E(t_{i,NL})$ and $Var(t_{i,NL})$ values are presented in Table 1 of

Ucar and Omay (2009) as in the following:

Table 1 Moments of $t_{i,NL}$ Statistic (Ucar and Omay, 2009: 6)

T	$E(t_{i,NL})$	$Var(t_{i,NL})$
5	-1.866	2.695
10	-1.620	0.823
15	-1.602	0.760
20	-1.602	0.740
25	-1.604	0.737
30	-1.605	0.735
40	-1.616	0.735
50	-1.626	0.727
100	-1.652	0.727
500	-1.675	0.725
1000	-1.677	0.721
100000	-1.677	0.716

Until here, cross-section dependency has not been mentioned. It is generally assumed that disturbances in panel data models are cross-sectionally independent (Pesaran, 2004). However, the cross-section dependency may arise due to several reasons such as spatial correlations, spillover effects, economic distance, omitted global variables and common unobserved shocks. The presence of cross-section dependence may lead biased estimates and misleading results. Thus, we take into account the cross-section dependence and run our tests under cross-section dependency to prevent any misleading results.

In addition to linear and nonlinear panel unit root tests, we also employed a panel causality technique to test the semi-strong form efficiency. The methodology that we employed is a new technique that takes cross dependence problem into account and has been developed by Emirmahmutoglu and Kose (2011) for heterogeneous mixed panels. The next section briefly describes this newly developed panel causality method.

4.2.3 Panel Causality Test

Emirmahmutoglu and Kose (2011) (henceforth: EK) have introduced a new panel Granger causality methodology based on Meta analysis² in heterogeneous mixed panels. They have used LA-VAR approach and extend it via Meta analysis to test Granger causality between variables in heterogeneous mixed type panel studies. They have considered heterogeneous panel VAR (k_i) model with p variables:

$$Z_{i,t} = \mu_i + A_{i1} z_{i,t-1} + \dots + A_{iki} z_{i,t-k_i} + u_{i,t} \quad i = 1, 2, \dots, N; \quad t = 1, 2, \dots, T \quad (13)$$

where the index i denotes individual cross-sectional units and the index t denotes time periods. μ_i is a p dimensional vector of fixed effects. A_{i1}, \dots, A_{iki} are fixed ($p \times p$) matrices of parameters that are allowed to vary across units. For each cross-section unit $i=1,2,\dots,N$, $u_{i,t}$ is a column vector of p error terms. For all time periods, the

² A statistical technique developed by Fisher (1932). For detailed explanation, see: Fisher, R.A., 1932. Statistical Methods for Research Workers, 4th edition. Oliver and Boyd, Edinburgh.

vector $u_{i,t}$ is independently and identically distributed (i.i.d) across individual with $E(u_{i,t})=0$ and $V(u_{i,t})=\Sigma u_i$ is positive definite covariance matrices. The order k_i of the process is assumed to be known or it may be estimated by some model selection criterion (Lutkepohl, 2005). Also, the lag structure (k_i) may differ across cross-sectional units.

Based on the statement that “Wald tests are standard tools for testing restrictions on the coefficients of VAR systems”, EK have led $\alpha_i = \text{vec}[\mu_i, A_{i1}, \dots, A_{iki}]$ for $i=1, \dots, N$ be the vector of all VAR coefficients. In order to test q_i independent linear restrictions on cross-sectional unit i , in the case of Granger non-causality, they have expressed the null and heterogeneous alternative hypotheses as follows:

$$H_0 : R_i \alpha_i = 0 \text{ for all } i \quad (14)$$

$$H_1 : R_i \alpha_i \neq 0 \text{ for } i = 1, \dots, N_1 \text{ and } R_i \alpha_i = 0 \text{ for } i = N_1 + 1, \dots, N \quad (15)$$

where R_i is a $(q_i \times p^2 k_i)$ matrix with rank q_i for each cross-sectional units and 0 is a $(q_i \times 1)$ zeros vector. They also have stated that, “if z_{it} is partitioned in m and $(p-m)$ dimensional subvectors $x_{i,t}$ and $y_{i,t}$, then:

$$z_{i,t} = (x_{i,t}, y_{i,t}) \text{ and } A_{ij} = \begin{bmatrix} A_{11,ij} & A_{12,ij} \\ A_{21,ij} & A_{22,ij} \end{bmatrix} \quad i = 1, 2, \dots, N ; j = 1, 2, \dots, k_i$$

where A_{ij} are partitioned in accordance with the partitioning of $z_{i,t}$, then $y_{i,t}$ does not Granger cause $x_{i,t}$ if and only if the heterogeneous hypothesis $H_0 : A_{12,ij} = 0$ for $i=1, 2, \dots, N, j=1, 2, \dots, k_i$ is true”. They have expressed the panel VAR (k_i) model (13) in the following matrix notation for all individual units as:

$$Z_i = B_i Q_i + U_i \quad (16)$$

where for all $i = 1, 2, \dots, N$:

$Z_i = (z_{i,1}, \dots, z_{i,T})(p \times T)$ matrix

$B_i = (\mu_i, A_{i1}, \dots, A_{iki}) (p \times (pk_i + 1))$ matrix

$$Q_{it} = \begin{bmatrix} 1 \\ z_{i,t} \\ \vdots \\ z_{i,t-k_i+1} \end{bmatrix} \quad p k_i + 1 \times 1 \text{ matrix}$$

$Q_i = (Q_{i,0}, \dots, Q_{i,T-1})(pk_i+1)$ matrix

$U_i = (u_{i,1}, \dots, u_{i,T})(p \times T)$ matrix

Then the OLS estimator of the B_i for all individual units is expressed as follows:

$$\hat{B}_i = Z_i Q_i' Q_i Q_i'^{-1} \quad (17)$$

and,

$$\hat{\alpha}_i = \text{vec } \hat{B}_i$$

The asymptotic normal distribution of $\hat{\alpha}_i$ is presented as:

$$\sqrt{T} \hat{\alpha}_i \xrightarrow{d} N(0, \Gamma_i^{-1} \otimes \sum u_i) \quad (18)$$

for all $i = 1, 2, \dots, N$, where $\Gamma_i = p \lim Q_i Q_i' / T$ and \xrightarrow{d} denotes convergence in distribution.

The standard individual Wald statistics for testing H_0 is given as:

$$W_i = T \hat{\alpha}_i' R_i' \left(R_i' Q_i Q_i'^{-1} \otimes \hat{\Sigma}_{u_i} \right)^{-1} R_i \hat{\alpha}_i \quad (19)$$

for $i=1, 2, \dots, N$; where $\hat{\Sigma}_{u_i}$ is consistent OLS estimator of $\sum u_i$. EK have stated that “the individual Wald statistics have an asymptotic chi-square distribution with q_i degrees of freedom if $\hat{\Sigma}_{u_i}$ is nonsingular. If variables in VAR process are stationary, OLS estimators and Wald statistics are valid. However, if variables contain unit roots, then Wald statistics based on OLS estimation of level VAR model have non-standard asymptotic distributions that may involve nuisance parameters (Sims et al., 1990). Therefore, Granger causality test is not valid for non-stationary variables”. In order to prevent this problem, they have referred to Toda and Yamamoto (1995) who proposed a simple alternative approach for testing coefficient restrictions of a level VAR model. For testing the null hypothesis (14), they have considered estimating a level VAR ($k_i + d\max_i$) in heterogeneous mixed panels:

$$z_{i,t} = \mu_i + A_{i1}z_{i,t-1} + \dots + A_{ik}z_{i,t-k} + \sum_{l=k_i+1}^{k_i+d\max_i} A_{il}z_{i,t-l} + u_{i,t} \quad i=1,2,\dots,N, t=1,2,\dots,N \quad (20)$$

By noticing that the parameter restrictions (14) do not contain A_{il} 's, EK have claimed that the null hypothesis (13) can be tested by using a standard Wald statistics. Under the null hypothesis (13), the individual Wald statistics have an asymptotic chi-square distribution with q_i degrees of freedom even if variables are non-stationary but integrated at order not greater than $d\max_i$. They have employed the Fisher test statistic proposed by Fisher (1932) for testing the Granger non-causality hypothesis in heterogeneous panels. They have stated that “if the test statistics are continuous, p -values p_i ($i=1, \dots, N$) are independent uniform (0,1) variables”. For the case, Fisher test statistic (λ) is expressed as follows:

$$\lambda = -2 \sum_{i=1}^N \ln p_i \quad (21)$$

for $i = 1, 2, \dots, N$, where p_i is the p -value corresponding to the Wald statistic of the i^{th} individual cross-section. This test statistic has a chi-square distribution with $2N$ degrees of freedom. The test is valid only if N is fixed as $T \rightarrow \infty$.

However, they have asserted that the limit distribution of the Fisher test statistic does not hold when cross correlations among the cross-sectional units exist. Therefore, to overcome this problem in panels with cross correlations, they have employed the bootstrap methodology to test the Granger causality for cross-sectional dependent panels.

They have considered the level VAR model with $k_i + d \max_i$ lags in heterogeneous mixed panels (Equations 22 and 23):

$$x_{i,t} = \mu_i^x + \sum_{j=1}^{k_i+d \max_i} A_{11,ij} x_{i,t-j} + \sum_{j=1}^{k_i+d \max_i} A_{12,ij} y_{i,t-j} + u_{i,t}^x$$

$$y_{i,t} = \mu_i^y + \sum_{j=1}^{k_i+d \max_i} A_{21,ij} x_{i,t-j} + \sum_{j=1}^{k_i+d \max_i} A_{22,ij} y_{i,t-j} + u_{i,t}^y$$

where $d \max_i$ is maximal order of integration suspected to occur in the system for each i . In simplicity, they have focused on testing the causality running from x to y in equation (23). They have applied a similar procedure for causality from y to x in equation (22). The steps of their bootstrap procedure have been explained in their paper as follows:

Step 1: Firstly, in order to determine maximal order of integration of variables in the system for each cross-section unit, they have used the traditional unit root tests as Dickey and Fuller (1981). Then, they have estimated the regression (23) by OLS for each individual and select the lag orders k_i 's via Schwarz information criteria (SIC) or Akaike information criteria (AIC) by starting $k_i=8$ and applying a top to down strategy.

Step 2: By using k_i and $d \max_i$ from step 1, they have re-estimated equation (23) by OLS under the non-causality hypothesis ($A_{21, i1} = \dots = A_{21, iki} = 0$) and obtain the residuals for each individual.

$$\hat{u}_{i,t}^y = y_{i,t} - \hat{\mu}_i^y - \sum_{j=k_i+1}^{k_i+d \max_i} \hat{A}_{21,ij} x_{i,t-j} - \sum_{j=1}^{k_i+d \max_i} \hat{A}_{21,ij} y_{i,t-j}$$

(24)

Step 3: Stine (1987) have asserted that residuals have to be centered with:

$$u_t = u_t - T^{-k-l-2} \sum_{t=k+l+2}^T u_t \quad (25)$$

where $u_t = (u_{1t}, u_{2t}, \dots, u_{Nt})'$, $k = \max(k_i)$ and $l = \max(d \max_i)$. Moreover, they have developed the $\begin{bmatrix} u_{i,t}^* \end{bmatrix}_{N \times T}$ from these residuals. They select randomly a full column with replacement from the matrix at a time to preserve the cross covariance structure of the errors. They have denoted the bootstrap residuals as $u_{i,t}^*$ where $t = 1, 2, \dots, T$.

Step 4: They have generated the bootstrap sample of y under the null hypothesis:

$$y_{i,t}^* = \hat{\mu}_i^y + \sum_{j=k_i+1}^{k_i+d \max_i} \hat{A}_{21,ij} x_{i,t-j} + \sum_{j=1}^{k_i+d \max_i} \hat{A}_{21,ij} y_{i,t-j}^* + \tilde{u}_{i,t}^* \quad (26)$$

Where, $\hat{\mu}_i^y$, $\hat{A}_{21,ij}$ and $\hat{A}_{21,ij}$ are estimations from step 2.

Step 5: They have substituted $y_{i,t}^*$ for $y_{i,t}$, estimated (equation (23)) without imposing any parameter restrictions on it and then the individual Wald statistics have been calculated to test non-causality null hypothesis separately for each individual. Considering these individual Wald statistics have an asymptotic chi-square distribution with k_i degrees of freedom, they have computed individual p-values. Then, the Fisher test statistics (equation (21)) have been obtained.

Finally, they have generated the bootstrap empirical distribution of the Fisher test statistics by repeating the steps 3–5 many times and specified the bootstrap critical values by selecting the appropriate percentiles of these sampling distributions.

CHAPTER 5

5. RESULTS

The main purpose of this thesis is to test the stock market efficiency in its weak and strong form using a panel of eleven Euro area member states. With this aim in mind, we employed various panel unit root and causality tests. The results of the analyses are presented below.

5.1 Linear and Nonlinear Panel Unit Root Test Results

To detect the presence of weak form stock market efficiency both linear and nonlinear panel unit root tests were applied to our panel of Euro area countries. If the stock market price index is found to be nonstationary, then we will conclude that the efficient market hypothesis holds in its weak form.

Table 2 Linear Panel Unit Root Test Results

Level with Intercept								
Series	LLC		IPS		ADF-Fisher		Hadri	
	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob
SI	0.30629	0.6203	-0.50795	0.3057	19.4425	0.6179	7.05312	0
Log SI	-0.0538	0.4786	-0.89128	0.1864	22.0288	0.4582	9.51204	0

Level with Intercept and trend								
Series	LLC		IPS		ADF-Fisher		Hadri	
	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob
SI	0.96395	0.8325	1.32211	0.9069	10.4191	0.9821	7.96176	0
Log SI	0.68492	0.7533	0.8059	0.7899	12.6331	0.9429	9.14567	0

Automatic selection of lags based on SIC (maximum lag of 1)

For the LLC, IPS and ADF-Fisher tests, the null hypothesis of a unit root is failed to be rejected at all levels of significance irrespective of the deterministic terms included in the test regressions. The results of the Hadri test also confirm that of the other tests by rejecting the null of the stationarity. Linear panel unit root test results strongly indicate that stock market index series contain unit root and are non-stationary. Therefore, it can be concluded that stock market prices of Euro area countries show random walk behavior and are therefore weak-form efficient for the period under study.

Although the previous tests conducted conclude that weak-form market efficiency holds in the Euro area stock markets, they can lead to biased and misleading estimates since it was mentioned previously that these tests ignore the presence of cross-section dependence. Considering this fact, in addition to those panel unit root tests, UO and IPS tests under the cross-section dependency assumption were run. The UO and IPS test results are presented in Table 3 and Table 4, respectively.

Table 3 UO Test under Cross-Section Dependency

Intercept		
Series	Level	P_Value
SI	-1.917	0.360
Log SI	-1.992	0.309

Intercept and trend		
Series	Level	P_Value
SI	-1.958	0.731
Log SI	-2.003	0.690

Table 4 IPS Test under Cross-Section Dependency

Intercept		
Series	Level	P_Value
SI	-1.690	0.422
Log SI	-1.768	0.375

Intercept and trend		
Series	Level	P_Value
SI	-1.909	0.731
Log SI	-2.003	0.660

Both the UO and IPS test results under cross-section dependency are in favor of weak form market efficiency and consistent with the previous ones. UO test fails to reject the null hypothesis of linear non-stationarity, and IPS test fails to reject the null hypothesis of a unit root. Based on these results, it can be concluded that even when the possible nonlinear behavior of the stock prices and the presence of cross-section dependency are taken into account, stock prices still show random walk behavior and Euro area stock markets are still weak-form efficient.

5.2 Panel Causality Test Results

For the purpose of testing weak-form efficiency, linear and nonlinear panel unit root testing procedures were employed. As a result of these exercises, we have concluded that Euro area member states' stock markets are weak-form efficient, which means that it is impossible to beat the market and gain high profits by analyzing past stock price behaviors. But can it still be possible to earn higher profits by utilizing anything else than past prices? The answer is "Yes". Even if a market is weak-form efficient; there can still be a chance to beat the market by using publicly available information only if it does not show semi-strong form efficiency. This conclusion led us to test semi-strong form efficiency.

Various methodologies testing causality among variables in panels are present in literature. Earliest one belongs to Holtz-Eakin et al. (1988). Holt-Eakin et al. proposed a methodology for estimating and testing Panel Vector Autoregression (PVAR) for homogeneous panel studies by using the Generalized Method of Moments (GMM) panel estimator of Arellano and Bond (1991).

Studies of Konya (2006) and Hurlin (2008) are examples to the methods used in determining dynamic relationship between variables in panel data. Konya (2006) developed a new panel causality test based on Seemingly Unrelated Regressions (SUR) estimator introduced by Zellner (1962) and Wald test with country specific bootstrap critical values. However, Konya's test there is no any pretesting for unit roots and cointegration apart from lag structure and that creates low power and contradictory results problems. On the other hand, Hurlin (2008) has introduced a new simple Granger non-causality test for heterogeneous panels with fixed coefficients. However, he assumed that lag orders on autoregressive coefficients and exogenous variable coefficients are all identical for all cross-section units and that panel is balanced, which cannot be valid for all cases. On contrary to preceding studies, EK approach for testing causality in panels takes into account cross-sectional dependence, and thus, in order to detect the causality relationship between macroeconomic variables and stock market indexes for testing semi-strong form efficiency, we employed the procedure developed by EK (2011).

The results, presented in Table 5, indicate that at 1% significance level, none of the macroeconomic variables Granger cause the stock market index. These results imply that, Euro area stock markets show semi-strong form efficiency at 1% level. However, for 5% significance level, unemployment rate (both for individual countries and Euro Area) and industrial production index are found to be Granger cause the stock market indices. On the other hand, for 10% significance level, only world gold price is found to be Granger cause the stock market indices. Thus, for the 5% and 10% levels of significance Euro area stock markets are found to violate the efficient market hypothesis in its semi-strong form.

Table 5 Causality under Cross-Dependence Test Results

Causality running from variable i to stock market index (SI)	Calculated Fisher Test Statistic (λ)
Uc \rightarrow SI	38.634**
Ue \rightarrow SI	60.173**
LIR \rightarrow SI	19.970
SIR \rightarrow SI	7.861
GOLD \rightarrow SI	42.751***
OIL \rightarrow SI	6.914
CPIc \rightarrow SI	13.867
CPIe \rightarrow SI	14.342
M1 \rightarrow SI	16.076
IP \rightarrow SI	37.160**

*Note that, *, **, and *** denotes significance levels at 1%, 5% and 10%, respectively. Lag order is selected by minimizing Schwarz Bayesian Criteria.*

CONCLUSION

The main purpose of this thesis is to test the EMH of the EMU stock markets in its weak and semi-strong forms. With this aim in mind, we have analyzed the monthly data of the eleven EMU countries for the period of 1999:01-2013:07. Research data consists of the stock exchange indices, unemployment rates, long-term and short-term interest rates, consumer price index, money supply and industrial production index.

Studies mentioned in chapters 1 and 4 suggest that many economic and financial series follow nonlinear processes and this fact should be taken into account to prevent spurious results. In addition, ignoring cross-sectional dependence in a panel setting may cause considerable size distortions in the analysis and may lead to over-rejections of the null hypothesis by causing substantial increases in the size of the linear panel unit root tests. Therefore, unlike many previous researches questioning EMH, our study takes into account the likely presence of nonlinearity and cross-sectional dependence simultaneously.

In this thesis, first, linear and nonlinear panel unit root tests were employed to test the weak form market efficiency. Second, after our tests confirmed the existence of weak form efficiency for EMU stock markets, we have run panel causality tests to detect the presence of semi-strong form efficiency.

Our findings appear to be consistent with previous empirical studies. We find strong evidence supporting that EMU countries are weak form efficient. Both the UO and IPS test results under cross-section dependency are in favor of the weak form market efficiency. Similar results are found in case of semi-strong market efficiency. The results indicate that at 1% significance level, none of the macroeconomic

variables Granger cause the stock market index. However, for the 5% and 10% levels of significance Euro area stock markets are found to violate the efficient market hypothesis in its semi-strong form. Thus, for these levels of significance there may still be a possibility for investors to obtain higher returns by using publicly available macroeconomic indicators. Even though technical analysis has no use for beating the market, fundamental analysis may be still slightly working for the EMU stock markets.

Overall our thesis suggests that the stock markets of the EMU countries support EMH in both weak and semi-strong forms. Therefore, for the EMU stock markets in question it seems to be impossible for investors to generate abnormal returns by using past and publicly available information. Moreover, it should be underlined that one of the contributions that our study makes to the area is the fact that it takes into account the crisis and post crisis period. Thus, by considering the previous research that argued against the semi-strong form efficiency for EMU countries, it may be a good policy recommendation to conclude that the stimulus packages employed during the crisis and the economic and financial reforms undertaken after it may have positively affected the efficiency of the stock markets.

Although, we have concluded in favor of weak and semi-strong form efficiency for EMU countries' stock markets, as Fama (1970) has stated, "*much remains to be done*". First of all, the conclusions of this thesis pave the way for testing the strong form efficiency for further research. Our study can be extended by analyzing the insider trading for EMU countries. Moreover, including the countries and the macroeconomic variables (i.e. exchange rates) which are excluded in this research would be also efficacious for reaching a broader insight in this field. Finally, it is also worthwhile to mention that, it would be a great contribution to investigate the pre and post economic and financial crisis periods separately to analyze the impacts of the precautions taken to pep up the economy on the EMU market efficiency.

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