# AN ANALYSIS OF DERIVATIVE MARKETS EFFICIENCY IN EMERGING ECONOMIES

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# ABSTRACT

AN ANALYSIS OF DERIVATIVE MARKETS EFFICIENCY

IN EMERGING ECONOMIES

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In this study, Efficient Market Hypothesis in weak form is applied to futures markets in European Emerging Economies, by testing whether the price series of these markets contain unit root. The hypothesis that futures market price index follow a random walk tested for Greece, Hungary, Poland, Russia and Turkey, using the linear unit root tests (ADF and PP), linear panel unit root test, nonlinear unit root test developed by Kapetanios *et al.* (2003) and nonlinear panel unit root test developed by Ucar and Omay (2009). The data is monthly and it was collected from DataStream. There are 70 monthly observations for each market between the period of September 2005 and June 2011. The results of ADF and PP show that all futures markets are weak form efficient. Nonlinear unit root test results indicate that Polish and Turkish futures markets are not weak form efficient. The findings of the linear panel unit root test show that this group when considered as a whole, are efficient in the weak form while the findings of the nonlinear panel unit root test indicates that they are inefficient as a group.

**Keywords:** Emerging Markets, Futures Market, Market Efficiency, Linear and Nonlinear Unit root, Panel Unit Root

# ÖZ

GELİŞMEKTE OLAN EKONOMİLERDE

TÜREV PİYASALARI ETKİNLİĞİ ANALİZİ

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Bu çalışmada, Avrupa'daki gelişmekte olan ekonomilerde vadeli piyasaların fiyat serilerinin birim kök içeren olup olmadığını test etmek için zayıf formda Etkin Piyasa Hipotezi uygulanmıştır. Doğrusal birim kök testleri (GDF ve PP), doğrusal panel birim kök testi, Kapetanios ve diğerleri (2003) tarafından geliştirilmiş doğrusal olmayan birim kök testi ve Omay ve Ucar (2009) tarafından geliştirilmiş doğrusal olmayan panel birim kök testi hipotezin vadeli piyasaların fiyat endekslerinin rassal yürüyüşü takip edip etmediğini test etmek amacıyla Yunanistan, Macaristan, Polonya, Rusya ve Türkiye'de kullanılmıştır. Veriler aylık ve DataStream'den alınmıştır. Eylül 2005 ve Haziran 2011 arasında her piyasa için 70 aylık gözlem bulunmaktadır. GDF ve PP testlerinin sonuçları bütün piyasaların etkin olduğunu göstermektedir. Doğrusal olmayan birim kök testi Polonya ve Türkiye piyasalarının etkin olmadığını belirtmektedir. Ayrıca, doğrusal panel birim kök testi bu grubun etkin olduğunu gösterirken, doğrusal olmayan panel birim kök testi grup olarak bu ülkelerin etkin olmadığını göstermektedir.

**Anahtar Kelimeler:** Gelişmekte Olan Piyasalar, Vadeli Piyasaları, Piyasa Etkinliği, Doğrusal ve Doğrusal olmayan Birim Kök, Panel Birim Kök

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# CHAPTER 1

## 1. INTRODUCTION

Efficiency can be defined in several forms in different areas. In finance, it is used to describe a market in which relevant information is impounded into the price of financial assets (Dimson and Mussavian, 1998: 91). Today, money and capital markets which are the parts of financial system have important role for providing economical efficiency and efficiency in financial markets is provided by the sharing of information fully and simultaneously to all participants.

Actually, for financial markets efficiency can be examined in three ways: Operational efficiency, capital allocation efficiency and informational efficiency. Operational efficiency is the way that resources are employed to facilitate the operation of the market (Dimson and Mussavian, 2000: 959) and it requires that transactions must be handled at minimum cost as possible. Capital allocation efficiency implies that limited resources, in compliance with their riskiness, must be transferred to areas of highest return (Kıran, 2006: 4). Informational efficiency, relates with the fact that, in estimating the future price of assets, investors in financial markets use all the available information that may affect the price of the assets.

Hence, for a market to be informational efficient, information should arrive completely and simultaneously to all market participants. An informationally efficient market is expressed as an efficient market by the Efficient Market Hypothesis in literature.

According to Efficient Market Hypothesis assets prices reflect all available information and future price of assets are unpredictable. When any information is released to public, all participants response it immediately and asset prices change spontaneously. 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. (Sharpe et. al., 1999: 93).

Though the Efficient Market Hypothesis which forms the basis of this study can actually be traced back to the sixteenth century, it was described first time in the literature by Samuelson's article in 1965 and then, in 1970, Fama, in his very well known famous study, distinguished three degrees of market efficiency, depending on what is meant by "available information": the weak form of market efficiency, the semi-strong form of market efficiency and the strong form of market efficiency.

If the "available information" or "particular set of information" refers to the "all information contained in past price movements", then weak form market efficiency is addressed. On the other hand, if the "available information" refers to the "all publicly available information" or "all pertinent information", then respectively, semi-strong or strong form of market efficiency is addressed.

Weak form efficiency indicates that all information contained in past price movements are fully reflected in security prices. So asset prices can rise, fall or do not change in any day independent from past price which requires the unpredictability of asset returns. In such a situation, asset returns can be argued to follow a "random walk" and stock prices can be characterized by a unit root.

In an efficient market, according to efficient market hypothesis, investors are assumed to be rational. But as argued by Worthington and Higgs (2003; 2004), emerging markets do not have proper structures, lack of technological infrastructure and accordingly distribution of information is usually not performed simultaneously and fully, regulations are not sufficient, information is affected to the stock prices change constantly and incomprehensible because of such reasons, investors can not behave rational. Hence, not surprisingly, the empirical researches show that emerging markets are not efficient in semi-strong and strong form generally, and the empirical evidence on the weak form market efficiency of emerging economies provide contradictory results.

Following the above (and below) arguments, in this research thesis, five European Emerging Futures Markets are analyzed for weak form efficiency, specifically the futures markets of Greece, Hungary, Poland, Russian and Turkey. The data are monthly and sourced from DataStream. To test the weak form market efficiency in these derivative markets the methodology is based on the Random Walk Model and the price series in these markets are searched for whether they contain unit root. For this purpose, first conventional Augmented Dickey Fuller and Phillips Perron unit root tests are employed along with nonlinear unit root test proposed by Kapetanios et. al. (2003). Then linear and nonlinear panel unit root tests are used. Lastly, Sieve bootstrap approach which is very well outlined in Ucar and Omay (2009) are implemented.

The results obtained from the conventional ADF and PP tests suggest that all futures markets index contracts price series contain unit root which indicates that they are weak form efficient. But, nonlinear unit root test results show that Polish and Turkish futures markets are inefficient. In addition, linear and nonlinear panel unit root tests were applied to this group of countries. The findings of the linear panel unit root test show that this group when considered as a whole, are efficient in the weak form while the findings of the nonlinear panel unit root test indicates that they are inefficient as a group.

The literature on market efficiency[1] in emerging economies is understudied relative to the researches undertaken for developed economies, and the existing limited literature provide contradictory results. So, no consensus could have been reached upto now on the market efficiency in emerging economies. For the derivative markets, the existing literature is even more limited. But given the importance of well-functioning financial markets for all market participants, for all economic agents and for the economic growth especially in emerging economies, the research undertaken in this thesis is hoped to contribute to the controversy literature on the validity of weak form of efficiency in the emerging markets by concentrating on the European emerging futures markets. This research topic is focused on the futures

[1] A detailed investigation of the empirical evidence on market efficiency for both developed and emerging economies is provided in Section 2 and empirical evidence on market efficiency in derivative markets is provided in Section 3. Besides, the related literature is summarized in a table submitted in the Appendix.

markets in emerging economies not only because it is relatively highly understudied but because efficient functioning of futures markets are also important for the well-functioning of the spot market and provide a basis for the asset pricing. Thus, it can be regarded as a considerable indicator. It is a valuable source of market information and provides such functions as price discovery and risk reduction. In today's highly globalized world, futures prove to be an important tool of hedging as they decrease risk arising from sudden price changes which may be brought by economic, political or natural disaster factors in spot markets. In the present day, futures become a very important part of economic system in the world and the volume of future markets is growing day by day. Considering the various functions futures markets serve for all market participants including the investors, speculators, hedgers, businesses etc., it appears to be a vital part of a well-functioning economy as a whole.

The remaining of this study is organized as follows: In the second section, Efficient Market Hypothesis is examined and empirical researches are reviewed. In third chapter, derivative markets are explained and empirical evidence on market efficiency in derivative markets is conveyed. In section four, methodology is discussed and data and analysis results are provided. Finally, chapter five concludes.

# CHAPTER 2

## 2. MARKET EFFICIENCY

### 2.1 Efficiency Concept

Efficiency is defined in several forms in different areas. Mathematically, efficiency is expressed as output per input; that is: Efficiency = Output / Input. With more clear words, efficiency can be defined as the maximum output from owned resources. If output from owned resources is not equal to the expected output, then it is defined as inefficient.

In production, plenty of production with owned resources does not mean that production is efficient. If the company, under certain conditions, produces the safest, the cheapest, the highest quality product in sufficient quantities, we can talk about efficient production.

Efficiency in economy, as described by Vilfred Pareto, refers to the inability of increasing the economic welfare of an agent without reducing the economic welfare of others which is called Pareto-optimality.

In Finance, the term efficiency is used to describe a market in which relevant information is impounded into the price of financial assets (Dimson and Mussavian, 1998: 91). Today, money and capital markets which are the parts of financial system have important role for providing economical efficiency. A large number of investors make transactions with using their capital in order to get return in these markets. Efficiency in markets is provided by sharing of information fully and simultaneously to all participants.

## 2.2 Efficiency Concept in Financial Markets

At the present day, financial markets are affecting countries, private companies operating in various industries and all investors. In recent years, economic troubles in the world have caused financial pressures. Many countries have revised their financial systems and have made regulations. At this point, the effective use of the financial system has become extremely important. Markets, with the help of developing technology, have been transformed into more free markets and have been become more tightly controlled. Thus, more participants can compete on equal conditions with each other. As a result of revised works and legal arrangements, especially in developed economies, financial instruments, financial institutions and financial markets are diversified with the aim to account for more efficient financial markets. Eventually, many variables that affect asset prices have emerged.

For financial markets, in general, efficiency is examined in three ways: Operational efficiency, capital allocation efficiency and informational efficiency.

### 2.2.1 Operational Efficiency

Operational efficiency is the way that resources are employed to facilitate the operation of the market (Dimson and Mussavian, 2000: 959). It requires that transactions must be handled at minimum cost as possible. Here, the intended transaction costs are reduced by brokerage firms. Thus, through additions of small investors in the market, the expansion of trade volume is provided.

For the transaction volume to be high and transactions to be carried at the lowest cost, primarily technical infrastructure of the stock market must be extremely strong. This requires that, there must be a lot of competing brokerage firms with strong infrastructures.

### 2.2.2 Capital Allocation Efficiency

"Capital allocation efficiency implies that limited resources, in compliance with their riskiness, must be transferred to areas of highest return. The reason for the existance of financial markets is to transfer funds from economic units with surplus funds to those who seek funds. The expectation is that, the prices of fund transfer tools must be consisted. That is, the marginal rate of return of the economic units with surplus funds equal to the marginal rate of return of the economic units with fund deficit. As financial markets achieve this, capital allocation efficiency can be enhanced." (Kıran, 2006: 4).

### 2.2.3 Informational Efficiency

Informational efficiency, relates with the fact that, in estimating the future price of assets, investors in financial markets use all the available information that may affect the price of the assets. Hence, for a market to be informational efficient, information should arrive completely and simultaneously to all market participants. Fama (1970) argued that:

> "The primary role of the capital market is allocation of ownership of the economy's capital stock. In general terms, the ideal is a market in which prices provide accurate signals for resource allocation: that is, a market in which firms can make production-investment decisions, and in which investors can choose among the securities that represent ownership of firms' activities under the assumption that security prices at any time 'fully reflect' available information. A market in which prices always 'fully reflect' available information is called 'efficient'." (Fama, 1970: 383)

Actually, an informationally efficient market is expressed as an efficient market by the Efficient Market Hypothesis in literature.

## 2.3 Efficient Market Hypothesis

"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" (Sharpe et. al., 1999: 93).

In an efficient market according to efficient market hypothesis, investors are assumed to be rational. Barberis and Thaler (2002) indicated that investors behave rationally in their study. There are two results of this rationality: First, when participants in the market receive new information, agents update their beliefs correctly and second, given their beliefs, agents make choices that are normatively acceptable (Barberis and Thaler, 2002: 2). In conclusion, when an information announced to public, all participants response it immediately, and thus it is reflected into the assets price spontaneously.

### 2.3.1 History of Efficient Market Hypothesis

Efficient market hypothesis which forms the basis of this study can actually be traced back to the sixteenth century. In this book "The Book of Games of Chance (Liber de Ludo Aleae)", Girolamo Cordano who is an Italian mathematician, argues that: "The most fundamental principle of all in gambling is simply equal conditions, e.g. of opponents, of bystanders, of money, of situation, of the dice box, and of the die itself. To the extent to which you depart from that equality, if it is in your opponents favour, you are a fool, and if in your own, you are unjust." (Sewell, 2011: 2)

Then, in 1863, a French stockbroker, Jules Regnault, observed that the longer you hold a security, the more you can win or lose on its price variations: The price deviation is directly proportional to the square root of time (Sewell, 2011: 2). Besides, in his book "The Stock Markets of London, Paris and New York", George Gibson in 1889, implicates the efficient markets with the following expression; "shares become publicly known in an open market, the value which they acquire may be regarded as the judgment of the best intelligence concerning them." (Gibson, 1889: 11)

In 1900, a French mathematician Louise Bachelier's thesis, "Theory of Speculation (Th´eorie de la Sp´eculation)" contains a detailed description of products available at that time in the French Stock Market, such as forward contracts and options. Bachelier begins the mathematical modeling of stock price movements and formulates the principle that "the expectation of the speculator is zero." (Courtault et. al., 2000: 343)

After Bachelier's thesis, Alfred Cowles (1933) analyzed the forecasting performance of 45 investment professional agencies and at the end of his study he supported that stock market forecasters can not forecast. In a continuation of this work, Cowles (1944) made a study and reported once again that investors do not beat the market. In 1934, Holbrook Working made a study and he concluded that wheat prices behave randomly. Following this study, Cowles and Jones (1937) found significant evidence of serial correlation in averaged time series indices of stock prices (Sewell, 2011: 3).

In the second half of the twentieth century, Efficient Market Hypothesis was described first time in the literature by Samuelson's article entitled 'Proof That Properly Anticipated Prices Fluctuate Randomly' in 1965. He used martingale model instead of random walk.

In 1970, Fama had handled the Efficient Market Hypothesis in his article. Then he extended his study in 1991 about Efficient Market Hypothesis and he mentioned that: Studies about Efficient Market Hypothesis which is not considered with getting information and cost of transaction can not show that the market is not efficient (Fama, 1991: 1575). In another study, Fama (1998) pointed out: "Market efficiency survives the challenge from the literature on long-term return anomalies. Consistent with the market efficiency hypothesis that the anomalies are chance results, apparent overreaction to information is about as common as underreaction" (Fama, 1998: 304).

### 2.3.2 Efficient Market Hypothesis Assumptions

For a market, in which investors can trade to obtain return, to talk about the efficient market hypothesis:

- There must be a lot of participants that behave rational and should be able to compete with each other. These participants must not have power to affect the market.
- Information which affect assets prices and expectations of participants, have to be arrived completely and at same time to all market participants.
- Market's institutional structure must be strongly developed.
- Market must have strong infrastructure.
- Transactions should be done at a low cost.

### 2.3.3 Types of Efficient Market Hypothesis

According to Fama, depending on what is meant by "available information", markets are consisted of three types: Weak Form, semi-strong form and strong form.

If the "available information" refers to the "all information contained in past price movements", then weak form market efficiency is addressed. On the other hand, if the "available information" refers to the "all publicly available information" or "all pertinent information", then respectively, semi-strong or strong form of market efficiency is addressed.

#### 2.3.3.1 Weak Form of Market Efficiency

The weak form of Efficient Market Hypothesis states that all information contained in past price movements are fully reflected in security prices. Thus, "weakly efficient markets were defined as markets where past prices provide no information that would allow a trader to earn a return above what could be attained with a naïve buy-and-hold strategy (Francis, 1991: 545).

Weak form tests contain in which the information subset of interest is just past price (or return) histories (Fama, 1970: 388). In 1991, Fama extended this definition: Instead of weak-form tests, which are only concerned with the forecast power of past returns, the first category now covers the more general area of test for return predictability (Fama, 1991: 1576).

If markets are efficient in the weak form, then it is impossible to make consistently superior profits by studying past returns (Brealey and Myers, 2003: 351). Past asset price movements have no effect on the formation of future prices. If past asset price movements have an effect, market would have foreseeable. To beat the market and to earn speculative returns, then most of the participants would analyze the past prices and would take position in the same direction. As a result of this, method will lose effectiveness. Hence, in weak form efficient market technical analysis will not work.

In a weak form efficient market, if the prices of the past are same with the current prices, it is entirely coincidental. There is no difference between the participants who make analyses on the past prices and those who do not. In other words, both participants have the same chance of earning extra risk adjusted returns. Asset price changes are completely coincidental and when a news announcement arrive the market, it will be reflected to the assets' prices immediately. As by definition a news release is an unknown information and unpredictable in nature, weak-form market efficiency is based on random walk model.

#### 2.3.3.2 Semi-Strong Form of Market Efficiency

The semi-strong form hypothesis states that all publicly available information regarding the prospects of an asset must be reflected already in the stock price (Bodie et. al., 2001: 343). A lot of data such as; central banks increment rate of interest, balance sheet of companies, unemployment rate, industrial production, retail sales, natural disasters, etc. have an impact on the price of assets. After announcement of these data, participants show immediate reaction and price of assets change quickly (Fama, 1970: 383).

A market which is efficient in semi-strong form is also efficient in weak form. So, in addition to technical analysis, fundamental analysis is also disabled. It is not possible to gain over the average market return. Only some of the participants can beat the market in case they can reach inside information. Past price information is used in weak-form. In semi-strong form, information set of publicly available information is also used at the same time.

#### 2.3.3.3 Strong Form of Market Efficiency

Strong form is the widest type of efficient market. In this form the available information can be defined as "all the information both publicly and privately held". So, even the insider information will not work in such a situation. Strong form of market efficiency requires that the information which is not open to the public has already been reflected into the assets price, which is highly unexpected in practical.

One group of studies of strong-form efficiency investigates insider trading. Insiders in firms have access to information that is not generally available. But if the strong form of the efficient-market hypothesis holds, they should not be able to profit by trading on their information (Ross et. al., 2002: 359). Hence, unlike other forms of market efficiency, in strong form it is impossible for the market participants to gain excess returns over the market average return.

A market which is efficient in strong form is also efficient in weak form and semi-strong form and there is no way to beat the market and hence, all analyses types are disabled. The relationship between differing degrees of market efficiency is presented in Figure 1.

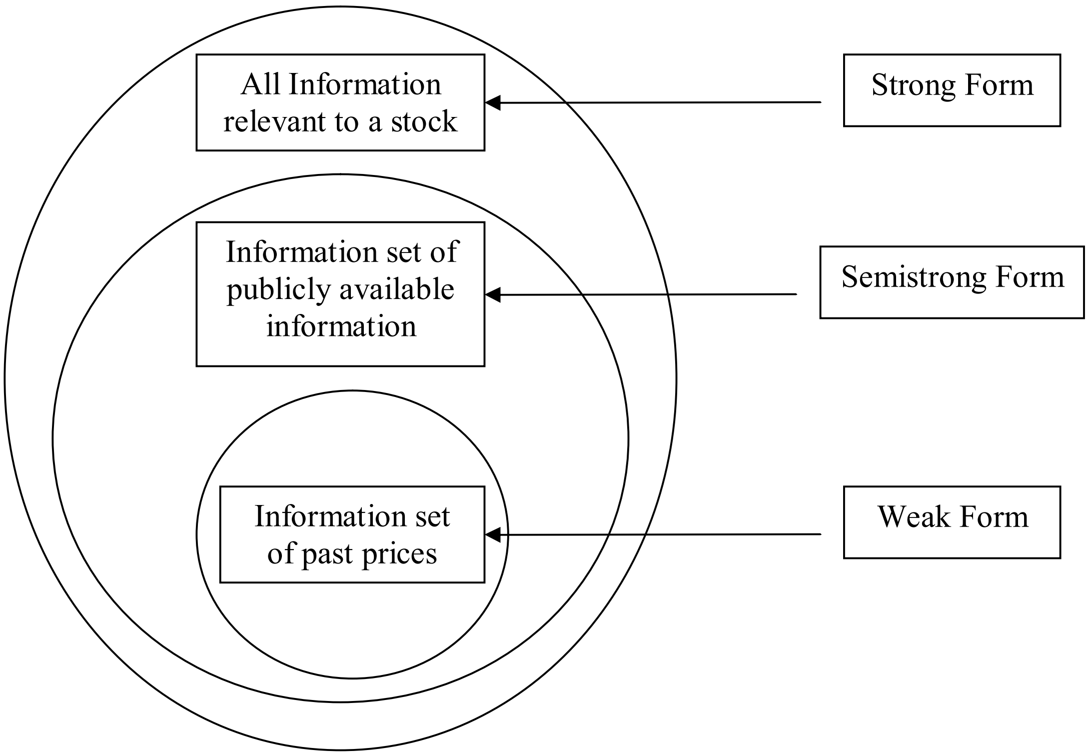


**Figure 1:** Relationship Among Three Different Information Sets (Ross et. al., 2002: 347)

### 2.3.4 Major Models Used in Testing Market Efficiency

Fama developed models for testing information affect on price of assets. These are: Expected Return (Fair Game), Submartingale, Random Walk.

#### 2.3.4.1 Expected Return or "Fair Game" Models

Condition of the market equilibrium can be stated in terms of expected return model (Fama, 1970: 384). Different theories describe risk in different ways and all expected return or fair game models can be described by Fama as follows:

$$E\,(P_{j,\,t+1} \mid \Phi_t) = [1+E(r_{j,\,t+1} \mid \Phi_t)]\; P_{j,\,t} \qquad (2.1)$$

In equation; j: security, t: time

E : Expected Value

$P_{j,t}$ : price of security j, at time t

$P_{j,t+1}$ : price of security j at time t+1

$r_{j,t+1}$ : One period percentage return $[(P_{j,t+1} - P_{j,t}) / P_{j,t}]$,

$\Phi_t$ : Set of information is assumed to be "fully reflect" in the price t

($P_{j,t+1}$) and ($r_{j,t+1}$) are considered as random variables.

"Expected return model is assumed to apply, the information $\Phi_t$ is fully utilized in determining equilibrium expected returns. Expected returns rule out the possibility of trading systems based only on information in $\Phi_t$ that have expected profits or return in excess of equilibrium expected profit or returns. Thus, $\Phi_t$ is "fully reflected" in the formation of the price $P_{j,t}$." (Fama, 1970: 384-385)

#### 2.3.4.2 Submartingale Model

Submartingale model is special case of expected return where the difference between current price of assets and future price of assets are equal to zero or greater than zero.

$$E(P_{j,t+1} \mid \Phi_t) \geq P_{j,t} \quad \text{or} \quad E(r_{j,t+1} \mid \Phi_t) \geq 0 \qquad (2.2)$$

This is a statement that the price sequence ($P_{j,t}$) for security j follows a submartingale with respect to the information sequence ($\Phi_t$). In other words, the basis of the information ($\Phi_t$), is equal or greater than the current price (Fama, 1970: 386).

Equation (2) shows that the non-negative expected return conditional on $\Phi_t$ directly implies that such trading rules based only on the information in $\Phi_t$ can not have greater expected profits than a policy of always buying and holding the security during the future period in question. Tests of such rules will be an important part of the empirical evidence on the efficient markets model (Fama, 1970: 386).

### 2.3.4.3 The Random Walk Model

In this model, the price of the asset can rise, fall or do not change in any day. It is independent from past price movements. According to Fama, two hypotheses constitute the random walk model: The model is the usual statement that the conditional and marginal probability distributions of an independent random variable are identical. In addition, the density function f must be the same for all t (Fama, 1970: 386).

$$f\,(r_{j,\,t+1} \mid \Phi_t) = f\,(r_{j,\,t+1}) \qquad (2.3)$$

$$E\,(r_{j,\,t+1} \mid \Phi_t) = E\,(r_{j,\,t+1}) \qquad (2.4)$$

The mean of the distribution of ($r_{j,\,t+1}$) is independent of the information available at t, ($\Phi_t$) whereas model (3) in addition says that the entire distribution is independent of ($\Phi_t$) (Fama, 1970: 387).

Technical analysis supports that the behavior of a security price in the past provides strong information about its future behavior (Kahraman and Erkan, 2005: 13). “The theory of random walk says that the future path of the price level of a security is no more predictable than the path of a series of cumulated random numbers. In statistical terms the theory says that successive price changes are independent, identically distributed random variables." (Fama, 1965: 34) As a result, past price movements can not use to predict future prices in random walk model.

## 2.4 Opinions against Market Efficiency

One of the assumptions of efficient market hypothesis is that market participants are rational. In contrast, it is argued that there are a lot of participants in a market who are irrational, without adequate knowledge and skills. These participants make indiscriminately purchase and selling operations. Investors who are using technical analysis defend the opinion that if all participants in the market are rational, there is no possibility to estimate the future prices of assets.

In 1985, De Bondt and Thaler made a long run study on New York Stock Exchange (NYSE). They examined firms' performance in two groups. One of the groups is called the winners and the other group is called the losers. They created two portfolios from stocks which are performed best and worst in market. They had chosen stocks from 1933 to 1980, for every year in past three years. Then, they examined every portfolio in five years periods. Eventually, portfolio losers had more return than portfolio winners.

The cumulative average residuals for winner and loser portfolios of 35 stocks for the average of 46 yearly replications starting every January between 1933 and 1978 with a length formation period of five years are presented in Figure 2.

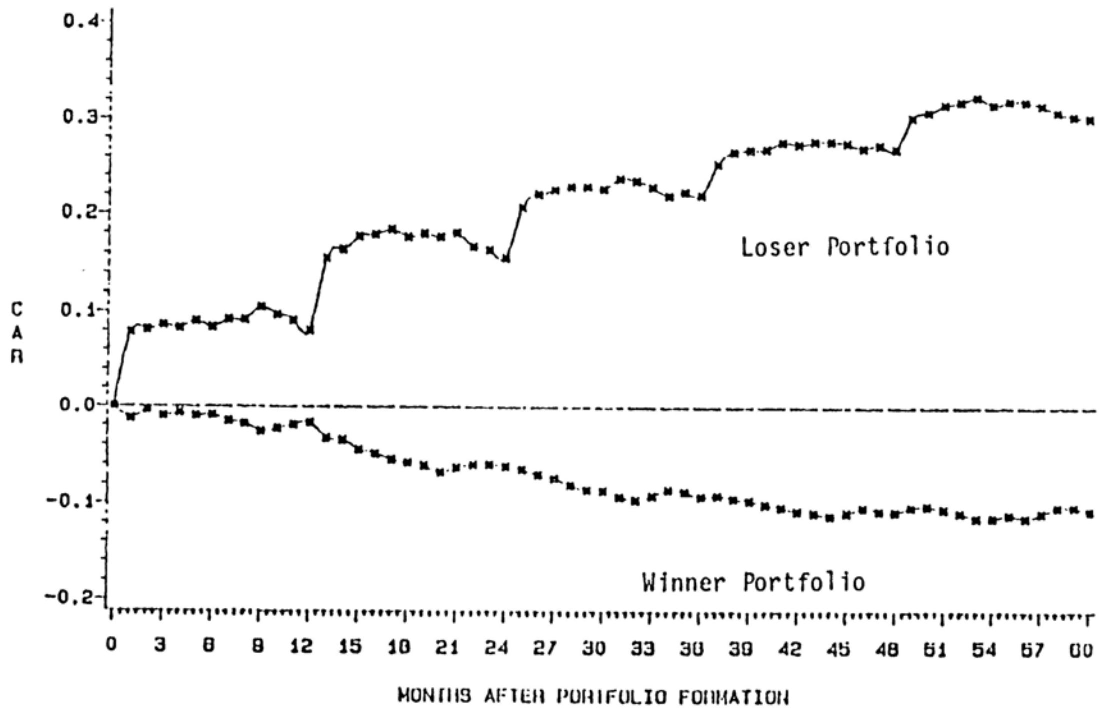


**Figure 2:** Cumulative Average Residuals for Winner and Loser Portfolios of 35 stocks (1-60 months into the test period) (De Bondt and Thaler, 1985: 803)

Figure 2 shows that portfolio loser obtains more return than portfolio winner. For portfolio loser the majority of the return is earned in January for all years. But during the last quarters of the years it seems that there is some loss for portfolio loser. On the other hand, the return of portfolio winner is distributed through the whole year except January.

A similar study is provided by Jegadeesh and Titman (1993). They examined all stocks trade in New York Stock Exchange (NYSE) and American Stock Exchange (AMEX) between 1965 and 1989, in 6-12 months period and found that price movements in 6-12 months period give the signal for the next 6-12 months period

(Jegadesh and Titman, 1993: 67). And they concluded that the winners' portfolio had considerable higher returns than the losers' portfolio around the quarterly earning announcements that are made in the first few months following the formation date. Nevertheless, the losers' portfolio had considerable higher returns than the winners' portfolio around the announcement date returns in the 8 to 20 months following the formation date.

One of the most striking events against to efficient market hypothesis was happened in 19th November 1987, Monday. Dow Jones Industry Index fell 22,6% without any information was announced.

William J. Ruane founded his own investment firm, Ruane, Cunniff and Goldfarb, with partner Richard T. Cunniff in 1970, and the same year they launched their flagship Sequoia Fund. The fund has routinely outperformed the S&P 500 index and has been one of the top performing mutual funds. In the 38 years in which Sequoia has been operational, the fund has averaged a return of approximately 15% versus about 13% for the S&P 500 (http://www.gurufocus.com/news.php?id=77483).

Charles Brandes started the Brandes Investment Partners Firm in 1974, and managed $121.7 billion as of September 2007. He manages multiple portfolios including US equity and Global Equity. His value equity fund has beaten the market in the past 15 years. His investing discipline has been summarized in his article 10 Core Beliefs: prices fluctuate, have a long term perspective, owning stock is owning the business, don't let emotions misguide you, focus on the company not on the market, sell when better opportunities come along, "under-performance is inevitable", and patience is golden (http://www.gurufocus.com/news.php?id=82970).

Kahn Brothers Group Inc. which was founded by Irving Kahn: Buy stocks at cheap prices relative to earnings, and then hold on for the long term. Kahn Brothers holds its investments for a minimum of three to five years, but often much longer; that's compared with a typical U.S. equity fund, which has about 85% turnover annually, according to Morningstar. The firm has returned about 16% annually from year-end 1994 to June 30, 2008, compared with almost 10% for Standard & Poor's 500-stock index over the same period (http://www.financialweek.com/apps/pbcs.dll/article?AID=/20081019/REG/310207556/1028).

### 2.5 Evidence on Market Efficiency in Developed and Emerging Markets

#### 2.5.1 Empirical Evidence on Market Efficiency in Developed Markets

Lo and Mackinlay (1988) examined US stock prices in NYSE and AMEX. In this work, they used random walk hypothesis for weekly stock market returns by using a simple volatility-based specification test. At the end of the 1216 weekly observations between 6th September 1962 and 26th December 1985, they found a strong positive serial correlation for weekly holding period returns. So their study rejected the random walk hypothesis for the sample period.

Poterba and Summers' (1986) study also support Lo and Mackinley's study. Poterba and Summers examined the changing risk premium hypothesis and the influence of changing stock market volatility on the level of stock prices. They used the time series properties of stock market volatility using daily return data on Standard and Poor's Composite Stock Index between 1928-1984. Both studies state that the rejections can not be explained entirely due to infrequent trading or time-varying volatilities.

Kenourgios and Samitas (2005) investigated London Metal Exchange (LME) between the period of January 3, 1989 and April 30, 2000. They employed stationarity Augmented Dickey-Fuller (ADF) and non-parametric Phillips- Perron (PP) unit root test on daily copper spot prices (LCOPSP) and daily prices for the copper futures contract with maturities of three months (LCOP3M) and fifteen months (LCOP15M). They found that LME was not weak form efficient.

Gan et. al. (2005) tested New Zealand Stock Exchange Index (NZSE), Australia Stock Exchange Index (ASX), Japan Nikkei Index and US New York Stock Exchange Index (NYSE). They used the Augmented-Dickey Fuller and Philip-Perron unit root tests. The time series are used for the daily, weekly and monthly closing stock market indexes from January 1990 to January 2003. At the end of the study, all sampled markets are found to be efficient in the weak form.

Torun and Kurt (2008) examined 11 European Monetary Union (EMU) countries' index between the period January 1999 and December 2006. These markets are Austrian Traded Index (Austria), Belgian 20 Price Index (Belgium), Helsinki Stock

Exchange All-Share Index (Finland), Compagnie des Agents de Change 40 Index (France), Deutscher Aktienindex (Germany), Irish Stock Ex-change Equity Overall Index (Ireland), Milano Italia Borsa 30 Index (Italy), Luxembourg Stock Exchange index (Luxemburg), Amsterdam Exchanges index (Nether-lands), Portuguese Stock Index 20 (Portugal) and, Association of Stock Exchanges (Spain). They studied these markets with two approaches: First, they tested the market efficiency in weak form by employing panel unit root tests, and second, they used panel co-integration and causality analysis to test the semi-strong form of market efficiency. The results indicate that all markets are efficient in the weak form. On the other hand, these markets are not totally efficient in semi-strong form.

Demireli et. al. (2010) tested S&P 500 Index between the period of January 2, 1991 and January 19, 2010. They employed Dickey Fuller Test, Phillip Perron Test and correlogram on weekly return series (weekly closing prices). Their findings supported random walk model indicating weak form market efficient.

### 2.5.2 Empirical Evidence on Market Efficiency in Emerging Markets

Magnusson and Wydick (2002) analyzed eight African stock markets (Botswana, Ivory Coast, Ghana, Kenya, Mauritius, Nigeria, South Africa, Zimbabwe) and compared the results with emerging stock markets of South Asia (Indonesia, Korea, Taiwan, Thailand) and Latin America (Argentina, Brazil, Chile, Ecuador, Mexico) between the period of 1989 and 1998. They employed Partial Auto-Correlation Function (PACF) and the Box-Pierce Q-statistic on monthly data. The results show that African stock market did not pass high barriers of weak form efficiency.

Tas and Dusunoglu (2005) investigated Istanbul Stock Exchange (ISE) National-30 Index between the period January 1995 and January 2004. They used Dickey-Fuller unit root test and run test for examining the weak form market efficiency, and they concluded that ISE was inefficient due to the low levels of trade volume and market capitalization of shares.

Moustafa (2004) examined United Arab Emirates (UAE) stock market between the period 2nd October 2001 and 1st September 2003. They employed run test for daily prices of the 43 stocks. They found that 40 stocks out of the 43 are random at a 5% level of significance. It shows that UAE Stock Market is efficient in the weak form.

Gilmore and Mcmanus (2003) investigated Warsaw Stock Exchange (WSE) Poland, Budapest Stock Exchange (BSE) Hungary, Prague Stock Exchange (PSE) Czech Republic between the period July 1995 through September 2000. They used four methods on weekly Investable and Comprehensive indices. These methods are unit root test, variance ratio test autocorrelation, Johansen and Granger causality, NAÏVE model with ARIMA and GARCH alternatives. The results are mixed. NAÏVE model with ARIMA and GARCH alternatives results are consistent. All tests except Granger causality show that WSE, BSE and PSE are inefficient.

Smith and Ryoo (2003) examined stock market price indices in Greece, Hungary, Poland, Portugal and Turkey between the period of third weak of April 1991 and the last week of August 1998 (385 observations) by using the variance ratio test. The results indicated that while markets in Greece, Hungary, Poland and Portugal did not follow the weak form market efficiency, only the Turkish market is efficient in the weak form.

Müslümov et. al (2003) tested Istanbul Stock Exchange (ISE-100) between the period of 1992 and 2002. They analyzed monthly data for the individual stocks and weekly return series of ISE-100 index. They employed generalized auto-regressive conditional heteroscedastic (GARCH) model. The results show that 65% of the stock returns of the individual stocks did not follow random walk and the rest of the individual stocks supported random walk. The first period of ISE-100 index analysis did not follow random walk, but the second period of ISE-100 index analysis supported random walk.

Abrosimova et. al. (2005) tested Russian Stock Market between the period of September 1, 1995 to May 1, 2001 by using daily, weekly and monthly Russian Trading System (RTS) index time series. They employed unit root test, variance ratio test and autocorrelation. They found that Russian Stock Market was weak form effcient.

Hassan et. al. (2006) investigated seven emerging economies. These are Russia, Czech Repuplic, Hungary, Poland, Greece, Slovakia and Turkey. The observation period started from December 1988 to August 2002. They used Ljung-Box Q-statistic, run test and variance ratio test on weekly observations. The results indicate that Greece, Turkey and Slovakia followed random walk model. Thus, these markets are concluded to be weak form efficient whereas Russia, Hungary, Poland and Czech Republic are not.

Kahraman and Erkan (2005) examined ISE 100 Index between the period of January 1, 1996 and October 27, 2004. The serial correlation test was used on closing price changes for one, five, nine and sixteen day differencing data. The results of this study show that ISE 100 did not support random walk model.

Mobarek et. al. (2008) analyzed Dhaka Stock Exchange (DSE) in Bangladesh between the period of 1988 and 2000. They used non-parametric tests (Kolmogrov-Smirnov: normality test and run test) and parametric tests (Auto-correlation test, Autoregressive model, ARIMA model) on the data of daily price indices of DSE and daily share prices of individual companies in DSE. They found that individual stock returns did not follow random walk.

Aga and Kocaman (2006, 2008) investigated Istanbul Stock Exchange (ISE) National 20 Index between the period of January 1986 and November 2005. They used arithmetic average, geometric average, market capitalization methods and GARCH-M model on monthly returns. They found that ISE was weak form efficient.

Atan et. al. (2009) tested ISE between the period of January 3, 2003 and December 30, 2005. They used ADF and KPSS unit root tests and exact local whittle (ELW) fractionally integrated estimator on fifteen minutes and session frequency data. Their results support that ISE is weak form efficient.

Çelik and Taş (2007) examined 12 emerging stock markets indices which were tested with runs test, unit root tests and variance ratio test by using weekly data between the period of April 1998 and April 2007. (Çelik and Taş, 2007: 12) These markets are

Argentina, Brazil, Czech Republic, Egypt, Indonesia, Hungary, India, Israel, Korea, Mexico, Russia and Turkey. For unit root tests, Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests were used. Unit root tests also employed for the period of April 2002 and April 2007. Eventually, they found that generally all tested markets supported random walk. The result of run test for the period 1998 – 2007 shows that all markets except Czech Republic supported random walk and the results for the period of 2002 – 2007 also show that all markets, except Argentinean market, supported random walk. Only Argentinean market did not support random walk at 5 % significance level. The result of unit root tests for the period 1998 – 2007 shows that all markets except Russia supported random walk. Besides, for the period of 2002 – 2007, the results had some discrepancy. In this period, Argentina, Czech Republic, Egypt, Hungary, Russia and Turkey supported random walk but other 5 markets did not follow random walk. The result of variance ratio test for the period 1998 – 2007 shows that Argentinean, Egyptian, Indonesian, Hungarian and Russian markets rejected random walk at 5 % significance level. On the other hand, for the period 2002 – 2007 all markets except Argentina followed random walk model. Turkish and Korean markets supported random walk model that applied to the all weak form efficiency tests.

Marashdeh and Shrestha (2008) investigated the United Arab Emirates (UAE) Securities Market between the period of August 31, 2003 and April 13, 2008. UAE Securities Market is composed of two financial markets. These are Abu Dhabi Securities Exchange (ADX) and Dubai Financial Market (DFM). The Emirates Securities Market is electronically linked with the previous two markets, established by the Securities and Commodities Authority. It has its own index which covers the trading on stocks for all listed companies in both markets. (Marashdeh and Shrestha, 2008: 145) Marashdeh and Shrestha used Augmented Dickey-Fuller (ADF) and Phillips-Perron tests on 1298 daily observations. They found that UAE Securities Market is weak form efficient.

Legoarde-Segot and Lucey (2008) investigated seven emerging Middle-Eastern North African (MENA) stock markets that are Egypt, Morocco, Tunisia, Jordan, Lebanon, Israel and Turkey between the period of 1994 and 2003. They employed Kwiatkowski, Phillips, Schmidt, Shin (KPSS) test, individual variance ratio analysis, multiple variance ratio analysis, non-parametric variance ratio analysis on daily data of stock markets indices. The KPSS and non-parametric variance ratio analyses results show that all markets rejected the random walk hypothesis. According to individual and multiple variance ratio tests, the random walk hypothesis was rejected for Egypt, Morocco and Lebanon.

Dima and Miloş (2009) examined Bucharest Stock Exchange (BET).The observation period started on 10 April 2000 and ended on 8 April 2009. They used BDS test, Correlogram, Augmented Dickey-Fuller stationarity test, Kwiatkowski-Phillips-Schmidt-Shin stationarity test and Elliott-Rothenberg-Stock stationarity test on daily observations. They found that BET is weak form efficient.

Poshakwale (1996) investigated Bombay Stock Exchange (BSE) in India between the period of 1987 and 1994 based on the day of the week effect. He employed Kolmogorov Smirnov Goodness of Fit Test, Runs Test and Serial Correlation

Coefficients Test. The results show that prices did not follow a normal or uniform distribution. He found that BSE is not weak form efficient.

Siddiqui and Gupta (2009) examined National Stock Exchange (NSE) in India between the period of January 1, 2000 and October 31, 2008. They used non-parametric (Kolmogrov –Smirnov normality test and run test) and parametric tests (Auto-correlation test, Auto-regression, ARIMA model) to test weak form efficiency on daily stock indices. The results show that Indian Stock Market is not weak form efficient.

Hassan et. al. (2000) tested Dhaka Stock Exchange (DSE) in Bangladesh between the period of September 1986 and November 1999. They employed variance ratio test on daily returns and found that DSE is not weak form efficient.

Mobarek and Keasey (2002) examined DSE between the period of 1988 and 1997. They used non-parametric (Kolmogrov –Smirnov normality test and runtest) and parametric (Auto-correlation test, Auto-regression, ARIMA model) tests on daily price indices of all listed DSE securities. After 2638 daily observations, they supported that DSE was not weak form efficient.

Omay and Karadagli (2010) investigated Bulgarian, Greek, Hungarian, Polish, Russian, Slovenian, Romanian and Turkish stock markets between the period from January 2002 and May 2010. They employed linear unit root tests and linear panel unit root tests with Augmented Dickey Fuller test and Phillips Perron test. They also used non linear unit root test procedure which was developed by Kapetanios et. al.

(2003) and non linear panel unit root test which was developed by Ucar and Omay (2009). All these tests were performed on 101 monthly observations. According to ADF and PP tests all markets are weak form efficient. On the contrary, non linear panel unit root test results show that all these stock markets are not weak form efficient and non linear unit root test results indicate that Russian, Polish and Romanian stock markets are not efficient in weak form.

Srinivasan (2010) tested Bombay Stock Exchange (BSE-30 or SENSEX) and The Standard & Poor's CRISIL NSE Index 50 (S&P CNX Nifty) between the period from July 1, 1997 to August 31, 2010. In this study, ADF test and PP unit root test were employed on 3244 daily observations. The results show that Indian Stock Market did not follow random walk model, indicating that it is not weak form efficient.

# CHAPTER 3

## 3. DERIVATIVE MARKETS

### 3.1 Derivative Market Concept

Derivative Markets are financial markets in which contracts that provide its holder either the obligation (such as futures and forwards), or the choice (like options) to buy or sell a financial asset, are traded. In derivative markets the delivery will be made in some predetermined future date. If such contracts are traded in an organized market, then they are sometimes referred as future markets as well. In these markets, metals (gold, silver, copper, etc), agriculture products (soybeans, wheat, cotton, etc), products which are used to produce energy (petrol, natural gas, etc) and financial instruments (interest rate, indices, foreign exchange, etc) can be purchased or sold. These products which are traded in derivative markets, are called derivative products as their values are derived from the value of financial assets on which they are underwritten. Hence, derivative products such as futures, forwards and options can be defined as an asset's or a financial instrument's value payment of a date in the future. Transactions are made by contracts which have assets' rights and obligations. So, there is no necessity to exchange assets in these markets. These contracts contain future contracts, forward contracts, options and swap transactions.

Futures are made for decreasing risk from sudden price changes which may be brought by economic, political or natural disaster factors in spot markets. For instance, suppose that there is a company that operates copper minory. If there is possibility of an increase in copper prices in next six months period, the company can buy (long position) copper contracts for six months against the risk of price rise. In opposite condition, the company can sell (short position) copper contracts. In this respect, futures can also be thought as a hedging instrument.

Futures transactions are made under the guarantee of the clearing house. The clearing house regulates obligations between buyers and sellers in the market. Investors are obliged to the clearing house. More clearly, after transactions, earnings of the investors are paid by the clearing house. In contrast, investors who are in loss have to pay up to loss to clearing house.

## 3.2 Historical Development of Derivative Markets

Futures transactions have been made from very ancient times to the present. Chinese traders and farmers made futures transactions to fix price before harvest time against unexpected price fluctuations. The first contracts recorded in history about futures are the auctions between old Greek Miletus' philosopher Thales and rendering plants for olive oil. The auctions were like today's option contracts.

At the end of 17$^{th}$ century, the first standard contracts have been sold regularly in Dojima Rice Market, in Japan. At the same time, Antwerp Grain Market was founded in Netherlands.

The beginning of 19th century is accepted as the beginning of futures. At these times, Chicago was a very important city. In 1837, Chicago became a city. After this date, Chicago has developed rapidly and became an important commercial center. Agricultural products which produce vicinity of Chicago were being stored in Chicago. In those years, there were transportation problems and there were not enough stores to sell these products. Due to such reasons product prices were fluctuating which causes producers and traders to make loss. To prevent this, Chicago Board of Trade (CBOT) was founded in 1848. The first recorded future contract had written on 3.000 kilos of corn which was to be delivered on June, in March 13, 1851 (Türev Araçlar Lisanslama Rehberi, 2011: 14).

Until 70's, futures had been made only on agricultural products in America. With the collapse of the Bretton Woods System, fluctuations on exchange rates and interest rates created risk for the market participants. Whereupon, International Monetary Market (IMM) was founded within Chicago Merchantile Exchange (CME) in 1972. In 1973, futures was made on exchance rates first. Hereafter, Government National Mortgage Association (GNMA) contracts which was the first arranged futures contracts based on  interest rate within CBOT (Dönmez et. al., 2002: 1).

The first contracts based on stock index was organized in 24 February 1982 from Kansas City Board of Trade (KCBT) on Value Line Compound Index (Dönmez et. al., 2002: 2). In the same year,  future contracts based on S&P 500 Index within CME started to be traded and future contracts based on New York Stock Exchange (NYSE) Index within New York Future Index was launced to the market (Sermaye Piyasası ve Borsa Temel Bilgiler Klavuzu, 2008: 452).

In the present day, futures have become a very important part of economic system in the world. The volume of future markets is growing day by day. Types of contracts which are traded in those markets are increasing in variety. Number of contracts and data on prices for the years of 2008, 2009 and 2010 are submitted in Appendix A.1 and A.2.

### 3.3 Derivative Market Contracts

Contracts in Derivative markets can be examined in four groups. These are forward contracts, futures, options and swaps.

#### 3.3.1 Forward Contracts

A forward contract is a contract that expresses a commercial transaction agreement between two parties to exchange assets or services at a predetermined price at a specified time in the future. Parties responsible against for each other and they can not transfer their obligations to a third party. Details of the contract are determined by the parties. Parties do not pay each other until the full term of the contract is realized. Cancellation of the contract before the due date can be possible with the agreement of the parties.

The difference between spot transaction and forward transaction is: Generally, in spot market transactions are made immediately. On the other hand, in forward contract transactions are usually made with maturities of one month, three months, six months. Profit and loss are calculated at the end of the contract.

### 3.3.2 Futures Contracts

Futures contracts and forward contracts are similar to each other. But, the biggest difference between futures contracts and forward contracts is that in futures investors are responsible to clearing house. Futures contracts are in standardized amounts and the prices of contracts are predetermined. Investors have to pay collateral for all transactions. Leverage can be used in transaction. It means, investors can buy or sell assets for more than their capitals. For example, an investor who has 10.000$ can buy or sell 100.000$ worth of wheat contract.

There is no need to wait until the full term of the contract. In general, investors do not wait until the full term of the contract (closing out position). In futures markets, daily price movements are limited. Investors can not buy (bid) or sell (ask) more than the limits. Profit and loss are calculated daily.

### 3.3.3 Options

Options provide the right to buy or sell an asset for a certain price and certain time in future. The right is entitled for buyers. Sellers have contingent liability to buyers. The most important difference among options and other financial contracts is the buyer of an option can choose to use or not to use his rights aroused by the contract.

#### 3.3.3.1 Basic Concepts of Option Contracts

**European-style and American Style Options:** A European-style option provides the right but not the obligation to exchange the underlying asset at a predetermined price on an agreed future date ( the maturity date of the option, which is called the **expiry or expiration date**). American-style contracts can be exercised before expiry date (Chisholm, 2004: 101).

**Put and Call Options:** A call option gives the buyer the right to buy the underlying asset by a certain date for a certain price. A put option gives the buyer the right to sell the underlying asset by a certain date for a certain price (Hull, 2002: 6).

**Exercise Price or Strike Price (Striking Price):** The price at which the stock may be bought or sold is the exercise price, also called the striking price. In the listed option market, "exercise price" and "striking price" are synonymous; in the older, over-the-counter options market, they have different meanings. (McMillan, 1993: 4)

**Option Premium:** The price of the option. It is usually charged in transaction time and it is not refundable.

**Table 1:** The Differences Between Forward Contracts, Future Contracts and Options (Sermaye Piyasası ve Borsa Temel Bilgiler Klavuzu, 2008: 451)

| Basic Features | Forward Contracts | Future Contracts | Options |
|---|---|---|---|
| **Hedging Tool** | Yes | Yes | Yes |
| **Standard Contracts** | No | Yes | Yes |
| **Markets / Over The Counter (OTC)** | OTC | Markets | OTC and Markets |
| **Physical Delivery** | Yes | Generally No | If used right |
| **Held-to-Cash Flow** | No | Yes | For Seller |
| **Leverage** | No | Yes | Yes |
| **Rights and Obligations** | Between Parties | Clearing House | No |
| **Guarantee** | No Need | Yes | For Seller |

### 3.3.4 Swaps

A swap is a contract calling for an exchange of payments over time. One party makes a payment to the other depending whether a price turns out to be greater or less than a reference price that is specified in the swap contract. Thus, it provides a means to hedge a stream of risky payments.

There are two basic types of swaps which are called **interest rate** swaps and **currency swaps**. The typical interest rate swaps are the exchange of cash flows arising from fixed rate of interest (fixed for the period to the maturity of the swap) for cash flows arising from a floating interest rate (perhaps a rate changed ever 6 months reflecting movements in a market rate such as **London Interbank Offered Rate (LIBOR)**). Currency swaps involve exchanging interest flows in one currency for interest flows in another (typically the US dollar is one of the currencies) (Redhead, 1997: 321).

### 3.4 Organizational Structure and Participants of Derivative Markets

Participants in the futures markets can be examined in four groups: Markets, clearinghouse, brokerage house, auditing agencies.

#### 3.4.1 Markets

The most important function of a market is transactions must be done easily among buyers and sellers in secure and competitive ambient. At the same time, there must be some criteria for functioning properly. The market needs to have strong technical infrastructure. Information which affects traders' decisions has to be announced real-time and up to date. The contracts have to be designed according to a particular standard. Initial margin and maintenance margin ratios have to be determined. Regulations have to done according to law for properly continuation of market.

#### 3.4.2 Clearinghouse

The most important part of a market is clearinghouse. As a result of the purchase and sale of transactions between the parties, parties suspect to fulfill the obligations against each other. At this point clearinghouse intervenes between parties. The main task of the clearinghouse is to keep track of all the transactions that take place during a day so it can calculate the net position of each of the buyers and the sellers (Hull, 2002: 26).

The clearinghouse matches buyers and sellers. Then the clearinghouse accepts the trades and is legally substituted as both buyer and seller on the contract trades. (Edwards and Ma, 1992: 26) The clearinghouse is a well-capitalized financial institution that guarantees contract performance to both parties (Kolb, 1993: 25).

The clearinghouse acts like a buyer for a seller and a seller for a buyer. It means that, when a buyer purchases futures contracts, the buyer will have obligations against clearinghouse. All profits and losses are calculated at the end of the day in futures markets. At the end of the day, the clearinghouse collects amount of net losses from participants who make loss and pay returns to the participants who make profit.

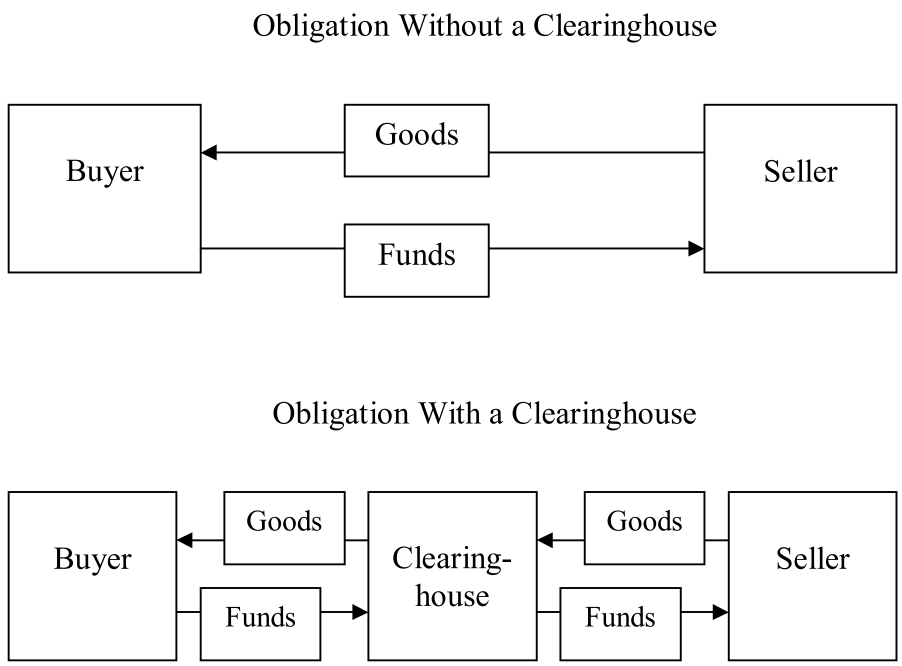


**Figure 3:** The Function of the Clearinghouse in Futures Markets (Kolb, 1993: 26)

### 3.4.3 Brokerage Houses

In futures markets, individuals can not make transactions by themselves. First, they have to open an account in a brokerage house which is a member of the market. Then customers can give their trading orders. The brokerage house collects margin balances from customers, maintains customer money balances, and records and reports all trading activity of its customers (Edwards and Ma, 1992: 24).

### 3.4.4 Auditing Agencies

Futures markets and institutions which are operating in the futures markets have to be audited. Audit agencies have authorized to examine contracts, to give authorization certificate to brokerage houses and confirm the decisions of futures markets. The aim here is to prevent the formation of artificial prices for the protection of investors.

## 3.5 Empirical Evidence on Market Efficiency in Derivative Markets

Nieto et. al. (1998) tested Spanish stock index (IBEX 35) and its futures contract between the period of 1st March 1994 and 30th September 1996. They used Granger causality test and Johansen co-integration test on daily prices of the Spanish stock index and futures contract. At the end of the test, they found that a futures contract on the IBEX 35 market behaves as an efficient market.

Wang and Ke (2002) tested Chinese wheat and soybean futures markets and assess the conditions in agricultural commodity futures and cash markets in China between the period of January 1998 and March 2002. They used data from China Zhengzhou Commodity Exchange (CZCE) for wheat, Dalian Commodity Exchange (DCE) for soybean, the Zhengzhou Grain Wholesale Market (ZGWM) and the Tianjin Grain Wholesale Market (TGWM) for two cash markets. They implemented unit root test both using the ADF and the Phillips-Perron methods and Johansen's cointegration tests on weekly futures price data of wheat and soybeans. The results show that a long-term equilibrium relationship between the futures price and cash price for soybeans and the soybean futures. The soybean futures market is weak form efficient. On the other hand, the wheat futures market in China is inefficient in weak form.

Tabak (2003) investigated Brent Crude Futures that are traded at the International Petroleum Exchange (IPE) between the period from January 1990 and December 2000. The unit root test with ADF method and Johansen's cointegration test was employed on observations that are 132 one-month contracts, 66 two-months contract and 44 three-months contract. The cointegration tests result show that just one-month futures series can be said to cointegrate with the realized spot rate. It means spot prices and one-month futures prices will move together.

Crowder and Phengpis (2003) tested S&P 500 and Nikkei 225 spot and futures markets. S&P 500 tested between the period from 21st April 1982 to 5th June 2003 and Nikkei 225 tested between the period from 5th September 1988 to 30th June 2003. They employed unit root tests with ZA test statistics and Johansen cointegration test on closing prices for each trading day. The results show that strong evidence of cointegration was found. Both markets were not weak form efficient.

Kenourgios (2005) examined the joint hypothesis of market efficiency and unbiasedness of futures prices for the FTSE-20 blue chip index futures contract/Athens Stock Exchange (ASE-20) stock index futures market between the period from March 2000 to March 2002. He tested the spot and futures indices with using the Johansen cointegration procedure and also employed unit root test. The result of this study indicates that FTSE/ASE-20 futures market was inefficient.

Mollah et. al. (2005) investigated DSE-20 (top 20 companies) between the period of 2001 and 2003. They used ARMA, ARIMA, ACF, PACF, and Dimson's Market model on daily price indices. They found that coefficient was not significant and it did not support weak-form market efficiency. In addition, they stated that past prices could be used to predict for the future prices in DSE-20.

Phukubje and Moholwa (2006) tested weak form efficiency in the South African Futures Exchange (SAFEX) for wheat and sunflower seeds between the period of 2000-2003. Unit root tests with ADF and PP methods, Ljung-Box Q statistic and F test statistics were employed on daily wheat and sunflower seeds settlement futures prices. The results support that futures price changes for both wheat and sunflower seeds are partially predictable from past price information. On the other hand, when taking into account the brokerage costs and the time value of money, out-ofsample predictive performance of the model shows that trading decisions based on the direction of predicted futures price changes do not lead to profitable trades for wheat and soybean seeds. Therefore, it does not indicate that South African futures markets for wheat and sunflower seeds are inefficient in weak form. In addition, there was no trend in market efficiency during the period of this study except the wheat December contract.

Pavlou et. al. (2007) investigated the difference in volatility during trading and non-trading periods. Several econometric methods, serial correlations, ADF test and Durbin-Watson test were employed on FTSE/ASE-20, FTSE/ASE-40, Hellenic Telecommunications Organization stocks, Public Power Corporation stocks and Intracom stocks between the period of 8th August 2004 and 9th August 2006. FTSE/ASE-20 consists of 20 Greek companies quoted on the Athens Stock Exchange (ASE), with the largest market capitalization (blue chips). FTSE/ASE-40 contains 40 mid-capitalization Greek companies. Other three companies have half of the turnover of the stock futures. The results show that futures on FTSE/ASE-20 and Public Power Corporation supported the Efficient Market Hypothesis, FTSE/ASE-40, Hellenic Telecommunications Organization and Intracom rejected.

Liu (2009) tested crude palm oil(CPO) futures market efficiency of Bursa Malaysia Derivatives(BMD) between the period 2001-2007. Johanson cointegration test and Vector Error Cointegration Mechnism (VECM) were used to test long-run and short-run efficiency test for the European spot market and one week, two weeks, one month and two months futures forecasting horizons. At the end of the test, there was a long-run equilibrium relationship exists between the futures price and spot price for all forecasting horizons. The short term efficiency hypothesis was rejected for the forecasting periods of one week and two month, it was accepted for two weeks and one month. Nonetheless, it was found that the futures market of BMD was not a very efficient.

Zhang et. al. (2010) investigated Chicago Board Options Exchange Market Volatility Index (VIX) futures market between the period of 26th March 2004 and 10 th June 2008. They employed ADF unit root test, KPSS test, autocorrelation test and Lo-Mackinlay Variance-Ratio test on daily settlement prices of 54 VIX futures contracts that were totaly 1059 trading days. They found that VIX futures market is weak form efficient and supports random walk.

Kour and Rao (2010) examined National Commodities And Derivatives Exchange (NCDEX) between the period of July 2008 and July 2009. They selected four commodities which are Pepper Malabar, Refined Soya Oil, Guar seed and Chana. These crops have two-thirds of the volume and value of agricultural commodities traded on NCDEX. The futures contracts' maturity period started at July 2008 finished in July 2009. They employed Autocorrelation test and Runs test on daily data. The tests results show that all these commodity markets are weak form efficient.

In this research thesis we attempt to investigate the weak-form market efficiency in derivative markets of five European Emerging Economies, specifically Greek, Hungarian, Polish, Russian and Turkish futures markets and believe to contribute to the limited and contradictory literature on the market efficiency in emerging economies derivative markets. To test the weak form market efficiency in these derivative markets the methodology is based on the Random Walk Model and the price series in these markets are searched for whether they contain unit root. For this purpose we not only carried out the conventional ADF and PP unit root tests as well as the linear panel unit root test IPS (İm, Pesaran and Shin (2002)), but also applied nonlinear unit root test proposed by Kapetanios et. al. (2003) and nonlinear panel unit root test recently proposed by Ucar and Omay (2010). All the proposed tests are reviewed in the following section "Methodology".

# CHAPTER 4

## 4. METHODOLOGY, DATA and APPLICATION

### 4.1 Methodology

If any time series' mean, variance and covariance vary independent of time, it shows that this time series is stationary. The provision of this three conditions, it is known as a weakly stationary, or covariance stationary, or second-order stationary, or wide sense, stochastic process (Gujarati, 2003: 797). This condition is expressed mathematically:

Mean: $E(Y_t) = \mu$ (4.1)

Varience: $\text{var}(Y_t) = E(Y_t - \mu)^2 = \sigma^2$ (4.2)

Covarience: $\gamma_k = E[(Y_t - \mu)(Y_{t+k} - \mu)]$ (4.3)

$Y_t$ : $Y_t$ be a stochastic time series with these properties

$\gamma_k$ : the covariance (or autocovariance) at lag k. It is the covariance between the values of $Y_t$ and $Y_{t+k}$.

If k = 0, we obtain $\gamma_0$, which is simply the variance of Y=$(\sigma^2)$; if k = 1, $\gamma_1$ is the covariance between two adjacent values of $Y$ (Gujarati, 2003: 797).

In Efficient Market Hypothesis, the random walk model is occured by nonstationary time series. In time series analysis, variables have a tendency to increase or decrease. To obtain accurate results in time series using with statistical methods, there should be no trend in time series and time series must be stationary. (Utkulu, 2003)

There are multiple methods to remove trend in time series and to convert time series stationary. At this point, many methods have been developed in order to test the effectiveness of the weak form of market efficiency. Among these methods, unit root tests are accepted the most common and valid. The simplest version of unit root tests is Dickey Fuller Test (1979).

### 4.1.1 Linear Unit Root Test

Random walk can be written without drift:

$$Y_t = Y_{t-1} + \varepsilon_t \tag{4.4}$$

In this equation $\varepsilon_t$ is a white noise error term. It shows that mean = 0 and variance $\sigma^2$. The value of Y at time t is equal to value at time (t-1). According to any series that is calculated regression of previous period random walk with drift can be written as:

$$Y_t = \rho Y_{t-1} + \varepsilon_t \quad (4.5)$$

If $\rho$ =1, we can say that there is a unit root. If it is not, $Y_t$ is nonstationary. When subrtacted $Y_{t-1}$ from both sides of equation. We obtain:

$$Y_t - Y_{t-1} = \rho Y_{t-1} - Y_{t-1} + \varepsilon_t \quad (4.6)$$

$$Y_t - Y_{t-1} = (\rho - 1)Y_{t-1} + \varepsilon_t \quad (4.7)$$

$$\Delta Y_t = \delta Y_{t-1} + \varepsilon_t \quad (4.8)$$

In this equation $\delta = (\rho - 1)$. If $\delta$ = 0, so $\rho$ =1. It means that time series under consideration is nonstationary and there is a unit root. A random walk process may have drift or may have no drift. For all these possibilities Dickey and Fuller (1979) suggested three diffrent forms.

$Y_t$ is a random walk: $$\Delta Y_t = \delta Y_{t-1} + \varepsilon_t \quad (4.9)$$

$Y_t$ is a random walk with drift: $$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \varepsilon_t \quad (4.10)$$

$Y_t$ is a random walk with drift around a stochastic trend:

$$\Delta Y_t = \beta_1 + \gamma Y_{t-1} + \beta_2 t + \varepsilon_t \quad (4.11)$$

There are 3 different contitions in Dickey and Fuller Model. Deterministic element $\beta_1$ under the influence of the trend $\beta_2$. For all models, if $\delta$ = 0, $Y_t$ has a unit root.

$H_0 : (\delta = 0)(\rho = 0)$ There is a unit root (random walk)

$H_1 : (\delta < 0)(\rho < 0)$ Stationary

In Dickey Fuller Test it was assumed that the error term $\varepsilon_t$ was uncorelated. To overcome this problem, Dickey and Fuller (1981) have developed a test which is called Augmented Dickey Fuller Test. This time, they added lagged values of the dependent variable $\Delta Y_t$ to all three equations. $Y_t$ (Gujarati, 2003: 817). The model can be written as for three equations:

$Y_t$ is a random walk : $$\Delta Y_t = \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \qquad (4.12)$$

$Y_t$ is a random walk with drift: $$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_t \qquad (4.13)$$

$Y_t$ is a random walk with drift around a stochastic trend:

$$\Delta Y_t = \beta_1 + \gamma Y_{t-1} + \beta_2 t + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_t \qquad (4.14)$$

According to DF test error terms $\varepsilon_t$ are independent and have constant variance. Then Augmented Dickey Fuller test developed. In this test, Dickey and Fuller added the lagged difference terms of the regressand. Phillips and Perron (1988) generalized DF test using with nonparametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms **(**Gujarati, 2003: 818).

$$y_t = \hat{\mu} + \hat{\rho} Y_{t-1} + \hat{\varepsilon}_t \tag{4.15}$$

$$y_t = \hat{\mu} + \hat{\beta}\left(t - \frac{1}{2}\mathrm{T}\right) + \hat{\rho} Y_{t-1} + \hat{\varepsilon}_t \qquad 4.(16)$$

In these equations T states observations, $\hat{\mu}$ states error term. This model allows weak connection and heterogeneity.

### 4.1.2 Individual Nonlinear Unit Root Test

The nonlinear unit root test developed by Kapetanios et. al. (2003). They derived the limiting nonstandard distribution of the proposed tests and they found via Monte Carlo simulation exercises that under the alternative of a globally stationary ESTAR process.

For testing the null of a unit root against the alternative of a globally stationary ESTAR process firstly, consider a univariate smooth transition autoregressive STAR model of order 1:

$$y_t = \beta y_{t-1} + \gamma y_{t-1}\Theta(\theta; y_{t-d}) + \varepsilon_t \qquad t = 1,\ldots, \mathrm{T} \tag{4.17}$$

In this equation $y_t$ is a mean stochastic process, $\varepsilon_t \sim iid(0,\ \sigma^2)$, $\beta$ and $\gamma$ are unknown parameters. The transition function ($\Theta(\theta; y_{t-d})$) adopted of the exponential form:

$$\Theta(\theta; y_{t-d}) = 1 - \exp(-\theta y_{t-d}^2) \tag{4.18}$$

It is assumed that $\theta \geq 0$, and $d \geq 1$ is the delay parameter. The exponential function is bounded zero and one also it is symmetrically U-shaped around zero.

$$\Theta : R \to [0,1]$$

$$\Theta(0) = 0 \qquad \lim_{x \to \pm\infty} \Theta(x) = 1$$

Using (2) in (1) is obtained the following exponential STAR (ESTAR) model:

$$y_t = \beta y_{t-1} + \gamma y_{t-1}\left[1 - \exp(-\theta y_{t-d}^2)\right] + \varepsilon_t \tag{4.19}$$

after reparameterise:

$$y_t = \phi y_{t-1} + \gamma y_{t-1}\left[1 - \exp(-\theta y_{t-d}^2)\right] + \varepsilon_t \tag{4.20}$$

where $\phi = \beta - 1$. If $\theta$ is positive, it effectively determines the speed of mean reversion. For asset markets, if the differential between the risk adjusted returns on two assets is wide, the profitability of "arbitrage" is higher otherwise, the profitability of "arbitrage" is lower. In other words, if deviations from the equilibrium (3) are small in size the arbitrage is non-profitable. On the contrary, if deviations from the equilibrium (3) are large in size the arbitrage is profitable. In the context of this model, this would imply that while $\phi \geq 0$ is possible, it must be $\gamma < 0$ and $\phi + \gamma < 0$ for the process to be globally stationary. Under these conditions, the process might display unit root or explosive behavior for small values for $y_{t-d}^2$, but for the large values $y_{t-d}^2$, it has stable dynamics and as a result is geometrically ergodic. According to Kapetanios et. al.'s (2003) work, ADF test may lack power when the true process is stationary but nonlinear.

Imposing $\theta = 0$ and $d = 1$ gives ESTAR model (4), the model can be written as:

$$\Delta y_t = \gamma y_{t-1}\left[1 - \exp\left(-\theta y_{t-1}^2\right)\right] + \varepsilon_t \tag{4.21}$$

Kapetanios et. al. (2003) focuses on a specific parameter, $\theta$, which is zero under the null and positive under the alternative. They tested $H_0 : \theta = 0$ against the alternative $H_1 : \theta > 0$. Although testing the null hypothesis directly is not feasible, since $\gamma$ is not identified under the null. To overcome this problem, Kapetanios et al. (2003) follow Luukkonen et al. (1988), and derive a t-type test statistic. If first order Taylor series approximation to the ESTAR model under the null is computed, the auxiliary regression can be written as:

$$\Delta y_t = \delta y_{t-1}^3 + error \tag{4.22}$$

The t-statistic for $\delta = 0$ against $\delta < 0$ is:

$$t_{NL} = \hat{\delta} / s.e.\left(\hat{\delta}\right) \tag{4.23}$$

Where $\hat{\delta}$ is the OLS estimate of $\delta$ and s.e. $\left(\hat{\delta}\right)$ is the standard error of $\hat{\delta}$.

To accommodate stochastic processes with nonzero means and/or linear deterministic trends, one needs following modifications. In the case where the data has nonzero mean, $x_t = \mu + y_t$, the de-meaned data $y_t = x_t - \bar{x}$ was used, where $\bar{x}$ is the sample mean. For the case where the data has a nonzero mean and a nonzero linear trend, i.e., $x_t = \mu + \delta t + y_t$, the de-meaned and de-trended $y_t = x_t - \hat{\mu} - \hat{\delta}\, t$ was used, where $\hat{\mu}$ and $\hat{\delta}$ are the OLS estimators of $\mu$ and $\delta$.

The more case where the errors in (21) are serially correlated. Model (24) is extended:

$$\Delta y_t = \sum_{j=1}^{p} \rho_j \Delta y_{t-j} + \gamma y_{t-1}\left[1 - \exp\left(-\theta y_{t-1}^2\right)\right] + \varepsilon_t \tag{4.24}$$

where $\varepsilon_t \sim iid\left(0, \sigma^2\right)$. The $t_{NL}$ statistic for testing $\theta = 0$ in this set up is given by the same expression as in (7), where $\hat{\delta}$ is the OLS estimate of $\delta$ and s.e.$\left(\hat{\delta}\right)$ is the standard error of $\hat{\delta}$ obtained from the following auxiliary regression with the $p$ augmentations:

$$\Delta y_t = \sum_{j=1}^{p} \rho_j \Delta y_{t-j} + \delta y_{t-1}^3 + error \tag{4.25}$$

In practice, the number of augmentations $p$ must be selected prior to the test. Kapetanios et. al. (2003) propose that standard model selection criteria or significance testing procedure be used for this purpose because under the null of a linear model, the properties of these criteria are well understood.

### 4.1.3 Linear Panel Unit Root Test

Dickey-Fuller used individual series. Their test is not sufficient enough to detect the fact that the time series are stationary. At this point, Im, Pesaran and Shin (2002) developed a test for unit root a number of similar time-series variables collected in a pool.

Suppose that $y_{it}$ are generated according to following finite-order $AR(p_i + 1)$ processes:

$$y_{it} = \mu_i \phi_i(1) \sum_{j=1}^{p_i+1} \phi_{ij} y_{i,t-j} + \varepsilon_{it} \qquad \text{i=1,…,N; t=,…,T} \tag{4.26}$$

This can be written as the ADF ( $p_i$ ) regressions:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} \sum_{j=1}^{p_i} \rho_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \qquad \text{i=1,…,N; t=,…,T} \tag{4.27}$$

In this equation, $\phi_i(1) = 1 - \sum_{j=1}^{p_i+1} \phi_{ij}$ , $\alpha_i = \mu_i \phi_i(1)$ , $\beta_i = -\phi_i(1)$ , $p_{ij} = \sum_{h=j+1}^{p_i+1} \phi_{ih}$ .

ADF regressions for each i in matrix notations:

$$\Delta y_i = \beta_i y_{i,-1} + Q_i \gamma_i + \varepsilon_{it} \tag{4.28}$$

In equation: $Q_i = \left(\tau_{\mathrm{T}}, \Delta y_{i,-1}, \Delta y_{i,-2}, ..., \Delta y_{i,-p_i}\right)$ and $\gamma_i = \left(\alpha_i, \rho_{i1}, \rho_{i2}, ..., \rho_{ip_i}\right)'$. In their study according to their assumptions, t-bar statistic is formed as a simple average of the individual t statistic for testing $\beta_i = 0$.

$$t - bar_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{i\mathrm{T}}\left(p_i, \rho_i\right) \tag{4.29}$$

In this equation: $t_{i\mathrm{T}}\left(p_i, \rho_i\right) = \dfrac{\sqrt{\mathrm{T} - p_i - 2}\left(y_{i,-1}^{'} \mathrm{M}_{Q_i} \Delta y_i\right)}{\left(y_{i,-1}^{'} \mathrm{M}_{Q_i} y_{i,-1}\right)^{1/2}\left(\Delta y_i^{'} \mathrm{M} x_i \Delta y_i\right)^{1/2}}$ ;

where $\rho_i = \left(\rho_{i1}, \rho_{i2}, ..., \rho_{ip_i}\right)'$, $\mathrm{M}_{Q_i} = \mathrm{I}_{\mathrm{T}} - Q_i\left(Q_i^{'} Q_i\right)^{-1} Q_i$, $\mathrm{M}_{x_i} = \mathrm{I}_{\mathrm{T}} - X_i\left(X_i^{'} X_i\right)^{-1} X_i$, $X_i = \left(y_{i,-1}, Q_i\right)$.

The standardization using $E\left[t_{i\mathrm{T}}\left(p_i, \rho_i\right)\right]$ and $Var\left[t_{i\mathrm{T}}\left(p_i, \rho_i\right)\right]$ is not be practical because of the individual ADF statistics ( $t_{i\mathrm{T}}\left(p_i, \rho_i\right)$ ) are depend on the nuisance parameters ( $\rho_i, i = 1, ..., p_i$), even under $\beta_i = 0$ when T is fixed. If T and N are sufficiently large it is possible to develop asymptotically valid t-bar type panel unit root tests that are free from the nuisance parameters.

After converge the individual ADF statistics ( $t_{i\mathrm{T}}(p_i, \rho_i)$ ) to $\eta_i$, the standardized t-bar statistic:

$$\mathrm{Z}_{tbar}(p,\rho) = \frac{\sqrt{\mathrm{N}}\{t - bar_{\mathrm{NT}} - \mathrm{E}(\eta)\}}{\sqrt{Var(\eta)}} = \frac{1}{\sqrt{\mathrm{N}}}\sum_{i=1}^{\mathrm{N}} \chi_i \mathrm{T}(p_i, \rho_i) \tag{4.30}$$

If the standadized t-bar statistic ($\mathrm{Z}_{tbar}(p,\rho)$) converges in distribution to a standard normal variate sequentially, when $\mathrm{T} \to \infty$ and $\mathrm{N} \to \infty$, it is indicated by $\overset{\mathrm{T,N}}{\Longrightarrow} \mathrm{N}(0,1)$. As a result of this the standadized t-bar statistic can be written as:

$$\mathrm{Z}_{tbar}(p,\rho) = \frac{\sqrt{\mathrm{N}}\left\{\tilde{t} - bar_{\mathrm{NT}} - \mathrm{E}\left(\tilde{t}_{\mathrm{T}}\right)\right\}}{\sqrt{Var\left(\tilde{t}\right)}} \overset{\mathrm{T,N}}{\Longrightarrow} \mathrm{N}(0,1) \tag{4.31}$$

### 4.1.4 Nonlinear Panel Unit Root Test

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

$$\Delta y_{i,t} = \alpha_i + \phi_i y_{i,t} + \gamma_i y_{i,t-1}\left[1 - \exp\left(-\theta_i y_{i,t-d}^2\right)\right] + \varepsilon_{i,t} \tag{4.32}$$

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

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

$$\Delta y_{i,t} = \alpha_i + \gamma_i y_{i,t-1}\left[1 - \exp\left(-\theta_i y_{i,t-d}^2\right)\right] + \varepsilon_{i,t} \tag{4.33}$$

Nonlinear panel data unit root test based on regression (33) 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 $\gamma_i$ is not identified under the null. The problem can be solved by applying first-order Taylor series approximation to the PESTAR(1) model around $\theta_i = 1$ for all i. Hence, the obtained auxiliary regression is:

$$\Delta y_{i,t} = \alpha_i + \delta_i y_{i,t}^3 + \varepsilon_{i,t} \tag{4.34}$$

where $\delta_i = \theta_i \gamma_i$.

The hypotheses for unit root testing based on regression (34) was established by Ucar and Omay (2009) as follows:

$H_0 : \delta_i = 0$, for all i, (linear nonstationarity)

$H_1 : \delta_i < 0$, for some i, (nonlinear stationarity)

They purposed panel unit root tests computed through taking the average of individual KSS statistics. The KSS statistic for the $i^{th}$ individual is simply t-ratio of $\delta_i$ in regression (34) defined by :

$$t_{i,NL} = \frac{\Delta y_i^{'} \mathrm{M}_\tau y_{i,-1}^3}{\hat{\sigma}_{i,NL} \left( y_{i,-1}^{'} \mathrm{M}_\tau y_{i,-1} \right)^{3/2}} \tag{4.35}$$

Where $\hat{\sigma}_{i,NL}$ is the consistent estimator such that $\hat{\sigma}_{i,NL}^2 = \Delta y_i^{'} \mathrm{M}_\tau \Delta y_i / (\mathrm{T}-1), \mathrm{M}_\tau = I_\mathrm{T} - \tau_\mathrm{T} \left( \tau_\mathrm{T}^{'} \tau_\mathrm{T} \right)^{-1} \tau_\mathrm{T}^{'}$. Notice here that $\Delta y_i = \left( \Delta y_{i,1}, \Delta y_{i,2}, ..., \Delta y_{i,\mathrm{T}} \right), y_{i,-1}^3 = \left( y_{i,0}^3, y_{i,1}^3, ..., y_{i,\mathrm{T}-1}^3 \right)$ and $\tau_\mathrm{T} = (1,1,...,1)^{'}$

Furthermore, when the invariance property and the existence of moments are satisfied, the usual normalization of $\bar{t}_{NL}$ statistic yields can be written as:

$$\bar{\mathrm{Z}}_{NL} = \frac{\sqrt{\mathrm{N}} \left( \bar{t}_{NL} - \mathrm{E}\left( t_{i,NL} \right) \right)}{\sqrt{Var\left( t_{i,NL} \right)}} \xrightarrow{d} \mathrm{N}(0,1) \tag{4.36}$$

In this equation: $\bar{t}_{NL} = \frac{1}{\mathrm{N}} \sum_{i=1}^{\mathrm{N}} t_{i,NL}$ , $\mathrm{E}\left( t_{i,NL} \right)$ and $Var\left( t_{i,Nl} \right)$ values are given in the table below:

**Table 2:** 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 |

In general, it is assumed that disturbances in panel data models are cross sectionally independent. (Pesaran, 2004: 1) The cross section dependency is occurred from some reasons. For instance; spatial correlations, spillover effects, economic distance, omitted global variables and common unobserved shocks. Pesaran (2004) employed a general diagnostic test for cross section dependence (CD) in panels and indicates that cross section dependency continues exist in small panels and also large panels. At this point, misspecification test should be done. CD test is applicable to a variety of panel data models, including stationary dynamic and unit-root heterogeneous panels with short T and large N. The test is based on a simple average of all pair-wise correlation coefficients of the Ordinary Least Squares (OLS) residuals from the individual regressions in the panel:

$$y_{it} = \alpha_i + \beta_i^{'} X_{it} + \varepsilon_{it}, \quad \text{for i=1,2,...,}N; \quad \text{t=1,2,...,}T \tag{4.37}$$

In this equation:

i: indexes the cross section dimension.

t: time series dimension.

$x_{it}$: kx1 vector of observed time-varying regressors

$\alpha_i$ : individual intercepts.

$\beta_i$ : the slope coefficients (defined on a compact set and allowed to vary accross i)

For each i an all t: $\varepsilon_{it} \sim IID\left(0, \sigma_{iu}^2\right)$ (they could be cross sectionally corelated)

Breusch and Pagan (1980) proposed an Lagrange multiplier statistic for testing the null of zero cross equation error correlations:

$$CD_{lm} = \mathrm{T}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^{2} \qquad (4.38)$$

$\hat{\rho}_{ij}$ is the sample estimate of the pair wise correlation of the residuals:

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} = \frac{\sum_{t=1}^{\mathrm{T}} e_{it} e_{jt}}{\left(\sum_{t=1}^{\mathrm{T}} e_{it}^2\right)^{1/2}\left(\sum_{t=1}^{\mathrm{T}} e_{jt}^2\right)^{1/2}} \qquad (4.39)$$

the $e_{it}$ is the OLS estimates of $\varepsilon_{it}$ defined by:

$$e_{it} = y_{it} - \hat{\alpha}_i - \hat{\beta}_i' X_{it} \qquad (4.40)$$

Pesarans's (2004) CD test when $N$ is large and $T$ is small. It is simple alternative which is biased on the pair wise correlation coefficients rather than Breusch and Pagan's squares used in the Lagrange Multiplier test:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \tag{4.41}$$

Omay and Kan (2010) employed Panel Smooth Transition Regression (PTSR). It allows a small number of extreme regimes where transitions in-between are smooth. The simplest case with two extreme regimes:

$$\Delta y_{it} = \mu_i + \beta_0' x_{it} + \beta_1' x_{it} F(s_{it};\gamma,c) + u_{it} \qquad \text{for i} = 1,...,N \text{ and t} = 1,...,T \tag{4.42}$$

where $N$ and $T$ denote the cross-section and time dimensions of the panel.

$e_{it}$ is the NLLS estimates on $u_{it}$ defined by:

$$e_{it} = \Delta y_{it} - \hat{\mu}_i - \hat{\beta}_0' x_{it} - \hat{\beta}_1' x_{it} F\left(s_{it};\gamma,\hat{c}\right) \tag{4.43}$$

where $F\left(\dot{s}_{it};\hat{\gamma},\hat{c}\right) = \dfrac{1}{1+e^{-\hat{\gamma}\left(\dot{s}_{it}-\hat{c}\right)}}$

Paralel with the preceding arguments, in this research thesis the above explained tests, specifically the conventional ADF and PP unit root tests, linear panel unit root test IPS, the Kapetanios et al. (2003)'s nonlinear unit root test as well as Ucar and

Omay (2010)'s nonlinear panel unit root test will be applied to test whether the sample markets, specifically the futures markets of Greece, Hungary, Poland, Russian and Turkey, are weak form efficient.

### 4.2 Data, Analyses and Results

The procedure that was defined in methodology section is employed to test futures markets of five European Emerging Economies. The price series of future indices in these markets will be searched for whether they contain unit root. In case a unit root exists, index prices will support random walk which will then indicate that the market is weak form efficient. Greek, Hungarian, Polish, Russian and Turkish futures markets are analyzed. In this study, monthly data are used between the period of September 2005 and June 2011. There are 70 observations for each markets for a total of 350 observations. The index values are sourced from DataStream.

**Table 3:** Description of Futures Index Price Series

| Country | Series | DataStream Code | Period covered | Number of observations |
|---|---|---|---|---|
| Greece | FTSE/ASE -20 | ADEX | 2005:09-2011:06 | 70 |
| Hungary | BUX | BSE | 2005:09-2011:06 | 70 |
| Poland | WIG-20 | WSE | 2005:09-2011:06 | 70 |
| Russia | RTS | RTS | 2005:09-2011:06 | 70 |
| Turkey | ISE-30 | TURKDEX | 2005:09-2011:06 | 70 |

Prices should be unpredictable in an efficient market. In fact, index prices may include time trend. To overcome this problem, de-meaned and de-trended series are considered on nonlinear unit root test which is described in previous chapter. These series were constituted by regressing the natural logarithms of index series on a constant and a linear time trend.

Firstly, ADF (Dickey and Fuller, 1981) and PP (Phillips and Perron, 1988) tests' results for nonstationarity of the series and their differences are denoted in Table 4. Both tests' results show that all futures prices indexes are *I(1)* processes, consistent with the efficient market hypothesis.

**Table 4:** Linear Unit Root Test Results

| | ADF | | PP | |
|---|---|---|---|---|
| Country | Log Level[a] | First Difference[b] | Log Level[a] | First Difference[b] |
| Greece | -2.512 | -5.693* | -2.281 | -5.693* |
| Hungary | -1.722 | -6.519* | -1.694 | -6.524* |
| Poland | -2.225 | -7.481* | -1.695 | -7.598* |
| Russia | -2.374 | -4.807* | -2.021 | -4.864* |
| Turkey | -1.478 | -7.061* | -1.797 | -7.129* |

Notes:
a) Regressions include an intercept and linear time trend.
b) Regressions include only intercept.
Optimal lag length in ADF test was selected using AIC with maximum lag order of 10. *, ** and *** indicate significance at 1%, 5% and 10% significance levels, respectively.

Secondly, AR(10) model was estimated for all series to apply the nonlinear unit root tests. Here, insignificant (at 10% significance level) augmentation terms were excluded. After estimation of augmentation terms, to calculate the $t_{NL}$ statistics regression with selected augmentations were estimated and delay parameter $d$ that maximized $R^2$ over $d = \{1,2,...,10\}$ was selected. Unlike the case of testing linearity against STAR type nonlinearity, the $t_{NL}$ test does not have an asymptotic standard normal distribution. For this reason, the $t_{NL}$ test statistic with 10,000 replications was bootstrapped. The test statistics and estimation results are presented in Table 5.

**Table 5:** Nonlinear Unit Root Test Results

| Country | $t_{NL}$ |
|---|---|
| Greece | -2.981 |
| Hungary | -2.526 |
| Poland | -4.828* |
| Russia | -2.228 |
| Turkey | -4.856* |

Notes: The $t_{NL}$ statistic was computed by bootstrapping with 10,000 replications. Asymptotic critical values of the $t_{NL}$ statistic at 1%, 5% and 10% significance levels and *, **and *** denote significance at 1%, 5% and 10% levels, respectively.

The results provided in Table 5 show that, Polish and Turkish series reject the null hypothesis of unit root at 1% significance level, indicating that these markets are not efficient. The remaining markets do not reject the null hypothesis of unit root at conventional levels which implies that Greek, Hungarian and Russian markets are efficient in the weak form.

In Table 6, group of countries are denoted in panel unit root context. The results show that the assumption of independence over cross-section units. However, Table 7 indicates that this assumption is violated.

**Table 6:** Linear and Nonlinear Panel Unit Root Test Results Without Cross Section Dependency

| | IPS | | UO | |
|---|---|---|---|---|
| | Log Level[a] | First Difference[b] | Log Level[a] | First Difference[b] |
| $t_{NL}$ | -1.909 | -6.312* | 0.869 | -3.356** |
| $z_{tbar}$ | 0.753 | -12.460* | 7.325 | -14.642** |

Notes:
a) Regressions include an intercept and linear time trend.
b) Regressions include only intercept.
Optimal lag length in IPS and UO tests were selected using AIC with maximum lag order of 10. *, ** and *** indicate significance at 1%, 5% and 10% significance levels, respectively.

**Table 7:** Cross Section Dependency Test

| | Statistical value | P value |
|---|---|---|
| $CD_{LM1}$ | 150.190 | 0.000 |
| $CD_{LM2}$ | 31.347 | 0.000 |
| $CD_{LM3}$ | 9.175 | 0.000 |
| Notes: Under the null hypothesis the CD statistics converge to a normal standard distribution. The values in the parentheses are *p* values. | | |

To solve cross section dependency problem, Sieve bootstrap approach was employed which is very well outlined in Ucar and Omay (2009). UO and IPS with Sieve bootstrap approach results are denoted in Table 8.

**Table 8:** Linear and Nonlinear Panel Unit Root Test Results With Cross Section Dependency

| | IPS | | UO | |
|---|---|---|---|---|
| | Log Level[a] | First Difference[b] | Log Level[a] | First Difference[b] |
| $t_{NL}$ | -2.145 | -6.312* | 0.875 | -2.813* |
| $z_{tbar}$ | -1.547 | -15.022* | 7.342 | -3.108* |

Notes:
a) Regressions include an intercept and linear time trend.
b) Regressions include only intercept.
Optimal lag length in IPS and UO tests were selected using AIC with maximum lag order of 10. *, ** and *** indicate significance at 1%, 5% and 10% significance levels, respectively.

From Table 8, it can be seen that IPS and UO tests have different results. According to IPS test, group of eastern European emerging countries failed to reject the null hypothesis of unit root, which shows that this group is efficient. On the contrary, UO test rejected the null hypothesis for this group, implying that they are inefficient as a group. The linear unit root and the panel unit root test suggest that these markets are individually and as a group, efficient markets, whereas nonlinear unit root and nonlinear panel unit root tests suggest that some of these markets are individually efficient but as a group they seem to be inefficient in weak form.

# CHAPTER 5

## 5. CONCLUSION

In this research thesis we attempt to investigate the weak-form market efficiency in derivative markets of five European Emerging Economies, specifically Greek, Hungarian, Polish, Russian and Turkish futures markets. To test the weak form market efficiency in these derivative markets the methodology is based on the Random Walk Model and the price series in these markets are searched for whether they contain unit root. For this purpose, conventional ADF and PP unit root tests, linear panel unit root test IPS, the Kapetanios et. al. (2003)'s nonlinear unit root test as well as Ucar and Omay (2009)'s nonlinear panel unit root test are applied.

ADF and PP test results suggest that all futures markets index contracts price series contain unit root, which indicates that all of the futures markets in the sample European emerging economies are weak form efficient. But nonlinear unit root test findings reject the null hypothesis of unit root for the Polish and Turkish futures markets, implying that these markets are not efficient. In addition, linear and nonlinear panel unit root test were applied to this group of markets. The results obtained by the linear panel unit root test show that this group when considered as a whole, are efficient in weak form sense while the findings of the nonlinear panel unit root test indicates that they are inefficient as a group.

In sum, it can be concluded that the sample futures markets of European emerging countries are weak form efficient in the linear sense, but nonlinear test results imply inefficiencies in these markets. When the markets are tested individually, nonlinear unit root test results suggest that the Polish and the Turkish futures markets are found to be inefficient. Moreover, the results of nonlinear panel unit root test which can be argued to have a better explanatory power, suggest that as a group they are inefficient. These results imply that it may be possible to gain above average market returns and earn speculative returns in these markets, especially in the Polish and the Turkish futures markets.

Furthermore, considering the various functions futures markets serve for all market participants including the investors, speculators, hedgers, businesses etc., as well as its impact on the spot market and its functions such as price discovery and risk reduction, Eastern European region countries, especially Poland and Turkey, seem to lack in providing the sufficient infrastructure, arrangements, trade volume and market capitalization, and hence can be argued to have a necessity to take precautions to overcome the obstacles inherit in their prevailing market structures and to ensure a more efficient derivative markets.

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# APPENDIX A

**Table A.1:** Derivative financial instruments traded on organized exchanges
By instrument and location (Number of contracts in millions)
Bank For International Settlements, BIS Quarterly Review March 2011
(http://www.bis.org/publ/qtrpdf/r_qa1103.pdf#page=127, 11 April 2011)

| | Contracts outstanding | | | | Turnover | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Instrument / location | Dec 2008 | Dec 2009 | Sep 2010 | Dec 2010 | 2009 | 2010 | Q1 2010 | Q2 2010 | Q3 2010 | Q4 2010 |
| **Futures** | | | | | | | | | | |
| **All markets** | **110.4** | **94.3** | **99.9** | **85.2** | **4,571.9** | **6,346.7** | **1,442.4** | **1,768.4** | **1,530.7** | **1,605.3** |
| Interest rate | 77.1 | 63.9 | 67.9 | 63.3 | 1,935.9 | 2,546.1 | 604.7 | 696.4 | 608.1 | 637.0 |
| Currency | 7.6 | 5.9 | 7.9 | 5.3 | 377.4 | 1,406.3 | 289.0 | 374.8 | 330.3 | 412.2 |
| Equity index | 25.7 | 24.5 | 24.1 | 16.7 | 2,258.6 | 2,394.3 | 548.8 | 697.2 | 592.3 | 556.1 |
| **North America** | **72.3** | **56.6** | **53.9** | **43.5** | **1,825.6** | **2,160.9** | **499.1** | **622.5** | **513.8** | **525.5** |
| Interest rate | 57.4 | 42.4 | 40.4 | 36.5 | 913.2 | 1,177.9 | 269.1 | 330.4 | 274.7 | 303.8 |
| Currency | 0.7 | 0.9 | 1.3 | 1.3 | 158.0 | 234.8 | 54.8 | 66.4 | 55.9 | 57.6 |
| Equity index | 14.1 | 13.3 | 12.3 | 5.7 | 754.4 | 748.2 | 175.2 | 225.7 | 183.2 | 164.1 |
| **Europe** | **20.4** | **19.1** | **20.2** | **17.1** | **1,674.9** | **1,988.4** | **472.0** | **560.7** | **471.5** | **484.2** |
| Interest rate | 9.3 | 10.1 | 10.5 | 9.0 | 759.3 | 931.3 | 240.6 | 256.6 | 218.2 | 215.8 |
| Currency | 5.4 | 2.8 | 2.2 | 1.5 | 84.0 | 145.6 | 19.1 | 31.8 | 36.7 | 58.0 |
| Equity index | 5.8 | 6.2 | 7.5 | 6.6 | 831.6 | 911.5 | 212.3 | 272.3 | 216.5 | 210.4 |
| **Asia and Pacific** | **5.9** | **6.5** | **7.5** | **6.2** | **709.2** | **1,641.2** | **343.7** | **438.9** | **406.8** | **451.9** |
| Interest rate | 3.0 | 2.9 | 3.1 | 3.0 | 92.5 | 119.2 | 26.1 | 30.6 | 32.2 | 30.3 |
| Currency | 0.2 | 1.0 | 2.2 | 1.0 | 42.3 | 913.0 | 187.3 | 243.6 | 213.0 | 269.1 |
| Equity index | 2.7 | 2.7 | 2.2 | 2.2 | 574.4 | 609.0 | 130.2 | 164.6 | 161.7 | 152.5 |
| **Other Markets** | **11.8** | **12.1** | **18.3** | **18.4** | **362.2** | **556.2** | **127.6** | **146.4** | **138.5** | **143.7** |
| Interest rate | 7.4 | 8.5 | 13.9 | 14.8 | 170.9 | 317.8 | 68.8 | 78.9 | 82.9 | 87.1 |
| Currency | 1.3 | 1.2 | 2.2 | 1.5 | 93.2 | 112.8 | 27.8 | 33.0 | 24.6 | 27.4 |
| Equity index | 3.1 | 2.3 | 2.1 | 2.1 | 98.2 | 125.6 | 31.0 | 34.5 | 31.0 | 29.2 |
| **Memorandum items:** | | | | | | | | | | |
| **Commodity contracts** | **20.1** | **36.1** | **43.0** | **40.7** | **1,908.9** | **2,675.4** | **589.8** | **638.2** | **687.3** | **760.1** |
| US markets | 15.7 | 28.6 | 31.6 | 30.4 | 561.8 | 663.9 | 153.4 | 173.7 | 164.8 | 172.1 |
| Other markets | 4.4 | 7.5 | 11.4 | 10.3 | 1,347.1 | 2,011.5 | 436.3 | 464.5 | 522.6 | 588.1 |
| **Options** | | | | | | | | | | |
| **All markets** | **130.0** | **137.5** | **158.5** | **139.0** | **4,816.3** | **5,812.2** | **1,317.6** | **1,509.9** | **1,377.4** | **1,607.3** |
| Interest rate | 35.3 | 51.8 | 64.5 | 62.1 | 527.5 | 653.0 | 173.9 | 176.7 | 150.6 | 151.7 |
| Currency | 2.8 | 2.8 | 2.8 | 2.9 | 42.4 | 56.4 | 14.3 | 13.3 | 11.8 | 16.9 |
| Equity index | 91.9 | 82.9 | 91.2 | 74.0 | 4,246.4 | 5,102.7 | 1,129.3 | 1,319.8 | 1,214.9 | 1,438.7 |
| **North America** | **33.1** | **38.1** | **43.0** | **39.3** | **528.0** | **627.6** | **147.7** | **180.6** | **145.8** | **153.5** |
| Interest rate | 15.6 | 19.0 | 20.3 | 19.3 | 224.2 | 269.1 | 59.3 | 76.1 | 64.3 | 69.4 |
| Currency | 0.9 | 0.5 | 0.7 | 0.6 | 6.3 | 12.0 | 2.3 | 3.7 | 2.9 | 3.0 |
| Equity index | 16.6 | 18.6 | 22.0 | 19.4 | 297.5 | 346.6 | 86.1 | 100.8 | 78.5 | 81.2 |
| **Europe** | **80.0** | **73.6** | **80.8** | **62.4** | **754.2** | **720.4** | **199.4** | **203.5** | **156.7** | **160.8** |
| Interest rate | 14.3 | 20.7 | 21.5 | 16.9 | 243.3 | 256.0 | 81.3 | 71.5 | 53.4 | 49.8 |
| Currency | 0.1 | 0.1 | 0.1 | 0.1 | 2.5 | 1.6 | 0.4 | 0.4 | 0.4 | 0.5 |
| Equity index | 65.6 | 52.8 | 59.3 | 45.4 | 508.4 | 462.7 | 117.7 | 131.5 | 103.0 | 110.5 |
| **Asia and Pacific** | **5.4** | **9.0** | **8.5** | **8.2** | **3,369.7** | **4,226.3** | **909.1** | **1,065.2** | **1,017.1** | **1,234.9** |
| Interest rate | 0.1 | 0.0 | 0.0 | 0.0 | 4.5 | 5.0 | 1.0 | 1.1 | 1.5 | 1.4 |
| Currency | – | – | – | 0.3 | – | 6.2 | – | – | – | 6.2 |
| Equity index | 5.3 | 9.0 | 8.5 | 7.8 | 3,365.2 | 4,215.1 | 908.1 | 1,064.1 | 1,015.6 | 1,227.3 |
| **Other Markets** | **11.5** | **16.8** | **26.1** | **29.1** | **164.4** | **237.8** | **61.4** | **60.6** | **57.8** | **58.0** |
| Interest rate | 5.3 | 12.2 | 22.6 | 25.9 | 55.6 | 122.8 | 32.4 | 28.0 | 31.4 | 31.0 |
| Currency | 1.8 | 2.2 | 2.0 | 1.8 | 33.5 | 36.7 | 11.6 | 9.2 | 8.6 | 7.3 |
| Equity index | 4.4 | 2.5 | 1.5 | 1.4 | 75.3 | 78.4 | 17.5 | 23.4 | 17.8 | 19.7 |
| **Memorandum items:** | | | | | | | | | | |
| **Commodity contracts** | **19.5** | **18.8** | **23.7** | **22.1** | **132.9** | **154.8** | **34.3** | **36.7** | **39.6** | **44.2** |
| US markets | 18.5 | 17.7 | 21.5 | 20.5 | 114.3 | 137.0 | 30.2 | 33.0 | 35.1 | 38.8 |
| Other markets | 1.0 | 1.1 | 2.2 | 1.7 | 18.6 | 17.7 | 4.1 | 3.7 | 4.5 | 5.5 |
| **Single equity contracts** | **341.9** | **365.3** | **407.9** | **386.9** | **5,624.1** | **6,001.8** | **1,469.7** | **1,665.2** | **1,342.4** | **1,524.5** |
| US markets | 235.8 | 256.7 | 271.2 | 282.3 | 4,175.0 | 4,284.4 | 1,041.0 | 1,206.0 | 930.0 | 1,107.4 |
| Other markets | 106.1 | 108.6 | 136.7 | 104.6 | 1,449.0 | 1,717.4 | 428.7 | 459.2 | 412.4 | 417.1 |

**Table A.2:** Derivative financial instruments traded on organized exchanges
By instrument and location (Notional principal in billions of US dollars)
Bank For International Settlements, BIS Quarterly Review March 2011
(http://www.bis.org/publ/qtrpdf/r_qa1103.pdf#page=126, 11 April 2011)

| | Amounts outstanding | | | | Turnover | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Instrument / location | Dec 2008 | Dec 2009 | Sep 2010 | Dec 2010 | 2009 | 2010 | Q1 2010 | Q2 2010 | Q3 2010 | Q4 2010 |
| **Futures** | | | | | | | | | | |
| **All markets** | **19,508.3** | **21,738.1** | **24,420.8** | **22,315.6** | **1,126,516.4** | **1,380,387.8** | **346,816.4** | **384,716.5** | **305,361.8** | **343,493.1** |
| Interest rate | 18,732.3 | 20,627.7 | 23,105.0 | 21,018.8 | 1,016,361.6 | 1,235,836.2 | 313,565.2 | 344,455.0 | 270,635.0 | 307,181.1 |
| Currency | 125.1 | 144.3 | 218.5 | 169.1 | 24,598.7 | 35,709.6 | 8,457.7 | 9,825.0 | 8,306.8 | 9,120.2 |
| Equity index | 650.9 | 966.1 | 1,097.2 | 1,127.7 | 85,556.0 | 108,841.9 | 24,793.5 | 30,436.5 | 26,420.1 | 27,191.9 |
| **North America** | **10,138.4** | **10,721.1** | **12,698.2** | **11,864.7** | **599,025.0** | **729,195.2** | **177,625.6** | **210,146.2** | **153,648.6** | **187,774.9** |
| Interest rate | 9,818.8 | 10,284.9 | 12,186.1 | 11,351.9 | 543,950.8 | 658,194.4 | 161,033.8 | 189,903.7 | 136,806.6 | 170,450.3 |
| Currency | 60.8 | 90.7 | 118.3 | 114.9 | 19,606.8 | 28,646.9 | 6,794.1 | 7,824.1 | 6,736.0 | 7,292.6 |
| Equity index | 258.7 | 345.5 | 393.8 | 398.0 | 35,467.4 | 42,354.0 | 9,797.7 | 12,418.3 | 10,106.1 | 10,031.9 |
| **Europe** | **6,506.3** | **8,053.3** | **7,767.7** | **6,332.1** | **449,387.0** | **533,144.9** | **145,105.9** | **144,657.6** | **120,590.1** | **122,791.2** |
| Interest rate | 6,252.3 | 7,608.7 | 7,244.9 | 5,806.3 | 420,030.6 | 498,761.9 | 136,405.8 | 135,108.9 | 112,784.2 | 114,463.0 |
| Currency | 5.3 | 2.7 | 2.1 | 1.4 | 78.8 | 195.7 | 19.1 | 36.0 | 56.9 | 83.7 |
| Equity index | 248.8 | 441.9 | 520.6 | 524.4 | 29,277.6 | 34,187.2 | 8,681.0 | 9,512.7 | 7,749.0 | 8,244.5 |
| **Asia and Pacific** | **2,466.3** | **2,408.3** | **3,041.8** | **3,173.5** | **63,125.2** | **92,282.6** | **18,106.3** | **23,036.8** | **24,956.1** | **26,183.4** |
| Interest rate | 2,327.1 | 2,250.6 | 2,869.1 | 2,987.3 | 43,808.5 | 60,908.2 | 12,316.5 | 15,057.7 | 16,352.3 | 17,181.7 |
| Currency | 7.7 | 9.7 | 9.7 | 1.5 | 552.4 | 1,594.4 | 335.6 | 420.6 | 379.9 | 458.2 |
| Equity index | 131.5 | 148.1 | 163.0 | 184.7 | 18,764.3 | 29,780.0 | 5,454.2 | 7,558.5 | 8,223.9 | 8,543.5 |
| **Other Markets** | **397.2** | **555.4** | **913.1** | **945.3** | **14,979.2** | **25,765.1** | **5,978.6** | **6,875.9** | **6,167.0** | **6,743.6** |
| Interest rate | 334.0 | 483.5 | 804.8 | 873.4 | 8,571.7 | 17,971.7 | 3,809.2 | 4,384.7 | 4,691.9 | 5,086.0 |
| Currency | 51.3 | 41.2 | 88.5 | 51.4 | 4,360.8 | 5,272.7 | 1,308.8 | 1,544.2 | 1,134.0 | 1,285.6 |
| Equity index | 11.9 | 30.7 | 19.8 | 20.5 | 2,046.7 | 2,520.7 | 860.6 | 947.0 | 341.0 | 372.0 |
| **Options** | | | | | | | | | | |
| **All markets** | **38,236.2** | **51,379.6** | **53,234.0** | **45,615.9** | **533,634.9** | **606,581.4** | **168,119.3** | **170,949.9** | **132,386.7** | **135,125.5** |
| Interest rate | 33,978.8 | 46,428.7 | 47,803.3 | 40,915.6 | 434,601.0 | 468,843.2 | 136,820.5 | 135,190.9 | 100,874.2 | 95,957.6 |
| Currency | 129.3 | 147.3 | 148.1 | 144.2 | 1,980.3 | 3,048.3 | 790.3 | 837.3 | 724.5 | 696.2 |
| Equity index | 4,128.1 | 4,803.5 | 5,282.6 | 4,556.1 | 97,053.6 | 134,689.9 | 30,508.5 | 34,921.7 | 30,788.0 | 38,471.7 |
| **North America** | **19,533.5** | **23,874.9** | **26,557.8** | **24,351.3** | **216,390.4** | **261,543.8** | **59,334.7** | **80,344.0** | **59,979.7** | **61,885.4** |
| Interest rate | 17,788.9 | 21,817.7 | 24,064.5 | 22,070.4 | 188,438.5 | 225,342.9 | 50,290.0 | 69,593.8 | 51,976.8 | 53,482.3 |
| Currency | 45.0 | 65.3 | 89.7 | 72.3 | 657.5 | 1,600.7 | 318.5 | 473.3 | 380.4 | 428.4 |
| Equity index | 1,699.5 | 1,991.9 | 2,403.6 | 2,208.6 | 27,294.3 | 34,600.2 | 8,726.2 | 10,276.8 | 7,622.5 | 7,974.7 |
| **Europe** | **18,115.7** | **26,322.6** | **24,860.4** | **19,208.5** | **258,556.9** | **251,454.7** | **88,978.4** | **68,100.2** | **50,149.7** | **44,226.3** |
| Interest rate | 15,879.5 | 23,905.0 | 22,392.1 | 17,285.3 | 240,483.9 | 233,903.3 | 84,172.3 | 63,463.5 | 46,382.6 | 39,884.9 |
| Currency | 0.6 | 0.3 | 0.3 | 0.3 | 7.7 | 5.1 | 1.4 | 1.5 | 1.0 | 1.2 |
| Equity index | 2,235.6 | 2,417.2 | 2,468.0 | 1,922.9 | 18,065.4 | 17,546.3 | 4,804.7 | 4,635.3 | 3,766.1 | 4,340.2 |
| **Asia and Pacific** | **219.4** | **310.4** | **383.4** | **384.8** | **52,751.4** | **82,739.4** | **16,995.8** | **19,905.6** | **19,577.1** | **26,260.9** |
| Interest rate | 83.8 | 7.2 | 17.6 | 3.5 | 2,825.0 | 2,605.6 | 558.8 | 568.2 | 718.2 | 760.5 |
| Currency | - | - | 0.0 | 0.3 | - | 6.2 | - | - | 0.0 | 6.2 |
| Equity index | 135.6 | 303.3 | 365.8 | 381.0 | 49,926.4 | 80,127.5 | 16,437.0 | 19,337.4 | 18,858.9 | 25,494.2 |
| **Other Markets** | **367.6** | **871.7** | **1,432.4** | **1,671.3** | **5,936.2** | **10,843.5** | **2,810.4** | **2,600.1** | **2,680.2** | **2,752.8** |
| Interest rate | 226.6 | 698.9 | 1,329.2 | 1,556.4 | 2,853.6 | 6,991.3 | 1,799.4 | 1,565.4 | 1,796.6 | 1,829.9 |
| Currency | 83.7 | 81.7 | 58.1 | 71.3 | 1,315.1 | 1,436.3 | 470.4 | 362.4 | 343.1 | 260.4 |
| Equity index | 57.4 | 91.1 | 45.1 | 43.6 | 1,767.5 | 2,415.9 | 540.7 | 672.2 | 540.5 | 662.5 |

# APPENDIX B

**Table B.1:** Summary of the empirical studies on weak form efficiency on developed markets

| DEVELOPED MARKETS | | | | |
|---|---|---|---|---|
| **Study** | **Country & Market** | **Period** | **Methodology** | **Results** |
| Lo and MacKinlay (1988) | US / NYSE & AMEX | 1962 – 1985 | simple volatility-based specification test | rejected random walk |
| Poterba and Summers (1986) | US / Standard and Poor's Composite Stock Index | 1928 – 1984 | time series properties of stock market volatility | rejected random walk |
| Kenourgios and Samitas (2005) | UK / London Metal Exchange (LME) | 1989 – 2000 | Stationarity Augmented Dickey-Fuller (ADF) test<br>Non-parametric Phillips- Perron (PP) unit root test | is not efficient in weak form |
| Gan et. al. (2005) | New Zealand Stock Exchange Index (NZSE), Australia Stock Exchange Index (ASX), Japan Nikkei Index, US New York Stock Exchange Index (NYSE) | 1990 – 2003 | Augmented-Dickey Fuller (ADF) and Philip-Perron (PP) unit root tests | all markets are efficient in weak form |
| Torun and Kurt (2008) | Austrian Traded Index (Austria), Belgian 20 Price Index (Belgium), Helsinki Stock Exchange All-Share Index (Finland), Compagnie des Agents de Change 40 Index (France), Deutscher Aktienindex (Germany), Irish Stock Ex-change Equity Overall Index (Ireland), Milano Italia Borsa 30 Index (Italy), Luxembourg Stock Exchange index (Luxemburg), Amsterdam Exchanges index (Nether-lands), Portuguese Stock Index 20 (Portugal) , Association of Stock Exchanges (Spain) | 1999 – 2006 | panel unit root tests<br><br>panel co-integration and causality analysis to test the semi-strong form of market efficiency | all markets are efficient in the weak form<br><br>markets are not totally efficient in semi-strong form |
| Demireli et. al. (2010) | US / S&P 500 Index | 1991 – 2010 | Dickey Fuller Test, Phillip Perron Test and correlogram | Supported random walk model indicating weak form market efficient |

**Table B.2:** Summary of the empirical studies on weak form efficiency on emerging markets

| EMERGING MARKETS | | | | |
|---|---|---|---|---|
| **Study** | **Country & Market** | **Period** | **Methodology** | **Results** |
| Magnusson and Wydick (2002) | African stock markets (Botswana, Ivory Coast, Ghana, Kenya, Mauritius, Nigeria, South Africa, Zimbabwe) South Asia (Indonesia, Korea, Taiwan, Thailand) and Latin America (Argentina, Brazil, Chile, Ecuador, Mexico) stock markets | 1989-1998 | Partial Auto-Correlation Function (PACF) and the Box-Pierce Q-statistic | African stock market did not pass high barriers of weak form efficiency |
| Tas and Dusunoglu (2005) | Turkey / Istanbul Stock Exchange (ISE) National-30 Index | 1995-2004 | Dickey-Fuller unit root test and run test | İneffcient in weak form |
| Moustafa (2004) | UAE | 2001-2003 | run test | Weak form efficient |
| Gilmore and Mcmanus (2003) | Warsaw Stock Exchange (WSE) Poland, Budapest Stock Exchange (BSE) Hungary, Prague Stock Exchange (PSE) Czech Republic | 1995-2000 | unit root test, variance ratio test autocorrelation, Johansen and Granger causality, NAÏVE model with ARIMA and GARCH alternatives | WSE, BSE and PSE were ineffcient according to all tests except Granger causality test |
| Smith and Ryoo (2003) | stock market price indices in Greece, Hungary, Poland, Portugal and Turkey | 1991– 998 | variance ratio test | Greece, Hungary, Poland and Portugal did not follow the weak form market efficiency, Turkish market is efficient in the weak form. |
| Müslümov et. al (2003) | Istanbul Stock Exchange (ISE-100) Turkey | 1992-2002 | auto-regressive conditional heteroscedastic (GARCH) model | 65% of the stock returns of the individual stocks did not follow random walk<br>First period ISE 100 Index did not follow random walk<br>Second period ISE 100 Index supported random walk |
| Abrosimova et. al. (2005) | Russia / Russian Trading System (RTS) index | 1995 - 2001 | unit root test, variance ratio test and autocorrelation | Weak form efficient |

| | | | | |
|---|---|---|---|---|
| Hassan et. al. (2006) | Russia, Czech Repuplic, Hungary, Poland, Greece, Slovakia and Turkey | 1988-2002 | Ljung-Box Q-statistic, run test and variance ratio test | Greece, Turkey and Slovakia followed random walk model and weak form efficient, Russia, Hungary, Poland and Czech Republic did not weak form efficient. |
| Kahraman and Erkan (2005) | Turkey / ISE 100 Index | 1996-2004 | Serial correlation test | ISE 100 did not support random walk model |
| Aga and Kocaman (2006, 2008) | Turkey / Stock Exchange (ISE) National 20 Index | 1986-2005 | arithmetic average, geometric average, market capitalization methods and GARCH-M model | Weak form efficient |
| Mobarek et. al. (2008) | Dhaka Stock Exchange (DSE) Bangladesh | 1988-2000 | Non-parametric tests (Kolmogrov-Smirnov: normality test and run test) and parametric tests (Auto-correlation test, Autoregressive model, ARIMA model) | Individual stock returns did not follow random walk |
| Atan et. al. (2009) | Turkey / Istanbul Stock Exchange (ISE) | 2003-2005 | ADF and KPSS unit root tests and exact local whittle (ELW) fractionally integrated estimator | Weak form efficient |
| Çelik and Taş (2007) | Argentina, Brazil, Czech Republic, Egypt, Indonesia, Hungary, India, Israel, Korea, Mexico, Russia and Turkey / Stock markets | 1998–2007 | Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests, Run test, Variance ratio test | Turkish and Korean markets supported random walk model that applied to the all weak form efficiency tests. Other markets' results are changing. |

| | | | | |
|---|---|---|---|---|
| Marashdeh and Shrestha (2008) | UAE / Abu Dhabi Securities Exchange (ADX) and Dubai Financial Market (DFM) | 2003-2008 | Augmented Dickey-Fuller (ADF) and Phillips-Perron tests | Weak form efficient |
| Legoarde-Segot and Lucey (2008) | Middle-Eastern North African (MENA) stock markets (Egypt, Morocco, Tunisia, Jordan, Lebanon, Israel and Turkey) | 1994-2003 | KPSS test, individual variance ratio analysis, multiple variance ratio analysis, non-parametric variance ratio analysis | KPSS and non-parametric variance ratio: all markets rejected Individual and multiple variance ratio: Egypt, Morocco and Lebanon rejected random walk |
| Dima and Miloş (2009) | Romania / Bucharest Stock Exchange (BET) | 2000-2009 | BDS test, Correlogram, Augmented Dickey-Fuller stationarity test, Kwiatkowski-Phillips-Schmidt-Shin stationarity test and Elliott-Rothenberg-Stock stationarity test | Weak form efficient |
| Poshakwale (1996) | India / Bombay Stock Exchange (BSE) | 1987–1994 | Kolmogorov Smirnov Goodness of Fit Test, Runs Test and Serial Correlation Coefficients Test. | Was not weak form efficient |
| Siddiqui and Gupta (2009) | India / National Stock Exchange (NSE) | 2000-2008 | Non-parametric (Kolmogrov – Smirnov normality test and run test), Parametric (Auto-correlation test, Auto-regression, ARIMA model) | Was not weak form efficient |
| Hassan et. al. (2000) | Bangladesh / Dhaka Stock Exchange (DSE) | 1986-1999 | variance ratio test | Was not weak form efficient |
| Mobarek and Keasey (2002) | Bangladesh / Dhaka Stock Exchange (DSE) | 1988-1997 | Non-parametric (Kolmogrov – Smirnov normality test and run test), Parametric (Auto-correlation test, Auto-regression, ARIMA model) | Was not weak form efficient |

| | | | | |
|---|---|---|---|---|
| Omay and Karadagli (2010) | Bulgarian, Greek, Hungarian, Polish, Russian, Slovenian, Romanian and Turkish stock markets | 2002-2010 | linear unit root tests and linear panel unit root tests with Augmented Dickey Fuller test and Phillips Perron test, non linear unit root test, non linear panel unit root test | Markets are weak form efficient according to ADF and PP tests Russian, Polish and Romanian stock markets are not efficient in weak form according to non linear unit root test markets are not weak form efficient according to non linear panel unit root test |
| Srinivasan (2010) | India / Bombay Stock Exchange (BSE-30 or SENSEX), The Standard & Poor's CRISIL NSE Index 50 (S&P CNX Nifty) | 1997-2010 | ADF test and PP unit root test | it was not weak form efficient |

**Table B.3:** Summary of the empirical studies on derivative markets

| DERIVATIVE MARKETS | | | | |
|---|---|---|---|---|
| **Study** | **Country & Market** | **Period** | **Methodology** | **Results** |
| Nieto et. al. (1998) | Spanish stock index (IBEX 35) Spain | 1994-1996 | Granger causality test and Johansen co-integration test | Futures contract on the IBEX 35 market behaves as an efficient market |
| Wang and Ke (2002) | China / Chinese wheat and soybean futures markets | 1998-2002 | unit root test both using the ADF and the Phillips-Perron methods and Johansen's cointegration tests | soybean futures market was weak form efficient wheat futures market was inefficient in weak form efficient |
| Tabak (2003) | Brent Crude Futures International Petroleum Exchange (IPE) | 1990-2000 | ADF and Johansen's cointegration test | spot prices and one-month futures prices will move together |
| Crowder and Phengpis (2003) | US and Japan / S&P 500 and Nikkei 225 spot and futures markets | 1982 -2003 (S&P 500) 1988–2003 (Nikkei 225) | ZA test statistics and Johansen cointegration test | Both markets were not weak form efficient |
| Kenourgios (2005) | Greece / FTSE-20 blue chip index futures contract/Athens Stock Exchange (ASE-20) stock index futures market | 2000 - 2002 | Johansen cointegration procedure and unit root test | FTSE/ASE-20 futures market was inefficient |
| Mollah et. al. (2005) | Bangladesh / DSE-20 | 2001 - 2003 | ARMA, ARIMA, ACF, PACF, and Dimson's Market model | DSE-20 did not support weak-form market efficiency |
| Phukubje and Moholwa (2006) | South Africa / South African Futures Exchange (SAFEX) | 2000 - 2003 | ADF and PP methods, Ljung-Box Q statistic and F test statistics | SAFEX was inefficient for wheat and sunflower seeds |
| Pavlou et. al. (2007) | Greece / FTSE/ASE-20, FTSE/ASE-40, Hellenic Telecommunications Organisation stocks, Public Power Corporation stocks and Intracom stocks | 2004 - 2006 | serial correlations, ADF test and Durbin- Watson test | futures on FTSE/ASE-20 and Public Power Corporation suppported the Efficient Market Hypothesis FTSE/ASE-40, Hellenic Telecommunications Organisation and Intracom rejected |
| Liu (2009) | Malaysia / crude palm oil(CPO) futures market in Bursa Malaysia Derivatives(BMD) | 2001 - 2007 | Johanson cointegration test and Vector Error Cointegration Mechnism (VECM) | the futures market of BMD was not a very efficient market for the European market. |
| Zhang et. al. (2010) | US / Chicago Board Options Exchange Market Volatility Index (VIX) futures market | 2004 – 2008 | ADF unit root test, KPSS test, autocorrelation test and Lo-Mackinlay Variance-Ratio test | VIX futures market is weak form efficient and supports random walk |
| Kour and Rao (2010) | India / National Commodities And Derivatives Exchange (NCDEX) | 2008 - 2009 | Autocorrelation test and Runs test | Weak form efficient |

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| Year | Place | Enrollment |
|---|---|---|
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