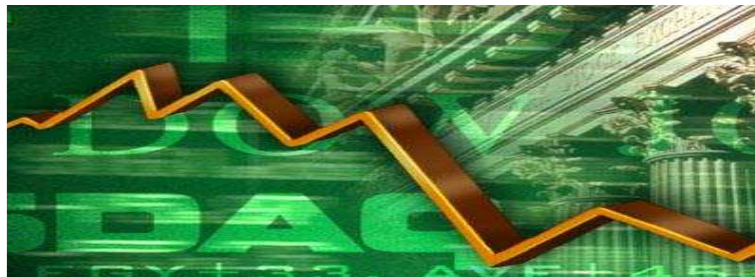




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**Subject: Dynamic Linkages between International Stock Markets: Evidence for Eastern Europe**

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## **Abstract**

This study examines the existence of dynamic linkages between six stock markets for the period from 1/9/1995 to 8/6/2009. We used data from two developed markets the United States and the United Kingdom and four major European emerging stock markets, Russia, Poland, Hungary and Czech Republic. With particular attention to the influence of the Russian Financial crisis we used an autoregressive VAR model and the Granger causality test to detect the interdependence of the above markets. One major finding is that the Eastern European stock markets have become more internationally integrated after the Russian crisis of 1998 and that the market of United States is the one that affects all the emerging markets but not vice versa.

## CHAPTER 1 - Introduction

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During the last years the science of the Portfolio Management searches methods helpful to the finding of the optimal portfolio. With the term “optimal portfolio” we defined the portfolio in which the risk-reward combination is such that it yields the maximum returns (provides the highest utility) possible under the current and anticipated circumstances. Its mathematical formulation was provided the University of California's noble laureate economist Harry Markowitz (born 1927) in 1952. But the achievement of the optimal portfolio is up to the percentage of the chosen assets and their integration. More specific its accomplishment based on the finding of the appropriate financial assets that are diversified enough.

Because of the globalization of the investments, researchers have extensively investigated the dynamic linkages between the international stock markets. There are many studies focused, traditionally, on major developed markets (some of them: Eun and Shim, 1989; Kasa, 1992; Bessler and Yang, 2003) and there are others, more recent, that have extended the line of the research to the dynamic linkages between emerging and developed stock markets (some of them: Arshanapalli, Doukas and Lang, 1995; Manning, 2002; Chen, Firth and Rui, 2002). The results of the above studies give to investors useful information, in order to take the right decision for the construction of an optimal portfolio. The globalization and the deregulation of the markets give a great chance to investors to choose an international diversified portfolio, making the study of the dynamic linkages between the financial markets compulsory.

Moreover, the last years there are many researchers investigated how stock markets integration may be affected by the global financial crisis. For example, Masih and Masih in 1997 reported that the long-run relationship in international markets between the pre and post crash period remains unchanged (1987's crisis). Additionally King and Wadhwan in 1990, argued that correlation between the stock markets returns increases, only, temporarily in periods of general market turbulence. Some evidence for the strengthening

of international stock market linkages after the crisis of 1987 is reported from Arshanapalli, Doukas and Lang in 1995. During the last decade there are some studies examining the affect of the 1997-1998 global emerging market crisis, most of them tend to suggest no dramatic impact on the interdependence across stock markets (Tuluca and Zwick, 2001; Chen, Firth and Rui, 2002)

The objective of this paper is to investigate the dynamic linkages between six (6) stock indexes from two developed markets, such as *USA* and the *United Kingdom* and from four emerging Eastern European markets such as *Russia, Poland, Hungary and Czech Republic*, with particular attention to the impact of the Russian financial crisis in 1998. Although, many previous papers have focused on emerging markets in Latin America or in Asia, few empirical studies examined the dynamic linkages of the European emerging markets something very useful and interesting for the international investors.

Our data consist of daily stock index closing prices (source: DataStream) for the period 1/9/1995-8/6/2009 also for the pre-crash period (01/09/1995 - 31/12/1997) and post crash period (01/01/1999 - 08/06/2009). The sample period is divided into this particular period to address the potential impact of the Russian financial crisis of 1998 on Eastern European stock market integration. As the literature (Gelos and Sahay, 2001; Chen, Firth and Rui 2002) identified the Russian crisis period from July 1998 to October 1998, we divide the observations to allow for possible transitive periods moving to and leaving from this particular crisis.

For the examination of the existence of the dynamic linkages, in this study, we are going to use an autoregression VAR model. For the control of the stationarity of our time series we use the unit root test and the Augmented Dickey-Fuller test. Finally the Granger causality test is used for the examination of the relationship between the above stock markets.

In the second chapter we present the main reasons for the interdependence of the International financial markets, whereas in the third we represent a theoretical approach of the market efficiency, as the information that are available to investors are one of the most important facts that affect their

choices and as a result the performance of the international stock exchanges. In chapter four there is an extent review of the previous studies are made for the examination of dynamic linkages. The methodology that we used is described in chapter five. Finally in the sixth chapter we present our empirical results and in the last chapter the conclusions of the empirical study.

## CHAPTER 2 - Reasons For the Interdependence of International Financial Markets

Globalization involves the union of existing economic, political and social activities that continually violates the traditional, political, economic, cultural and geographical boundaries of each country. International trade, and other industries, is increasing internationally. Predictably, then, globalization also affects the stock markets, which extend across the globe.

In their effort to achieve higher returns with a lower risk, investors form diversified portfolios composed of Greek and foreign shares.

A result, therefore, of the above was that this growing globalization became a point of interest for many researchers, who tried to study the relations between international financial markets. Research started in the early 70s and, as expected, showed that the degree of interdependence of the markets was quite low. Differences in monetary and economic policy, government restrictions and the operation of each country were perhaps the most important reasons for the non-existence of dynamic relationships between financial markets.

With time however, as can be seen by analyzing the empirical studies of several researchers, the degree of integration between major international financial markets increased.

The factors that contributed to the increasing interdependence of international financial markets are presented and analyzed below.

### 1. Market Deregulation

Globalization is a phenomenon that has intensified in the late twentieth century, having many advantages, such as economic growth and rapid and less costly access to a whole range of products.

The definition of globalization, according to McGrew (1992) is:

*“Globalization refers to an abundance of links and interconnections between the states and societies that constitute the global system. It describes the process by which events, decisions and activities on the one side of the world have significant consequences for individuals and communities in very remote parts of the world. Globalization is characterized by two different phenomena: extent (spread) and intensity (depth). On the one hand, it defines a class of procedures that apply to most of the world or at world level. Thus, this phenomenon has a spatial dimension. On the other hand, it implies an intensification of levels of interaction, interconnection and interdependence between the states and societies that constitute the global community. Thus, in parallel with the spread, there is also a deepening of global processes”.*

The difference, therefore, of the era of globalization with the past is located in its spread, i.e. the number of countries involved and the intensity of their relations. It should be noted that, now, no country is outside the global financial system.

As is well known, each country is governed by laws and rules that define the handling of transactions. However, some state laws and restrictions represent inhibiting factors for the growth of a country. In recent years, considerable efforts have been made to remove barriers and limit government intervention and controls resulting in the deregulation of markets and hence their interdependence. The establishment of a broad set of regulations was considered necessary for the effective functioning of the financial market. Additionally, the implementation of structural and institutional reforms in critical areas has resulted in the strengthening of the economic situation of each country and the enhancement of its performance. The deregulation of short-term capital movements between Greece, the European Union and third countries in 1994 has enabled the rapid and free inflow and outflow of foreign investment capital in the short term for the purchase and sale of securities (shares, bonds, other forms of placement) without



excessive red tape. This regulation paved the way and created security and flexibility conditions for financial investments that were not feasible previously.

## **2. Technological development.**

Innovation and the constant development of technology have facilitated trade between different countries and the monitoring of international developments.

The use of modern computer software and programs accelerates the flow of information and data between exchanges. Information obtained throughout the daytime can be channelled to investors accurately, quickly and without cost. Suffice it to note that important data and elements are transferred within a few minutes from one side of the world to another to contribute in making difficult investment decisions.

The Internet, for example, transmits information from various remote corners of the earth in a few seconds, while satellites provide consumers real-time images of events that take place in distant countries. Finally, the use of computers and the Internet has contributed significantly to simplifying the process of electronic trade, as transactions can now be made anytime during the day.

## **3. Cross listing of companies.**

Apart from technological developments and the easy dissemination of information, the dynamic interrelationship between international stock markets is also due to the possibility of entering a company into two or more exchanges. If a company share is listed on two exchanges, obviously, the developments taking place in the market of the country that negotiates the share will directly affect the second market.

The cross-listing shares in more than one stock exchange was first applied in the early 70s, pioneered by large multinational companies, which were then followed by smaller companies.

The number of companies listed on one or more stock exchanges is estimated to rise in coming years, as the application of international accounting standards will eliminate accounting differences between countries and will reduce the cost of listing in most foreign stock exchanges.

The following table shows some of the international stock exchanges in which both domestic and foreign companies participate. Observing the statistics of the table, we see that most international stock exchanges have marked an increase in the proportion of foreign listed companies in the last three years. The Luxembourg stock exchange is in first position, followed by Mexico and Singapore.

**Number of companies listed in international stock exchanges**

International Stock Exchanges	2008			2007			2006					
	Total	Domestic Companies	Foreign Companies	% Foreign Companies	Total	Domestic Companies	Foreign Companies	% Foreign Companies	Total	Domestic Companies	Foreign Companies	% Foreign Companies
London SE	3.096	2.415	681	22,00%	3.307	2.588	719	21,74%	3256	2.913	343	10,53%
Nasdaq	2.952	2.616	336	11,38%	3.069	2.762	307	10,00%	3133	2.812	321	10,25%
Tolyo SE Group	2.390	2.374	16	0,67%	2.414	2.389	25	1,04%	2416	2.391	25	1,03%
NYSE Group	3.011	2.596	415	13,78%	2.297	1.876	421	18,33%	2280	1.829	451	19,78%
Australian SE	2.009	1.924	85	4,23%	1.998	1.913	85	4,25%	1829	1.751	78	4,26%
Singapore Exchange	767	455	312	40,68%	762	472	290	38,06%	708	461	247	34,89%
American SE	486	391	95	19,55%	599	495	104	17,36%	592	492	100	16,89%
Mexican Exchange	373	125	248	66,49%	367	125	242	65,94%	335	132	203	60,60%
Luxembourg SE	262	34	228	87,02%	261	34	227	86,97%	260	36	224	86,15%
Oslo Bors	259	209	50	19,31%	248	208	40	16,13%	229	195	34	14,85%
Lima SE	244	201	43	17,62%	226	188	38	16,81%	221	189	32	14,48%

Source: World Federation of Exchanges (FIBV) and Federation of European Securities Exchanges (FESE)

#### **4. Location.**

Another reason that explains the strong interaction between different countries is their geographic position. Given their economic and commercial cooperation, countries that are geographically close are closely linked. Developments in one country are very likely to affect the markets of neighbouring countries and thus the state of their stock markets. At this point, it should be noted that the country considered as invalidating the above rule is the United States, which, by holding the dominant position in the market affect almost all markets, irrespective of their geographical position.

#### **5. The impact of the USA**

As mentioned earlier, the dominant market in the world is the U.S., whose developments affect almost all stock markets. The developments which take place in the U.S. have an impact on the psychology and decisions of investors and hence on the state of international stock markets. The above leads to an increase in the degree of interdependence between stock markets.

For example, a few months after the negative trend that had begun in 2000, the Athens Stock Exchange had begun to find a proper balance. Events, however, mostly originating in the global environment, such as September 11 and the crisis of credibility in the published results of colossal U.S. companies, with “Enron Corp.” first and foremost, again affected the course of the Greek stock market.

We see that, now, financial crises are driven by the US market, a market that has a significant influence on all other stock markets, without however being affected by their developments.

## 6. Investor Psychology.

Finally, we should make reference to the psychology of investors, which is affected by the trend of major stock exchanges.

In *“Against the Gods”*, Peter L. Bernstein indicates that events “reveal recurring patterns of absurdity, inconsistency and incompetence in the ways people arrive at decisions and choices when faced with the unknown”. Research and studies have led to the emergence of a new branch of financial studies known as “Behavioural Finance”. This new and constantly evolving field sheds considerable light into the psychology of investors and strives to understand and interpret how the various emotions and situations experienced by investors can affect their decisions.

Studying the course of stock markets it has been shown that investor psychology is considered one of the factors that play a key role in the rise or fall of share prices. It has often been observed that the fall or rise of a stock exchange because of an economic, political or social event, has led to a fall or rise, respectively, of some other exchange. It is considered that a fundamental cause of this domino effect is the investors’ reaction towards these developments. If, for example, the Wall Street stock exchange displays a very good course, it is likely to influence the psychology of investors in the stock market in London, as political and economic developments in one country affect the other and increased performances in one country raise the expectations of investors in another. In seeking to interpret their reactions and behaviours of investors, researchers have turned to the study of psychology and other social sciences, which may explain many anomalies in the functioning of stock exchanges, such as the so-called stock exchange “bubbles” and collapsing stocks.

Nevertheless, there the extent to which financial markets are economically integrated is still unclear because there are many economic barriers facing

each country. As will be analyzed in a following section, some studies have shown that there is strong interaction between stock markets. This may be due to the different level of development of each country, the different monetary policy followed or even differences in the composition of stock indices.

Reasons such as the abolition of state intervention and control, the modernization of technology and the facilitation of the transfer of information have accelerated the process of financial integration. Specifically, the coordination of economic policies of countries participating in the European Union, aiming to implement a single economic and monetary policy, has resulted in developments in one state influencing other member states. Therefore, the above result in increased interaction between European stock markets.

## CHAPTER 3 - Efficient Market Hypothesis

### Efficient Market Hypothesis

In presenting the reasons for the existence of dynamic interrelationships between international financial markets, it was observed that all information significantly affects the course of relations between different countries. Accordingly, the subject of interest in this chapter will be the concept of market efficiency and the forms in which it may appear, depending on the type of existing information.

According to Fama (1970), the efficient market hypothesis argues that, in any given time, the current prices of securities incorporate and react swiftly to any new public information available, which originate in events that have already taken place, and events that are expected to take place. At the same time, according to Jensen (1978) “A market is efficient if prices incorporate information to the point where the marginal benefits of investors acting based on current information do not exceed the marginal costs”. The conditions for an efficient market are:

1. The stock market must be in balance and there must be a perfect stock market.
2. All investors think rationally, analyzing and evaluating all information available to make decisions and seek to maximize total utility.
3. All investors can lend and borrow at the same rate, without purchase costs.
4. The decisions and moves an investor cannot influence prices.
5. The information is available to all investors simultaneously, at no cost and distributed randomly.

The above mean that, when a market is efficient, no investor can achieve surplus earnings (super profits), as the existing information will be available to all investors and would be reflected in the prices of securities. Even if an

investor achieves super profits, these cannot be maintained for long, because a significant number of people in the market will understand the trend of change and will want to participate in this market to exploit the opportunity. Conversely, if a market is inefficient, it is possible to achieve higher yields than normal. Remember that a normal return is defined as the return justified by systematic risk and is calculated using an asset valuation model, such as the CAPM (Capital Asset Pricing Model).

### **Forms of Efficiency**

In his attempt to outline the Efficient Market Hypothesis, Eugene Fama (1970) argued that, depending on the type of information, there are three forms of market efficiency.

In specific:

- ❖ *Weak form efficient*, when market prices reflect all historical information available. Most investors use historical data to take financial decisions. The historical data of an investment asset refer to the prices a variable has assumed through time and its course in a specific period. Thus, based on their need for relevant, reliable and comparable information, investors use historical data, which assist in assessments and in taking investment decisions.
- ❖ *Semi strong form efficient*, when all existing public information is incorporated in current prices.
- ❖ *Strong form efficient*, when the current prices of securities include not only public but also existing internal information. The use of internal information by employees of a company may cause scandal, and adversely affect the finances of the company. Nomura Holdings, Japan's largest financial holdings' firm, had announced the dismissal of an employee after an investigation by the prosecutor. The charges concerned the use of existing internal information. It was retrospectively proved that the employee, who worked in the advisory services department, in the area of mergers and acquisitions, had repeatedly used the internal information in various agreements. As



published in the daily financial newspaper Nikkei, the parties in this case received profits of \$ 390,000 from trading shares in 21 companies. This internal information scandal, the second within five years for the company, has led to the fall of Nomura's share price by 3.9%.

It is therefore understood that all information may influence the course of a share. In order to invest funds in profitable securities, bonds, equities and portfolios, investors wish to receive available information. The market, however, is considered efficient in the sense of weak form as the prices of securities reflect information that can be drawn from their historical prices.

## CHAPTER 4 – Literature Review

During this study we considered the literature review as essential. So, in this chapter we are going to present some of the most important papers which had as objective the examination of the dynamic linkages between the international stock markets.

The first essays with this particular subject had been worked out in the decade of '70s. The results from the majority of those studies had shown no integration between the stock markets. However there had been some few articles that proved their existence. For example, Agmon in 1972 by the examination of the markets of UK, German, USA, and Italy for the time period 1961-1966 showed the integration between the stock markets of these countries. Additionally, Ripley in 1973 endorsed the idea that the open markets in foreign investments presence integration with other markets, in contrast with the markets that are more isolated.

In the other hand, the more recent studies have shown that the dynamic linkages between the stock markets have grown, as the time passed. As it mentioned before this growth is a result of globalization, deregulation, and technological development.

Below, we represent the conclusions of some of the most important papers:

### ❖ **Cheol S. Eun and Sangdal Shim (1989)**

The study of Eun and Shim is one of the first studies that reveal the integration between the stock markets of nine countries (UK, France, German, Australia, Hong Kong, US, Switzerland, Japan and Canada) from 1980 since 1985. These markets are considered as the biggest financial markets in world.

The researchers with daily data shown that correlations between countries that are in the same “neighborhood” are stronger than the correlation between markets that are far away.

Furthermore, there is strong evidence, for one more time, that the US market is the leader, which influences all the other markets of the world.

#### ❖ **Taylor and Tonks (1989)**

In this survey, Taylor and Tonks by using monthly data of the stock indices of five countries, the United Kingdom, Western Germany, Japan, USA and Netherlands for the periods 1973-1979 and 1979-1986 examined the consequences of the abolition of exchange control in UK to the linkages between the international stock markets.

They used co-integrations techniques and the Granger causality test and they found that there is no significant increase in the correlation of short-run stock market returns for the UK market and the others post 1979. Additionally, appeared to be an increase in the degree to which these markets move together in the long run after this date. So there appeared to be no long-run gain from diversification.

#### ❖ **Ike Mathur, Vijaya Subrahmanyam (1990)**

The researchers used the concept of Granger causality, among the stock market indices for USA and four Nordic countries (Denmark, Sweden, Finland, and Norway). The data consist of monthly prices from the stock indices for the period of 1974 to 1985 and they were obtained from international Financial Statistics, published by the IMF.

In contrast with other studies, this have shown that the US market have affection only in Denmark and not in the other three Nordic markets. The Swedish affects both the Norwegian and the Finish markets, but not the Danish. The markets of Norway, Denmark and Finland have not any significant affection in any of the other three markets in question. So, the results from the aggregation model indicate that the Nordic stock markets may be less than fully integrated.

#### ❖ **Paul D. Koch and Timothy W. Koch (1991)**

Paul Koch and Timothy Koch investigated through this paper the dynamic linkages between eight stock indices of Australia, Western Germany, Switzerland, the United Kingdom, USA, Japan, Singapore and Hong Kong for the years 1972, 1980 and 1987.

The data consists of daily observations of the above stock indices and through a dynamic model they proved the existence of dynamic linkages between neighbor countries. There was also evidence for interactions between the indices for the time of 24 hours. Finally researchers found that the impact of the Japanese market was getting stronger, becoming competitive to the US market.

#### ❖ **A.G Malliaris and J.L.Urrutia (1992)**

In this survey, researchers analyzed the lead-lag relationships for the stock indexes of USA, the United Kingdom, Japan, Australia, Singapore and Hong Kong for the periods before, during and after the financial crisis of October 1987. The data were daily and they used unidirectional and bidirectional causality tests, and with Granger methodology they found no lead-lag relationships for the pre-crash and post-crash periods.

Important relationships were found only for the months of the crash. Generally, the findings suggested that the October market crash was an international crisis which begun simultaneously in all the national stock markets.

#### ❖ **Yan-Leung Cheung and Sui-Choi Mak (1992)**

Yan-Leung Cheung and Sui-Choi Mak examined the relationship between eight Asian – Pacific markets: Australia, Hong Kong, Korea, Malaysia, Philippines, Singapore Taiwan and Thailand and the two largest markets in global economy, the US market and the Japanese, using weekly stock index data during 1978-1988

From their results, it was obvious that the US market led most of the Asian – Pacific markets except from Korea, Taiwan and Thailand which were relatively closed markets, as they imposed strong restrictions on foreign investors in order to protect local investors.

Unlike the US market , the Japanese markets was not appeared as important leading market and the global factor appears to have more significant impact on the Asian – Pacific markets than the regional factor.

#### ❖ **Kenneth Kasa (1992)**

Kenneth Kasa adopted the methodology of Johansen and Jesulius trying to find and to investigate the stochastic trends of the markets of the United Kingdome, Germany, USA, Canada and Japan for the period January 1974 – August 1990. The data that they used were monthly observations in the same currency, the US dollar.

The results had shown that the trends are more important in Japan and less important in Canada and that the countries with the same stochastic trend had an important long- term correlation

#### ❖ **Bala Arshanapalli and John Doukas (1993)**

The aim of this paper was the investigation of the linkages and dynamic interactions among stock markets movements. Using daily closing data from the five biggest economies of the world (UK, USA, Japan, Germany and France) for the period 1980-1990 they adopted the theory of cointegration. Additionally, they investigated the relationships between the countries for the periods pre and post the crash of October 1987.

As the evidence had shown, the degree of international co-movements in stock price indices had changed significantly since the crash of October 1987, except only the Nikkei index. Specifically, for the pre-crash period they found that Germany, France, and UK stock markets are not related to the US market. However for the post-crash period the three stock markets above were strongly linked with the US market. Finally with the error-correction

model for the post-crash period they found that the US markets affects all the other markets but not the opposite.

#### ❖ **Corhay, Rad and Urbain (1993)**

Corhay, Rad and Urbain concentrate their interest in the relationship between the United Kingdom, France, Germany, Italy and Netherland. Firstly, with the Augmented Dickey-Fuller test they found the existence of a unit root. Secondly, with the Johansen method they proved that there was cointegration between the above markets.

In this point, it is important to mention that the market of Italy was found to have no effect to the long –run relationship that existed between the other countries.

#### ❖ **Byers and Peel (1993)**

The researchers in this survey and with the unit root test and the Johansen method they examined the relationship between the Western Germany, Japan, the United Kingdom, USA and Netherland. For one more time, the examined period was the period before and after the crash of October 1987.

Firstly, through the Phillips Perron test was proved the existence of a unit root. Secondly, with the cointegration method they found that there was no relationship for the whole number of the above countries and for every couple of countries singularly.

#### ❖ **Espitia and Santamaria (1994)**

Espitia and Santamaria used a VAR model for the examination of the existence linkages between the stock indices of Tokyo, Milan, New York, Madrid, Frankfurt, Paris and London for the time period 1987-1992.

The results proved that the New York had the greater impact of all the other examined markets. The researchers used same sample in the currency of Switzerland, in order to find if the dependency is a result of the changes in the

prices of the currencies. But the conclusions were the same. The market of New York is the one that explains the movements of the other examined markets, and the one that its movements could not be explained from the others.

Additionally, they investigated the reaction of the above markets in an impulse shock that flowed from one of them. Through the research was clear that an information that came from the Wall Street affected more the markets of Frankfurt and Tokyo the day after. In general, the countries that were more sensible to the innovations were the markets with the biggest merchantability. In the other hand, markets without so big merchantability were not that sensible in information and as a result the affect from them were not that assimilable.

Finally Espitia and Santamaria examined the existence of integration between the five European markets in order to find the power of the economy of the US on them. From the results was obvious that the European markets were independent.

#### ❖ **Anthony Richards (1995)**

Anthony Richards examined the existence of cointegration between sixteen stock markets for the time period 1970-1974. Firstly, he investigated the stationarity of the time series of the UK, Australia, Austria, France, Japan, Germany, Denmark, Switzerland, USA, Spain, Italy, Canada, Norway, Netherlands, Sweden and Hong Kong.

The results from the Augmented Dickey-Fuller test proved that the examined time series had a unit root. Using, also, the Johansen method and the method of Engle-Granger, they estimated a VAR model, with two and ten lags and he found that there was no cointegration between the above countries. So these significant markets will continue to move with a different way.

#### ❖ **M.Kabir Hassn and Asuyuki Naka (1996)**

The researchers, using daily data from the April of 1984 to May of 1991 examined the probability of the existence of long – lasting or short – term linkages between Germany, the United Kingdom, Japan and USA.

For this specific survey, they used a Vector Error Correction model (VECM) and they discover the existence of long and short term dynamic linkages between all the countries.

#### ❖ **Gregory Koutmos (1996)**

Gregory Koutmos with a multivariable VAR – EGARCH model investigated the dynamic linkages between the United Kingdom, France, Germany and Italy. For the time period of January 1986 to December 1991 the research showed that the time series have a unit root and that cointegration relationship existed between the examined countries. Every stock market reacts to every evolution taking place in any of the other countries.

#### ❖ **Abul M.M. Masih, Rumi Masih (1997)**

There are many researches conducted on the issue prior to October 1987's Black Monday global Financial collapse. In one of these, Abul M.M. Masih, Rumi Masih in 1997 using data of end-of –month closing share price indexes of six important stock markets ( US, Japan, Canada, France, Germany and United Kingdom) that were obtained from International Financial Statistics examined the impact of the stock market crash of October 1987. The techniques that they used were the unit root testing, cointegration, vector error –correction modeling and forecast error variance decomposition analysis.

The study showed that the crash had not affected the leading role of the US market over the other countries, also the German and the British markets had become more dependent on other markets over the post-crash era. Finally another result of the crash was the greater interaction amongst markets.



#### ❖ **Taufiq Choudhry (1997)**

The long-run relationship between stock indices from six Latin American (Argentina, Brazil, Chile, Colombia, Mexico and Venezuela) markets and the United States were investigated in this paper, using weekly data of the stock price indices. The empirical investigation was conducted by means of unit root tests, Johansen method of cointegration tests and error-correction models.

The cointegration tests showed the presence of common stochastic trends between the above indices with and without The US index. More specific, we can find a stationary long-run relationship between the indices of the six Latin countries, but also between the six Latin indices and the US. The results from the error-correction tests indicated causality among all the indices. Finally, the speed of adjustment to a long-run equilibrium was found to be slow.

#### ❖ **Booth, Martikainen and Tse (1997)**

The object of this study was the examination of the existence of integration between Denmark, Norway, Sweden and Finland for the period 1988-1994. For this survey the researchers used a multivariable EGARCH model in order to examine if there is any cointegration relationship between the above markets.

The results showed that the returns of any country are related only with its own historical returns. The markets, even if they have strong trade and economic relationship do not affect each other's stock indices.

#### ❖ **Sundaram Janakiamanan, AsjeeS.Lamba (1998)**

In this paper, the researchers Sundaram Janakiamanan and AsjeeS.Lamba examined the linkages between the stock markets in the Pacific-Basin region during the period 1988-1996. The data on daily market indices (Australia, Hong Kong, Japan, New Zealand, Singapore, USA and the developing markets of Indonesia Malaysia and Thailand) were measured in local currency terms and they were obtained mainly from Knight –Ridder's Equinet database.

Using a vector autoregression model (VAR) they found that US market, as expected, influences all the examined markets except from the isolated market of Indonesia. When researchers excluded the US market from the VAR system found linkages between the others markets which were traced to the indirect influences of the US market. Another observation was that markets that are geographically and economically close have significant influence over each other. As conclusion, the effect of US market on the Australian markets has diminished over recent years, whereas the emerging market of Indonesia is becoming more integrated with all the other markets.

#### ❖ **Christofi and Pericli (1999)**

In 1999 Christofi and Pericli investigated the relationship between Argentina, Brazil Colombia, Mexico and Chile for the period 1992-1997. The researchers using an EGARCH model proved the existence of integration between the examined markets. Finally, they found that these particular countries are vulnerable in the externals shocks.

#### ❖ **Isakov and Perignon (2000)**

In this survey, the researchers tried to examine the interdependence of the market of Switzerland and the markets of United Kingdom, France, Germany, USA and Japan for the time period 1988-1998.

Through a bivariate asymmetric EGARCH model they showed that the stock market of Switzerland was being affected from all the others, but it could not affect any of them. Furthermore, in this particular paper was confirmed that the external shocks increase its volatility and that the US markets had the strongest influence on the Swiss market in terms of volatility and returns.

#### ❖ **Gong-meng Chen, Michael Firth, Oliver Meng Rui (2002)**

Using data from 1995 to 2000 the researchers investigated the dynamic interdependence of the stock market indexes of Brazil, Argentina, Chile, Colombia, Venezuela and Mexico. They employed cointegration analysis and

error correction vector autoregressions as the index level series were non-stationary.

Through the multivariate cointegration test proposed by Johansen they found that the six Latin American stock price indexes share one long - term equilibrium relationship up until 1999. Secondly, movements in all the markets except from Colombia are explained from fluctuations in market prices in Mexico. For Chile Argentina and Mexico decomposition of the forecast error variances have shown that a large proportion of the stock market index variance was attributed to shocks from foreign markets within Latin America.

The researchers partitioned the data into two time periods based on the Asian financial crisis and the Russian Financial crisis. The results of those periods were not different than those for the whole period of 1995 to 2000. A different picture is shown for the period 1999 to June 2000 as there is no statistical support for cointegration and also there were no evidence of a single underlying equilibrium relationship.

#### ❖ **Dimitris Kenourgios and Aristeidis Samitas (2003)**

In this paper, using both the Eagle-Granger's cointegration tests and the Johansen Maximum Likelihood procedure, Kenourgios and Samitas has examined the linkages between the Greek "blue-chip" index market and indices of six European markets. The data consist of daily price "blue-chip" indices of stock market in Greece (FTSE/ASE20), UK (FTSE100), Belgium (BEL 20), Italy (MIB 30), Portugal (PSI 20) and France (CAC 40), and they cover the period from March 1998 to December 2000.

The results have shown that the Athens Stock Exchange can be used for a European – oriented effective portfolio diversification because of the lack of cointegration between the Greek and the other European markets. Only between the Greek and the British stock market exists a long-run price co-movement. As a result researchers show that arbitrage opportunities can be explored over time.

#### ❖ **Dr. Yochanan Shachmurove (2005)**

In this paper the researcher investigated the dynamic linkages among the emerging Middle Eastern and the United States markets, using the Vector Auto Regression (VAR) and the Bayesian VAR models. The data comprised of daily observations of stock market indexes of seven middle - eastern countries (Egypt, Israel, Jordan, Lebanon, Morocco, Oman and Turkey) and the major world stock market, the US market.

The results proved that no stock market is completely isolated and independent, however the dynamic linkages are small. Dr. Yochanan Shachmurove concluded that an international investor who wants to benefit from the diversification of his portfolio should include stocks in these emerging markets. Furthermore, the stock markets of these countries and their economies, in general, may benefit from further liberalizing by making their financial markets more accessible to international investors.

#### ❖ **Jian Yang, Cheng Hsiao, Qi Li, Ziun Wang (2005)**

This particular study, examines the dynamic price transmission and the long-run price relationship among four major Eastern European emerging stock markets (Czech Republic, Hungary, Poland and Russia), USA and Germany. The writers pay particular attention to the impact of the 1998 Russian financial crisis.

The data that had been used were daily closing prices of the DAX (Germany), S&P 500(US), P150 (Czech), BUX (Hungary), WIG (Poland) and Moscow Times (Russia). The data source was from DataStream. All stock indexes were expressed in local currency terms, just to avoid the confusing effect of the regional-wide currency devaluation. The sample period was divided into the pre and the post crash periods to examine the impact of the Russian crisis on Eastern Europe financial markets. More particular, the two periods were: from January 1995 to December 1997 and from July 1999 to June 2002.

The researchers using a VAR model reveal that both the short-run dynamic linkages and the long –run cointegration relationships were strengthened after the Russian financial crisis. Additionally, emerging markets of Eastern Europe

had been more integrated after the crisis and more vulnerable to external shocks. The effect of Hungary was more important than the Russia's in the post-crash period. Finally, the global influence of the US market it was noticeable only after the crisis.

❖ **Abbas Valadkhani, Surachai Chancharat (2007)**

This paper examines the existence of cointegration and causality between the stock market price indices of Thailand and its major partners, Australia, Hong Kong, Indonesia, Japan, Malaysia, the Philippines, Singapore, Taiwan, the UK and finally the US. The data were monthly for the period December 1987 to December 2005 and they used Gregory and Hansen test.

Based on cointegration results the researchers found no evidence of long-run relationships between the above stock price indices. Secondly, they found three pair-wise unidirectional Granger causalities, whereby the returns in the Philippines, Hong Kong and UK may affect the Thai stock market. There were also two unidirectional Granger causalities, the one running from Thailand to Indonesia and the other running from Thailand to US. Thirdly, there were evidence of bidirectional Granger causality between the stock returns of Malaysia, Singapore, Taiwan and Thailand.

❖ **Jan De Gooijer and Selliah Sivarajasingham (2008)**

Jan de Gooijer and Selliah Sivarajasingham examined the long - term linear and nonlinear casual linkages among eleven stock markets, six of them were industrializing markets and five were emerging markets of South-East Asia. The data (eleven time series of daily closing stock market price indices, measured in domestic currencies) covers two periods the first from the November 1987 until June 1997, denoting the pre-Asian financial crisis and the second, the post-Asian financial crisis period with data from June 1997 until December 2006.

In particular, this study shown that almost all stock markets considered have become more internationally integrated after the Asian Financial crisis, but no

significant long – term casual linkages were found between Sri Lanka and any other countries during both the pre- and post- Asian financial crisis. The leading role of the US market in the world stock market is clearly visible, in this study also, throughout all causality tests. Another finding is that no major differences exist between the persistence and strength of the bi-directional casual linkages among the industrialized markets and the emerging markets in the post – Asian financial crisis period.

❖ **Z. Ozdemir, H. Olgun and B. Saracoglu (2008)**

In this paper, the researchers examined the dynamic linkages between the equity market of US representing the center and emerging markets using the Granger- casualty test. The data consist of daily US dollar value of the S&P 500 price index and that of 15 emerging markets (DataStream).

The results show a significant casual relation from S&P 500 to all emerging stock markets induced in the sample, but not the opposite. So, this evidence indicates that a kind of center periphery relation exist in international stock markets.

## General Conclusions of Literature

Studying the literature, we see that the methodology followed by each researcher on the interdependence of international stock markets is more or less common. The conclusions arising from the conduct of tests show that markets react not only to domestic information but also to innovations taking place in international markets. It is noteworthy that the impact of adverse events in any country is much greater than the effect of positive innovations.

Additionally, most studies show that the U.S. financial market is characterized as the “dominant market in the world”, as it exerts a major influence on all international markets, while it is not “sensitive” to innovations in other countries.

At this point it should be noted that some surveys, such as that by Elyasiani, Perera & Puri, Anthony Richards, Huang Yang & Hu, have not confirmed the existence of interdependence between the markets under study. The absence of interdependence between international financial markets may be due to:

1. The duration of the examination period of the phenomenon of interdependence. Specifically, in 1989, Meric showed that the longer the investigation period, the greater the degree of stagnation in the relations between international financial markets.
2. The existing economic system in the countries under study in that period. There were times in the past and quite possibly even today, where the laws and regulations of each country were a limiting factor for its development and integration. A restriction on the movement of capital hinders the independence of the market.

Nevertheless, albeit showing that there is no long-term equilibrium in the relationships of the financial markets under study, they agreed on the existence of short-term dependencies, according to the Granger causality method.

The question of whether or not interdependence between international financial markets exists has preoccupied and will continue to preoccupy many researchers. It is of interest, as it represents an important factor in investment decisions.



## CHAPTER 5 – Methodology’s Description

### 5.1 - VAR Description

The Vector autoregression (VAR) is an econometric model that is used to capture the evolution and the interdependencies between multiple time series, generalizing the univariate AR models.

All the variables in a VAR are treated symmetrically by including for each variable an equation explaining its evolution based on its own lags and the lags of all the other variables in the model.

A VAR model describes the evolution of a set of  $k$  variables (*called endogenous variables*) over the same sample period ( $t = 1, \dots, T$ ) as a linear function of only their past evolution.

The variables are collected in a  $k \times 1$  vector  $y_t$ , which has as the  $i^{\text{th}}$  element  $y_{i,t}$  the time  $t$  observation of variable  $y_i$ .

For example, a (reduced)  $p$ -th order VAR, denoted **VAR(p)**, has the following form:

$$Y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + e_t$$

Where  $c$  is a  $k \times 1$  vector of constants (intercept),  $A_i$  is a  $k \times k$  matrix (for every  $i = 1, \dots, p$ ) and  $e_t$  is a  $k \times 1$  vector of error terms satisfying.

The above equation of VAR, it can be written in matrix form as:

$$\begin{bmatrix} Y_{1,t} \\ Y_{2,t} \\ \cdot \\ \cdot \\ \cdot \\ Y_{k,t} \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ \cdot \\ \cdot \\ \cdot \\ c_k \end{bmatrix} + \begin{bmatrix} a_{11,i} & a_{12,i} & \dots & a_{1k,i} \\ a_{21,i} & a_{22,i} & \dots & a_{2k,i} \\ \cdot \\ \cdot \\ \cdot \\ a_{k1,i} & a_{k2,i} & \dots & a_{kk,i} \end{bmatrix} \begin{bmatrix} Y_{1,t-1} \\ Y_{2,t-1} \\ \cdot \\ \cdot \\ \cdot \\ Y_{k,t-1} \end{bmatrix} + \dots + \begin{bmatrix} a_{11,i} & a_{12,i} & \dots & a_{1k,i} \\ a_{21,i} & a_{22,i} & \dots & a_{2k,i} \\ \cdot \\ \cdot \\ \cdot \\ a_{k1,i} & a_{k2,i} & \dots & a_{kk,i} \end{bmatrix} \begin{bmatrix} Y_{1,t-p} \\ Y_{2,t-p} \\ \cdot \\ \cdot \\ \cdot \\ Y_{k,t-p} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ \cdot \\ \cdot \\ \cdot \\ e_{kt} \end{bmatrix}$$

The  $l$ -periods back observation  $y_{t-l}$  is called the  $l$ -th lag of  $y$ . Thus, a  $p$ -th-order VAR is also called a **VAR with  $p$  lags**. There are many criteria that are used in order to estimate the best numbers of lags on condition that the hypothesis

of stationarity remains unbiased, the types of these criteria are going to be mentioned later in this chapter.

In order to understand better the general equation lets consider the case of a VAR model of order 1 consisting of two variables  $y_{1t}$ ,  $y_{2t}$ . In this case  $c$  and  $e_t=2 \times 2$  vector. The VAR has the following form:

$$Y_{1,t} = c_1 + A_{1,1}y_{1,t-1} + A_{1,2}y_{2,t-1} + e_{1,t}$$

$$Y_{2,t} = c_2 + A_{2,1}y_{1,t-1} + A_{2,2}y_{2,t-1} + e_{2,t}$$

According to the first equation the coefficient  $A_{12}$  denotes the linear dependence of the  $y_{1t}$  on  $y_{2,t-1}$ . If  $A_{12} \neq 0$  and statistically significant, it means that  $y_{1t}$  depends not only on its own past, but also on the past of the variable  $y_{2t}$ .

If we consider the two equations jointly, then in case where  $A_{12} = 0$  and  $A_{21} \neq 0$ , there is an unidirectional relationship from  $y_{1t}$  to  $y_{2t}$ . if  $A_{12}=0$  and  $A_{21}=0$  the time series  $y_{1t}$ ,  $y_{2t}$  are unrelated and if  $A_{12} \neq 0$  and  $A_{21} \neq 0$  there is a feedback relationship between the two series.

## 5.2 - Granger causality test

Granger causality test is a technique for determining whether one time series is useful in forecasting another. Ordinarily, regressions reflect "mere" correlations, but Clive Granger, who won a Nobel Prize in Economics, argued that there is an interpretation of a set of tests as revealing something about causality.

A time series  $X$  is said to Granger-cause  $Y$  if it can be shown, usually through a series of F-tests on lagged values of  $X$  (and with lagged values of  $Y$  also known), that those  $X$  values provide statistically significant information about future values of  $Y$ .

The test works by first doing a regression of  $\Delta Y$  on lagged values of  $\Delta Y$ . Once

the appropriate lag interval for Y is proved significant (t-stat or p-value), subsequent regressions for lagged levels of  $\Delta X$  are performed and added to the regression provided that they 1) are significant in and of themselves and 2) add explanatory power to the model. This can be repeated for multiple  $\Delta X$ s (with each  $\Delta X$  being tested independently of other  $\Delta X$ s, but in conjunction with the proven lag level of  $\Delta Y$ ). More than one lag level of a variable can be included in the final regression model, provided it is statistically significant and provides explanatory power.

It is important to note that the statement “X granger causes Y” does not imply that Y is the effect or the result of X. granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term.

The Granger Causality test is based on the following equations:

$$Y_t = \kappa_o + \sum_{i=1}^n a_i Y_{t-i} + \sum_{i=1}^n \beta_i X_{t-i} + u_t$$

$$X_t = \mu_o + \sum_{i=1}^n \gamma_i Y_{t-i} + \sum_{i=1}^n \delta_i X_{t-i} + e_t$$

(n is the number of the lags)

### 5.3 - Unit Root test

To examine the existence of unit roots, in the present study, we used the **Augmented Dickey - Fuller test**.

This test is an augmented version of the Dickey–Fuller test for a larger and more complicated set of time series models.

Consider the following equations:

$$y_t - y_{t-1} = \alpha + \beta y_{t-1} - y_{t-1} + \square_t \Rightarrow$$

$$\Delta y_{t-1} = \alpha + (\beta - 1) y_{t-1} + \square_t \Rightarrow$$

$$\Delta y_{t-1} = \alpha + \theta y_{t-1} + \square_t$$

Where  $y_t$  is the variable of interest, t is the time trend,  $\Delta$  is the differencing operator and  $\square$  is the white noise residual of zero and constant variance.  $\{\alpha, \beta\}$

is a set of parameters to be estimated.

In unit root test the null and the alternative hypothesis are:

$H_0 : \theta = 0$  ( $y_t$  is non-stationary)

$H_1 : \theta < 0$  ( $y_t$  is stationary)

If the t-test statistic from this test is negatively less than the critical value tabulated the unit root of the Augmented Dickey –Fuller can be rejected. In other words, if the null hypothesis of  $\theta$  equals zero is not rejected then a unit root exists in the series  $y_t$ .

#### 5.4 - Schwartz Criterion

In this particular study the Schwartz Criterion (1978) is used to select the lags in the VAR model and in the above tests. According to this criterion the number of the lags is the number that minimizes the equation:

$$SBC = \ln \left( \frac{RSS}{n-k} \right) + \frac{k}{n} \ln(n)$$

Where RSS is the residual sum of squares from the estimated model. Note that the term for  $-2 \cdot \ln L$  used in this specialization is equal to the rescaled normal log likelihood up to an additive constant that depends only on  $n$

## CHAPTER 6 – Data and Empirical Results

### 6.1 - Data

The objective of this particular study is to examine the dynamic linkages between the stock markets of USA, United Kingdom and four Eastern European emerging markets, Russia, Hungary, Poland and Czech Republic.

Our data consist of daily stock index closing prices (source: DataStream) for the period 1/9/1995-8/6/2009 (3.592 including observations) and also for the period before the Russian financial crisis (1/9/1995-31/12/1997) and the period after the crisis (1/1/1999-8/6/2009). It is useful to mention that all the used data are converted into US Dollars, as it happens in the majority of the literature.

The sample period is divided into the pre- and post crash periods to address the potential impact of the Russian financial crisis of 1998 on Eastern European stock market integration. As the literature (Gelos and Sahay, 2001; Chen, Firth and Rui 2002) identified the Russian crisis period from July 1998 to October 1998, we divide the observations to allow for possible transitive periods moving to and leaving from this particular crisis.

	Country	Price Index
1	United Kingdom	FTSE 100
2	USA	S&P 500
3	Russia	RTS
4	Poland	WIG
5	Hungary	A
6	Czech Republic	PX

Finally, all the tests that are going to be represented later in this study have been done with the Econometric Program Eviews.

In the first table (table 6.1) of this chapter some statistical information for the series of returns, are presented:

	CZECH	HUNGARY	POLAND	RUSSIA	UK	USA
Mean	0.000310	0.000508	0.000284	0.000667	7.14E-05	0.000142
Median	0.000619	0.001024	0.000599	0.000360	0.000383	0.000176
Maximum	0.174554	0.183780	0.127811	0.202039	0.122189	0.109572
Minimum	-0.176325	-0.189584	-0.121846	-0.211994	-0.105381	-0.094695
Std. Dev.	0.016835	0.020829	0.018313	0.028496	0.013561	0.012924
Skewness	-0.286358	-0.508709	-0.312838	-0.446668	-0.101519	-0.180156
Kurtosis	1.679.294	1.484.179	8.057.247	1.053.618	1.345.978	1.128.154

## 6.2 - Results from the Augmented Dickey-Fuller test

Before testing whether the examined price series are integrated, one should check that each series is non-stationary. The Granger causality test requires that the data are stationary, so a standard procedure, the Augmented Dickey fuller test is applied to check the non-stationarity of each individual series.

As we mentioned before our data sample is divided, except from the whole examined period, into two periods, the one before the Russian financial crisis and the one after the crisis. The tables 6.2 and 6.3 represent the results for the existence of a unit root in our series, during the total examined period.

Augmented Dickey - Fuller test (Closing Prices)			
	Lags	t-Statistic	p-values
CZECH	8	-0,953189	0,7715
HUNGARY	4	-1,364715	0,6011
POLAND	1	-1,080416	0,7257
RUSSIA	1	-1,021336	0,7478
UK	6	-1,67339	0,4448
USA	2	-2,238401	0,1928

<b>Table 6.3 - Unit Root Test- Total Period</b>			
<b>Augmented Dickey - Fuller test (Returns)</b>			
	<b>Lags</b>	<b>t-Statistic</b>	<b>p-values</b>
<b>CZECH</b>	1	-42,07291	0,0000
<b>HUNGURY</b>	0	-54,71766	0,0001
<b>POLAND</b>	0	-52,72477	0,0001
<b>RUSSIA</b>	0	-52,76614	0,0001
<b>UK</b>	4	-30,070202	0,0000
<b>USA</b>	1	-46,80467	0,0001

The first one (table 6.2), as it is obvious, proves the existence of a unit root in all our series of closing prices for the total examined period, fact that it was predictable. The table 6.3 proves that the returns of the above stock markets have no unit root. So, the closing prices are not stationary in contrast with the returns that are stationary.

<b>Table 6.4 - Unit Root Test- Pre crash Period</b>			
<b>Augmented Dickey - Fuller test (Closing prices)</b>			
	<b>Lags</b>	<b>t-Statistic</b>	<b>p-values</b>
<b>CZECH</b>	1	-0,890922	0,7911
<b>HUNGURY</b>	0	-0,62596	0,8620
<b>POLAND</b>	1	-1,89766	0,3335
<b>RUSSIA</b>	4	-0,684539	0,8482
<b>UK</b>	0	0,035239	0,9540
<b>USA</b>	0	-0,349352	0,9147

<b>Table 6.5 - Unit Root Test- Pre crash Period</b>			
<b>Augmented Dickey - Fuller test (Returns)</b>			
	<b>Lags</b>	<b>t-Statistic</b>	<b>p-values</b>
<b>CZECH</b>	0	-19,83912	0,0000
<b>HUNGURY</b>	0	-23,55142	0,0000
<b>POLAND</b>	0	-20,47909	0,0000
<b>RUSSIA</b>	0	-21,85022	0,0000
<b>UK</b>	0	-23,31877	0,0000
<b>USA</b>	0	-24,46479	0,0000

As the previous two tables, the tables 6.4 and 6.5 show the existence of a unit root in all series of closing prices and the stationarity of the returns, in the period before the Russian crisis. The same results are presented in the post crash period as it is clear in the next two tables (Table 6.6, Table 6.7).

<b>Table 6.6 - Unit Root Test- Post crash Period</b>			
<b>Augmented Dickey - Fuller test (Closing prices)</b>			
	<b>Lags</b>	<b>t-Statistic</b>	<b>p-values</b>
<b>CZECH</b>	6	-0,996362	0,7566
<b>HUNGURY</b>	4	1,218369	0,6687
<b>POLAND</b>	1	-1,029839	0,7446
<b>RUSSIA</b>	1	-1,14744	0,6989
<b>UK</b>	6	-1,056922	0,7346
<b>USA</b>	2	-1,488826	0,5394

<b>Table 6.7 - Unit Root Test- Post crash Period</b>			
<b>Augmented Dickey - Fuller test (Returns)</b>			
	<b>Lags</b>	<b>t-Statistic</b>	<b>p-values</b>
<b>CZECH</b>	1	-37,47821	0,0000
<b>HUNGURY</b>	3	-24,27946	0,0000
<b>POLAND</b>	0	-46,90529	0,0001
<b>RUSSIA</b>	0	-46,80125	0,0001
<b>UK</b>	4	-26,15469	0,0000
<b>USA</b>	1	-41,4063	0,0000



## 6.4 - Granger causality test's results

As we mentioned before in this study, the Granger causality test is used for the examination for the possible existence of causalities between the six examined stock markets. In this part we analyze daily returns ( $R_t = P_t - P_{t-1}$ ), where  $P_t$  is the closing price of an index on day  $t$ .

The tables 6.8, 6.9 and 6.10 shows analytically the effects that the stock market of Czech Republic receives in the total examined period and as well in the pre and post the Russian crash. As it is obvious, we found no alteration, between the two periods, in the impact from the other stock markets. The Granger causality test proves that the stock index of Czech is affected from all the other stock indexes except from the Russian one. Moreover, the stock markets of Poland and Hungary seem to be affected from the market of Czech only after the crisis (tables 6.11-6.13 and tables 6.14-6.16).

<b>Table 6.8 - CZECH REPUBLIC (Total Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>HUNGURY</b>	1	20,454480	0,0000	YES
<b>POLAND</b>	2	30,651900	0,0000	YES
<b>RUSSIA</b>	1	2,143210	0,1432	NO
<b>UK</b>	1	14,245390	0,0002	YES
<b>USA</b>	2	289,288600	0,0000	YES

<b>Table 6.9 - CZECH REPUBLIC(Pre-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>HUNGURY</b>	1	20,13293	0,0000	YES
<b>POLAND</b>	1	7,024549	0,0080	YES
<b>RUSSIA</b>	1	3,756323	0,0526	NO
<b>UK</b>	1	22,57211	0,0000	YES
<b>USA</b>	1	5,442382	0,0197	YES

<b>Table 6.10 - CZECH REPUBLIC(Post-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>HUNGARY</b>	4	50,97892	0,0000	YES
<b>POLAND</b>	2	27,77737	0,0000	YES
<b>RUSSIA</b>	1	0,024872	0,8747	NO
<b>UK</b>	1	8,527909	0,0035	YES
<b>USA</b>	2	277,1044	0,0000	YES

In contrast with the previous results, the Hungarian stock market (tables 6.11, 6.12., 6.13) is appeared to be more isolated in the pre-crash period as it presents Granger causality only with the Russian and the American stock indexes. In the other hand, in the total examined period and in the post crash period we can see that it is affected from all the examined stock markets. The impact of the Hungarian stock market to the markets of Czech and Poland is obvious, especially after the Russian crisis (tables 6.8-6.10 and tables 6.14-6.16).

<b>Table 6.11 - HUNGARY (Total Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	1	5,316556	0,0211	YES
<b>POLAND</b>	1	4,135639	0,0420	YES
<b>RUSSIA</b>	3	6,579985	0,0466	YES
<b>UK</b>	1	21,28296	0,0000	YES
<b>USA</b>	1	376,3963	0,0000	YES

<b>Table 6.12 - HUNGARY (Pre-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	1	0,046196	0,8298	NO
<b>POLAND</b>	1	0,850539	0,3564	NO
<b>RUSSIA</b>	5	16,57663	0,0054	YES
<b>UK</b>	1	0,168778	0,6812	NO
<b>USA</b>	1	110,5023	0,0000	YES

<b>Table 6.13 - HUNGARY(Post-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	4	12,6848	0,0129	YES
<b>POLAND</b>	2	9,855575	0,0072	YES
<b>RUSSIA</b>	2	7,78644	0,0204	YES
<b>UK</b>	3	7,923133	0,0476	YES
<b>USA</b>	1	260,541	0,0000	YES

The results in tables 6.14, 6.15, 6.16 suggest that there are linkages between the stock market of Poland and all the other markets except, again, from the Russian. Moreover, it is clear, for one more time, that in the period before the crisis of 1998 the stock market of Poland was not as influenced as in the period after the crisis from their neighbor countries (Hungary and Czech). As it was predictable the US and UK market has an effect in this market also. Additionally, the polish stock market influences the neighbor stock markets (Czech, Hungary and Russian) especially during the post crash period (tables 6.8-6.10, 6.11-6.13 and 6.14-6.16).

<b>Table 6.14 - POLAND (Total Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	2	12,58284	0,0019	YES
<b>HUNGURY</b>	1	16,18657	0,0001	YES
<b>RUSSIA</b>	3	6,579985	0,0866	NO
<b>UK</b>	1	20,58683	0,0000	YES
<b>USA</b>	1	479,0661	0,0000	YES

<b>Table 6.15- POLAND (Pre-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	1	1,606369	0,2050	NO
<b>HUNGURY</b>	1	0,57177	0,4496	NO
<b>RUSSIA</b>	1	1,098679	0,2946	NO
<b>UK</b>	1	8,435278	0,0037	YES
<b>USA</b>	1	94,40668	0,0000	YES

<b>Table 6.16 - POLAND (Post-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	2	11,55668	0,0031	YES
<b>HUNGURY</b>	2	13,18986	0,0014	YES
<b>RUSSIA</b>	1	0,560529	0,4540	NO
<b>UK</b>	1	8,762724	0,0031	YES
<b>USA</b>	1	332,625	0,0000	YES

From the tables above we saw that the Russian stock market does not Granger cause the other Eastern European emerging stock markets, except from the Hungarian (tables 6.8-6.10, 6.11-6.13 and 6.14-6.16). In the next tables (6.17, 6.18, 6.19) the Russian market it is shown to be more integrated in the post crash period as it is affected from all the examined countries except from Czech one. In contrast in the pre crash period it seems to be a very isolated market as the US market is the only one that Granger cause it, but in general, a relationship is presented also between the Russian and the UK market.

<b>Table 6.17 - RUSSIA (Total Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	1	0,546321	0,4598	NO
<b>HUNGURY</b>	1	0,438583	0,5076	NO
<b>POLAND</b>	1	3,635348	0,0815	NO
<b>UK</b>	1	16,72342	0,0000	YES
<b>USA</b>	1	177,6046	0,0000	YES

<b>Table 6.18 - RUSSIA (Pre-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	1	2,950258	0,0859	NO
<b>HUNGURY</b>	5	3,458105	0,6297	NO
<b>POLAND</b>	1	0,027865	0,8674	NO
<b>UK</b>	1	3,812041	0,0509	NO
<b>USA</b>	1	70,50096	0,0000	YES

<b>Table 6.19 - RUSSIA (Post-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	1	1,660961	0,1975	NO
<b>HUNGURY</b>	2	8,914275	0,0116	YES
<b>POLAND</b>	1	12,17266	0,0005	YES
<b>UK</b>	1	19,82909	0,0000	YES
<b>USA</b>	1	158,0743	0,0000	YES

The next six tables (6.20 – 6.25) represent the results from the Granger causality test for the UK and US markets. As it was expected, it is clear that none of the developed markets are affected from the emerging markets of Eastern Europe. Finally our results confirm the leading role of the American market as it is the only that Granger causes all the examined countries during all the examined period.

<b>Table 6.20 - UNITED KINGDOME (Total Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	1	0,992377	0,3192	NO
<b>HUNGURY</b>	1	1,237773	0,2659	NO
<b>POLAND</b>	1	0,131147	0,7172	NO
<b>RUSSIA</b>	1	0,224568	0,6356	NO
<b>USA</b>	5	32,10521	0,0000	YES

<b>Table 6.21 - UNITED KINGDOME (Pre-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	1	0,791592	0,3736	NO
<b>HUNGURY</b>	1	0,168778	0,6812	NO
<b>POLAND</b>	1	1,560176	0,2116	NO
<b>RUSSIA</b>	1	1,306401	0,2530	NO
<b>USA</b>	1	42,0128	0,0000	YES

<b>Table 6.22 - UNITED KINGDOM (Post-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	1	0,398865	0,5277	NO
<b>HUNGURY</b>	3	7,574905	0,0557	NO
<b>POLAND</b>	1	0,847398	0,3573	NO
<b>RUSSIA</b>	1	0,015289	0,9016	NO
<b>USA</b>	5	485,8744	0,0000	YES

<b>Table 6.23 - USA (Total Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	2	4,590084	0,1008	NO
<b>HUNGURY</b>	1	1,466859	0,2258	NO
<b>POLAND</b>	1	0,074032	0,7843	NO
<b>RUSSIA</b>	1	0,051032	0,8213	NO
<b>UK</b>	5	32,10521	0,0000	YES

<b>Table 6.24 - USA (Pre-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	1	2,491209	0,1145	NO
<b>HUNGURY</b>	1	0,553848	0,4567	NO
<b>POLAND</b>	6	3,960613	0,1466	NO
<b>RUSSIA</b>	2	4,142805	0,1260	NO
<b>UK</b>	1	0,431562	0,5112	NO

<b>Table 6.25 - USA (Post-crash Period)</b>				
	<b>Lags</b>	<b>Chi-sq</b>	<b>p-values</b>	<b>Granger Causality</b>
<b>CZECH</b>	2	4,391144	0,1113	NO
<b>HUNGURY</b>	1	2,95663	0,0835	NO
<b>POLAND</b>	1	0,033751	0,8542	NO
<b>RUSSIA</b>	1	0,123052	0,7257	NO
<b>UK</b>	5	33,68199	0,0000	YES

## CHAPTER 7 – Conclusions

There have been numerous essays that have focused on the issue of market integration and interdependencies. Dynamic linkages of international stock markets underlie a major corner-stone of modern portfolio theory that addresses the issue of asset diversification. The advantages of this diversification had discussed in literature several times, in which much effort was devoted for the reduction of risk. Moreover, the observation that stock prices have the trend to move closely together attracted the attention of many researchers who tried to explain the existing relationships between the international stock markets.

While developed markets have received a lot of attention, the study of emerging markets is relatively scant. This is the main reason for our choice to examine the integration of the Eastern European emerging markets. Additionally, their rapid economic growth and their opening up as markets for foreign investors were important for our selection.

This study examines the existence of dynamic linkages between two developed markets (US, UK) and four major Eastern European emerging markets (Russia, Poland, Hungary and Czech Republic). Our research pays attention to the impact of the financial crisis of Russia that begins on July 1998 and ends on October 1998 (as literature refers). Financial crisis can lead to dramatic alterations in the behavior of investors, so it is important to study the dynamic linkages before and after a significant economic shock.

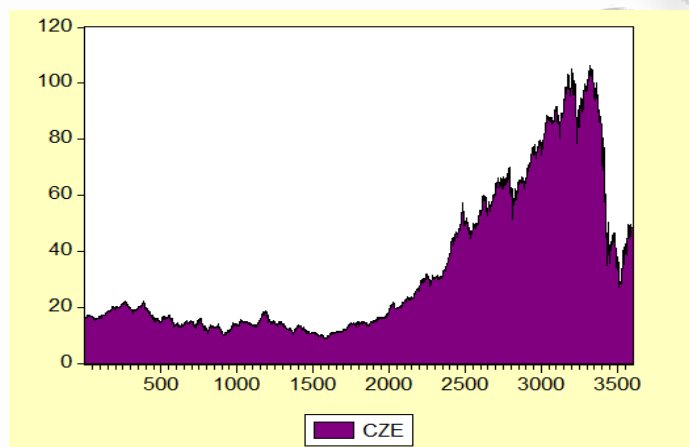
During this study we used an autoregressive VAR model and the Granger causality test to examine the relationship between the mentioned stock markets. From our results, it is clear that the Eastern European emerging markets were more isolated in the period before the Russian crisis. Except from the stock market of Czech in which no alteration was found in the pre and the post crash period the Polish, the Hungarian and the Russian stock markets became obviously more integrated in the period after the crisis. The Hungarian stock market is proved to be the one that affects all the other emerging markets and the most integrated market of all, as it is influenced

from all the examined countries. In contrast, the Russian stock market seems to be the most isolated as it is affected only from the two developed markets (UK, US) and it does not affect many neighbor markets as it was expected. Finally, our results confirm the leading role of the American market, as it influences all the examined stock indexes. Important, also proved to be the role of the market of the United Kingdom as it is found to affect almost all the emerging markets.

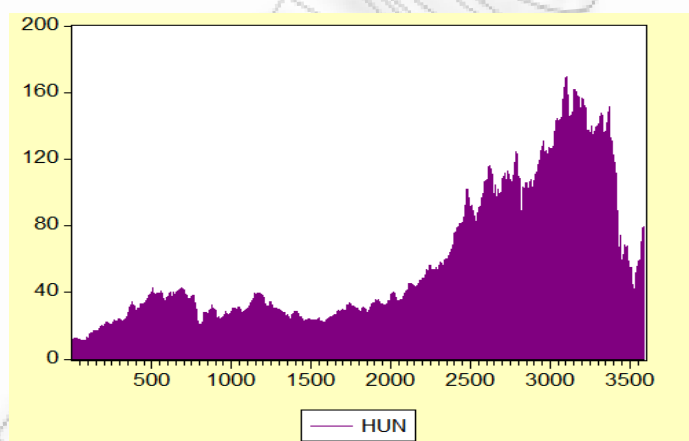


## APPENDIX

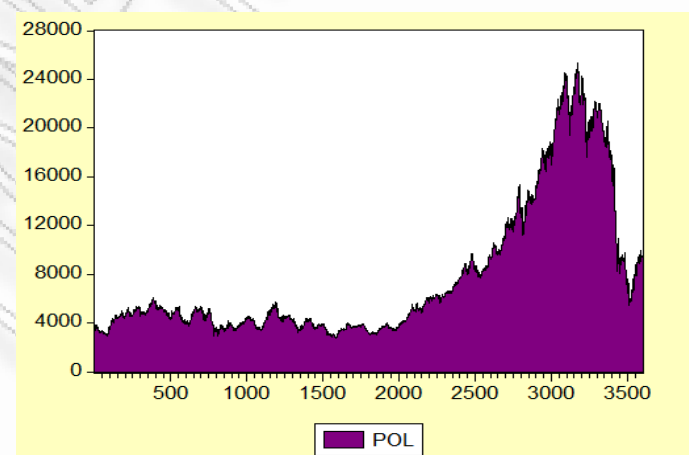
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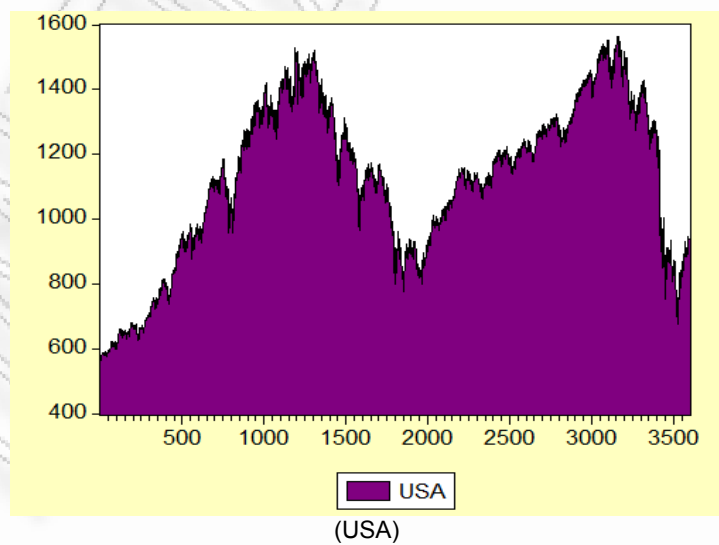
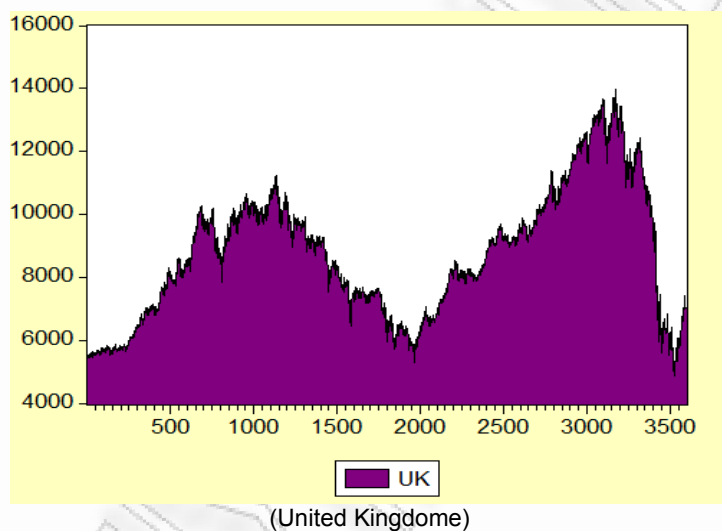
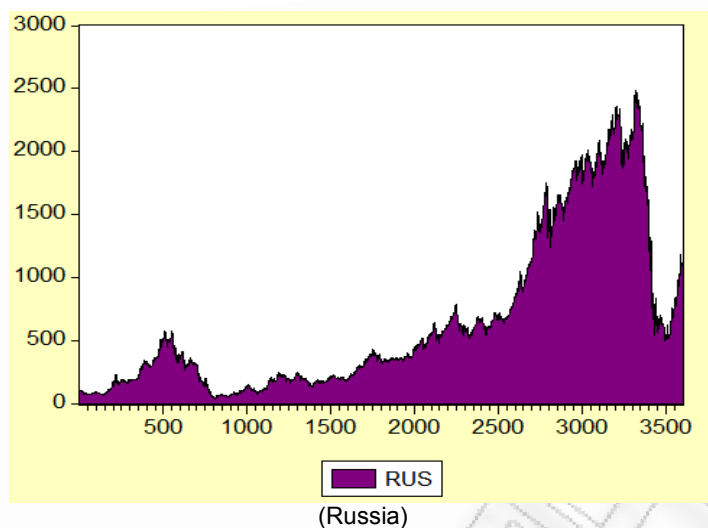
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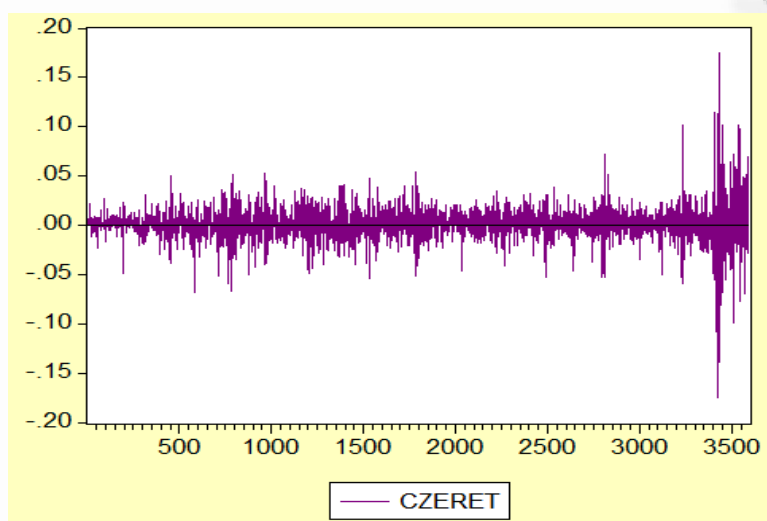
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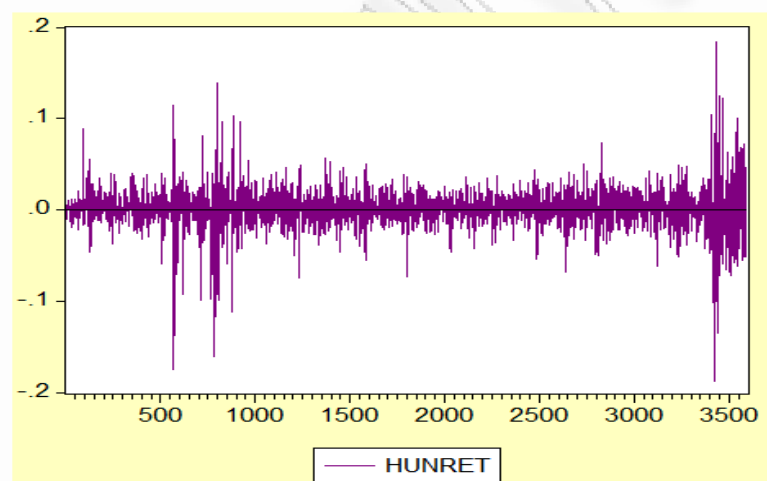
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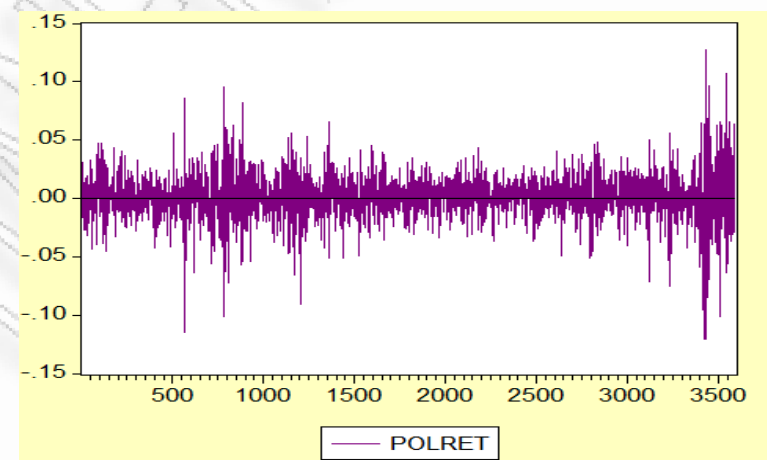
### Returns for the Total period



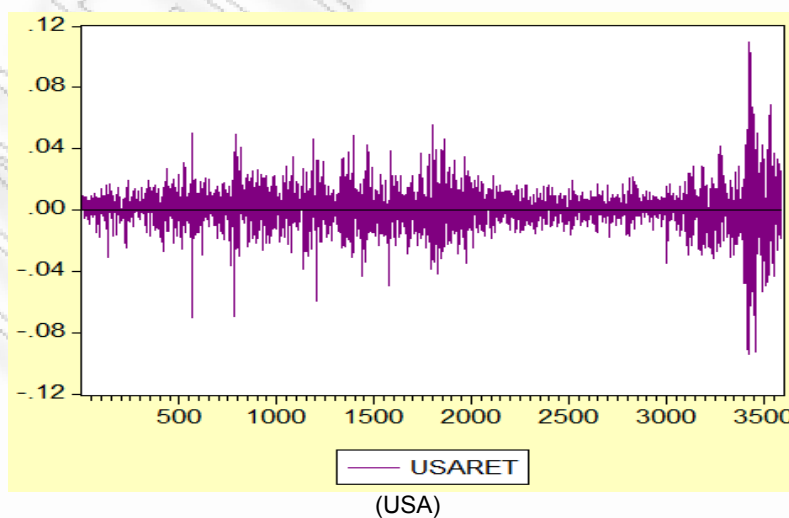
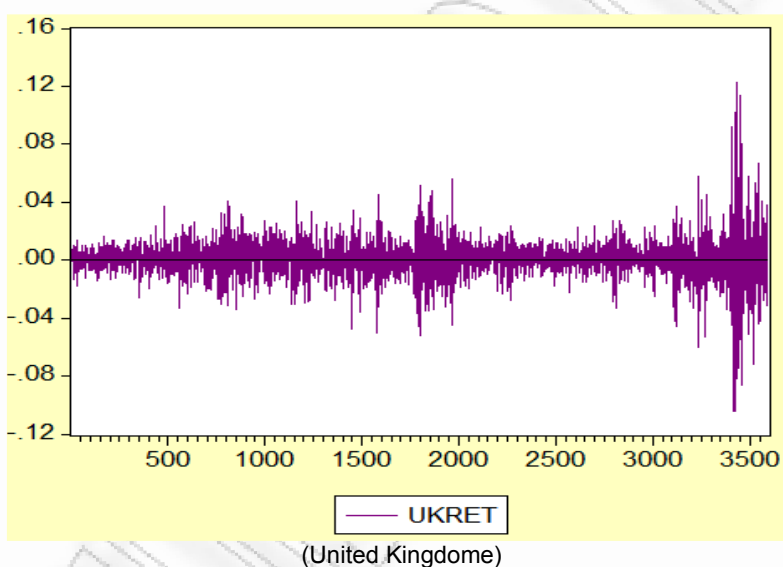
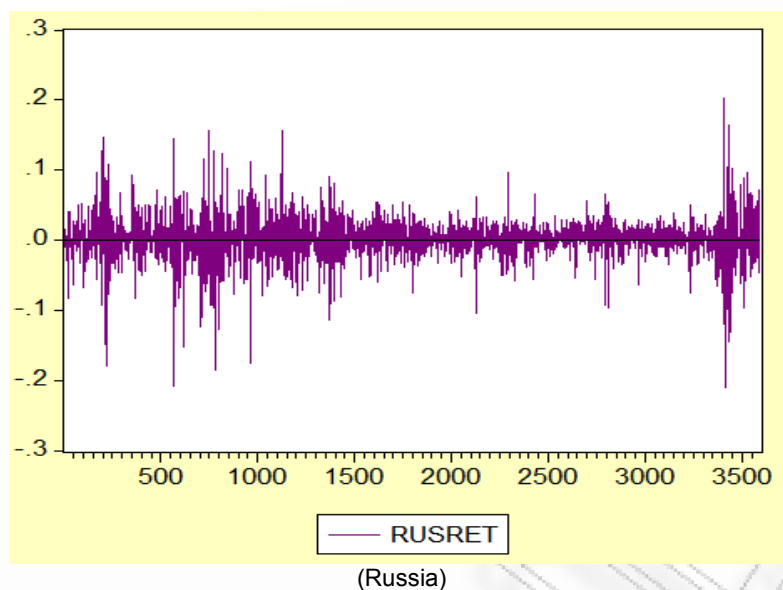
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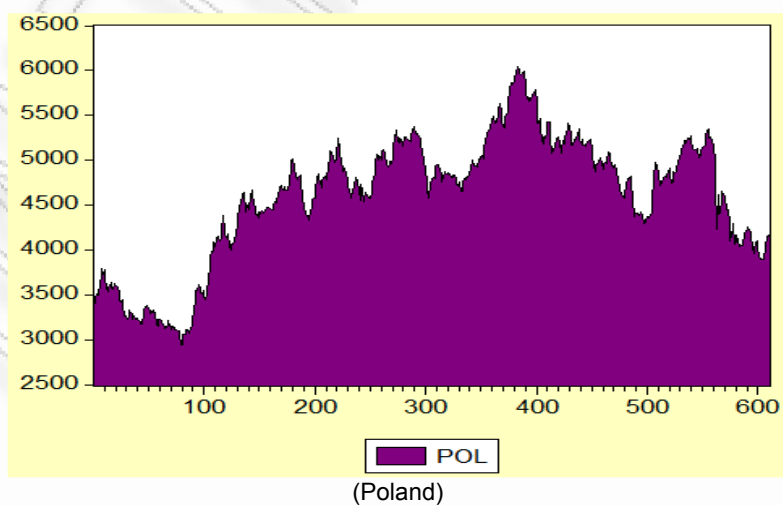
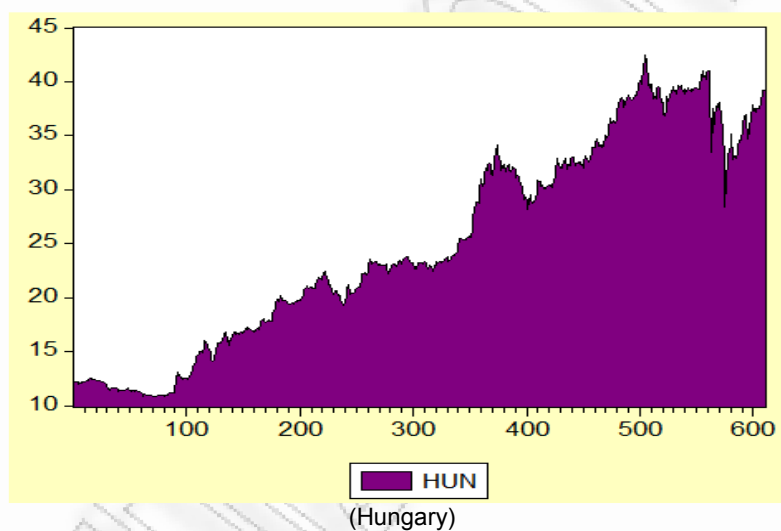
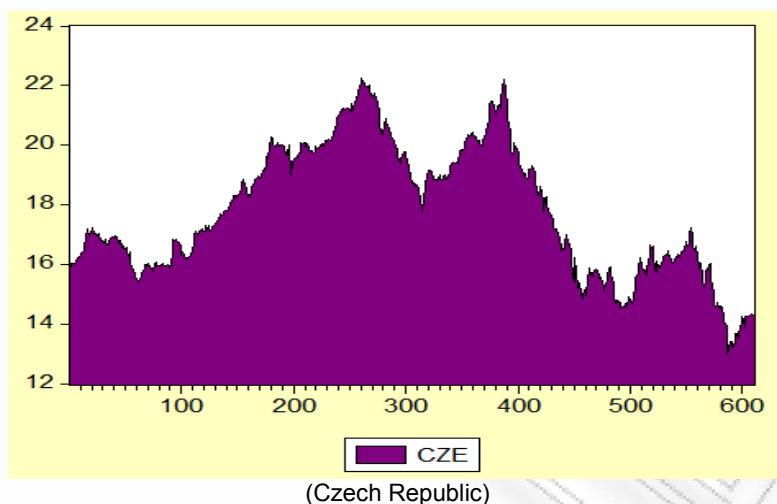
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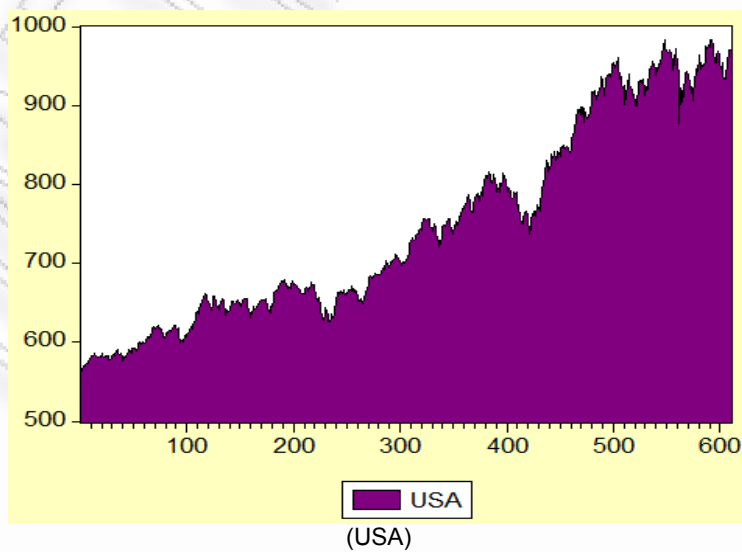
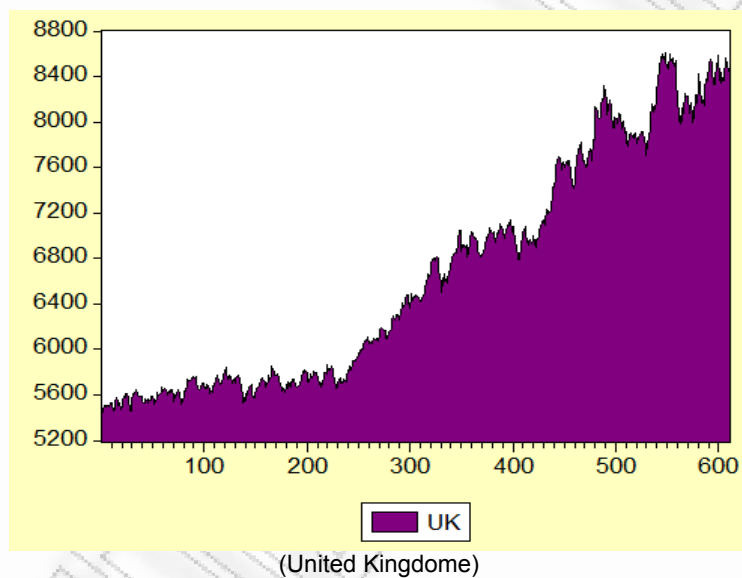
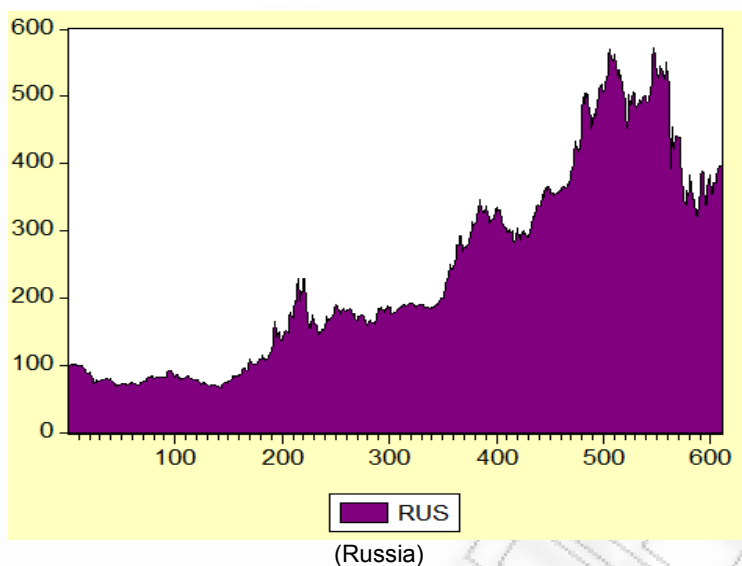


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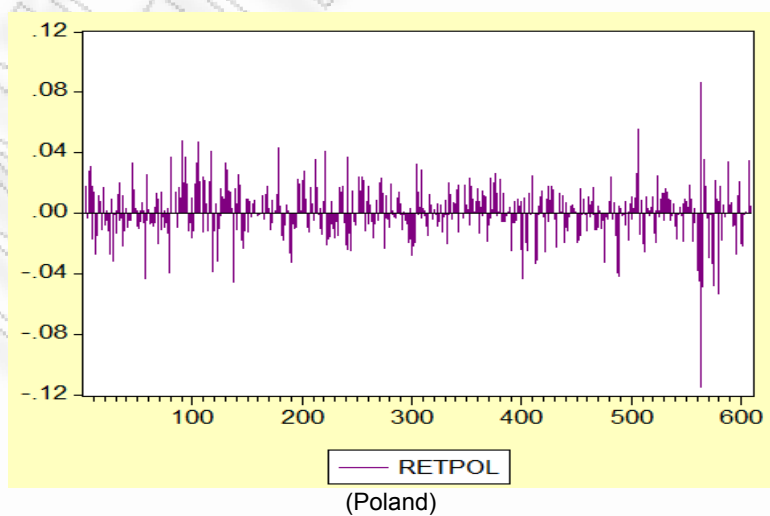
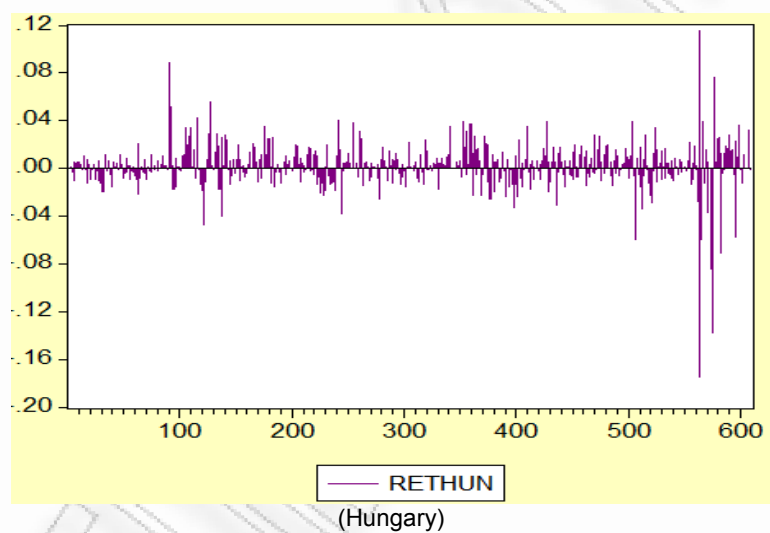
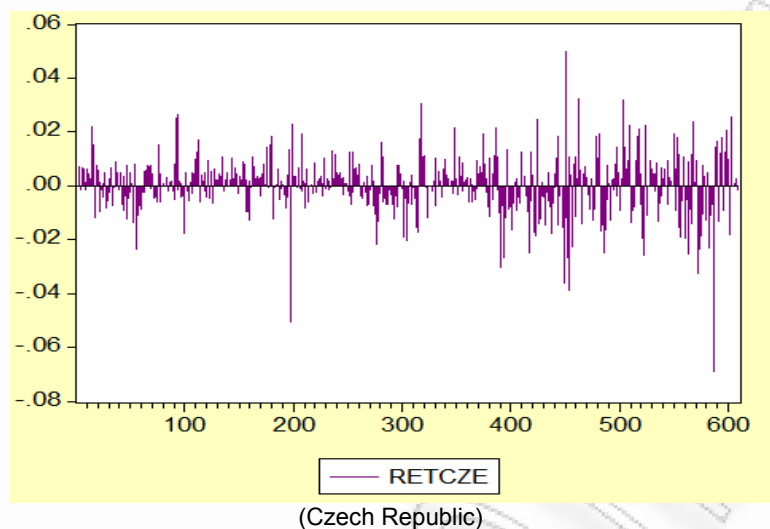


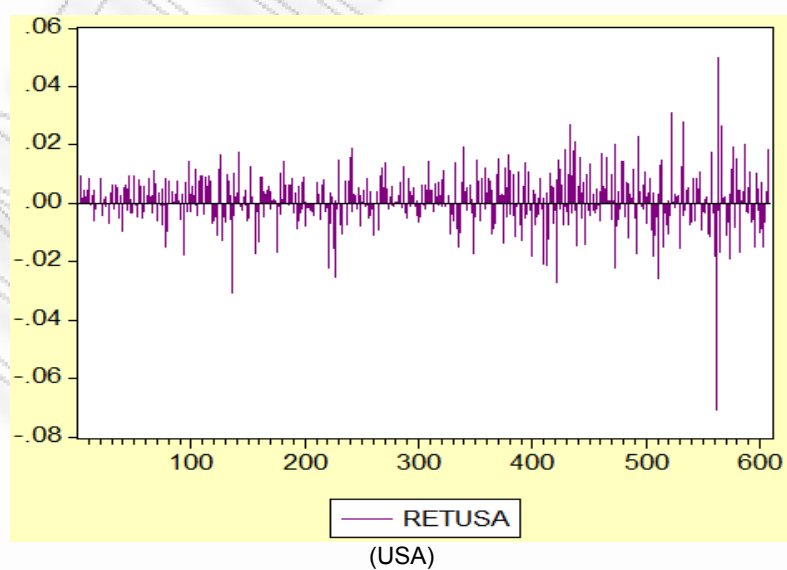
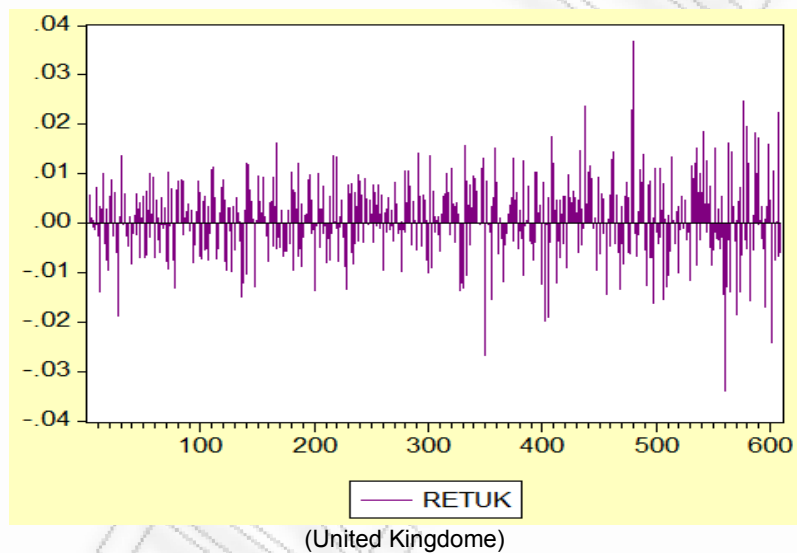
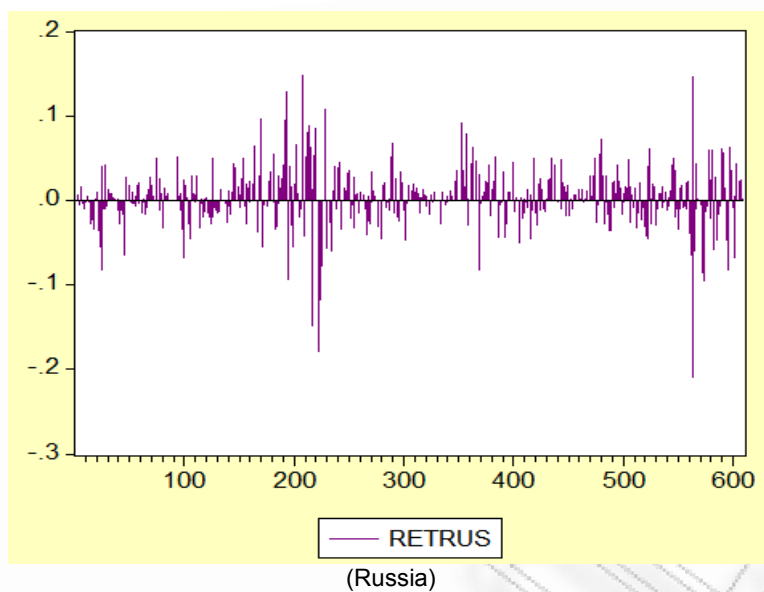
## Closing prices for the Pre-crash period





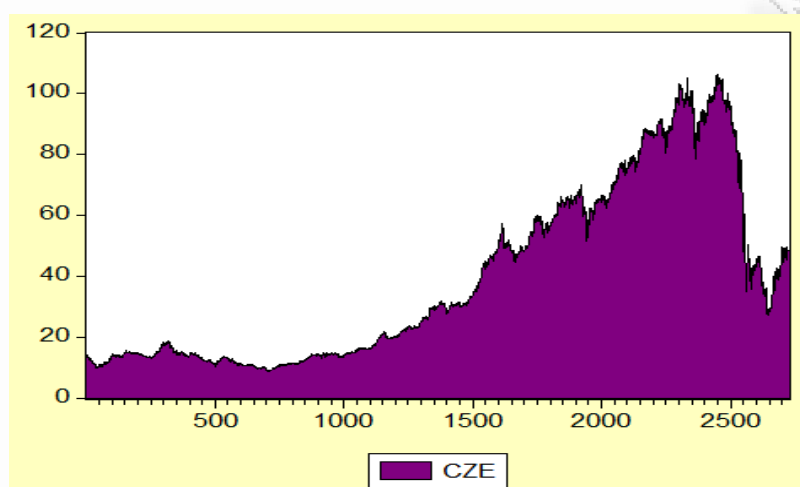
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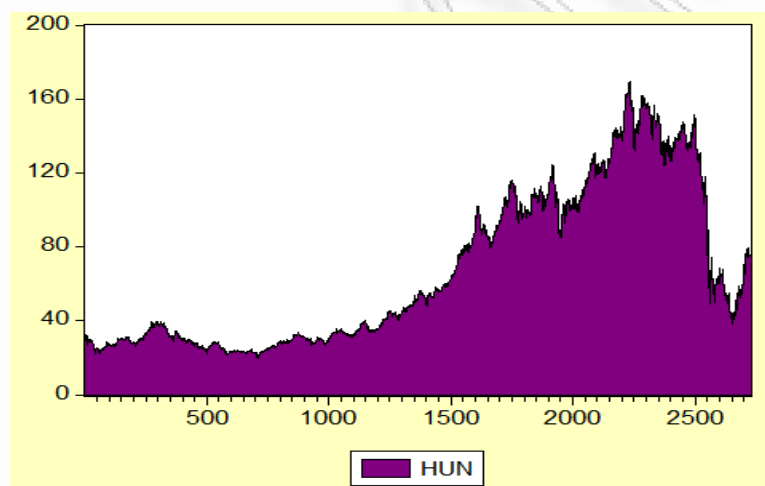




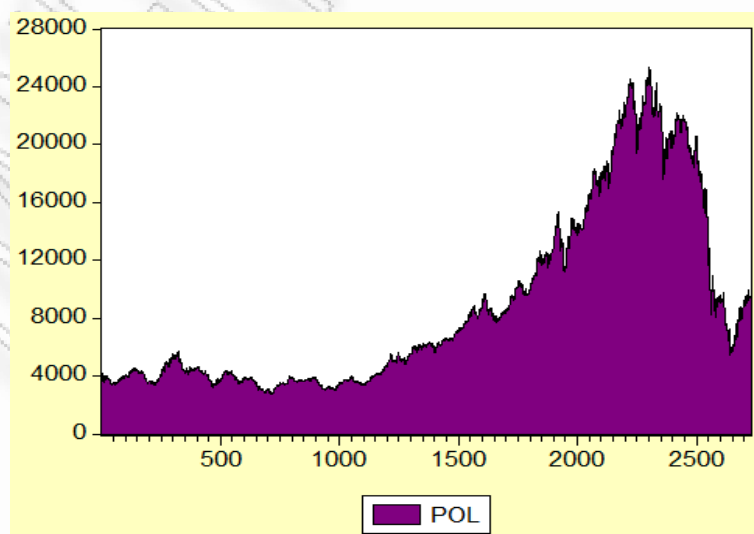
## Closing prices for the Post-crash period



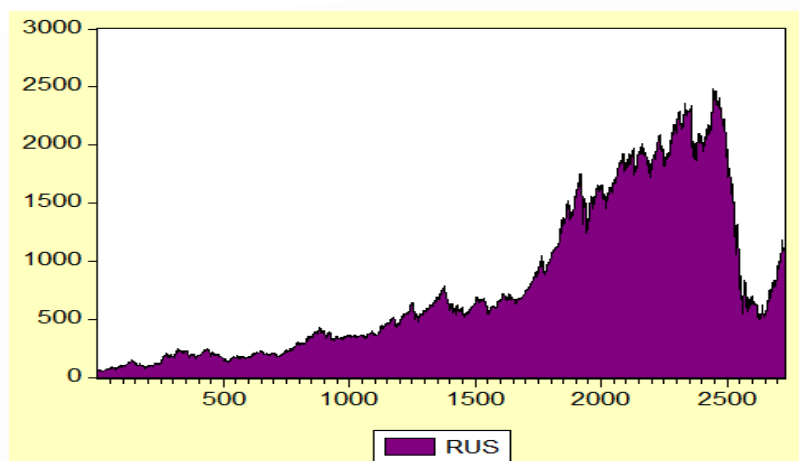
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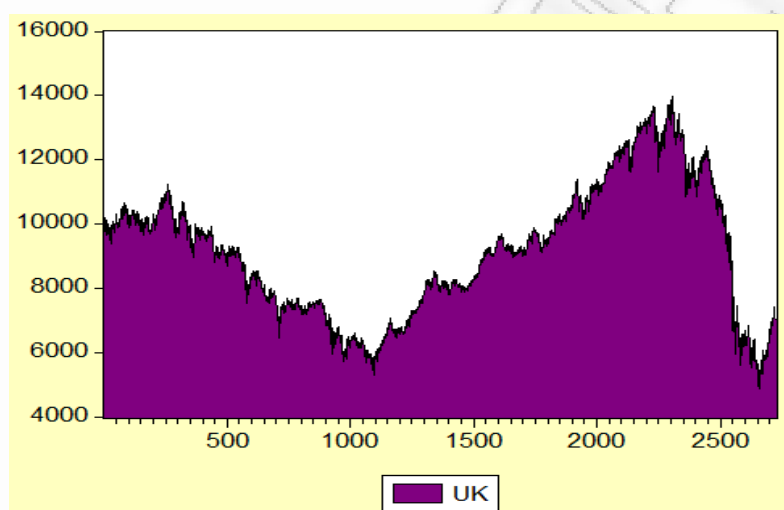
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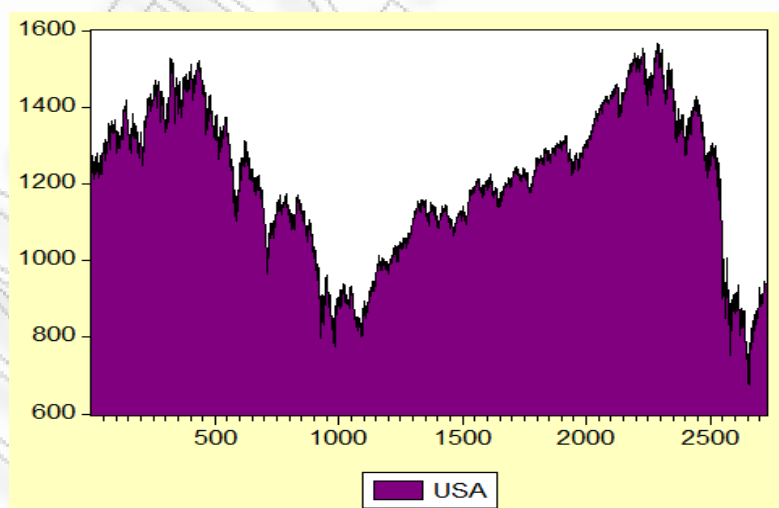
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(Russia)

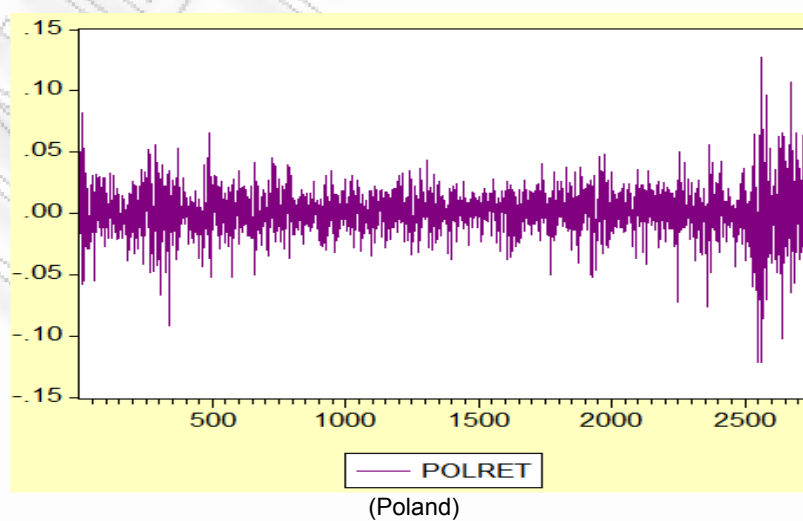
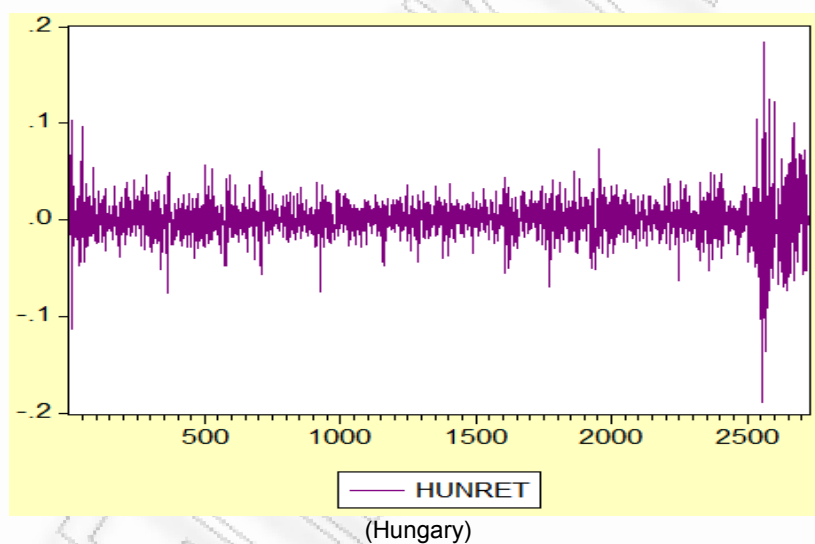
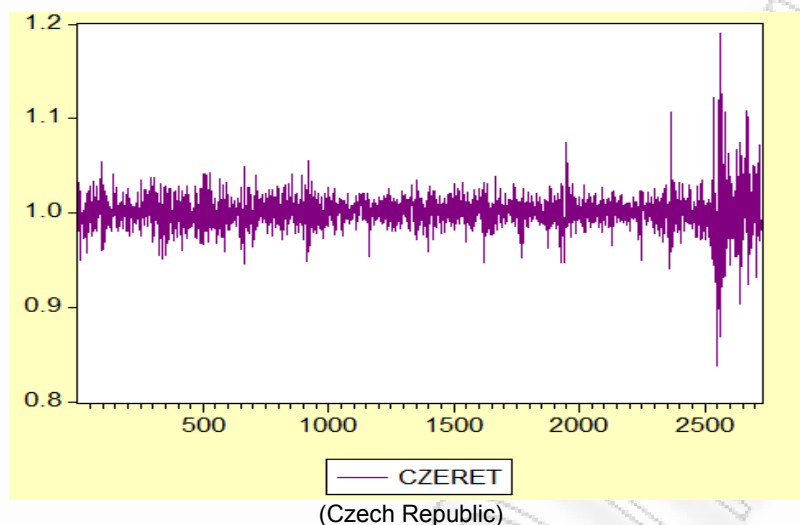


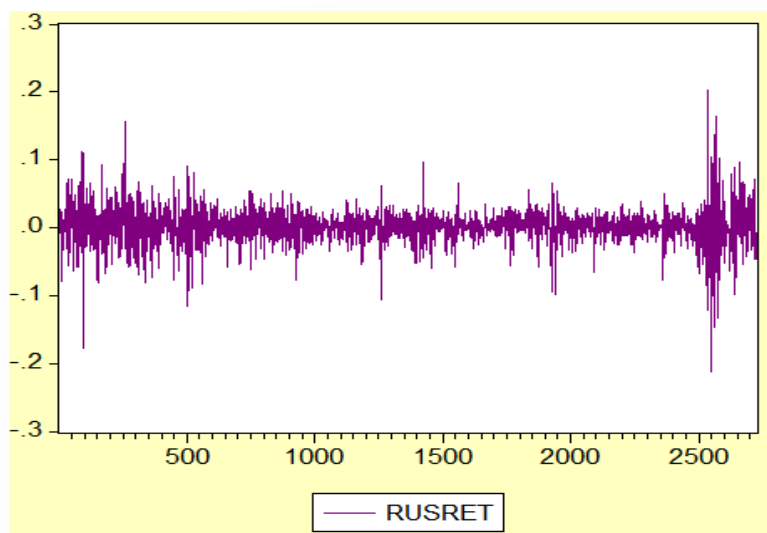
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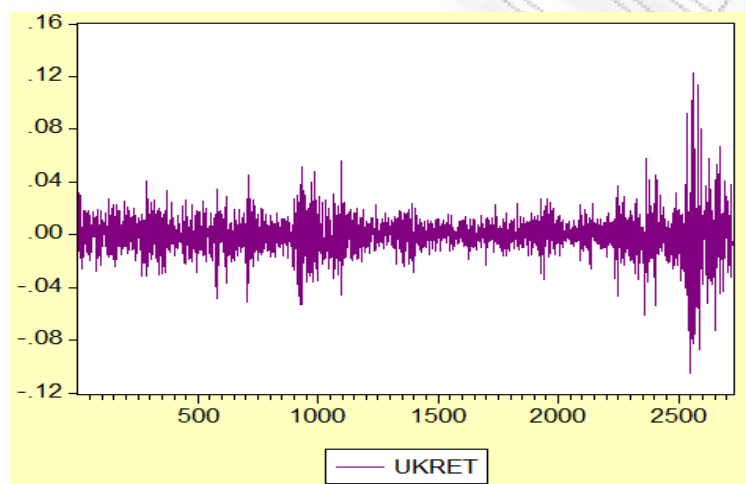
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## Returns for the Post – crash period

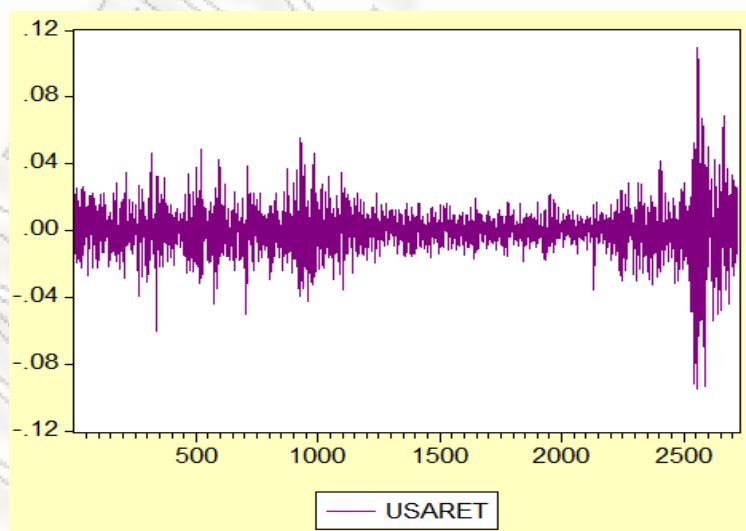




(Russia)



(United Kingdome)



(USA)

## References

- Arshanapalli, B. and J. Doukas, 1993, International stock market linkages: Evidence from the pre and post-October 1987 period, *Journal of Banking and Finance*, Vol. 17, 193-208.
- Arshanapalli B., Doukas J., Lang L.P.H.. 1995, Pre and Post-October 1987 stock market linkages between US and Asian markets, *Pacific-Basin Finance Journal* 3 57-73.
- Agmon T., 1972, The relations among equity markets: A study of share price co-movements in the United States, United Kingdom Germany and Japan, *Journal of Finance* 27, 839-855
- Becker G.K., Finnerty E.J., Gupta M., 1990, The intemporal relation between the US and Japanese Stock markets, *The Journal of finance*, Vol XLV, No 4
- Blackman, C. S., K. Holden and A. W. Thomas, 1994, Long-Term Relationships Between International Share Prices, *Applied Financial Economics*, Vol. 4, 297-304.
- Booth, G. G., T. Martikainen and Y. Tse 1997, Price and Volatility Spillovers in Scandinavian Stock Markets, *Journal of Banking and Finance*, Vol. 21, 811-823.
- Brealey, R. A., S.C. Myers, F. Allen, 2006, *Corporate Finance*, 8<sup>th</sup> ed. McGraw-Hill, 13, 349-354.
- Bessler DA, Yang 2003, The structure of interdependence, in international stock markets, *Journal of International and finance* 22: 261-287
- Byers, J. D. and D. A. Peel, 1993, Some Evidence on the Interdependence of National Stock Markets and the Gains from International Portfolio Diversification, *Applied Financial Economics*, Vol. 3, 239-242.
- Chen, G., M. Firth and O. M. Rui, 2002, Stock market linkages: Evidence from Latin America, *Journal of Banking and Finance*, Vol. 26, 1113-1141.
- Choudhry, T., 1997, Stochastic Trends in Stock Prices: Evidence

from Latin American Markets, *Journal of Macroeconomics*, Vol. 19, 285-304.

- Christofi, A. and A. Pericli, 1999, Correlation in Price Changes and Volatility of Major Latin American Stock Markets, *Journal of Multinational Financial Management*, Vol. 9, 79-93.
- Corhay, A, A. T. Rad and J. P. Urbain, 1993, Common Stochastic Trends in European Stock Markets, *Economics Letters*, Vol. 42, 385-390.
- Cheung Y.L., Mak Sui, 1992, The International transmission of stock market fluctuation between the developed markets and the Asian –Pacific markets, *Applied Financial Economics*, 2, 43-47.
- Dickey, D. A. and W. A. Fuller, 1979, Distribution of the Estimators for Autoregressive Time Series with a Unit Root', *Journal of the American Statistical Association*, 74, 427-431.
- Dungey M. and Martin L. V., 2007, Unravelling Financial Market Linkages during crises, *Journal of Applied Econometrics* 22: 89-119
- Elyasiani, E., P. Perera and N. T. Puri, 1998, Interdependence and Dynamic Linkages between Stock Markets of Sri Lanka and its Trading Partners, *Journal of Multinational Financial Management*, Vol. 8, 89-101.
- Engle, R. F. and C. W. J. Granger, 1987, Cointegration and Error Correction Representation, Estimation and Testing, *Econometrica*, 55, 251-276.
- Espitia, M. and R. Santamaria, 1994, International Diversification among the Capital Markets of the EE, *Applied Financial Economics*, Vol. 4, 1-10.
- Eun, C. S. and Shim S., 1989, International transmission of stock market movements, *Journal of Financial and Quantitative Analysis*, Vol. 24, 241-256.
- Forbes, Kristin J. and Rigobon, Roberto, 1999, No Contagion, Only Interdependence: Measuring Stock Market Co-movements, NBER Working Paper No. W7267
- Gikas Hardouvelis, Dimitrios Malliaropoulos, Richard Priestley,

### EMU and European Stock Market Integration.

- Gelos R., Sahay, 2001, Financial market spillovers in transition economies. *Economics of Transition*, 9: 53-86
- Hassan, M. K., Naka A., 1996, Short-run and long-run dynamic linkages among international stock markets, *International Review of Economics and Finance*, Vol. 5, 387- 405.
- Hyang, B. N, C. W. Yang and J. Hu, 2000, Causality and Cointegration of Stock Markets among the United States, Japan, and the South China Growth Triangle, *International Review of Financial Analysis*, 281-297.
- In F. Kim, S. Yoon, J. H. and C. Viney, 2001, Dynamic Interdependence and Volatility Transmission of Asian Stock Markets. Evidence from the Asian crisis, *International Review of Financial Analysis*, Vol.10, 87-96.
- Isakov, D. and C. Perignon, 2000, On the Dynamic Interdependence of International Stock Markets: A Swiss Perspective, Forthcoming in the *Swiss Journal of Economics and Statistics*.
- Johansen, S., 1988, *Statistical Analysis of Cointegration Vectors*, *Journal of Economic Dynamics and Control*, 12, 231-254.
- Jan G. De Gooijer, Selliah Sivarajasinghm, 2008, Parametric and nonparametric Granger causality testing: Linkages between international stock markets, *Physica A* 387, 2547-2560
- Janakiraman S., Lamba A., 1998, An empirical examination of linkages between Pacific-Basin stock markets, *Journal of International Markets Institutions and Money* 8(1998) 155-173
- Kanas, A., 1998, Volatility Spillovers across Equity Markets: European Evidence, *Applied Financial Economics*, Vol. 8, 245-256.
- Kasa, K., 1992, Common stochastic trends in international stock markets, *Journal of Monetary Economics*, Vol. 29, 95-124.
- Kenourgios D., Samitas A., 2003, The Interdependence of Major European Stock Markets: Evidence for Greece, *Spoudai* Vol. 53, No 4, University of Piraeus, pp.54-56

- Koch, P. D., Koch, T.W., 1991, Evolution in dynamic linkages across daily national stock indexes, *Journal of International Money and Finance*, Vol. 10, 231-251.
- Koutmos, G., 1996, Modelling the Dynamic Interdependence of major European Stock Markets, *Journal of Business Finance and Accounting*, Vol. 23, 975-988.
- King M., Wadhvani S. 1990, Transmission of Volatility between stock markets, *Review of Financial Studies* 3: 5-33.
- King M., Wadhvani S., Sentana E. ,1994, Volatility and links between stock markets, *Econometrica*, Vol 62 No 4, 901-933
- Licht N. A., 1997, Stock market Integration in Europe, Harvard Law School.
- Malliaris, A. G. and J. L. Urrutia, 1992, The International Crash of October 1987: Causality Tests, *Journal of Financial and Quantitative Analysis*, Vol. 27, 353-364.
- Masih, R. and M. A. Masih, 2001, Long and Short Term Dynamic causal Transmission amongst International Stock Markets, *Journal of International Money and Finance*, Vol. 20, 563-587.
- Manning n. 2002, Common trends and Convergence ,South East Asian equity markets 198-1999, *Journal of International Money and Finance* 21:183-202.
- Meric, I. and G. Meric, 1989, Potential Gains from International Portfolio Diversification and Inter Temporal Stability and Seasonality in International Stock Market Relationships, *Journal of Banking and Finance*, Vol. 13, 627-640.
- Mathur Ike, Subrahmanyam Vijaya, 1990, Interdependences among the Nordic an U.S. stock markets, *Scand. J. of Economic* 92 (4) 587-597
- Ostermark, R., 2001, Multivariate Cointegration Analysis of the Finnish-Japanese Stock Markets, *European Journal of Operational Research*, Vol. 134, 498-507.
- Philips, P.C. and P. Perron P., 1998, Testing for a unit root in time series regression, *Biometrika*, 75, 335-346.



- Rangvid, J., 2001, Increasing Convergence among European Stock Markets: A Recursive Common Stochastic Trends Analysis, *Economics Letters*, Vol. 71, 383-389.
- Richards, J. A., 1995, Comovements in National Stock Market Returns: Evidence of Predictability, but not Cointegration, *Journal of Monetary Economics*, Vol. 36, 631-654.
- Sheng, H. C. and H. A. Tu, 2000, A Study of Cointegration and Variance Decomposition among National Equity Indices before and during the Period of the Asian Financial Crisis, *Journal of Multinational Financial Management*, Vol. 10, 345-365.
- Shachmurove Y., 2005, Dynamic Linkages among the emerging Middle Eastern and the United States stock markets, *International Journal of Business*, 10(1)
- Taylor, M. P. and I. Tonks, 1989, The Internationalization of Stock Markets and the Abolition of U.K. Exchange Control, *The Review of Economics and Statistics*, 332-336
- Tuluca SA, Zwick B. 2001, The effects of the Asian crisis on global equity markets, *Financial Review* 36: 125-142
- Valadkhani A. Chancharat S, 2007, Dynamic Linkages between Thai and international stock markets.
- Yang J., Hsiao C., Qi Li, Zijun Wang, 2005, The emerging market Crisis and Stock Market Linkages: Further evidence
- Zhiwu Chen, Peter Knez, 1995, Measurement of Market Integration and Arbitrage, *The Review of Financial Studies*, Vol. 8, pp287-325

#### **Web site**

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- [www.world-exchanges.org](http://www.world-exchanges.org)
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