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1. INTRODUCTION

In the global economy that we live in, the main theme supports investors to diversify their assets across national borders, as long as returns to stock in these other markets are less than perfectly correlated with the domestic market. The case for international portfolio diversification was established in the 60s and 70s. It is well known that the greater diversification benefits exist the less correlated the markets are. Accordingly, U.S., Japanese, and other investors have become increasingly active in foreign stock markets. For well-balanced portfolios, the action has helped created a profit center even while the equities market shivers violently.

The question is whether international portfolio diversification is always a reasonable method of reducing the risk of an investment portfolio without negatively affecting its return expectations. Unfortunately, there is still not a simple answer to this question. When ex-post data are examined, potential benefits of international diversification can certainly be detected. However, we also argue that it might be difficult for investors to select an optimal investment strategy ex-ante, when the correlation structure among the international equity is unstable over time. Maintaining the perfect portfolio is difficult and takes a lot of time and skill. No matter what, success cannot be achieved unless investors erase their xenophobic ways and invest internationally.

The benefits of international portfolio diversification remain as a controversial issue in the financial literature. Its defenders argue that international diversification helps investors to reduce the risk of an investment while holding the expected return constant. On the other hand, it is claimed international diversification to have no economic rationale.

However, the concept of integrated markets has strong consequences for international investors, as it implies that the benefits of international portfolio diversification are diminishing according to integration level.

Restrictions on foreign investment have been reduced, and modern technology allows investors to buy and sell securities all over the world almost

instantaneously. It is conceivable that this trend towards greater globalization has caused stronger co-movements among markets as well as large increases in cross-border capital flows, thus reducing the potential benefits of international diversification. Means of achieving diversification include internal development, acquisitions, strategic alliances, and joint ventures. As each route has its own set of issues, benefits, and limitations, various forms and means of diversification can be mixed and matched to create a range of options.

This study investigates the dynamic interdependence and volatility transmission among fourteen European stock markets (Austria, Belgium, Denmark, Germany, Greece, Ireland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, Turkey and U.K.), U.S. and Japan. We use monthly real returns for the sixteen equity markets from 1/2/1988 to 1/3/2009 (full sample), applying Granger causality tests in mean and in volatility. The data are sourced by DataStream and expressed in U.S. dollars. Causality tests in volatility are computed with two different methodologies. Firstly, we use the squared values of the real returns and then the absolute values of the real returns for the examined equity markets. We also separate the sample into two subperiods, one before the introduction of euro 1/2/1988 – 1/12/1998 (pre-euro period) and one after the introduction of euro 1/1/1999 – 1/3/2009 (post-euro period), so as to find out the changes in the linkages among those markets through time.

2. REASONS FOR INTERNATIONAL INTERDEPENDENCE

a) Newly issued flexible exchange rate techniques:

The governments of more and more countries have been adopting more flexible exchange rate regimes. One of the main reasons for restrictions on cross-borders capital flows had been to mitigate the pressure, which capital outflows would place on a fixed or pegged exchange rate. With exchange rates now generally more flexible, there is less need to control capital flows.

b) Privatization of the public sector:

Capital markets increase the available financing sources for firms to fund new investment.

- The privatization link with poverty reduction stems from the relative ineffectiveness of public ownership to fulfil economic growth needs.
- While no established framework is evident as to how nongovernment organizations' participation should be structured into the planning and implementation of privatization, study observations suggest that they can be most effective in the design and implementation of social awareness campaigns, retraining, and compensation for displaced employees and communities.
- While experience of privatization has been positive, privatization has proceeded largely without attention to the sequencing of reforms and appropriateness of approach for maximizing its effectiveness.

c) Deregulation concerning the capital movements & new technology adaptation:

The extraction of the regulatory boundaries posed on capital movements, along with increased trade, increases communications and capital flows which have contributed to the globalization of business activity. Moreover, policy coordination among major industrialized countries about trade and capital flows also have contributed to greater similarities in economic conditions and developments, which are usually reflected in stock market indices. With recent financial market deregulation, improvements in telecommunications and computer technology, reductions in the transaction costs and significant increases in the cross-listing of stocks of multinational companies in the 80s, international stock markets have become more integrated. The normative perspective assumes that the full liberalization of market forces through open trade and foreign investment regimes will stimulate sustained growth and greater convergence of income per capita throughout the world.

d) Geographical position:

Geographical interdependence aims at using the comparative advantages of space, namely to insure a better access to markets, labour, parts and resources. A spatial complementarity is established through a set of origin destination relationships between the actors of a commodity chain. Economies are achieved through the principle of location where each actor seeks to find cost and/or income effective locations. Thus, in a conventional situation production systems tended to have a regionally oriented location of its components and finished goods could be exported. With geographical integration, spatially fragmented commodity chains can emerge, where each element can undertake a locational choice to maximize efficiency. The function of distribution may also be expanded to cope with this geographical specialization, with the complexity of physical flows, namely in terms of a growth in tons-km. The only exception to this rule, however, seems to be the

US, which pose great influence to all economies worldwide, regardless its geographical position.

e) Investors' psychology:

Most financial theory is based on the idea that everyone takes careful account of all available information before making investment decisions. But there is much evidence that is not the case. Behavioural finance, a study of the markets that draws on psychology, is throwing more light on why people buy or sell the stocks they do - and even why they do not buy stocks at all. The ideas of behavioural finance apply as much to financial analysts as they do to individual investors. For example, research indicates that professional analysts are remarkably bad at forecasting the earnings growth of individual companies. Indeed, it seems that forecasts for a particular company can be made more accurately by ignoring analysts' forecasts and forecasting earnings growth at the same rate as the average company. The underlying reasons for the abject failure of the professionals are classic behavioural finance: they like to stay close to the crowd; and their forecasts tend to extrapolate from recent past performance, which is very often a poor guide to the future.

There is evidence that institutional investors behave differently than individuals, in part because they are agents acting on behalf of the 'ultimate' investors. Compensation devices like profit-splitting schemes seek to align the interests of principals with their agents - portfolio managers and other advisers - but still differences persist. For example, agents may be reluctant to take risks - even when probabilities strongly suggest they should for their clients' interests - when the risks are small but real that they might be fired. Behavioural finance still remains at the fringes of portfolio management and modern financial theory, perhaps because there is still no behavioural equivalent of the CAPM, a technique developed in academia but widely used in practice. Yet many believe that the humans flaws pointed out by the analysis of investor psychology are consistent and predictable, and that they offer investment opportunities. All the above mentioned indicate that, both

institutional and individual investors worldwide are finding it increasingly attractive and convenient to engage in international portfolio diversification. However, research addresses the possibility that increased globalization is, in fact, reducing the potential benefits of international diversification. With national economies becoming more closely linked, however there is greater potential for their stock markets to become more highly correlated, and thus reducing the benefits of international diversification. Knowing the correlations between the returns of various national markets is important to allocate the process of the investments among these markets.

3. LITERATURE REVIEW

In this chapter there will be en extended review of the previous studies since the interdependence of the international stock markets appears as a theme of analysis of many researchers from the early '70.

Recent research finds evidence for linkages among equity markets. Grubel (1968), pointed out the benefits of international diversification and since then there have been numerous studies examining the relationships among national stock markets. Earlier studies by Granger and Morgenstein (1970), Levy and Sarnat (1970), Grubel and Fadner (1971), Amagon (1972) using simple correlation and regression methods and based on weekly or monthly data from the 1960's and 1970's, reported little or no correlation among national stock markets. Other studies found linkages among European equity markets that allow capital transfer (Ripley 1973). Fiarstenberg and Jeon (1989) and Roll (1989) investigated the comovement of several stock markets before and after the crash. They did find an increased amount of correlation among markets during and shortly after the crash, but they were not able to confirm whether this was a long-term phenomenon or the result was valid for the crash period only. Higher-frequency data reveal that there is evidence of correlation among equity markets, especially after the 1987 crisis.

Eun and Shim (1989), examined the interdependence between major national stock markets. They concentrated on the stock markets of Australia, Japan, Hong Kong, U.K., Switzerland, France, Germany, Canada and U.S.A. using a Vector Autoregressive system. Their data were daily stock market indices at closing time expressed in local currencies. All data were sourced from Morgan Stanley Capital International Perspective, Geneva. Their sample consisted of 1.560 observations covering the period from 31 December 1979 to 20 December 1985. Eun and Shim concluded that there is strong evidence of integration among several international equity markets. Events occurring in the US stock market are quickly transmitted to stock

markets in other countries. However, no individual stock market has substantial influence on the US stock market.

Gelos and Sahay (2001) investigated the financial market spillovers among European economies. Using data from 1993 to 2000, they focused on three widely-cited crisis episodes (the Asian, Czech, and Russian). At first, they carried out VAR analyses and Granger Causality tests with daily stock and exchange market data. Then, they examined whether correlations among European country's financial markets increased markedly during crisis events. They ended with the conclusion that there was only weak evidence of linkages during the Czech and Asian crises but higher financial market comovements after the 1998 Russian crisis. Finally, they compared their results with the experience of Latin American markets during the Asian and Russian crises and those of Asian economies during the Asian crisis. These episodes looked surprisingly similar to the experience of European economies around the Russian crisis. This fact means that with greater financial market integration, the European financial markets can be expected to behave more and more like these of Asia and Latin America.

Chelley and Steeley (2005), examined economic comovements among the Eastern European equity markets of Hungary, Poland, Russia, Czech Republic and those of the developed countries of Germany, France, Japan, the UK and US. They collected daily equity market data from Datastream and IFS (International Financial Statistics) for the period July 1994 until December 1999. Using the variance decompositions from a vector autoregressive representation of returns they found that all four Eastern European markets could be described as heavily segmented. However, over time, the degree of segmentation experienced by some of these markets has declined significantly. They modelled a system of bivariate equity market correlations in order to analyze how rapidly these countries are moving away from market segmentation. Hungary's and Poland's equity markets seem to have made rapid progress towards becoming integrated markets. In addition Czech Republic's market made some progress towards market integration, but at a much slower pace than Hungary's and Poland's. The weakest progress

towards market integration was found in Russia, despite a promising move towards integration up until 1997. Finally, comparing the periods 1994-1996 and 1996-1998, they found increasing linkages between the Eastern European equity markets and those of the developed countries.

Jochum, Kirchgassner, and Platek (1999) analyzed the behaviour of four Eastern European markets (Russia, Poland, Hungary and Czech Republic) previous to and during the 1997/98 crisis. Using daily data that were obtained from Bloomberg Information System, they applied the Hansen and Johansen (1993) test to investigate the constancy of cointegration before and during the crisis period. They also tested for bivariate cointegration among each pair of markets and then examined the (multivariate) cointegration behaviour of groups of markets. They finally detected strong evidence of linkages in Eastern Europe during the pre-crisis period (1995–1997). However, they reported no cointegration for the third quarter of 1997, as the Asian crisis spread and the political and economic instability in Russia were increased.

Voronkova (2004) examined the long-run relations between emerging Central European stock markets (Czech Republic, Hungary, and Poland) and the developed stock markets of Europe (Britain, France, and Germany). She implemented the Gregory and Hansen (1996) test for cointegration, which detects structural breaks that can reveal evidence of long-run relationships that are not identified by static cointegration tests. She used daily closing prices for the indices of emerging CE markets, developed European markets and the United States, covering the time period from 7 September 1993 through 30 April 2002. The data were obtained from the national stock exchanges and the Karlsruher Kapitalmarktdatenbank (University of Karlsruhe, Germany). She accepted as an example Jochum, Kirchga¨sser, and Platek (1996), using indices expressed in the national currencies and creating a sample of 1862 observations. She concluded that there is a strong evidence of cointegration within the CE markets and between them and the more developed markets.

Scheicher (2001) also examined the integration between the principal emerging stock markets of Hungary, Poland and Czech Republic from 1 January 1995 to 7 October 1997. He obtained data from the Central European Clearing Houses and Exchange (CECE) in Vienna reporting stylized facts of these markets. Then he estimated a vector autoregression with multivariate GARCH to evaluate the impact of price and volatility shocks and performed a variety of diagnostic tests. His sample contained 723 observations, comprising the daily values of the Czech, Hungarian and Polish Traded Indices. The common currency of these four indices is US Dollars. He used daily frequency data so as to take a larger number of observations than earlier studies on emerging markets with weekly or monthly data. He found evidence of integration among the three countries, particularly between Hungary and Poland. His conclusions also noted that Eastern Europe's economies are influenced by Western financial markets.

The influence of UK and German economies to the markets of Czech Republic, Hungary and Poland were examined by Rockinger and Urga (2000). They introduced a model, based on the Kalman filter framework, which allows to latent factors, time varying parameters, and a general GARCH structure for the residuals, to extend the Bekaert and Harvey (1997) model. With this extension it is possible to test if an emerging stock market becomes more integrated with other already established markets. They applied this model to the Czech, Polish, Hungarian, and Russian stock markets, using data at daily frequency running from 7 April 1994 to 10 July 1997. They concluded that the influence of London is stronger for the Czech and Polish markets than that of Frankfurt. The Hungarian market is little affected by either.

Gilmore and McManus (2003) inspected closely the cointegration between the German stock market and three Central European equity markets namely those of Czech Republic, Hungary and Poland, but in a different time period. Using weekly closing price indices, they applied the methodology of cointegration analysis to test the presence of long-run relationships among those equity markets, for the time period from July 5, 1995, through March 27,

2002. They used a number of cointegration tests so as to find out whether stock prices of different national markets move together over the long run. The data of this study consisted of the DAX index for the German equity market and IFC Investable (IFCI) indices for the Central European markets. These indices were obtained from the Emerging Markets Data Base (EMDB) of the International Finance Corporati and were used in local-currency terms. They finally reported a lack of bilateral and multilateral cointegration of the equity markets of the Czech Republic, Hungary and Poland with the German market for the years 1995 through early 2002.

Bartram, Taylor and Wang (2005) and Baele (2005), also explored the level of financial integration between European equity markets, by analyzing return indices across countries using high frequency data and time-series methods. Bartram, Taylor and Wang (2005) deduced that the equity markets of countries within the Euro area are significantly integrated, especially in late 1997 or early 1998 after the Euro membership had been determined and announced. In addition, Baele (2005) found that the interdependence of 13 European equity markets increased over the 1980s and 1990s and that the US is the dominating influence in European equity markets.

Kearney and Poti (2005) studied for correlation dynamics between 5 national stock markets with the heaviest capitalization in Europe (Germany, France, Italy, Spain and Holland). They used daily equity market return indexes covering the period 1993-2002. Their data were obtained from Bloomberg and were expressed in euro. They employed the symmetric and asymmetric version of the DCC-MVGARCH model of Engle (2001), Engle and Sheppard (2002) and Engle (2002) using conditional and unconditional estimation methodologies. They reported strong evidence of structural break in the time period before the introduction of Euro in Euro-zone. This confirmed the results reported by Cappiello, Engle and Sheppard (2003) and Baele (2002).

Gilmore, Lucey and McManus (2006) researched short-term and long-term comovements between developed European Union (EU) stock markets

(Germany and the UK) and three Central European (CE) countries (Czech Republic, Poland and Hungary)for the period July 1995 to February 2005. They chose MSCI daily indices because these indexes are constituted on a consistent basis and thus they are fully comparable across countries. They used the standard methodology of static cointegration analysis developed by Johansen (1988) and Johansen and Juselius (1990). Firstly they examined the presence of long-run relationships of the Frankfurt and, alternatively, the London equity market with the major Central European equity markets. Then they investigated the changing nature of linkages between these markets over time. Finally, they analyzed the extent to which the comovements of the CE and the two developed EU markets can be related to common factors over time. They reported a little evidence of relationship between the CE equity markets and those of the UK and Germany.

Fratzscher (2002), studied the integration process in the Europe area since 1986 and the effect of EMU on this process. He created an interest parity condition using asset prices taken from Datastream International and he used a trivariate GARCH model for 16 countries (Austria, Belgium, Finland, France, Germany, Italy, the Netherlands, Spain, Denmark, Sweden, the UK, Australia, Canada, Japan, Norway, and Switzerland). The reason he choose these countries was to find out if there are differences in the relationships between Europe members and other countries. His sample consisted of 3.783 daily observations for every country running from January 1986 to June 2000. He reported strong evidence of integration between European equity markets since 1996. The drive towards EMU contributed at this financial integration process, eliminating exchange rate volatility and uncertainty in the process of monetary unification.

Syllignakis and Kouretas (2006), studied the financial relationships among seven Central Eastern European (CEE) stock markets (Czech Republic, Hungary, Slovakia, Slovenia, Estonia and Romania) and the developed stock markets of German and US. Firstly, they applied the Gonzalo and Granger (1995) methodology to find out the number of common trends among the selected stock markets. Then they used the Engle and Sheppard (2001) and

Engle (2002) Dynamic Conditional Correlation (DCC) specification to investigate the conditional relationships among the examined stock markets and the Markov Switching ARCH-L (SWARCH-L) model of Hamilton and Susmel (1994) to examine the structural breaks in volatility of the selected stock markets. Finally, they applied the methodology of cointegration analysis to study the process of integration among those markets. Their sample consisted of daily and weekly data, running from 1995 to 2005. The indices were taken from Datasream and used in local currency terms .They found that the examined stock markets are partially integrated, since the Estonian and Romania markets are segmented. They also found that during the Asian and Russian crises, the short term relationships between the CEE stock markets and the developed stock markets were stronger.

Aggarwal, Lucey and Muckley (2005), studied the integration of European equity markets over the 1985-2002 period. They applied three different methods that underline the extent of time at which equity markets are integrated. At first they used the traditional cointegration analysis, then the Haldane and Hall (1991) Kalman filter technique and finally the dynamic eigenvalue analysis. This is the first study which has deployed these techniques simultaneously. Their sample consisted of daily data for the largest stock markets of EU (France, Germany, Italy, the Netherlands, Spain, Sweden and the UK) and USA. They used FTSE All-World indices that were sourced from Thompson Datastream. They reported increasing levels of integration in Europe area, especially after the establishment of the EMU and the ECB during the 1997-1998 period. This study also showed that the US market is still the dominating market in the world, despite this increased integration among European equity markets.

Herrmann and Jochem (2003), also researched the degree of financial integration between central (Czech Republic, Hungary, Poland, Slovac Republic and Slovenia) and east (Bulgaria, Estonia, Latvia, Lithuania and Romania) European equity markets and EMU equity markets. They collected data from Datastream, Bloomberg and IMF starting from 31 December 1998, the day before the introduction of the euro (Poland and the Slovak Republic:

31 January 1999) and ending on 30 June 2002. They applied the covered interest parity (CIP) technique using three-month money market rates and three-month forward rates. They came to the conclusion that the equity markets of Czech Republic, Hungary, Poland and Slovak republic are heavily integrated with the euro area. In addition, the financial correlations among those countries have been strengthened during the 1999-2002 period.

Ilhan and Gulser Meric (1997), looked over the comovements of the twelve largest European equity markets (Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland and the UK) before and after the 1987 international equity market crash. Their sample consisted of monthly equity market index returns that were sourced from Morgan Stanley Capital International Perspective (MSCIP) publications. At first, they used the correlation analysis so as to find and compare the level of integration before and after the crash. Then, they applied the Box M test to estimate the equality of correlations of different groups of observation. Finally, they documented that the comovements of these twelve equity markets increased significantly after the crash and also that the financial relationship between the US and the European equity markets has become stronger after the crash reducing diversification benefits.

Bhar and Hamori (2008), proposed an alternative way to analyzing integration among European equity markets. Focusing on four large European equity markets (France, German, Italy and the UK), they adopted a methodology with two stages. At first, they applied the Markov framework to create probability series for the expansion and contraction level of each country measuring the relationships between the equity markets and the industrial production. Then, they examined the degree of concordance between those probability series, so as to estimate the level of integration among the equity markets. In their study, they used monthly data of industrial production index (seasonally adjusted) and stock returns sourced from IMF and MSCI respectively. Their sample consisted of 354 observations for each country, running from January 1971 to June 2000. They concluded that there is evidence of comovements between those four markets over the sample

period and that these results differ from the results obtained from simple sample correlations of the probability series.

Taing and Worthington (2002), investigated the long-term and short-term relationships between equity sectors across European markets during the post-euro adoption period 1999-2002. They examined six equity markets of European Union (Belgium, Finland, France, Germany, Ireland and Italy), using the consumer discretionary, consumer staples, financial, industrials and materials sectors. The sector indices were classified to the Global Industry Classification Standard (GICS). The GICS assigns each company to a sub-industry, and to a corresponding industry, industry group and sector, according to the definition of its principal business activity. In their study they employed value-weighted equity sector indices for the six markets that were obtained from Morgan Stanley Capital International (MSCI) and covered the period 1 January 1999 to 29 February 2002. They applied multivariate cointegration procedures, Granger-causality tests and generalized variance decomposition analyses based on error-correction and vector autoregressive models. They reported few long-run relationships between sectors in different markets and many short-run linkages between these sectors. Finally, they concluded that irrespective of the sector examined the equity markets of France, Germany and Italy remain the most influential.

Friedman and Shachmurove (1997), applied a Vector Auto Regressive (VAR) model to examine whether EC stock markets behave like a single, integrated multi-regional market. This model is appropriate for the investigation of integration among several equity markets. Granger causality test (Granger, 1969) was also used in this study. Friedman and Shachmurove used daily stock market indices for the eight major EC stock exchanges: Belgium, Britain, Denmark, France, Germany, Italy, Netherlands, and Spain, sourced by Morgan Stanley-Capital International Perspective (MSCIP) for the period 1 January 1988 to 31 December 1994. The daily returns were expressed in terms of German Marks. This study reported strong evidence of integration among the large stock markets of the EC (Britain, France, Germany, and the Netherlands), but lower levels of

integration among the smaller EC markets. Finally, Friedman and Shachmurove concluded that investors would achieve larger benefits from international portfolio diversification by including the smaller markets in their opportunity set.

The behavior of price indices among different European stock markets was analyzed by Corhay, Rad and Urbain (1993). Using co-integration analysis tests, they reviewed the period from 1 March 1975 to 30 September 1991. Their data were sourced from Datastream and consisted from 389 biweekly observations of stock price indices of five major European stock markets (France, Germany, Italy, the Netherlands and the United Kingdom). They reported evidence of cointegration between the stock price series of several European countries. They also interestingly reported that while a long-run relationship seems to hold among European stock prices, Italian stock prices do not seem to influence this long-run relation.

Rumi Masih and A. Mansur M. Masih (2004), examined the dynamic linkages and the common trends among five European stock markets (France, Germany, Netherlands, Italy and the United Kingdom) focusing on the pre-and post-October 1987 crash period. A dynamic vector error-correction modeling formulation (VECM) was used to test for the temporal causal dynamics among the stock price indexes. The data were monthly closing share price indexes of the five European equity markets and were sourced from International Financial Statistics (IFS) defining three samples. The one before the crash (January 1979 to September 1987), the one after the crash (November 1987 to June 1994) and the full sample of crash (January 1979 to June 1994). They found no long-run relationship of stock markets over the entire sample period, but they reported evidence of a single co-integrating relationship in each of the pre- and post-crash samples.

Friedman and Shachmurove (2005), used a Vector Autoregressive approach to study the dynamic relationships between European stock market before and after the introduction of the euro. Their sample was consisted of daily returns for the major countries of Euro-zone (France, Germany,

Netherlands, Italy and Spain) running from 1 January 1990 to 31 May 2003. The UK was also included in the analysis due to its dominance in the European stock market, even though it is not part of the Euro-zone. The data were sourced from Morgan Stanley Capital International (MSCI) and were expressed in German Marks for the pre-Euro period and in Euros for the post Euro period. Friedman and Shachmurove deduced that the relationships among the European stock markets have been increased after the introduction of the Euro, especially for the stock markets of Germany, France, Netherlands, Italy and Spain. Compared with previous studies, they found increased international financial integration and that means that the benefits from diversification within Euro-zone stock markets have been decreased considerably over the recent years.

The correlation dynamics among ten European and World stock market were also reviewed by Gjerde and Settem (1995). They employed a multivariate vector autoregressive (VAR) model using daily closing prices for the following equity markets: the United Kingdom, Germany, France, Switzerland, Italy, Sweden, Denmark, Norway, Japan and the United States. Their sample consisted of 27.390 observations and the data were sourced from the Datastream database and provided by DnB Fonds covering the period of 1 January 1984 to 30 June 1994. The findings of this study reported a high degree of international comovement among stock price indices. Gjerde and Settem also found that the US stock market influences the stock markets in every country, except Italy. On the other hand the European stock markets do not influence at all the world's two largest equity markets in New York and Tokyo.

Arshanapalli and Doukas (1993), used the theory of cointegration and explored the linkages and dynamic interactions among International stock markets before and after the October 1987 crash period. They concentrated on the countries with the world's largest stock markets (USA, Germany, England, Japan and France). The data they used were daily closing stock market index time series expressed in local currency units and sourced from the Wall Street Journal. Their sample consisted of 2,709 observations

running from January1980 through May 1990. Unlike previous researches, they reported strong evidence of integration among national stock markets before and especially after the October 1987 crash period. In addition, the US stock market was found to affect the French, German and UK markets in the post-crash period, while the Japanese equity market found to have no relationships with the stock markets of France, Germany, UK and US during the same period.

Chen, Firth and Rui (2000), studied the dynamic linkages among the emerging and also the largest stock markets of Latin America. They applied cointegration analysis and error correction vector autoregressions (VAR) techniques examining the stock markets of Argentina, Brazil, Chile, Colombia, Mexico and Venezuela. Their data consisted of end-of-day stock price indexes, expressed in local currencies and were obtained from DataStream International. The study covered the period from 1 February 1995 to 30 June 2000, containing both the Asian (1997) and Russian (1998) financial crisis. The findings in this study indicated that there is one long-term equilibrium relationship among the six national stock markets up until 1999. Furthermore, Mexico was found to influence substantially all the other markets except that of Colombia. Chen, Firth and Rui concluded that investing in different Latin American countries has limited benefits.

Ahlgren and Antell (2002), re-examined the relationships between international stock prices. Johansen's ML cointegration method and LR tests were used in this study to examine the stock markets of Finland, France, Germany, Sweden, the UK and the USA. They used both monthly and quarterly data denominated in US dollars. Their sample consisted of 206 monthly observations and 69 quarterly observations, covering the period from January 1980 to February 1997. All the data were obtained from Morgan Stanley Capital International (MSCI). This study provided only weak evidence for cointegration among international stock prices, finding only one cointegrating vector in monthly data and no cointegrating vectors in quarterly data. It concluded that international stock prices are not cointegrated.

Hassan and Naka (1996), applied a vector error correction (VEC) model of cointegrated variables created by Johansen (1988, 1991) and Johansen and Juselius (1990) so as to investigate the integration among international stock markets. They examined the world's four largest stock exchanges of U.S.A, Japan, U.K. and Germany, for the 1 April 1984 to 31 May 1991 period, including the October 1987 crash period. Their sample consisted of 1.678 observations of national daily stock price indexes (852 observations for the pre-crash period and 806 observations for the post-crash period), sourced from the Citibank and the Wall Street Journal. The results from this study reported strong evidence of cointegration among the US-UK- Japan-Germany, US-Japan-UK, and US-UK-Germany stock market indices for the entire sample period. However, the US-Japan-Germany stock market indices, and the Japan-UK-Germany indices are not cointegrated with each other and this could lead to diversification benefits.

Kanas (1998), studied the linkages between the US equity market and the equity markets of UK, Germany, France, Switzerland, Italy, and Netherlands. He applied three different methodologies and particularly the multivariate trace statistic Pz, the Johansen (1988) method, and the Bierens (1997a) nonparametric approach. His data consisted of 3.630 observations of daily closing prices, expressed in natural logarithms and denominated in local currency units. The study examined the period from 3 January 1983 to 29 November 1996 including the pre-crash (3 January 1983 - 30 September 1987) and post-crash (1 November 1987 - 29 November 1996) periods. Unlike previous evidence related to the linkages between the US and European markets, Kanas concluded that there is no co-integration between the U.S. equity market and the six major European equity markets. According to the findings from this study, diversifying in US stocks and stocks in any of the major European markets could bring potential benefits.

Gulser Meric, Leal, Ratner and Ilhan Meric (2001), researched the comovements between the equity markets of US and Latin America before and after the 1987 crash period. Particularly, in Latin America, the four largest capitalization markets namely those of Argentina, Brazil, Chile and

Mexico were examined thoroughly. The writers separated the sample period into three periods each consisted of 44 months (Period 1: February 1984–September 1987, Period 2: November 1987–June 1991 and Period 3: July 1991–February 1995) and examined them using two methodologies. At first, they used correlation analysis to estimate the integration of the five equity markets in the pre- and post-crash periods. Moreover, they applied rolling correlation analysis to examine the stability of correlations of the five equity markets over the sample period. The data were monthly index returns that were sourced from S&P 500 index (USA), the General Index (Argentina), the IBOVESPA Index (Brazil), the IGPA Index (Chile), and the IPC Index (Mexico). This study concluded that the comovements among the U.S., Argentine, Brazilian, Chilean, and Mexican equity markets has increased during the February 1984 – February 1995 period. Therefore the benefits from diversifying in these five countries over the same period have decreased significantly.

Gerrits and Yuce (1999), studied the short- and long-run linkages among stock markets of Germany, the UK, the Netherlands and the US. The methodology they used in this study was based on the vector error correction model (VEC) and the data were daily closing prices for the four stock market indexes. Their sample included 1.188 observations starting from 1 March 1990 and ending 5 October 1994. The results from this study reported a significant impact of the US market to the other three European markets. Furthermore, the equity markets of Germany, the UK and the Netherlands are interdependent in the short and long run. Finally, Gerrits and Yuce concluded that diversification among these four national stock markets will not greatly reduce the portfolio risk without sacrificing the expected return.

Choudhry (1996), explored the long-run relationships between European stock markets during the 1920s and 1930s. He concentrated on the stock markets of Czechoslovakia, France, Italy, Poland, Spain and Sweden. He used the Johansen method of multivariate cointegration separating the sample period into three different time intervals. At first, the author looked into the period of 1925-1936 which was the longer one, then the pre October

1929 period (1925-1929) and finally the post-October 1929 period (1929-1936). The data used in this research were monthly stock indices provided by Tinbergen (1934 and 1938), covering the interval from January 1925 to December 1936. The findings in this study indicated a stationary long-run relationship between these six European markets during the longest period (1925-1936) and also during the pre-October 1929 period (1925-1929). On the other hand, no stationary relationship was found during the post-crash period (1929-1936). Choudhry concluded that the substantial economic and financial cooperation that took place in Europe after the First World War may explain the international link of these indices.

Later, Arshanapalli, Doukas and Lang (1995), scanned whether there existed any linkages between U.S. and Asian markets before and after the 1987 crash period. As concerns Asia, they were particularly concentrated on the equity markets of Japan, Hong Kong, Malaysia, Philippines, Singapore and Thailand. They applied multivariate cointegration tests (Johansen (1988)) and multivariate error- correction analysis (Engle and Granger (1987)). Their sample consisted of 1.661 observations, running from 1 January 1986 through 12 May 1992. The data used in this study were daily closing stock market index time series sourced from Datastream International of the Dun and Bradstreet Corporation. Their results reported the presence of a long-run equilibrium relationship between the U.S. and Asian stock market movements during the post-October 1987 period. In addition, the U.S. stock market was found to influence substantially the other markets during the same period. Finally, this paper found that the Asian equity markets are less integrated with Japan's equity market than they are with the U.S. market.

Rangvid (1999), investigated the degree of convergence among European stock markets. He focused on three major European markets, namely those of France, Germany, and the United Kingdom. The methodology used in this study was the procedure of recursive cointegration tests, as presented in Hansen and Johansen (1992, 1998). The data consisted of quarterly observations of share prices, provided from the International Financial Statistics database of the IMF and running from the first quarter of 1960 to the

first quarter of 1999. The findings from this study showed an increase in the number of cointegration vectors among these three European stock markets, especially since the beginning of the 1980s. Therefore, Rangvid assumed that the level of integration among European stock markets has been increased during the last two decades.

Gilmore, and McManus (2001), examined the relationships among the U.S. and three Central European equity markets, those of the Czech Republic, Hungary and Poland. They employed the methodology of cointegration, using weekly closing price indices for the four equity markets. Their sample consisted of 310 observations spanning from 1 July 1995 to 1 August 2001. The data used in this study were sourced from Emerging Markets Data Base (EMDB) of the International Finance Corporation and were used in local-currency terms. They inferred that there are low short-term correlations between the three Central European markets and US, but no long-term relationships. Furthermore, using the Granger-causality test they found a causality running from the Hungarian to the Polish market, but none with the US. Consequently, US investors can benefit from diversifying into the Central European equity markets.

Laopodis (2004) analyzed the cointegration among the United States and 11 European Union equity markets, namely those of Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, and the UK. Using cointegration and Granger causality methodologies he looked over the period before and after the convergence period of 1995. The data used in this study were daily price index levels produced by Datastream and running from January 1987 to December 2002. The author split the sample period into three sub periods, from January 1987 to December 1995 (the “preconvergence” period), from January 1996 to December 2002 (the “postconvergence” period), and from January 1999 to December 2002 (the “Euro introduction” period). This study resulted that during the preconvergence and postconvergence periods, some country groups, with and without the US equity market, exhibited cointegration while others did not. Moreover, for the European Union markets, however, at least one

cointegrating vector emerged in either period, but no cointegration among them surfaced during the Euro introduction period of 1999. Finally, Laopodis concluded that a US investor can still be assisted by the country diversification within the European Union markets.

Theodossiou and Lee (1993), investigated the interdependence between major national stock markets and the degree to which volatility in these markets influences expected returns. They examined the stock markets of the U.S., the U.K., Japan, Canada and Germany using a multivariate GARCH-M model. Their data included weekly stock market returns and were based on local currencies. All data were obtained from Barron's National Business and Financial Weekly covering the period from 11 January 1980 to 27 December 1991. This study found that statistically significant mean spillovers radiate from stock markets of the U.S. to the U.K., Canada and Germany, and then from the stock markets of Japan to Germany. Furthermore, significant volatility spillovers radiate from the U.S. stock market to all four stock markets, from the U.K. stock market to the Canadian stock market and from the German stock market to the Japanese stock market. Finally, Theodossiou and Lee found no relation between conditional market volatility and expected returns.

Roca (1999) explored the short-term and the long-term price linkages among the stock markets of Australia and that of the U.S., U.K., Japan, Hong Kong, Singapore, Taiwan and Korea. The author applied cointegration, Granger- causality, forecast variance decomposition, and impulse response analyses within a vector autoregression (VAR) context. Weekly indices were used in this study, running from 27 December 1974 to 8 December 1995 for Australia, US, UK, Japan, Hong-Kong and Singapore and from 8 January 1988 to 8 December 1995 for Taiwan and Korea. All data were collected from Morgan Stanley Capital International (MSCI). This study found no cointegration between Australia and the other markets. However, the Granger- causality and forecast variance decomposition analyses reported significant linkages among the stock market of Australia and that of the US and the UK over the short-run.

Malliaris and Urrutia (1992), studied the relationships among six major stock markets. Particularly, they examined the stock markets of the U.S., Japan, the U.K., China, Singapore and Australia, before and after the 1987 crash period. Their data consisted of daily closing prices for the six stock markets collected from the Wall Street Journal for the time period 1 May 1987, through 31 March 1988. As concerns their methodology, unidirectional and bidirectional causality tests were employed by means of the Granger methodology. This study reported no lead-lag relationships for the pre-crash and post-crash periods. However, important feedback relationships and unidirectional causality were detected for the month of the crash. There was also an increase in contemporaneous causality during and after the month of the crash. Malliaris and Urrutia, concluded that the October 1987 market crash probably was an international crisis of the equity markets and that it might have begun simultaneously in all the national stock markets.

Yang, Kolari and Min (2003) examined the equity market integration concentrating on the 1997–1998 Asian financial crises. Particularly, they researched long-run relationships and short-run dynamic causal linkages among the US, Japanese and ten Asian stock markets. They employed an error correction model (ECM) using daily stock index closing prices for the stock markets of the US, Japan, Indonesia, Korea, Malaysia, Philippines, Thailand, Hong Kong, Singapore, Taiwan, India and Pakistan. Their sample included 1.662 observations covering the period from 2 January 1995 through 15 May 2001. All stock indices were expressed in both local currency and US dollar terms and were sourced from Datastream. Yang, Kolari and Min concluded that both long-run cointegration relationships and short-run causal linkages among these markets were strengthened during the crisis and that these markets have been more integrated after the crisis than before the crisis.

Byers and Peel (1993) examined the relationships among the stock markets of the USA, England, Japan, West Germany and the Netherlands. The search for the existing of the interdependences among the equity markets is conducted for the time period of 1979-1989 but also for the period 1979-

1987, which is until the 1987 crisis. A first examination of the correlations among the stock markets showed that these markets appear a high correlation which is also the highest for the total time period comparatively to the period before the crisis. Byers and Peel examined the existing of a cointegration, based upon the Johansen's methodology, using monthly data from Datastream either for the total of the stock markets or for the allocated pairs of them. The results do not support the existing of cointegration among those markets. The markets of England and Japan are the only exception of the time period before the crisis.

The allegation that the countries that are geographically near one another and have the same culture are more integrated is contradicted by Booth, Martikainen and Tse (1997), who examined the interactions among four Scandinavian countries (Denmark, Norway, Sweden, Finland) for the period 1988-1994 using a multivariable EGARCH model. They applied daily closing prices of the markets from 2 February 1988 to 30 June 1994 collecting a sample of 1.574 observations. Initially the writers examined the existence of cointegration among the countries that are under examination. The lack of cointegration indicates that the possible "price spillovers" will be short run while the existence of "volatility spillovers" will have to be considered as "pairwise phenomenon". It is deduced that the Scandinavian stock markets are more vulnerable to events that happen in other markets especially when these events are negative and they are less vulnerable when the events are positive. As a result they inferred that the possibility of the existence of a common stock market for the Scandinavian countries is the best alternative solution for the achievement of an integrated market.

Richards (1995) examined the interaction of sixteen stock markets from 1970 to 1994 and he found out that there is no clear indication for the existence of a cointegration of the stock markets of these countries. More specifically Richards examined the following countries: Australia, Austria, Canada, Norway, Japan, Spain, Germany, Hong- Kong, Italy, Denmark, France, Netherlands, Sweden, Switzerland, England, and U.S.A. Applying the methods of Johansen and Eagle-Granger, he estimated a multivariable

VAR model, inferring that there is no cointegration among the markets. Consequently, the equity markets will be long-run moved in a different way showing by this that the investments aboard will lead to advantages relatively to the decline of the danger (risk).

Blackman, Holden and Thomas (1994) applied the cointegration theory in order to examine the long run relationships among the international stock markets. They used monthly data for seventeen important equity markets for the periods 1970-1979 and 1984-1989 in order to confirm their point of view which is that the big changes that happened in the markets from the end of '70 to the early '80 (these are the denormalization and the technological improvements in the telecommunication field) were led to an integration of the markets. The data they applied were expressed in US dollars and they used the Johansen's methodology to proceed to a cointegration control. The results of the research indicate that while for the period 1970-1979 there exists no cointegration, in the second period they examine there is an increase in the number of the integration vectors which influences the profits of the international diversification.

4. DESCRIPTION OF THE DATA

The data are comprised of monthly stock price indices published by DataStream International for 16 National equity markets (Austria, Belgium, Denmark, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Norway, Spain, Switzerland, Sweden, Turkey, the U.K., and the U.S.). DataStream calculates its own aggregate sector and market price indices, together with associated aggregations such as sector price/earnings ratio (PE) and dividend yield (DY). Sector and market aggregations are weighted by market value and are calculated using a representative list of shares.

- The index is calculated as follows:

I_0 = index value at base date = 100

$$I_t = I_{t-1} * \frac{\sum_{1}^{n} (P_t * N_t)}{\sum_{1}^{n} (P_{t-1} * N_t * f)}$$

Where:

I_t = index value at day t

I_{t-1} = index value on previous working day (of t)

P_t = unadjusted share price on day t

P_{t-1} = unadjusted share price on previous working day (of t)

N_t = number of shares in issue on day t

f = adjustment factor for a capital action occurring on day t

n = number of constituents in index

The summations are performed on the constituents as they exist on day t.

All monthly stock prices are expressed in U.S. dollars and transformed firstly to monthly stock returns and then to monthly real stock returns which are then used in our analysis.

1. For each country, monthly stock returns, r_t, are computed as the first differences of the natural logarithms of P_t.
That is: $r_t = (lnP_t - lnP_{t-1})$.
Where P_t is the level of price index at time t.
r_t is the logarithm stock price returns at time t.

2. Then, for each country, monthly real stock returns, Rr_t, are computed subtracting the first differences of the natural logarithms of CPI_t, from the first differences of the natural logarithms of P_t.
That is: $Rr_t = (lnP_t - lnP_{t-1}) - (lnCPI_t - lnCPI_{t-1})$.
Where P_t is the level of price index at time t.
Rr_t is the logarithm real stock price returns at time t.
CPI_t is the logarithm Consumer Price Index at time t.

Monthly CPI indices are also provided by DataStream.

Furthermore, the data is divided into two subperiods except from the full sample period (1/2/1988 – 1/3/2009), one before the introduction of euro (1/2/1988 – 1/12/1998) and one after the introduction of euro (1/1/1999 – 1/3/2009). In this way, we are able to investigate whether the interdependence of the stock markets increased over time. The full sample consists of 254 observations, the pre-euro sample of 131 observations, and the post-euro sample of 123 observations.

Data Table

COUNTRY	EQUITY INDEX SOURCE	CURRENCY	DS MNEMONIC	CPI SOURCE	DS MNEMONIC	FULL SAMPLE PERIOD	PRE-EURO PERIOD	POST-EURO PERIOD
Austria	Datastream	$	TOTMKOE	Datastream	OECONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Belgium	Datastream	$	TOTMKBG	Datastream	BGCONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Denmark	Datastream	$	TOTMKDK	Datastream	DKCONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Germany	Datastream	$	TOTMKBD	Datastream	BDCONPRCE	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Greece	Datastream	$	TOTMKGR	Datastream	GRCONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Ireland	Datastream	$	TOTMKIR	Datastream	IRCONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Italy	Datastream	$	TOTMKIT	Datastream	ITCONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Japan	Datastream	$	TOTMKJP	Datastream	JPCONPRCE	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Netherlands	Datastream	$	TOTMKNL	Datastream	NLCONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Norway	Datastream	$	TOTMKNW	Datastream	NWCONPRCE	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Spain	Datastream	$	TOTMKES	Datastream	ESCONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Sweden	Datastream	$	TOTMKSD	Datastream	SDCONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Switzerland	Datastream	$	TOTMSW	Datastream	SWCONPRSF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
Turkey	Datastream	$	TOTMKTK	Datastream	TKCONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
United Kingdom	Datastream	$	TOTMKUK	Datastream	UKCONPRCF	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09
United States	Datastream	$	TOTMKUS	Datastream	USCONPRCE	Feb '88 – Mar '09	Feb '88 – Dec'98	Jan'99 – Mar '09

5. SUMMARY STATISTICS

Tables 5.1, **5.2** and **5.3** present summary statistics for the real returns of the sixteen equity markets for the entire period and the two subperiods. Investors will be interested in the mean, the variance and the standard deviation of these returns, as indicators of the expected level and the volatility of their investment.

Table 5.1

Summary statistics for monthly real returns in US dollars (full sample: 1/2/1988 – 1/3/2009)

Equity Market	Mean	Median	Max	Min	Std	Var
Austria	0.0030	0.0080	0.2004	-0.3804	0.0672	0.0045
Belgium	0.0014	0.0056	0.1597	-0.3630	0.0569	0.0032
Denmark	0.0056	0.0133	0.1325	-0.2817	0.0571	0.0033
Germany	0.0026	0.0090	0.1811	-0.2265	0.0591	0.0035
Greece	-0.0002	0.0000	0.4479	-0.3688	0.0998	0.0100
Ireland	0.0006	0.0115	0.1567	-0.2727	0.0638	0.0041
Italy	-0.0022	-0.0008	0.1872	-0.2417	0.0678	0.0046
Japan	-0.0027	-0.0035	0.2203	-0.2600	0.0671	0.0045
Netherlands	0.0017	0.0095	0.1452	-0.3451	0.0575	0.0033
Norway	0.0049	0.0074	0.1703	-0.3663	0.0776	0.0060
Spain	0.0010	0.0022	0.2026	-0.2496	0.0625	0.0039
Sweden	0.0025	0.0107	0.1751	-0.2510	0.0743	0.0055
Switzerland	0.0053	0.0077	0.1949	-0.1604	0.0502	0.0025
Turkey	-0.0301	-0.0371	0.4610	-0.6074	0.1728	0.0299
U.K.	0.0001	0.0041	0.1344	-0.2350	0.0495	0.0025
U.S.	0.0022	0.0081	0.1220	-0.1710	0.0436	0.0019

Notes: var is the variance of monthly real returns, std is the standard deviation of monthly real returns, Min and Max are the minimum and maximum observations, respectively.

The above **Table 5.1** presents the summary statistics for monthly real returns of the 16 equity markets over the total period from 1/2/1988 – 1/3/2009 (full sample). Analyzing the table, we are observing that the mean of the real returns of the stock markets fluctuates from -0.0301 (Turkey) to 0.0056 (Denmark). In addition maximum positive values are appeared in Switzerland (0.0053), Norway (0.0049) and Austria (0.0030) whereas negative values are appeared in Greece (-0.0002), in Italy (-0.0022) and Japan (-

0.0027). The median of the real returns ranges from -0.0371 (Turkey) to 0.0133 (Denmark). However maximum median values are appeared by Ireland (0.0115), Sweden (0.0107) and Netherlands (0.0095) while negative median values are appeared by Italy (-0.0008) and Japan (-0.0035). The maximum real returns of the equity markets fluctuate from 0.1220 (USA) to 0.4610 (Turkey) while on the contrary the minimum ones range from -0.6074 (Turkey) to -0.1604 (Switzerland). The standard deviation ranges from 0.0436 (USA) to 0.1728 (Turkey). In variance the values range from 0.0019 (USA) to 0.0299 (Turkey). Observing the values of the variance of the stock markets for the full sample we infer that there is stability in USA (0.0019), in England (0.0025) and in Switzerland (0.0025) while on the contrary there is instability in Turkey (0.0299), in Greece (0.0100) and Norway (0.0060).

Table 5.2

Summary statistics for monthly real returns in US dollars (pre-euro: 1/2/1988 – 1/12/1998)

	Mean	Median	Max	Min	Std	Var
Austria	0.0060	0.0078	0.2004	-0.1951	0.0648	0.0042
Belgium	0.0086	0.0082	0.1530	-0.1232	0.0429	0.0018
Denmark	0.0103	0.0115	0.1325	-0.1330	0.0489	0.0024
Germany	0.0085	0.0131	0.1251	-0.1474	0.0485	0.0023
Greece	0.0057	-0.0002	0.4479	-0.2875	0.1105	0.0122
Ireland	0.0102	0.0139	0.1567	-0.2118	0.0568	0.0032
Italy	0.0016	-0.0003	0.1872	-0.2226	0.0708	0.0050
Japan	-0.0041	-0.0090	0.2203	-0.2600	0.0753	0.0057
Netherlands	0.0097	0.0112	0.1114	-0.1173	0.0393	0.0015
Norway	0.0078	0.0085	0.1703	-0.3329	0.0720	0.0052
Spain	0.0048	0.0024	0.2026	-0.2078	0.0630	0.0040
Sweden	0.0073	0.0128	0.1751	-0.1868	0.0671	0.0045
Switzerland	0.0121	0.0104	0.1949	-0.1604	0.0492	0.0024
Turkey	-0.0453	-0.0609	0.4004	-0.6074	0.1785	0.0319
U.K.	0.0054	0.0084	0.1344	-0.1052	0.0471	0.0022
U.S.	0.0099	0.0117	0.1220	-0.1185	0.0358	0.0013

Notes: var is the variance of monthly real returns, std is the standard deviation of monthly real returns, Min and Max are the minimum and maximum observations, respectively.

In addition, by observing the real returns of the sixteen stock markets for the period 1/2/1988-1/12/1998 (pre-euro period) in the **Table 5.2**, we infer that the mean of the real returns of all the countries we examine fluctuates from -0.0453 (Turkey) which is also the lowest to 0.0121 (Switzerland) which is the highest. The next lower values however, are the ones of Japan (-0.0041) and of Italy (0.0016) while the next higher after the ones of Switzerland are the ones of Denmark (0.0103) and of Ireland (0.0102). The median which is regarded as a parameter and comes out of the analysis of the real returns of the stock markets fluctuates from 0.0609 (Turkey) to 0.0139 (Ireland). There is a particularly low median in Japan (-0.0090), in Italy (-0.0003) and Greece (-0.0003) whereas high values are appeared in Germany (-0.0003) and Sweden (0.0128). The maximum real returns of the stock markets fluctuate from 0.4479 (Greece) to 0.1114 (Netherlands) while on the contrary the lowest ones fluctuate from -0.6074 (Turkey) to -0.1052 (UK). The standard deviation of the real returns ranges from 0.0358 (US) to 0.1785 (Turkey) and the variance also ranges from 0.0013 (US) to 0.0319 (Turkey). So, by analyzing carefully the variance of the real returns of all the equity markets for the pre-euro period we conclude that there appears stability in Belgium, Netherlands and US while Turkey, Greece and Japan appear to be less volatile.

Finally, by observing the real returns of the stock markets for the period 1/1/1999 -1/3/2009 (post-euro period) in the **Table 5.3** we deduce the following: The mean of the real returns of the stock markets fluctuates from -0.0139 (Turkey) to 0.0019 (Norway). In addition there are many negative values of the mean of which the highest ones are measured for Ireland (-0.0101) for Netherlands (-0.0078) and for Greece (-0.0076). The median of the real returns fluctuates from -0.0020 (Italy) to 0.0162 (Denmark). However, high average values are appeared by Turkey (0.0146) and Austria (0.0135) while negative values are appeared by Belgium (-0.0017), Spain (-0.0004) and US (-0.0011). The maximum real returns of the stock markets range from 0.0854 (England) to 0.4610 (Turkey) while on the contrary the lowest ones range

Table 5.3

Summary statistics for monthly real returns in US dollars (post-euro: 1/1/1999 – 1/3/2009)

	Mean	Median	Max	Min	Std	Var
Austria	-0.0005	0.0135	0.1216	-0.3804	0.0700	0.0049
Belgium	-0.0071	-0.0017	0.1597	-0.3630	0.0677	0.0046
Denmark	-0.0001	0.0162	0.1209	-0.2817	0.0643	0.0041
Germany	-0.0041	0.0006	0.1811	-0.2265	0.0682	0.0047
Greece	-0.0076	0.0015	0.1781	-0.3688	0.0868	0.0075
Ireland	-0.0101	0.0050	0.1106	-0.2727	0.0693	0.0048
Italy	-0.0071	-0.0020	0.1449	-0.2417	0.0640	0.0041
Japan	-0.0015	0.0015	0.1620	-0.1637	0.0577	0.0033
Netherlands	-0.0078	0.0046	0.1452	-0.3451	0.0707	0.0050
Norway	0.0019	0.0076	0.1359	-0.3663	0.0837	0.0070
Spain	-0.0036	-0.0004	0.1781	-0.2496	0.0620	0.0038
Sweden	-0.0026	0.0047	0.1678	-0.2510	0.0815	0.0066
Switzerland	-0.0022	0.0041	0.1411	-0.1508	0.0505	0.0025
Turkey	-0.0139	0.0146	0.4610	-0.5539	0.1666	0.0277
U.K.	-0.0061	0.0007	0.0854	-0.2350	0.0513	0.0026
U.S.	-0.0063	-0.0011	0.1035	-0.1710	0.0493	0.0024

Notes: var is the variance of monthly real returns, std is the standard deviation of monthly real returns, Min and Max are the minimum and maximum observations, respectively.

from -0.5539 (Turkey) to -0.1508 (Switzerland). The standard deviation fluctuates from 0.0493 (USA) to 0.1666 (Turkey). The variance values range from 0.0024 (US) to 0.0277 (Turkey). Looking carefully these values of the variance of the 16 equity markets for the post-euro period we infer that there appears stability in USA (0.0024), in Sweden (0.0025) and in England (0.0026) while on the contrary there is volatility in Norway (0.0070) in Greece (0.0075) and Turkey (0.0277).

6. EMPIRICAL ANALYSIS

The empirical tests are based on the Granger causality tests. These are essentially tests of the predictive ability of time series models. The Granger causality test (Granger, 1969) is a simple way to ascertain whether a particular market is affected by innovations in other markets. The test indicates whether innovations in one market help forecast a one-step ahead returns in another market. An important advantage of this test is that it is unaffected by the ordering of the VAR system. A time series {Yt} causes another time series {Xt} in the Granger sense if present X can be predicted better by using past values of Y than by not doing so, considering also other relevant information, including past values of X.

- Granger Causality Test

To implement Granger Causality test, we assume a particular autoregressive lag length p. An important part of the analysis is to determine the appropriate lag structure in the VAR Model. Standard recommendations for the selection of the appropriate lag length is to choose the number of lags to be long enough to ensure that the residuals are white noise, but not too long since the estimates can become imprecise. The lag length is therefore often selected somewhat arbitrarily. The number of lags was chosen based on the Information Criteria suggested by Schwarz (1968).

We estimate

$$x_t = c_1 + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \ldots + \alpha_p x_{t-p} + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots + \beta_p y_{t-p} + u_t$$

by OLS. We then conduct an F test of the null hypothesis

$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_p = 0.$$

To implement this test we calculate the sum of squared residuals from

$$RSS_1 = \sum_{t=1}^{T} \hat{u}_t^2$$

and compare this with the sum of squared residuals of a univariate autoregression for x_1,

$$RSS_0 = \sum_{t=1}^{T} \hat{e}_t^2$$

(note that in order for t to run from 1 to T as indicated, we actually need T + p observations on x and y, namely, $x_{-p+1}, x_{-p+2}, \ldots, x_T$ and $y_{-p+1}, y_{-p+2}, \ldots, y_T$.)

where

$$x_t = c_0 + \gamma_1 x_{t-1} + \gamma_2 x_{t-2} + \ldots\ldots + \gamma_p x_{t-p} + e_t$$

is also estimated by *OLS.* If

$$S_1 = \frac{T\,(RSS_0 - RSS_1)\,/\,p}{RSS_1\,/\,(T-2p-1)}$$

is greater than the 5% critical value for an $F(p, T - 2p - 1)$ distribution, then we reject the null hypothesis that *Y* does not Granger-cause x. That is, if S_1 is sufficiently large, we conclude that *Y* does Granger-cause x.

Then, we estimate

$$y_t = c_1 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \ldots + \alpha_p y_{t-p} + \beta_1 x_{t-1} + \beta_2 x t_{-2} + \ldots + \beta_p x_{t-p} + u_t$$

by OLS. We conduct an F test of the null hypothesis

$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_p = 0,$$

and repeat the above process. If

$$S_1 = \frac{T\,(RSS_0 - RSS_1)\,/\,p}{RSS_1\,/\,(T-2p-1)}$$

is greater than the 5% critical value for an $F(p, T - 2p - 1)$ distribution, then we reject the null hypothesis that x does not Granger-cause *Y.* That is, if S_1 is sufficiently large, we conclude that x does Granger-cause *Y.*

The test statistic would have an exact *F* distribution for a regression with fixed regressors and Gaussian disturbances. With lagged dependent variables as in the Granger-causality regressions, however, the test is valid only asymptotically. An asymptotically equivalent test is given by

$$S_2 = \frac{T\,(RSS_0 - RSS_1)}{RSS_1}$$

We would reject the null hypothesis if S_2 is greater than the 5% critical values.

- Granger Causality in mean

We apply the above methodology setting as x the values of the real stock returns of one stock market and as y the values of the real stock returns of another stock market.

- Granger Causality in variance

We compute realized volatility using:

1) The square values of the real stock returns: $\sigma_t^2 = r_t^2$
   where r_t are the real stock returns for time **t**,

and

2) The absolute values of the real stock returns: $\sigma_t^2 = | r_t |$
   where r_t are the real stock returns for time **t**.

We apply again the above methodology twice. At first, we set as x the square values of the real stock returns of one stock market and as y the square values of the real stock returns of another stock market. And then, we set as x the absolute values of the real stock returns of one stock market and as y the absolute values of the real stock returns of another stock market.

7. RESULTS OF GRANGER CAUSALITY TESTS

Table 7.1 presents the results of Granger Causality test in mean for the sixteen equity markets, for the pre-euro period (1/2/1988 – 1/12/1998). It can be observed that there are significant causal links among these markets. There are also enough causalities in several pairwise combinations, mainly among the smaller stock markets such as Austria, Greece, Denmark and Ireland. Large stock markets like those of Spain, Italy, the U.K. and the U.S. affect the majority of the equity markets, while at the same time they are the least affected markets, together with Turkey and Sweden. On the other hand, Austria, Denmark, Greece, Switzerland and the Netherlands appear to be the most influenced and least influential stock markets. Despite the fact that Germany is considered to be a strong market, it affects only four stock markets namely those of Austria, Greece, the Netherland and Switzerland. Interestingly, Japan Granger causes in mean only five countries, while it is not affected by other market. This can be explained by considering the different track the Japan market has followed over the last few years.

In addition, **Table 7.2** displays the results of Granger Causality test in mean for the equity markets, for the post-euro period (1/1/1999 – 1/3/2009). It is obvious that the number of the return spillovers has increased. Feedbacks have also been increased. The U.S., the U.K., Spain and Italy, remain the major markets affecting both a lot of markets and each other. During this period, Sweden, Greece, Norway and Switzerland are the most influenced markets while Germany and the Netherlands seem to have become stronger. Japan, Belgium and Ireland seem to remain at the same levels in terms of influence. Comparing the results of the pre- and the post-euro periods, it is obvious that the European stock markets have become more interdependent after the introduction of euro.

Table 7.1 (results of Granger causality test in mean for the pre-euro period: 1/2/1988 – 1/12/1998)

	Affected Markets															
Affecting Markets	**Austria**	**Belgium**	**Denmark**	**Germany**	**Greece**	**Ireland**	**Italy**	**Japan**	**Netherlands**	**Norway**	**Spain**	**Sweden**	**Switzerland**	**Turkey**	**UK**	**US**
Austria	-	0.9282 (0.8186)	30.1957 (0.0000)	7.6999 (0.0213)	39.6574 (0.0000)	3.3375 (0.5030)	4.8458 (0.1834)	-0.7620 (1.0000)	26.2991 (0.0000)	0.1007 (0.7509)	3.0264 (0.2202)	25.8355 (0.0001)	18.6418 (0.0003)	2.3525 (0.5025)	38.6382 (0.0000)	1.4743 (0.4785)
Belgium	7.4548 (0.0587)	-	7.7611 (0.0206)	4.0946 (0.0430)	55.7545 (0.0000)	5.1584 (0.2714)	1.8210 (0.1772)	-0.7975 (1.0000)	32.5096 (0.0000)	1.6125 (0.2041)	4.8579 (0.0881)	0.2893 (0.5907)	12.4389 (0.0020)	21.6588 (0.0001)	1.7632 (0.1842)	-0.1251 (1.0000)
Denmark	42.4957 (0.0000)	0.7599 (0.3834)	-	-0.0147 (1.0000)	55.0434 (0.0000)	18.9671 (0.0003)	-2.6144 (1.0000)	-0.5754 (1.0000)	15.8407 (0.0032)	18.0403 (0.0000)	58.6713 (0.0000)	0.5819 (0.4456)	-0.1201 (1.0000)	2.4439 (0.4855)	2.3633 (0.3068)	3.2127 (0.0731)
Germany	18.7801 (0.0001)	0.1295 (0.7189)	1.1315 (0.2874)	-	11.6158 (0.0404)	1.5834 (0.8118)	-0.7852 (1.0000)	-0.7490 (1.0000)	7.4388 (0.0242)	-0.2836 (1.0000)	0.4495 (0.5026)	2.0278 (0.1544)	7.5801 (0.0059)	2.1976 (0.3333)	0.4057 (0.5242)	-0.0319 (1.0000)
Greece	26.0310 (0.0000)	14.1724 (0.0008)	5.4190 (0.0666)	8.4493 (0.1331)	-	13.7144 (0.0011)	3.2507 (0.1968)	0.7784 (0.6776)	18.4549 (0.0001)	1.5472 (0.4613)	0.2242 (0.8940)	2.1668 (0.3384)	11.2559 (0.0036)	3.3874 (0.1838)	1.3480 (0.5097)	4.8738 (0.0874)
Ireland	3.2947 (0.1926)	2.2349 (0.3271)	28.8447 (0.0000)	2.2922 (0.3179)	14.0050 (0.0009)	-	4.0638 (0.1311)	0.0046 (0.9977)	10.6032 (0.0050)	4.6675 (0.0969)	7.8222 (0.0200)	2.3611 (0.3071)	4.9500 (0.0842)	1.4823 (0.4766)	1.9157 (0.3837)	4.6279 (0.0989)
Italy	17.5552 (0.0005)	5.6106 (0.0179)	4.3016 (0.0381)	1.0993 (0.2944)	26.3271 (0.0001)	10.3245 (0.0353)	-	-0.7723 (1.0000)	31.8266 (0.0000)	1.5763 (0.2093)	-0.3030 (1.0000)	1.4509 (0.2284)	3.2424 (0.0718)	10.5465 (0.0051)	0.6878 (0.4069)	0.2279 (0.6331)
Japan	3.1673 (0.0751)	1.0441 (0.3069)	1.0796 (0.2988)	5.8317 (0.0157)	38.2485 (0.0000)	0.1246 (0.9887)	8.9011 (0.0028)	-	9.2479 (0.0552)	6.3351 (0.0118)	3.8366 (0.0501)	3.8353 (0.0502)	8.4110 (0.0037)	0.6460 (0.7240)	0.3400 (0.5598)	1.2209 (0.2692)
Netherland	17.4502 (0.0016)	23.8700 (0.0002)	35.5786 (0.0000)	4.5198 (0.3402)	61.8251 (0.0000)	3.9220 (0.4167)	8.6450 (0.0706)	2.5107 (0.6427)	-	7.8802 (0.0961)	4.3437 (0.1140)	3.9623 (0.1379)	20.5055 (0.0004)	3.6786 (0.1589)	48.9131 (0.0000)	3.0646 (0.6900)
Norway	2.7891 (0.0949)	1.6012 (0.2057)	6.0946 (0.0475)	1.6834 (0.1945)	27.5426 (0.0000)	8.0663 (0.0177)	-1.6239 (1.0000)	-0.5660 (1.0000)	10.6378 (0.0049)	-	0.3066 (0.5797)	-0.0509 (1.0000)	-1.3240 (1.0000)	1.9898 (0.3698)	3.6672 (0.0555)	-0.0601 (1.0000)
Spain	11.1853 (0.0478)	5.5143 (0.0189)	23.2966 (0.0007)	7.5237 (0.0232)	45.4949 (0.0000)	6.7161 (0.1517)	53.3134 (0.0000)	-0.7828 (1.0000)	25.4442 (0.0001)	1.1096 (0.2922)	-	6.0971 (0.0474)	20.0197 (0.0000)	2.9260 (0.2315)	7.7393 (0.0209)	1.8904 (0.1692)
Sweden	25.6312 (0.0001)	2.8077 (0.0938)	-0.0194 (1.0000)	9.9946 (0.0016)	5.2414 (0.0728)	4.5381 (0.3381)	15.6559 (0.0001)	-0.4922 (1.0000)	3.5628 (0.1684)	5.6269 (0.0600)	16.0009 (0.0003)	-	15.0643 (0.0001)	1.1122 (0.5734)	8.2276 (0.0041)	-0.1180 (1.0000)
Switzerland	21.8632 (0.0001)	2.2418 (0.1343)	0.0020 (0.9643)	11.6687 (0.0006)	5.2414 (0.0728)	7.4406 (0.1144)	10.0202 (0.0015)	-0.8232 (1.0000)	23.1169 (0.0001)	4.0176 (0.0450)	3.2133 (0.0730)	-1.0292 (1.0000)	-	2.9424 (0.2296)	1.8637 (0.1722)	0.2591 (0.6107)
Turkey	1.8408 (0.6061)	2.8925 (0.2355)	4.4391 (0.1087)	2.2281 (0.3282)	2.8404 (0.2417)	2.5756 (0.6311)	13.4240 (0.0012)	1.0335 (0.5965)	4.1964 (0.3801)	6.6646 (0.0357)	4.6910 (0.0958)	1.5545 (0.4597)	4.1266 (0.1270)	-	1.3001 (0.5220)	0.1091 (0.9469)
U.K.	57.8589 (0.0000)	6.3635 (0.0116)	22.7678 (0.0004)	11.4068 (0.0007)	66.9746 (0.0000)	2.5130 (0.6423)	2.6607 (0.1029)	-0.5800 (1.0000)	85.6507 (0.0000)	1.0835 (0.2979)	6.9847 (0.0304)	1.5545 (0.4597)	-1.0672 (1.0000)	1.8792 (0.3908)	-	-0.0801 (1.0000)
U.S.	9.1246 (0.0104)	7.2085 (0.0073)	3.9521 (0.0468)	1.4618 (0.2266)	24.2386 (0.0002)	6.7726 (0.0338)	-0.4711 (1.0000)	-0.6832 (1.0000)	28.2594 (0.0000)	6.4381 (0.0112)	0.7314 (0.3924)	0.2673 (0.6052)	0.0221 (0.8818)	2.0746 (0.3544)	2.1778 (0.1400)	-

Notes: Tests indicate Granger caused by row to column and Granger causes by column to row. The numbers in the parentheses are the p-values, while the others are the F-statistics. Red colours denote the causal links.

Table 7.2 (results of Granger causality test in mean for the post-euro period: 1/1/1999 – 1/3/2009)

	Affected Markets															
Affecting Markets	**Austria**	**Belgium**	**Denmark**	**Germany**	**Greece**	**Ireland**	**Italy**	**Japan**	**Netherlands**	**Norway**	**Spain**	**Sweden**	**Switzerland**	**Turkey**	**UK**	**US**
Austria	-	10.6782 (0.0011)	6.7426 (0.0094)	1.5421 (0.2143)	35.8136 (0.0000)	1.0654 (0.3020)	2.9132 (0.0879)	0.3077 (0.5791)	21.7512 (0.0002)	10.3757 (0.0013)	3.3770 (0.0661)	6.2726 (0.0123)	41.5667 (0.0000)	2.1859 (0.3352)	2.9758 (0.0845)	3.1311 (0.2090)
Belgium	0.6555 (0.4182)	-	8.3322 (0.0039)	0.2196 (0.6393)	38.6189 (0.0000)	0.2319 (0.6301)	0.0008 (0.9780)	0.3819 (0.5366)	15.2289 (0.0042)	7.7670 (0.0053)	2.3357 (0.1264)	7.0713 (0.0078)	50.7463 (0.0000)	1.5340 (0.4644)	10.4111 (0.0013)	6.3186 (0.0971)
Denmark	2.6595 (0.1029)	0.2978 (0.5852)	-	0.0284 (0.8661)	114.2461 (0)	4.9720 (0.1739)	7.7065 (0.0212)	0.3157 (0.5742)	2.2052 (0.1375)	16.1977 (0.0003)	26.9306 (0.0001)	7.0637 (0.0079)	22.0812 (0.0002)	2.5617 (0.1095)	3.1761 (0.0747)	0.7659 (0.6818)
Germany	6.6888 (0.0097)	11.1829 (0.0008)	14.7772 (0.0001)	-	25.2630 (0.0003)	0.0123 (0.9116)	6.6058 (0.0368)	0.5693 (0.4505)	4.7239 (0.0297)	8.8478 (0.0029)	3.6193 (0.0571)	10.7226 (0.0011)	37.4013 (0.0000)	1.3834 (0.5007)	9.3056 (0.0023)	2.3608 (0.3072)
Greece	18.2227 (0.0057)	20.8114 (0.0020)	69.4712 (0.0000)	5.4242 (0.4907)	-	2.7666 (0.0963)	24.4424 (0.0004)	3.9473 (0.6838)	1.6806 (0.1949)	5.3643 (0.0206)	1.8456 (0.1743)	0.0105 (0.9183)	64.2225 (0.0000)	0.0544 (0.8156)	1.0072 (0.3156)	9.9723 (0.1258)
Ireland	2.4773 (0.1155)	4.6009 (0.1002)	0.6907 (0.4059)	2.5861 (0.1078)	104.5737 (0)	-	4.7657 (0.0290)	0.4039 (0.5251)	1.9861 (0.1587)	13.4637 (0.0012)	52.4230 (0.0000)	22.6392 (0.0000)	25.9030 (0.0000)	7.8607 (0.0196)	1.0966 (0.2950)	2.1936 (0.3339)
Italy	3.5619 (0.0591)	5.3185 (0.0700)	26.7386 (0.0000)	4.2833 (0.1175)	73.8579 (0.0000)	0.0002 (0.9887)	-	0.2299 (0.6316)	29.3446 (0.0000)	12.9789 (0.0015)	75.0311 (0.0000)	29.3322 (0.0000)	53.7971 (0.0000)	0.0791 (0.7785)	21.2873 (0.0000)	0.3836 (0.5357)
Japan	0.7850 (0.3756)	1.3797 (0.2402)	-0.2522 (1.0000)	0.8528 (0.3558)	22.2706 (0.0011)	3.9334 (0.0473)	2.3758 (0.1232)	-	1.6767 (0.7950)	1.1010 (0.2941)	22.8185 (0.0001)	0.5859 (0.4440)	14.7376 (0.0053)	0.2567 (0.8795)	-0.2768 (1.0000)	6.3034 (0.0428)
Netherland	0.7451 (0.3880)	3.3328 (0.5038)	0.0827 (0.7737)	5.3201 (0.2560)	112.4257) (0)	0.5473 (0.4594)	2.5174 (0.6415)	4.8561 (0.3024)	-	2.6936 (0.6103)	51.5558 (0.0000)	55.5762 (0.0000)	44.6008 (0.0000)	75.6369 (0.0000)	2.9216 (0.0874)	3.3996 (0.4933)
Norway	-0.3680 (1.0000)	-0.0653 (1.0000)	7.6688 (0.0216)	0.7009 (0.4025)	5.6510 (0.4634)	1.5475 (0.4613)	0.5607 (0.7555)	0.0077 (0.9302)	6.9648 (0.1378)	-	8.1577 (0.0860)	8.8318 (0.0121)	3.3860 (0.4954)	5.6619 (0.0590)	0.1534 (0.6953)	0.5992 (0.7411)
Spain	1.2195 (0.2695)	15.2402 (0.0042)	0.5946 (0.4406)	3.7467 (0.4414)	118.0068 (0)	0.3185 (0.5725)	4.8932 (0.0270)	0.5622 (0.4534)	0.2124 (0.6449)	10.7055 (0.0301)	-	21.0322 (0.0008)	57.7129 (0.0000)	46.2902 (0.0000)	55.3755 (0.0000)	20.3187 (0.0004)
Sweden	0.6690 (0.4134)	0.1656 (0.6840)	0.8149 (0.3667)	1.4218 (0.2331)	3.1966 (0.0738)	20.2837 (0.0001)	4.1039 (0.2505)	0.4216 (0.5161)	4.3781 (0.3572)	3.7353 (0.1545)	0.0081 (0.9283)	-	28.7905 (0.0000)	17.3046 (0.0002)	0.4970 (0.4808)	5.7967 (0.0161)
Switzerland	18.6949 (0.0009)	2.9263 (0.5702)	3.1025 (0.0782)	3.1848 (0.5274)	0.5614 (0.4537)	12.4078 (0.0146)	4.4863 (0.3442)	0.7132 (0.3984)	0.8759 (0.3493)	13.9854 (0.0073)	21.5604 (0.0006)	0.0002 (0.9890)	-	0.2256 (0.6348)	0.3757 (0.5399)	4.9672 (0.0258)
Turkey	1.9424 (0.3786)	0.9821 (0.6120)	2.6722 (0.2629)	-0.0697 (1.0000)	21.3295 (0.0016)	1.4203 (0.4916)	1.9348 (0.3801)	0.0244 (0.9879)	23.6018 (0.0003)	2.5847 (0.2746)	7.0940 (0.2137)	5.1617 (0.0757)	7.1003 (0.1307)	-	1.0224 (0.3120)	4.5314 (0.1038)
U.K.	0.4328 (0.5106)	1.1379 (0.2861)	16.4086 (0.0003)	0.0404 (0.8407)	108.2282 (0)	7.8578 (0.0051)	2.8020 (0.2463)	0.3892 (0.5327)	8.1092 (0.0877)	3.9746 (0.0462)	41.0749 (0.0000)	7.5097 (0.0573)	8.1354 (0.0867)	52.7250 (0.0000)	-	8.3844 (0.0387)
U.S.	15.5677 (0.0004)	23.3152 (0.0000)	9.6898 (0.0079)	9.2122 (0.0100)	27.0585 (0.0001)	26.8390 (0.0000)	16.7699 (0.0008)	17.9770 (0.0001)	4.2393 (0.3746)	10.9831 (0.0041)	51.5034 (0.0000)	17.9050 (0.0005)	63.1691 (0.0000)	2.4113 (0.2995)	19.0290 (0.0003)	-

Notes: Tests indicate Granger caused by row to column and Granger causes by column to row. The numbers in the parentheses are the p-values, while the others are the F-statistics. Red colours denote the causal links.

Concerning the full sample (1/2/1988 – 1/3/2009), the results of the Granger Causality test in mean are presented at the **Table 7.3**. Observing closely this table, the following conclusions can be inferred:

- There is a large number of causal links and bidirectional causalities in mean among the sixteen equity markets.

- It is well-defined that the large equity markets of the U.S., the U.K., Spain and Italy are the most influential in the sample.

- The U.S. seems to be the dominant equity market, as it influences almost all other markets while being the least affected one.

- Greece, Turkey, Switzerland and Ireland are affected by the majority of the equity markets.

- Japan and Norway do not play an important role in the European interdependence.

- Germany, Sweden, Greece, Turkey and Switzerland actively participate in the European interdependence, as they influence and are influenced, by many markets in return.

Table 7.3 (results of Granger causality test in mean for the full sample: 1/2/1988 – 1/3/2009)

	Affected Markets															
Affecting Markets	**Austria**	**Belgium**	**Denmark**	**Germany**	**Greece**	**Ireland**	**Italy**	**Japan**	**Netherland**	**Norway**	**Spain**	**Sweden**	**Switzerland**	**Turkey**	**UK**	**US**
Austria	-	0.0246 (0.8755)	9.5628 (0.0886)	7.4049 (0.0065)	20.4160 (0.0023)	3.8572 (0.4257)	2.2983 (0.5128)	2.3116 (0.1284)	15.6330 (0.0036)	1.0127 (0.3143)	14.8979 (0.0108)	2.3094 (0.1286)	21.1913 (0.0007)	7.2555 (0.0266)	0.1084 (0.7420)	0.6694 (0.8804)
Belgium	5.8597 (0.0155)	-	1.3016 (0.2539)	3.2177 (0.0728)	2.5452 (0.2801)	0.0002 (0.9888)	12.8308 (0.0016)	1.8220 (0.1771)	22.4080 (0.0002)	4.0141 (0.0451)	0.1084 (0.7420)	4.0894 (0.0432)	27.3089 (0.0000)	2.5452 (0.2801)	2.9704 (0.0848)	7.7274 (0.1021)
Denmark	13.5631 (0.0186)	3.4805 (0.0621)	-	1.3612 (0.2433)	124.3368 (0)	17.4961 (0.0015)	7.2620 (0.0640)	2.0556 (0.1516)	10.6677 (0.0584)	14.6197 (0.0001)	39.5960 (0.0000)	3.3777 (0.0661)	10.7137 (0.0574)	32.7502 (0.0000)	55.7072 (0.0000)	2.5604 (0.4645)
Germany	1.7607 (0.1845)	0.3434 (0.5579)	0.0423 (0.8371)	-	19.4369 (0.0016)	9.2615 (0.0260)	18.1319 (0.0004)	2.3834 (0.1226)	5.5871 (0.2322)	0.0270 (0.8695)	26.8215 (0.0000)	0.9100 (0.3401)	-1.0467 (1.0000)	7.2085 (0.0272)	2.3862 (0.1224)	2.6265 (0.2689)
Greece	17.6991 (0.0070)	36.7615 (0.0000)	99.6265 (0)	6.9707 (0.2228)	-	58.7968 (0.0000)	33.1133 (0.0000)	6.9009 (0.2281)	90.1039 (0)	0.0711 (0.9999)	1.2563 (0.2624)	43.0600 (0.0000)	67.9405 (0.0000)	3.4805 (0.0621)	0.6252 (0.4291)	9.5894 (0.1430)
Ireland	23.3064 (0.0001)	6.3346 (0.0118)	5.8676 (0.2093)	3.0471 (0.0809)	64.1595 (0.0000)	-	6.9489 (0.0310)	1.7158 (0.1902)	5.8433 (0.2112)	3.7486 (0.0529)	55.7840 (0.0000)	4.8033 (0.0284)	27.1096 (0.0000)	57.5860 (0.0000)	0.0002 (0.9888)	3.4805 (0.0621)
Italy	18.8931 (0.0003)	0.4184 (0.8112)	8.1930 (0.0422)	3.9952 (0.1357)	43.3403 (0.0000)	26.4251 (0.0000)	-	6.6677 (0.0357)	25.5477 (0.0000)	2.7872 (0.2482)	56.0698 (0.0000)	9.2126 (0.0100)	36.6658 (0.0000)	16.4337 (0.0003)	2.5452 (0.2801)	12.2238 (0.0067)
Japan	0.0784 (0.7794)	1.9337 (0.1644)	1.8730 (0.1711)	-0.3511 (1.0000)	5.6668 (0.3400)	0.6252 (0.4291)	-0.3999 (1.0000)	-	4.1841 (0.3817)	1.8119 (0.1783)	4.6333 (0.3270)	1.2590 (0.2618)	-1.2074 (1.0000)	3.6788 (0.1589)	2.7455 (0.0975)	3.0724 (0.2152)
Netherland	11.2387 (0.0240)	5.3451 (0.2537)	104.4659 (0)	10.1682 (0.0377)	156.2534 (0)	90.3370 (0)	11.3653 (0.0228)	6.2921 (0.1784)	-	7.8448 (0.0974)	50.0211 (0.0000)	47.1440 (0.0000)	35.4665 (0.0000)	60.0255 (0.0000)	83.3384 (0)	3.9795 (0.4088)
Norway	2.9704 (0.0848)	0.6072 (0.4358)	1.8850 (0.1698)	1.2563 (0.2624)	2.1464 (0.8285)	1.3173 (0.2511)	1.1042 (0.5757)	2.4704 (0.1160)	18.1968 (0.0011)	-	3.0318 (0.5525)	3.7367 (0.0532)	2.9189 (0.5715)	14.9271 (0.0006)	5.1505 (0.0232)	5.6010 (0.1327)
Spain	19.5031 (0.0015)	13.7172 (0.0083)	8.7673 (0.1187)	8.0212 (0.0908)	76.0328 (0.0000)	38.2345 (0.0000)	16.4800 (0.0024)	15.7026 (0.0034)	5.2655 (0.2611)	5.9241 (0.2049)	-	12.3078 (0.0152)	95.0993 (0)	75.4860 (0.0000)	13.6013 (0.0087)	24.8987 (0.0001)
Sweden	0.1738 (0.6768)	0.8142 (0.3669)	27.7358 (0.0000)	57.5860 (0.0000)	67.8995 (0.0000)	9.2615 (0.0260)	12.2238 (0.0067)	1.0205 (0.3124)	5.9966 (0.1994)	2.0550 (0.1517)	6.5550 (0.1614)	-	33.1400 (0.0000)	12.5642 (0.0019)	22.7111 (0.0000)	4.5874 (0.2046)
Switzerland	30.2026 (0.0000)	4.0331 (0.4015)	16.6654 (0.0052)	2.2588 (0.1329)	82.4725 (0.0000)	14.3307 (0.0063)	10.8722 (0.0280)	1.5531 (0.2127)	15.0433 (0.0046)	1.3750 (0.8485)	2.9704 (0.0848)	2.3442 (0.6727)	-	51.9523 (0.0000)	10.4965 (0.0328)	7.7274 (0.1021)
Turkey	2.5452 (0.2801)	3.1880 (0.2031)	50.1026 (0.0000)	1.3380 (0.5122)	24.9064 (0.0004)	68.9814 (0.0000)	1.5373 (0.4636)	2.5681 (0.2769)	35.9397 (0.0000)	1.1792 (0.5546)	29.2912 (0.0001)	3.7382 (0.1543)	14.5925 (0.0056)	-	39.1942 (0.0000)	8.0484 (0.0450)
U.K.	17.5541 (0.0002)	15.6330 (0.0036)	16.6907 (0.0051)	5.7149 (0.0168)	125.5544 (0)	21.1913 (0.0007)	9.2615 (0.0260)	1.5806 (0.2087)	24.7786 (0.0001)	0.0126 (0.9106)	7.4049) (0.0065)	26.5199 (0.0000)	9.7872 (0.0442)	41.4220 (0.0000)	-	21.1913 (0.0007)
U.S.	14.3763 (0.0024)	30.2579 (0.0000)	10.3671 (0.0157)	5.8650 (0.0533	24.5234 (0.0004)	54.5494 (0.0000)	18.6219 (0.0003)	8.3560 (0.0153)	6.3713 (0.1731)	13.3303 (0.0040)	66.9547 (0.0000)	14.1026 (0.0028)	31.8922 (0.0000)	12.0096 (0.0074)	18.1319 (0.0004)	-

Notes: Tests indicate Granger caused by row to column and Granger causes by column to row. The numbers in the parentheses are the p-values, while the others are the F-statistics. Red colours denote the causal links.

We applied two different tests so as to investigate the Granger causality in variance for the sixteen equity markets for the pre-euro period (1/2/1988 – 1/12/1998). Both **Table 7.4** and **7.5** indicate the results that computed using squared values and absolute values of real returns respectively. It appears that, the conclusions from these two tables are to a large extent identical. There are not many volatility spillovers among the sixteen equity markets. Bidirectional causalities in variance are also limited. However, the U.S., the U.K., Spain, Italy and Germany Granger cause in variance more equity markets, than other markets do. The Netherlands and Switzerland do not seem to affect any other market. Moreover the U.S. and Italy are not affected by any other market while on the other hand Greece, Japan, Denmark, Austria and Belgium are the most influenced markets.

Volatility transmission among the examined stock markets has increased significantly after the introduction of euro. **Table 7.6** and **7.7** present the results of the Granger causality tests in variance for the post-euro period (1/1/1999 – 1/3/2009) computed also using two methodologies (squared values and absolute values of real returns respectively). Looking carefully at these two tables, we may infer that Belgium, Greece, Ireland and Switzerland seem to be more sensitive to volatility spillovers. Contrarily, Japan, Norway, Sweden and U.K. are not influenced considerably. The U.K., the U.S., Spain, Italy and Germany are the most dominant markets, as they Granger cause in variance the majority of markets. On the other hand, Greece, Ireland, Japan, Switzerland and Turkey only affect a small number of markets. Bidirectional causalities in variance are also increased relatively to the pre-euro period. Some important feedbacks in volatility lay between the U.S. and the U.K., the U.S. and Spain, Italy and Spain and between Germany and Spain.

Table 7.4 (results of Granger causality test in volatility (using squared values of real returns) for the pre-euro period: 1/2/1988 – 1/12/1998)

	Affected Markets															
Affecting Markets	**Austria**	**Belgium**	**Denmark**	**Germany**	**Greece**	**Ireland**	**Italy**	**Japan**	**Netherlands**	**Norway**	**Spain**	**Sweden**	**Switzerland**	**Turkey**	**UK**	**US**
Austria	-	35.6445 (0.0000)	0.0386 (0.8443)	13.3223 (0.0013)	10.0682 (0.0733)	2.4345 (0.1187)	0.0833 (0.7729)	50.0992 (0.0000)	0.0708 (0.7902)	1.3942 (0.2377)	1.1975 (0.2738)	7.3830 (0.0066)	1.5472 (0.2136)	1.1148 (0.2910)	3.2474 (0.0715)	2.5793 (0.1083)
Belgium	3.9821 (0.2634)	-	-0.1157 (1.0000)	-1.4749 (1.0000)	2.1104 (0.3481)	0.0069 (0.9337)	0.3722 (0.5418)	14.1620 (0.0008)	0.0214 (0.8837)	-0.0932 (1.0000)	0.7816 (0.3766)	-0.3696 (1.0000)	0.9301 (0.3348)	-0.5827 (1.0000)	-0.1539 (1.0000)	-0.0050 (1.0000)
Denmark	0.8112 (0.3678)	-0.3532 (1.0000)	-	-0.0126 (1.0000)	3.8966 (0.0484)	1.7985 (0.1799)	0.7311 (0.3925)	0.0383 (0.8449)	-0.0001 (1.0000)	0.7391 (0.3899)	0.0411 (0.8393)	3.2474 (0.0715)	0.0327 (0.8564)	0.4683 (0.4938)	0.3953 (0.5296)	-0.0056 (1.0000)
Germany	10.1422 (0.0063)	10.2630 (0.0059)	0.6361 (0.4251)	-	1.9391 (0.1638)	1.8398 (0.1750)	1.1637 (0.2807)	7.9898 (0.0047)	0.5287 (0.4672)	0.0952 (0.7577)	0.8123 (0.3674)	0.6024 (0.4376)	-0.0002 (1.0000)	0.0599 (0.8066)	0.0734 (0.7864)	0.0184 (0.8922)
Greece	3.2769 (0.1943)	22.8496 (0.0000)	0.3692 (0.5435)	0.0264 (0.8708)	-	0.1547 (0.6941)	0.2380 (0.6256)	0.2354 (0.6276)	0.3953 (0.5296)	2.4672 (0.1162)	0.2044 (0.6512)	1.1125 (0.2915)	3.1420 (0.0763)	0.1154 (0.7341)	0.0386 (0.8443)	0.0411 (0.8393)
Ireland	0.2069 (0.6492)	0.5025 (0.4784)	6.1674 (0.0130)	1.2343 (0.2666)	0.8483 (0.3570)	-	2.1335 (0.1441)	2.9885 (0.0839)	0.7395 (0.3898)	0.8227 (0.3644)	0.1642 (0.6853)	1.3833 (0.2395)	0.8890 (0.3457)	0.4503 (0.5022)	1.1351 (0.2867)	0.0608 (0.8052)
Italy	-0.0014 (1.0000)	0.4540 (0.5005)	4.9938 (0.0254)	1.2953 (0.2551)	1.4960 (0.2213)	0.7917 (0.3736)	-	0.7543 (0.3851)	7.4233 (0.0064)	0.0383 (0.8448)	0.0014 (0.9702)	5.4546 (0.0195)	1.5066 (0.2197)	-0.0029 (1.0000)	-0.0021 (1.0000)	1.3818 (0.2398)
Japan	1.7451 (0.4179)	-0.7511 (1.0000)	0.6920 (0.4055)	0.6092 (0.4351)	17.3066 (0.0000)	0.8000 (0.3711)	1.5599 (0.2117)	-	1.0918 (0.2961)	0.0026 (0.9595)	2.9762 (0.0845)	1.7061 (0.1915)	0.8612 (0.3534)	0.7585 (0.3838)	1.0489 (0.3058)	1.3127 (0.5188)
Netherland	0.0179 (0.8936)	-0.3406 (1.0000)	1.0949 (0.2954)	0.0631 (0.8017)	0.4463 (0.5041)	0.4855 (0.4860)	0.6190 (0.4314)	2.9665 (0.0850)	-	0.4228 (0.5155)	2.4886 (0.1147)	0.7829 (0.3762)	0.2461 (0.6198)	1.3896 (0.2385)	0.1758 (0.6750)	3.6730 (0.0553)
Norway	8.5080 (0.0142)	12.9466 (0.0015)	0.1105 (0.7396)	0.2301 (0.6315)	0.0046 (0.9461)	0.2859 (0.5929)	0.5435 (0.4610)	0.3936 (0.5304)	1.0603 (0.3031)	-	0.1578 (0.6912)	0.5427 (0.4613)	37.8515 (0.0000)	1.7507 (0.1858)	0.1577 (0.6913)	0.6920 (0.4055)
Spain	1.0055 (0.3160)	0.2521 (0.6156)	4.9051 (0.0268)	-0.0496 (1.0000)	1.4346 (0.2310)	1.6168 (0.2035)	-.0013 (1.0000)	3.1544 (0.0757)	6.7742 (0.0092)	0.0745 (0.7848)	-	0.3184 (0.5726)	2.2726 (0.1317)	0.0009 (0.9760)	0.7559 (0.3846)	0.4584 (0.4984)
Sweden	0.0180 (0.8932)	2.5893 (0.1076)	1.6919 (0.1934)	0.5137 (0.4735)	2.7845 (0.0952)	4.4224 (0.0355)	0.2421 (0.6227)	15.3518 (0.0001)	1.5672 (0.2106)	0.1270 (0.7216)	9.9280 (0.0016)	-	2.0962 (0.1477)	0.1000 (0.7518)	0.2202 (0.6389)	0.5389 (0.4629)
Switzerland	7.0867 (0.0289)	-0.9852 (1.0000)	0.9239 (0.3364)	0.0728 (0.7873)	1.6770 (0.1953)	0.5697 (0.4504)	0.0161 (0.8991)	1.3030 (0.2537)	0.4517 (0.5015)	0.0976 (0.9524)	1.9420 (0.1634)	0.6967 (0.4039)	-	0.9171 (0.3382)	0.0030 (0.9563)	2.4652 (0.2915)
Turkey	1.3815 (0.2399)	8.2798 (0.0159)	1.3486 (0.2455)	0.6370 (0.4248)	0.3808 (0.5372)	0.2534 (0.6147)	2.1255 (0.1449)	0.0349 (0.8518)	0.5823 (0.4454)	0.2661 (0.6060)	0.5013 (0.4789)	1.3871 (0.2389)	0.0025 (0.9598)	-	0.3325 (0.5642)	0.0062 (0.9370)
U.K.	10.7302 (0.0047)	-0.7961 (1.0000)	5.6888 (0.0171)	0.1808 (0.6707)	6.8308 (0.0090)	0.3766 (0.5394)	1.8645 (0.1721)	0.0068 (0.9344)	0.7636 (0.3822)	0.2392 (0.6248)	0.1567 (0.6922)	0.1185 (0.7306)	0.7935 (0.3731)	0.0064 (0.9360)	-	0.3766 (0.5395)
U.S.	7.5659 (0.0228)	-0.6467 (1.0000)	0.2328 (0.6294)	0.0185 (0.8919)	4.9455 (0.0844)	0.6116 (0.4342)	1.1219 (0.2895)	26.2126 (0.0000)	6.4155 (0.0404)	1.6899 (0.4296)	8.0678 (0.0177)	0.0008 (0.9777)	12.5752 (0.0019)	2.2418 (0.1343)	0.9310 (0.3346)	-

Notes: Tests indicate Granger caused by row to column and Granger causes by column to row. The numbers in the parentheses are the p-values, while the others are the F-statistics. Red colours denote the causal links.

Table 7.5 (results of Granger causality test in volatility (using absolute values of real returns) for the pre-euro period: 1/2/1988 – 1/12/1998)

	Affected Markets															
Affecting Markets	**Austria**	**Belgium**	**Denmark**	**Germany**	**Greece**	**Ireland**	**Italy**	**Japan**	**Netherlands**	**Norway**	**Spain**	**Sweden**	**Switzerland**	**Turkey**	**UK**	**US**
Austria	-	8.2113 (0.0042)	2.1712 (0.1406)	10.2945 (0.0058)	1.7886 (0.1811)	4.4827 (0.0342)	0.0707 (0.7902)	0.0307 (0.8608)	0.7440 (0.3884)	7.9328 (0.0049)	1.2946 (0.2552)	2.1084 (0.1465)	3.8341 (0.0502)	0.4255 (0.5142)	0.0307 (0.8608)	2.8494 (0.0914)
Belgium	1.2422 (0.2650)	-	3.9438 (0.0470)	2.7614 (0.0966)	6.2821 (0.0432)	1.0382 (0.3082)	0.0133 (0.9083)	1.2668 (0.2604)	1.1779 (0.2778)	-0.1422 (1.0000)	2.3213 (0.1276)	0.6486 (0.4206)	-0.1046 (1.0000)	-0.3823 (1.0000)	1.6665 (0.1967)	-0.1804 (1.0000)
Denmark	1.7490 (0.1860)	0.3741 (0.5408)	-	0.7353 (0.3912)	4.9426 (0.0262)	2.0642 (0.1508)	0.5745 (0.4485)	0.2587 (0.6110)	0.1120 (0.7379)	0.0149 (0.9029)	-0.0076 (1.0000)	4.8433 (0.0278)	0.0073 (0.9318)	0.7893 (0.3743)	2.8786 (0.0898)	0.0825 (0.7739)
Germany	9.2137 (0.0100)	0.1094 (0.7408)	2.6571 (0.1031)	-	2.6790 (0.1017)	3.2885 (0.0698)	1.0310 (0.3099)	5.2541 (0.0219)	3.4052 (0.0650)	-0.1214 (1.0000)	0.5295 (0.4668)	0.4327 (0.5107)	0.0791 (0.7785)	-0.1728 (1.0000)	0.3464 (0.5562)	0.3333 (0.5637)
Greece	0.7293 (0.3931)	0.9761 (0.3232)	0.6169 (0.4322)	2.1886 (0.1390)	-	1.0982 (0.2947)	-0.0030 (1.0000)	0.0664 (0.7966)	3.0291 (0.0818)	6.5375 (0.0106)	-0.0007 (1.0000)	3.5953 (0.0579)	2.2969 (0.1296)	1.4173 (0.2339)	6.4114 (0.0113)	0.1225 (0.7263)
Ireland	0.7257 (0.3943)	1.0104 (0.3148)	5.5987 (0.0180)	2.9913 (0.0837)	2.5808 (0.1082)	-	1.0455 (0.3065)	2.7861 (0.0951)	1.2492 (0.2637)	1.0793 (0.2989)	0.3052 (0.5806)	1.1216 (0.2896)	0.5675 (0.4512)	1.8752 (0.1709)	5.5057 (0.0637)	0.0495 (0.8240)
Italy	0.0845 (0.7713)	-0.1142 (1.0000)	1.2936 (0.2554)	6.5774 (0.0373)	1.4187 (0.2336)	0.8215 (0.3647)	-	0.3693 (0.5434)	3.5323 (0.0602)	0.0006 (0.9808)	0.0359 (0.8498)	4.7565 (0.0292)	0.3034 (0.5818)	0.1590 (0.6901)	0.3087 (0.5785)	2.9675 (0.0850)
Japan	1.6335 (0.2012)	-0.1508 (1.0000)	2.1291 (0.1445)	-0.0053 (1.0000)	10.0253 (0.0015)	1.1262 (0.2886)	0.8182 (0.3657)	-	0.2131 (0.6444)	0.2607 (0.6096)	2.3608 (0.1244)	0.8701 (0.3509)	0.0307 (0.8608)	0.5337 (0.4651)	1.2180 (0.2697)	0.0940 (0.7592)
Netherland	0.8075 (0.3689)	-0.2529 (1.00000)	1.5168 (0.2181)	0.3549 (0.5513)	2.8178 (0.0932)	0.0884 (0.7662)	0.1127 (0.7371)	2.6626 (0.1027)	-	1.0072 (0.3156)	2.3423 (0.1259)	0.9365 (0.3332)	0.0441 (0.8336)	0.0387 (0.8441)	0.0089 (0.9249)	2.2713 (0.1318)
Norway	0.4182 (0.5179)	-0.0966 (1.0000)	0.1360 (0.7123)	0.1642 (0.6854)	-0.0011 (1.0000)	0.9950 (0.3185)	0.1155 (0.7340)	0.9052 (0.3414)	0.1015 (0.7501)	-	0.0723 (0.7881)	0.6593 (0.4168)	0.0105 (0.9185)	0.1291 (0.7194)	0.0477 (0.8270)	0.3685 (0.5438)
Spain	0.0292 (0.8643)	0.2903 (0.5900)	2.7354 (0.0981)	0.5100 (0.4751)	4.2208 (0.0399)	2.1097 (0.1464)	0.0693 (0.7923)	4.3378 (0.0373)	3.6680 (0.0555)	0.5225 (0.4698)	-	0.7399 (0.3897)	3.8375 (0.0501)	0.3692 (0.5434)	0.8224 (0.3645)	1.9972 (0.1576)
Sweden	2.0688 (0.1503)	1.9580 (0.1617)	3.3236 (0.0683)	1.9925 (0.1581)	5.2856 (0.0712)	6.3896 (0.0115)	0.3814 (0.5369)	5.7598 (0.0164)	1.3288 (0.2490)	-0.0245 (1.0000)	9.0904 (0.0026)	-	0.9978 (0.3178)	1.0208 (0.3123)	0.6314 (0.4268)	0.0271 (0.8693)
Switzerland	0.1882 (0.6644)	1.3232 (0.2500)	2.2213 (0.1361)	0.0802 (0.7771)	1.8985 (0.1683)	0.3546 (0.5515)	0.3239 (0.5693)	0.9955 (0.3184)	0.7017 (0.4022)	-0.0189 (1.0000)	2.6442 (0.1039)	1.5315 (0.2159)	-	0.7309 (0.3926)	0.0156 (0.9006)	2.1084 (0.1465)
Turkey	0.0577 (0.8101)	1.0774 (0.2993)	0.5617 (0.4536)	0.1518 (0.6969)	0.1405 (0.7078)	-0.0339 (1.0000)	2.9992 (0.0833)	0.4838 (0.4867)	0.9239 (0.3364)	-0.0226 (1.0000)	0.1295 (0.7189)	7.2363 (0.0071)	0.0985 (0.7536)	-	0.7376 (0.3904)	0.0483 (0.8261)
U.K.	1.3184 (0.2509)	-0.3216 (1.0000)	6.8591 (0.0088)	2.5029 (0.1136)	7.7302 (0.0054)	0.0059 (0.9386)	2.8700 (0.0902)	0.0074 (0.9316)	12.5752 (0.0019)	-0.0066 (1.0000)	0.0185 (0.8918)	0.1198 (0.7292)	0.3347 (0.5629)	1.7137 (0.1905)	-	-0.0014 (1.0000)
U.S.	-0.0001 (1.0000)	-0.1820 (1.0000)	0.4629 (0.4963)	0.2875 (0.5919)	4.8632 (0.0274)	1.2248 (0.2684)	1.1537 (0.2828)	8.3317 (0.0155)	0.7756 (0.3785)	1.9015 (0.1679)	0.2883 (0.5913)	0.4863 (0.4856)	6.2518 (0.0439)	1.3068 (0.2530)	0.6788 (0.4100)	-

Notes: Tests indicate Granger caused by row to column and Granger causes by column to row. The numbers in the parentheses are the p-values, while the others are the F-statistics. Red colours denote the causal links.

Table 7.6 (results of Granger causality test in volatility (using squared values of real returns) for the post-euro period: 1/1/1999 – 1/3/2009)

	Affected Markets															
Affecting Markets	**Austria**	**Belgium**	**Denmark**	**Germany**	**Greece**	**Ireland**	**Italy**	**Japan**	**Netherlands**	**Norway**	**Spain**	**Sweden**	**Switzerland**	**Turkey**	**UK**	**US**
Austria	-	128.0364 (0)	4.9542 (0.0260)	1.2519 (0.2632)	39.8147 (0.0000)	3.7270 (0.0535)	6.4543 (0.1677)	0.0077 (0.9303)	16.3915 (0.0001)	10.1684 (0.0172)	1.7565 (0.1851)	8.1164 (0.0044)	0.7663 (0.3814)	1.0940 (0.2956)	0.7378 (0.3904)	3.2467 (0.3551)
Belgium	42.9482 (0.0000)	-	16.5408 (0.0000)	5.7175 (0.0573)	0.8128 (0.3673)	0.0283 (0.8664)	0.5089 (0.4756)	-0.3085 (1.0000)	12.5381 (0.0004)	3.5728 (0.0587)	0.7891 (0.3744)	1.4937 (0.2216)	21.9006 (0.0001)	26.7084 (0.0004)	1.5584 (0.2119)	33.1019 (0.0000)
Denmark	0.0930 (0.7604)	61.4354 (0.0000)	-	0.5141 (0.4734)	38.1707 (0.0000)	2.7443 (0.0976)	3.6007 (0.0578)	0.7663 (0.3814)	2.4757 (0.1156)	10.8988 (0.0043)	2.4461 (0.1178)	9.4822 (0.0021)	3.8230 (0.0506)	2.7581 (0.0968)	2.0336 (0.1539)	0.3001 (0.5838)
Germany	0.4954 (0.7806)	0.3390 (0.8441)	9.1392 (0.0104)	-	2.4183 (0.1199)	11.1714 (0.0108)	25.9287 (0.0005)	4.3075 (0.0379)	1.1380 (0.5661)	5.2982 (0.0707)	12.9171 (0.0003)	0.5160 (0.4725)	6.4457 (0.0111)	0.0319 (0.8584)	0.4260 (0.8082)	8.3820 (0.0038)
Greece	11.8675 (0.0006)	-0.0008 (1.0000)	4.6590 (0.0973)	0.1951 (0.6587)	-	39.4937 (0.0000)	0.8850 (0.3468)	-0.4733 (1.0000)	3.1307 (0.0768)	12.0072 (0.0025)	1.6074 (0.4477)	0.2057 (0.6502)	5.8178 (0.0545)	-0.0637 (1.0000)	0.1759 (0.6749)	2.7511 (0.9070)
Ireland	134.5643 (0)	0.4216 (0.5161)	119.5366 (0)	2.9132 (0.0879)	0.5129 (0.4739)	-	5.1270 (0.0770)	5.6328 (0.0598)	102.1799 (0)	58.6441 (0.0000)	1.6709 (0.6434)	2.6554 (0.1032)	2.5168 (0.1126)	0.9111 (0.3398)	90.1106 (0)	0.0069 (0.9338)
Italy	1.0928 (0.2959)	7.5552 (0.0060)	0.7059 (0.4008)	3.3281 (0.0681)	14.0664 (0.0002)	23.8142 (0.0000)	-	2.8137 (0.0935)	-0.0001 (1.0000)	1.3838 (0.2394)	10.2402 (0.0014)	0.1898 (0.6631)	16.8066 (0.0000)	0.3447 (0.5571)	6.2507 (0.0439)	26.5239 (0.0000)
Japan	2.1125 (0.1461)	-0.0605 (1.0000)	0.7372 (0.3906)	0.1630 (0.6864)	2.8089 (0.0937)	3.2467 (0.3551)	0.0554 (0.8140)	-	0.2361 (0.6271)	0.9229 (0.3367)	0.2038 (0.6517)	0.0014 (0.9699)	1.4718 (0.2251)	-0.0336 (1.0000)	0.0798 (0.7775)	1.8647 (0.1721)
Netherland	2.6048 (0.1065)	51.5458 (0.0000)	0.6828 (0.4086)	14.3143 (0.0008)	0.7009 (0.4025)	33.8229 (0.0000)	3.6504 (0.0561)	2.5586 (0.1097)	-	4.9361 (0.0847)	4.4624 (0.7252)	3.1107 (0.0778)	9.7003 (0.0078)	0.6039 (0.4371)	22.6081 (0.0000)	2.1859 (0.3352)
Norway	2.7885 (0.9039)	136.4974 (0)	26.2947 (0.0000)	7.4769 (0.3810)	100.2322 (0)	7.3524 (0.3931)	19.4320 (0.0000)	8.7313 (0.2725)	36.4903 (0.0000)	-	102.7126 (0)	10.1635 (0.0014)	11.3795 (0.1229)	2.0020 (0.1571)	8.4484 (0.2947)	5.1860 (0.6373)
Spain	39.4790 (0.0000)	4.3309 (0.2279)	19.6282 (0.0002)	15.2581 (0.0328)	22.8466 (0.0018)	21.3745 (0.0001)	1.8435 (0.1745)	1.1520 (0.2831)	18.9921 (0.0008)	1.2822 (0.7334)	-	0.7329 (0.3919)	15.4703 (0.0001)	1.2519 (0.2632)	30.4099 (0.0001)	27.8798 (0.0000)
Sweden	0.0042 (0.9484)	6.9398 (0.0084)	0.2706 (0.6030)	1.7565 (0.1851)	10.0497 (0.0015)	3.8817 (0.0488)	0.8660 (0.3521)	10.3352 (0.0013)	0.1096 (0.7405)	0.3761 (0.5397)	9.0583 (0.0026)	-	4.0501 (0.0442)	8.7213 (0.0031)	3.6002 (0.0578)	2.7511 (0.9070)
Switzerland	1.6709 (0.6434)	0.3720 (0.9460)	4.7003 (0.0954)	5.0097 (0.0252)	2.5168 (0.1126)	0.6311 (0.7294)	8.2989 (0.0040)	15.5421 (0.0001)	1.0850 (0.5813)	3.1649 (0.2055)	22.5005 (0.0000)	0.1223 (0.7266)	-	0.1548 (0.6940)	2.8361 (0.4176)	5.9153 (0.5497)
Turkey	0.8000 (0.3711)	0.5129 (0.4739)	1.5254 (0.2168)	0.3038 (0.5815)	0.0707 (0.7903)	0.2406 (0.6238)	4.3579 (0.0368)	4.2659 (0.0389)	0.7413 (0.3893)	0.0077 (0.9303)	0.8206 (0.3650)	0.3117 (0.5767)	3.4763 (0.0623)	-	0.0022 (0.9629)	1.1341 (0.2869)
U.K.	12.9995 (0.0003)	18.2122 (0.0004)	5.8949 (0.0152)	10.4190 (0.0055)	5.8057 (0.0160)	40.3454 (0.0000)	3.0181 (0.2211)	2.1126 (0.1461)	1.4807 (0.2237)	3.6555 (0.0559)	24.2616 (0.0000)	1.6715 (0.1961)	30.0281 (0.0000)	0.0120 (0.9128)	-	18.7868 (0.0000)
U.S.	5.5329 (0.2369)	18.2083 (0.0111)	4.2423 (0.2365)	14.3986 (0.0001)	19.3208 (0.0072)	38.7901 (0.0000)	2.2326 (0.1351)	18.1921 (0.0111)	0.0069 (0.9338)	7.7975 (0.1678)	9.4897 (0.0087)	5.2532 (0.0219)	22.8522 (0.0000)	14.7794 (0.0389)	31.2161 (0.0001)	-

Notes: Tests indicate Granger caused by row to column and Granger causes by column to row. The numbers in the parentheses are the p-values, while the others are the F-statistics. Red colours denote the causal links.

Table 7.7 (results of Granger causality test in volatility (using absolute values of real returns) for the post-euro period: 1/1/1999 – 1/3/2009)

	Affected Markets															
Affecting Markets	**Austria**	**Belgium**	**Denmark**	**Germany**	**Greece**	**Ireland**	**Italy**	**Japan**	**Netherlands**	**Norway**	**Spain**	**Sweden**	**Switzerland**	**Turkey**	**UK**	**US**
Austria	-	20.6322 (0.0000)	4.3270 (0.0375)	0.4104 (0.5217)	3.1157 (0.0775)	3.3254 (0.0682)	1.0460 (0.3064)	1.5345 (0.2154)	6.6959 (0.0097)	10.3794 (0.0013)	0.5311 (0.4662)	5.6426 (0.0175)	8.6176 (0.0033)	0.8757 (0.3494)	3.2203 (0.0727)	2.1651 (0.1412)
Belgium	2.7443 (0.0976)	-	0.5141 (0.4734)	2.7335 (0.0983)	-0.0073 (1.0000)	1.8708 (0.1714)	3.4361 (0.0638)	0.0912 (0.7627)	0.1556 (0.6932)	1.9394 (0.1637)	1.8376 (0.1752)	2.2900 (0.1302)	17.8983 (0.0005)	-0.0603 (1.0000)	0.0059 (0.9385)	4.1986 (0.0405)
Denmark	0.4308 (0.5116)	13.2832 (0.0003)	-	1.0143 (0.3139)	9.0447 (0.0026)	0.1276 (0.7210)	6.9826 (0.0082)	1.5039 (0.2201)	3.2203 (0.0727)	7.5534 (0.0060)	7.4769 (0.3810)	6.9845 (0.0082)	2.7443 (0.0976)	6.6282 (0.0100)	4.9752 (0.6630)	1.0460 (0.3064)
Germany	6.3153 (0.0120)	2.7554 (0.0969)	0.1614 (0.6879)	-	2.9666 (0.0850)	4.9423 (0.0262)	2.0318 (0.1540)	1.5314 (0.2159)	0.4896 (0.7829)	0.1364 (0.7119)	7.6361 (0.0057)	0.1437 (0.7046)	6.0690 (0.0138)	0.1110 (0.7390)	2.1563 (0.3402)	3.3478 (0.0673)
Greece	0.6818 (0.4090)	2.1782 (0.1400)	0.2506 (0.6167)	2.8752 (0.0900)	-	4.7983 (0.0285)	0.8342 (0.3611)	-0.2024 (1.0000)	0.7663 (0.3814)	2.8412 (0.0919)	0.0725 (0.7877)	1.4597 (0.2270)	1.6913 (0.1934)	1.3513 (0.2450)	0.9205 (0.3373)	2.4461 (0.1178)
Ireland	0.3205 (0.5713)	3.8154 (0.0508)	0.2496 (0.6173)	3.2965 (0.0694)	2.9800 (0.0843)	-	3.1725 (0.0749)	0.0141 (0.9054)	0.5246 (0.4689)	1.6192 (0.2032)	4.1031 (0.0428)	1.8588 (0.1728)	1.2054 (0.2722)	0.4490 (0.5028)	0.6207 (0.4308)	1.2706 (0.2596)
Italy	1.4603 (0.2269)	7.3716 (0.0066)	0.3001 (0.5838)	2.3593 (0.1245)	10.2487 (0.0014)	8.0005 (0.0047)	-	0.4095 (0.5222)	0.4074 (0.5233)	2.0336 (0.1539)	6.3951 (0.0114)	1.1699 (0.2794)	10.6318 (0.0011)	2.4763 (0.1156)	3.8230 (0.0506)	9.0010 (0.0027)
Japan	-0.0949 (1.0000)	0.6370 (0.4248)	-0.0498 (1.0000)	0.3640 (0.5463)	5.5086 (0.0189)	2.7710 (0.0960)	0.7683 (0.3808)	-	0.3137 (0.5754)	0.6574 (0.4175)	-0.1172 (1.0000)	0.0507 (0.8218)	0.4098 (0.5221)	1.1044 (0.2933)	0.8482 (0.3571)	0.3676 (0.5443)
Netherland	0.2549 (0.6136)	13.6848 (0.0002)	-0.0414 (1.0000)	12.9766 (0.0015)	3.2980 (0.0694)	6.5873 (0.0103)	5.4769 (0.0193)	0.0419 (0.8378)	-	2.4757 (0.1156)	6.3153 (0.0120)	3.5639 (0.0590)	2.8179 (0.0932)	0.7257 (0.3943)	2.4573 (0.1170)	5.2442 (0.0220)
Norway	2.6976 (0.1005)	17.0914 (0.0000)	-0.0828 (1.0000)	2.7802 (0.0954)	8.2162 (0.0042)	1.6163 (0.2036)	2.1215 (0.1452)	2.1651 (0.1412)	1.3925 (0.2380)	-	11.5983 (0.0007)	0.7729 (0.3793)	3.6007 (0.0578)	0.2130 (0.6445)	2.1566 (0.1420)	1.5252 (0.2168)
Spain	8.2191 (0.0041)	1.1187 (0.2902)	0.0294 (0.8640)	4.9486 (0.0261)	1.7574 (0.1849)	5.2702 (0.0217)	8.1201 (0.0044)	0.1276 (0.7210)	1.1238 (0.2891)	3.4231 (0.0643)	-	5.9747 (0.0145)	9.1679 (0.0025)	6.8294 (0.0090)	3.9858 (0.0459)	10.6174 (0.0011)
Sweden	2.2473 (0.1338)	4.4177 (0.0356)	0.0029 (0.9572)	0.4961 (0.4812)	7.0190 (0.0081)	7.1936 (0.0073)	1.2328 (0.2669)	2.4047 (0.1210)	0.1072 (0.7433)	2.0216 (0.1551)	5.0566 (0.0245)	-	5.9771 (0.0145)	14.1471 (0.0002)	3.5981 (0.0578)	3.6036 (0.0577)
Switzerland	-0.0271 (1.0000)	0.3941 (0.9415)	-0.0017 (1.0000)	2.6141 (0.1059)	2.0482 (0.1524)	2.1057 (0.1468)	3.7270 (0.0535)	7.8950 (0.0050)	0.0560 (0.8129)	-0.0294 (1.0000)	9.3741 (0.0022)	1.3967 (0.2373)	-	0.7886 (0.3745)	0.1626 (0.6868)	4.2762 (0.0386)
Turkey	0.5311 (0.4662)	2.2727 (0.1317)	-0.0238 (1.0000)	0.0856 (0.7698)	0.5314 (0.4660)	0.3993 (0.5275)	1.4742 (0.2247)	1.6044 (0.2053)	-0.0081 (1.0000)	0.3004 (0.5836)	-0.0048 (1.0000)	-0.0105 (1.0000)	2.8465 (0.0916)	-	1.9791 (0.1595)	0.5043 (0.4776)
U.K.	8.6176 (0.0033)	9.7994 (0.0017)	0.4104 (0.5217)	11.0079 (0.0041)	69.3316 (0.0000)	5.8863 (0.0153)	4.1808 (0.0409)	0.6875 (0.4070)	21.3363 (0.0033)	1.6399 (0.2003)	8.1733 (0.0043)	3.9363 (0.0473)	3.6990 (0.0544)	19.8311 (0.0059)	-	2.5035 (0.1136)
U.S.	1.0143 (0.3139)	9.2397 (0.0024)	-0.0582 (1.0000)	14.4951 (0.0001)	5.9630 (0.0146)	8.2191 (0.0041)	8.0871 (0.0045)	3.3254 (0.0682)	4.1267 (0.0422)	1.0460 (0.3064)	13.8070 (0.0002)	8.4548 (0.0036)	13.4587 (0.0002)	4.9894 (0.0255)	7.9053 (0.0049)	-

Notes: Tests indicate Granger caused by row to column and Granger causes by column to row. The numbers in the parentheses are the p-values, while the others are the F-statistics. Red colours denote the causal links.

Finally, **Table 7.8** and **7.9** indicate the results of Granger Causality tests in volatility (using also squared values and absolute values of real returns respectively) for the full sample (1/2/1988 – 1/3/2009). The main reason that the number of causal links in variance among the sixteen countries has increased, is the introduction of euro. Observing closely these two tables, the following conclusions can be inferred:

- The U.K., the U.S., the Netherlands, Sweden and Italy are the dominant markets, causing in variance the majority of the markets.

- Japan, Switzerland and Turkey affect only a few markets.

- The most influenced markets seem to be Greece, Ireland, and Switzerland

- The U.K., the U.S., Germany, Turkey and Japan are the least influenced markets.

- Austria, Belgium and Denmark, participate considerably in the European interdependence as they affect and are also affected, by a significant number of markets.

- Important bidirectional causalities in variance also appear in the full sample mainly among the large and strong markets such as those of the U.S., the U.K., Spain and Italy.

Table 7.8 (results of Granger causality test in volatility (using squared values of real returns) for the full sample: 1/2/1988 – 1/3/2009)

	Affected Markets															
Affecting Markets	**Austria**	**Belgium**	**Denmark**	**Germany**	**Greece**	**Ireland**	**Italy**	**Japan**	**Netherland**	**Norway**	**Spain**	**Sweden**	**Switzerland**	**Turkey**	**UK**	**US**
Austria	-	85.5222 (0)	6.4760 (0.0109)	0.0953 (0.7576)	12.6098 (0.0004)	38.3523 (0.0000)	0.0952 (0.7576)	3.5115 (0.0609)	9.8846 (0.0017)	27.7358 (0.0000)	1.2072 (0.2719)	16.8355 (0.0000)	2.8267 (0.0927)	0.1084 (0.7420)	2.1057 (0.1468)	1.5220 (0.2173)
Belgium	17.1434 (0.0000)	-	7.5452 (0.0060)	3.5115 (0.0609)	1.7074 (0.1913)	16.7936 (0.0008)	3.8238 (0.0505)	0.1480 (0.7005)	16.9968 (0.0000)	11.3020 (0.0008)	7.6341 (0.0220)	3.9200 (0.0477)	3.5115 (0.0609)	0.0176 (0.8945)	2.4511 (0.1174)	63.6375 (0.0000)
Denmark	1.0584 (0.3036)	66.4562 (0.0000)	-	17.5454 (0.0002)	13.7033 (0.0002)	51.5397 (0.0000)	8.1469 (0.0043)	1.0342 (0.3092)	7.1055 (0.0077)	14.5098 (0.0001)	2.1651 (0.1412)	18.0965 (0.0000)	14.5661 (0.0007)	2.4363 (0.1186)	0.6370 (0.4248)	3.0731 (0.0796)
Germany	0.4885 (0.7833)	0.2455 (0.8845)	4.1075 (0.1283)	-	3.1377 (0.0765)	11.3249 (0.0101)	2.3580 (0.1246)	4.5206 (0.0335)	1.9181 (0.3833)	3.6121 (0.1643)	15.9603 (0.0003)	0.0269 (0.8698)	10.8555 (0.0010)	0.1836 (0.6683)	3.2088 (0.2010)	16.4020 (0.0001)
Greece	6.1230 (0.0133)	-0.0299 (1.0000)	0.5415 (0.4618)	-0.0097 (1.0000)	-	0.3243 (0.5690)	0.0107 (0.9177)	120.6152 (0)	0.7157 (0.3976)	5.4540 (0.0195)	2.5832 (0.2748)	0.7858 (0.3754)	7.7601 (0.0053)	0.0481 (0.8263)	6.6505 (0.0099)	1.5790 (0.2089)
Ireland	47.8952 (0.0000)	93.9963 (0)	65.1436 (0.0000)	3.0286 (0.0818)	8.7180 (0.0032)	-	10.0622 (0.0015)	3.2118 (0.0731)	59.7789 (0.0000)	29.4861 (0.0000)	3.1082 (0.0779)	4.8027 (0.0284)	22.7006 (0.0000)	1.1424 (0.2851)	3.0286 (0.0818)	2.1651 (0.1412)
Italy	48.9131 (0.0000)	3.2427 (0.0717)	7.5659 (0.0228)	1.7974 (0.1800)	8.7407 (0.0031)	6.4155 (0.0404)	-	1.9754 (0.1599)	0.0096 (0.9218)	1.7513 (0.1857)	4.4341 (0.0352)	2.7218 (0.0990)	15.1953 (0.0001)	0.1830 (0.6688)	7.0044 (0.0081)	6.8088 (0.0091)
Japan	0.1385 (0.7098)	0.4074 (0.5233)	0.1291 (0.7194)	0.5897 (0.4426)	38.1930 (0.0000)	0.1310 (0.7174)	2.0295 (0.1543)	-	0.9522 (0.3292)	0.0147 (0.9036)	1.3535 (0.2447)	1.9496 (0.1626)	0.7637 (0.3822)	1.0437 (0.3070)	0.3061 (0.5801)	0.0019 (0.9649)
Netherland	0.0808 (0.7762)	85.4461 (0)	0.8583 (0.3542)	27.2940 (0.0000)	5.9398 (0.0148)	29.2357 (0.0000)	10.8005 (0.0010)	0.4066 (0.5237)	-	15.9390 (0.0001)	15.5836 (0.0004)	7.8063 (0.0052)	11.3839 (0.0007)	0.1333 (0.7151)	0.4383 (0.5080)	2.7081 (0.0998)
Norway	0.2195 (0.8961)	89.8442 (0)	2.0145 (0.1558)	0.0903 (0.7638)	0.0953 (0.7576)	11.1923 (0.0107)	0.0175 (0.8949)	1.0454 (0.3066)	26.9827 (0.0000)	-	0.0903 (0.7638)	10.5640 (0.0012)	2.5035 (0.1136)	0.0503 (0.8225)	3.3054 (0.0691)	0.7852 (0.3756)
Spain	25.9923 (0.0000)	2.5947 (0.2732)	1.4074 (0.4948)	0.0658 (0.9676)	6.6538 (0.0099)	14.9894 (0.0018)	13.0521 (0.0003)	3.6319 (0.0567)	3.7751 (0.1514)	3.9005 (0.1422)	-	5.2601 (0.0218)	14.3513 (0.0002)	4.2510 (0.0392)	1.4313 (0.4889)	9.9134 (0.0070)
Sweden	0.1005 (0.7512)	9.7870 (0.00180	0.0886 (0.7660)	2.9570 (0.0855)	7.5288 (0.0061)	8.9675 (0.0027)	4.4180 (0.0356)	13.0325 (0.0003)	0.1083 (0.7421)	0.7253 (0.3944)	21.1713 (0.0000)	-	10.7057 (0.0011)	4.7463 (0.0294)	6.7870 (0.0092)	17.5580 (0.0000)
Switzerland	1.6628 (0.4354)	1.1603 (0.5598)	3.3498 (0.1873)	0.3795 (0.5379)	4.4391 (0.0351)	0.5450 (0.7615)	4.1140 (0.0425)	6.3230 (0.0119)	0.6655 (0.4146)	4.1798 (0.1237)	14.0475 (0.0002)	0.0608 (0.8052)	-	0.2643 (0.6072)	1.1982 (0.5493)	1.5191 (0.2177)
Turkey	2.4886 (0.1147)	0.3760 (0.5398)	2.9534 (0.0857)	1.4274 (0.2322)	0.0791 (0.7785)	1.2331 (0.2668)	0.0165 (0.8978)	1.0881 (0.2969)	0.8504 (0.3564)	1.2862 (0.2568)	5.3697 (0.0682)	0.0984 (0.7538)	0.9864 (0.3206)	-	0.0996 (0.7523)	0.5393 (0.4627)
U.K.	3.4092 (0.0648)	7.7476 (0.0054)	0.1399 (0.7084)	13.2039 (0.0014)	10.3448 (0.0013)	20.3082 (0.0001)	1.9342 (0.1643)	0.1071 (0.7434)	2.5866 (0.1078)	6.5587 (0.0104)	7.7325 (0.0209)	1.9287 (0.1649)	10.9088 (0.0043)	10.2911 (0.0013)	-	19.6539 (0.0000)
U.S.	66.4562 (0.0000)	3.8385 (0.4283)	3.4083 (0.3329)	16.7239 (0.0000)	4.8020 (0.0284)	17.4150 (0.0016)	2.5649 (0.1093)	16.6231 (0.0000)	7.0044 (0.0081)	4.7554 (0.3133)	17.0602 (0.0002)	5.9369 (0.0148)	14.1629 (0.0002)	17.8979 (0.0000)	0.1570 (0.6919)	-

Notes: Tests indicate Granger caused by row to column and Granger causes by column to row. The numbers in the parentheses are the p-values, while the others are the F-statistics. Red colours denote the causal links.

Table 7.9 (results of Granger causality test in volatility (using absolute values of real returns) for the full sample: 1/2/1988 – 1/3/2009)

	Affected Markets														
Affecting Markets	**Austria**	**Belgium**	**Denmark**	**Germany**	**Greece**	**Ireland**	**Italy**	**Japan**	**Netherland**	**Norway**	**Spain**	**Sweden**	**Switzerland**	**Turkey**	**UK**	**US**
Austria	-	22.4890 (0.0000)	7.8225 (0.0052)	0.6370 (0.4248)	5.4661 (0.0194)	0.3941 (0.9415)	0.1072 (0.7433)	0.4104 (0.5217)	5.2587 (0.0218)	20.2892 (0.0000)	1.6192 (0.2032)	11.3490 (0.0008)	2.1651 (0.1412)	0.0321 (0.8579)	3.2203 (0.0727)	2.5035 (0.1136)
Belgium	0.1745 (0.6762)	-	1.4766 (0.2243)	6.6544 (0.0099)	2.8000 (0.0943)	5.2601 (0.0218)	2.3665 (0.1240)	0.5200 (0.4709)	0.3127 (0.5760)	5.0645 (0.0244)	7.0922 (0.0077)	4.4247 (0.0354)	1.3333 (0.2482)	-0.0832 (1.0000)	2.9180 (0.0876)	6.1911 (0.0128)
Denmark	3.5163 (0.0608)	8.5736 (0.0034)	-	0.3941 (0.9415)	13.9850 (0.0002)	9.9915 (0.0016)	2.5764 (0.1085)	0.9617 (0.3268)	4.1504 (0.0416)	6.7748 (0.0092)	0.5311 (0.4662)	13.2416 (0.0003)	4.0010 (0.0455)	5.6481 (0.0175)	0.4104 (0.5217)	1.8376 (0.1752)
Germany	4.1113 (0.0426)	3.1000 (0.0783)	1.2082 (0.2717)	-	5.8057 (0.0160)	10.1272 (0.0015)	0.4383 (0.5080)	4.7185 (0.0298)	1.3056 (0.5206)	1.4548 (0.2278)	9.5047 (0.0020)	1.2401 (0.2655)	6.2334 (0.0125)	0.1390 (0.7093)	3.9652 (0.0465)	9.3366 (0.0022)
Greece	1.1531 (0.2829)	1.5220 (0.2173)	0.7947 (0.3727)	3.0731 (0.0796)	-	3.4735 (0.0624)	0.6467 (0.4213)	0.2941 (0.5876)	1.8726 (0.1712)	10.1192 (0.0015)	0.1360 (0.7123)	4.4629 (0.0346)	5.2207 (0.0223)	3.0247 (0.0820)	8.0280 (0.0046)	0.5521 (0.4574)
Ireland	1.8460 (0.1742)	4.9535 (0.0260)	1.7551 (0.1852)	6.5178 (0.0107)	6.2901 (0.0121)	-	4.6067 (0.0318)	1.8786 (0.1705)	0.8824 (0.3475)	0.6006 (0.4383)	1.6728 (0.1959)	3.3701 (0.0664)	2.7026 (0.1002)	2.0145 (0.1558)	4.4663 (0.0346)	1.2493 (0.2637)
Italy	12.5752 (0.0019)	2.1934 (0.1386)	7.5659 (0.0228)	1.4965 (0.2212)	10.3354 (0.0013)	5.7691 (0.0163)	-	1.2670 (0.2603)	13.3223 (0.0013)	1.4538 (0.2279)	14.1620 (0.0008)	4.4735 (0.0344)	6.7562 (0.0093)	2.1057 (0.1468)	6.7742 (0.0092)	1.0456 (0.3065)
Japan	1.2072 (0.2719)	-0.0428 (1.0000)	0.3451 (0.5569)	-0.0033 (1.0000)	17.8979 (0.0000)	1.9820 (0.1592)	1.8197 (0.1774)	-	0.1822 (0.6695)	0.4064 (0.5238)	1.3427 (0.2466)	0.4870 (0.4853)	0.1078 (0.7427)	2.1564 (0.1420)	1.8350 (0.1755)	-0.0021 (1.0000)
Netherland	2.8593 (0.0908)	14.4859 (0.0001)	3.4624 (0.0628)	14.5583 (0.0007)	6.5941 (0.0102)	7.0044 (0.0081)	4.7427 (0.0294)	0.7636 (0.3822)	-	4.1387 (0.0419)	11.5695 (0.0007)	6.7589 (0.0093)	4.5447 (0.0330)	0.3574 (0.5499)	4.0205 (0.0450)	16.8434 (0.0000)
Norway	0.7852 (0.3756)	13.4421 (0.0002)	1.1278 (0.2882)	3.5729 (0.0587)	3.0946 (0.0786)	3.8821 (0.0488)	3.1082 (0.0779)	0.0175 (0.8949)	1.0132 (0.3141)	-	7.9239 (0.0049)	1.3665 (0.2424)	3.3054 (0.0691)	-0.0087 (1.0000)	2.3650 (0.1241)	3.8398 (0.1466)
Spain	0.0953 (0.7576)	0.7075 (0.4003)	1.9299 (0.1648)	2.8267 (0.0927)	7.7344 (0.0054)	5.8353 (0.0157)	4.3831 (0.0363)	4.3295 (0.0375)	1.2452 (0.2645)	3.7485 (0.0529)	-	5.0551 (0.0246)	13.0521 (0.0003)	5.0392 (0.0248)	4.9092 (0.0267)	7.9961 (0.0047)
Sweden	5.6673 (0.0173)	6.7344 (0.0095)	3.0286 (0.0818)	2.9858 (0.0840)	10.2911 (0.0013)	15.1288 (0.0001)	2.6579 (0.1030)	6.6745 (0.0098)	0.4871 (0.4852)	2.1430 (0.1432)	16.6231 (0.0000)	-	8.0666 (0.0045)	3.9174 (0.0478)	6.0561 (0.0139)	6.3474 (0.0118)
Switzerland	0.5027 (0.4783)	0.5568 (0.4556)	0.9248 (0.3362)	0.8888 (0.3458)	5.1664 (0.0230)	1.6085 (0.2047)	2.9936 (0.0836)	5.6034 (0.0179)	0.0903 (0.7638)	-0.0007 (1.0000)	11.0643 (0.0009)	2.7081 (0.0998)	-	-0.0276 (1.0000)	0.2979 (0.5852)	3.8236 (0.0505)
Turkey	0.0952 (0.7576)	2.4446 (0.1179)	0.3730 (0.5414)	0.1708 (0.6794)	0.0393 (0.8428)	0.0735 (0.7863)	0.5531 (0.4571)	2.6086 (0.1063)	0.0719 (0.7885)	6.7742 (0.0092)	0.4083 (0.5229)	2.9688 (0.0849)	2.1914 (0.1388)	-	3.1832 (0.0744)	-0.0075 (1.0000)
U.K.	6.7742 (0.0092)	3.5115 (0.0609)	5.8665 (0.0154)	6.5680 (0.0104)	13.2191 (0.0003)	10.2630 (0.0059)	38.2485 (0.0000)	0.2361 (0.6270)	8.5080 (0.0142)	2.6930 (0.1008)	5.1069 (0.0238)	3.4469 (0.0634)	1.5902 (0.2073)	10.6032 (0.0050)	-	6.4155 (0.0404)
U.S.	17.4502 (0.0016)	9.1805 (0.0024)	42.4957 (0.0000)	13.2957 (0.0003)	11.5093 (0.0007)	3.6091 (0.0575)	48.9131 (0.0000)	0.0921 (0.7615)	6.6538 (0.0099)	0.2195 (0.8961)	6.5357 (0.0106)	3.7582 (0.0526)	4.9871 (0.0255)	38.2485 (0.0000)	4.2510 (0.0392)	-

Notes: Tests indicate Granger caused by row to column and Granger causes by column to row. The numbers in the parentheses are the p-values, while the others are the F-statistics. Red colours denote the causal links.

8. SUMMARY & CONCLUSIONS

This study investigates the dynamic interdependence and volatility transmission among fourteen European stock markets (Austria, Belgium, Denmark, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, Turkey and the U.K.), the U.S. and Japan. Granger causality tests in mean and in volatility have been applied using monthly real returns for the sixteen equity markets from 1/2/1988 to 1/3/2009 (full sample). The data are sourced by DataStream and expressed in U.S. dollars. Causality tests in volatility are applied using two different methodologies. The squared values of the real returns are used firstly, followed by the absolute values of the real returns. The sample has also been separated into two subperiods, one before the introduction of euro 1/2/1988 – 1/12/1998 (pre-euro period) and one after the introduction of euro 1/1/1999 – 1/3/2009 (post-euro period), so as to discover the changes in the linkages among those markets through time.

We infer that there were limited causality links in mean and in volatility among the examined markets, before the introduction of euro. However the results indicate that the European stock markets have become more interdependent after the introduction of euro. The number of bidirectional causalities in both mean and volatility also increased in the post-euro period. The U.S., the U.K., Spain, and Italy are the dominant markets in the European area, as they Granger cause in mean and in volatility the majority of the markets, mainly in the post-euro period. Japan and Norway do not seem to play an important role in the European interdependence, while on the other hand the Netherlands, Ireland, Austria Belgium, Denmark and Sweden affect and are affected by a significant number of markets. Despite their size, these markets seem to participate actively in the interdependence of the European area. Contrary to the pre-euro period, Germany becomes much stronger after the introduction of euro, affecting many markets. Greece, Turkey and Switzerland are sensitive to European innovations mainly in the post-euro period, but they influence only a few markets.

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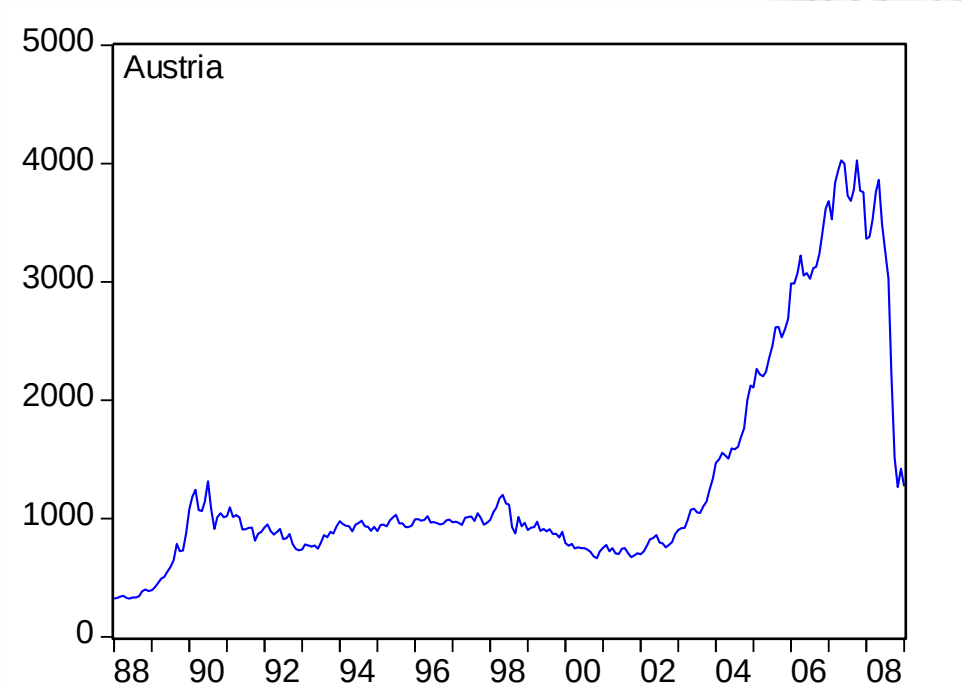
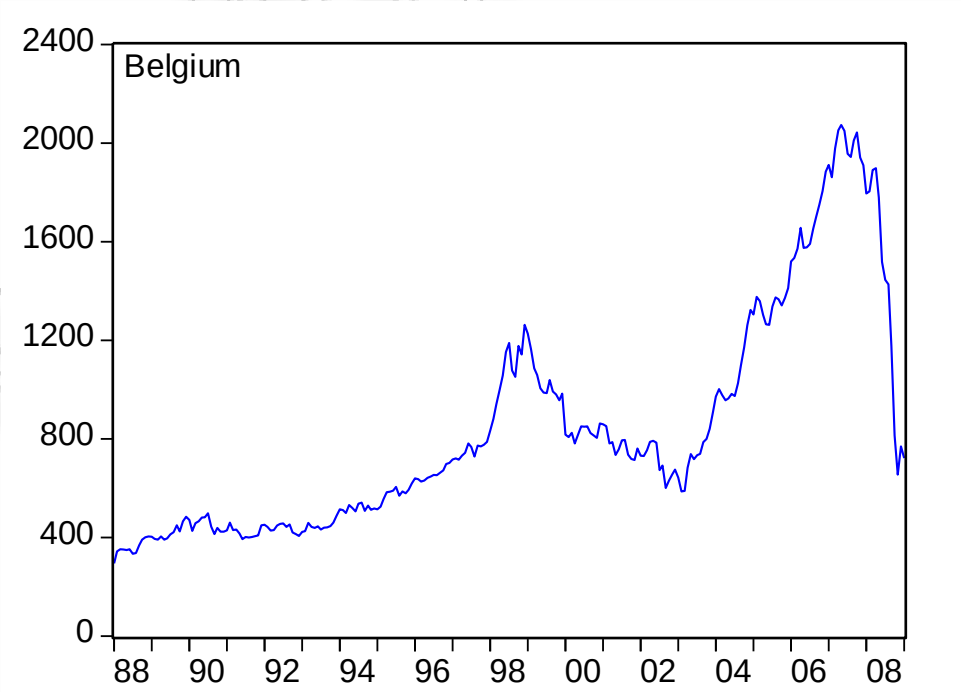
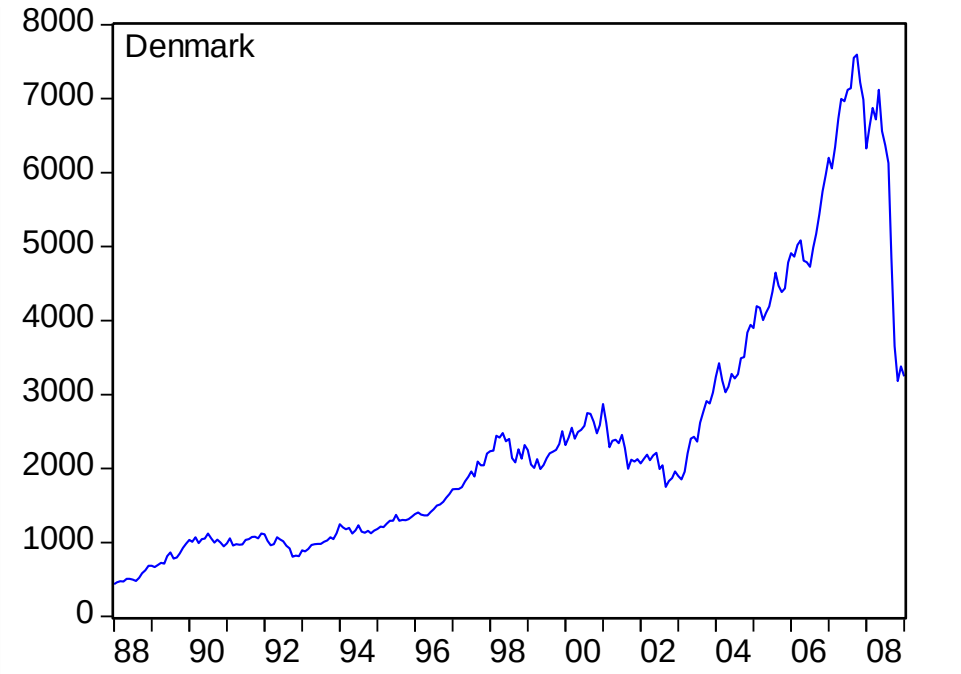
10. APPENDIX A

➢ Graphs of Stock Prices of the sixteen Stock Markets
1/2/1988 - 1/3/2009



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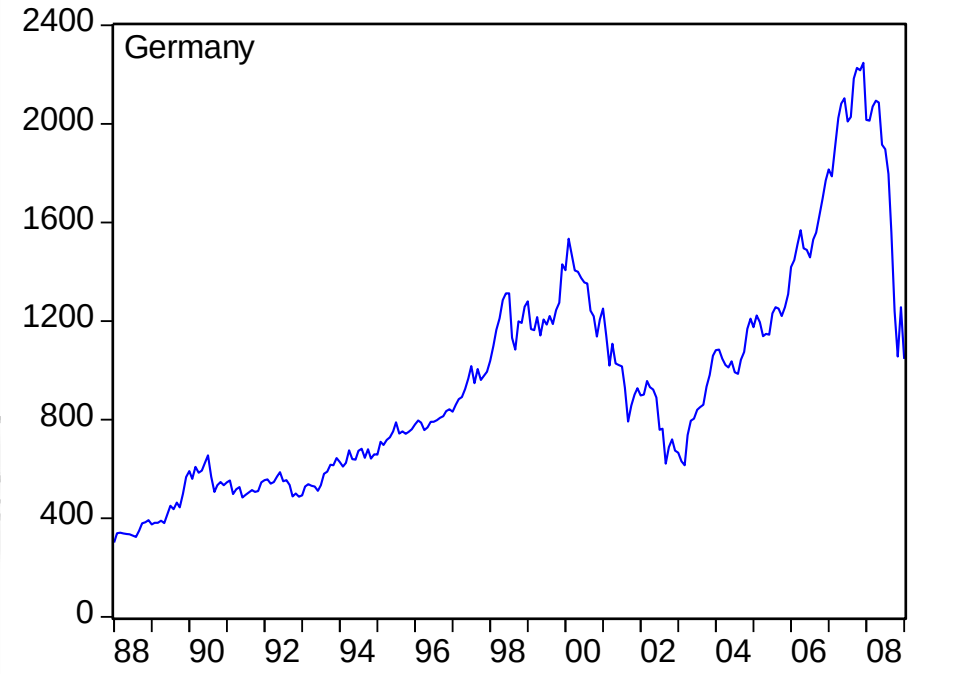
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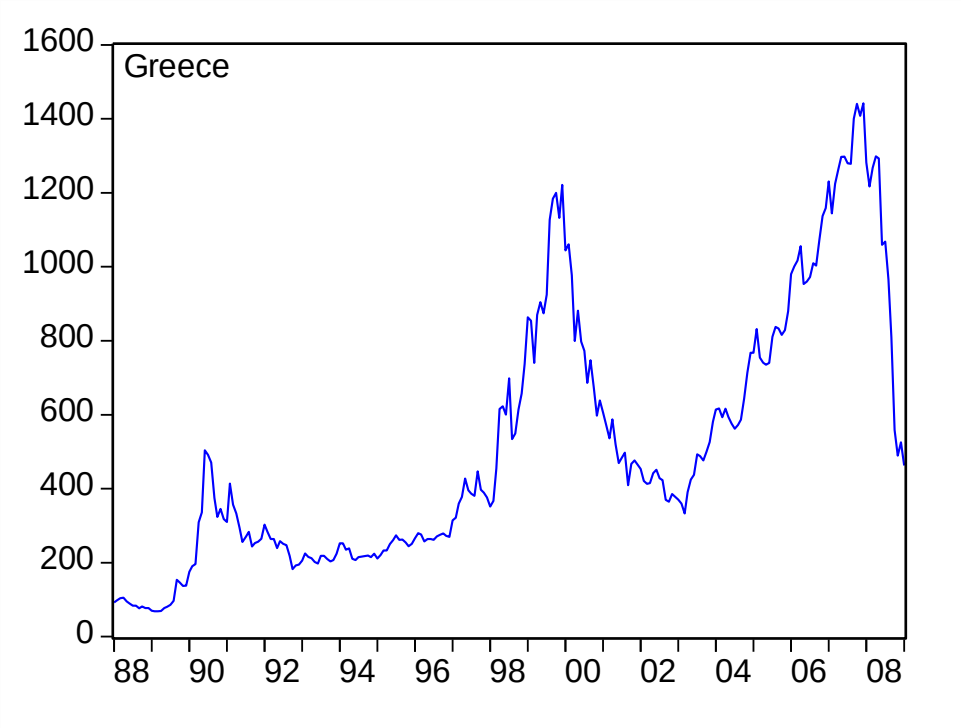
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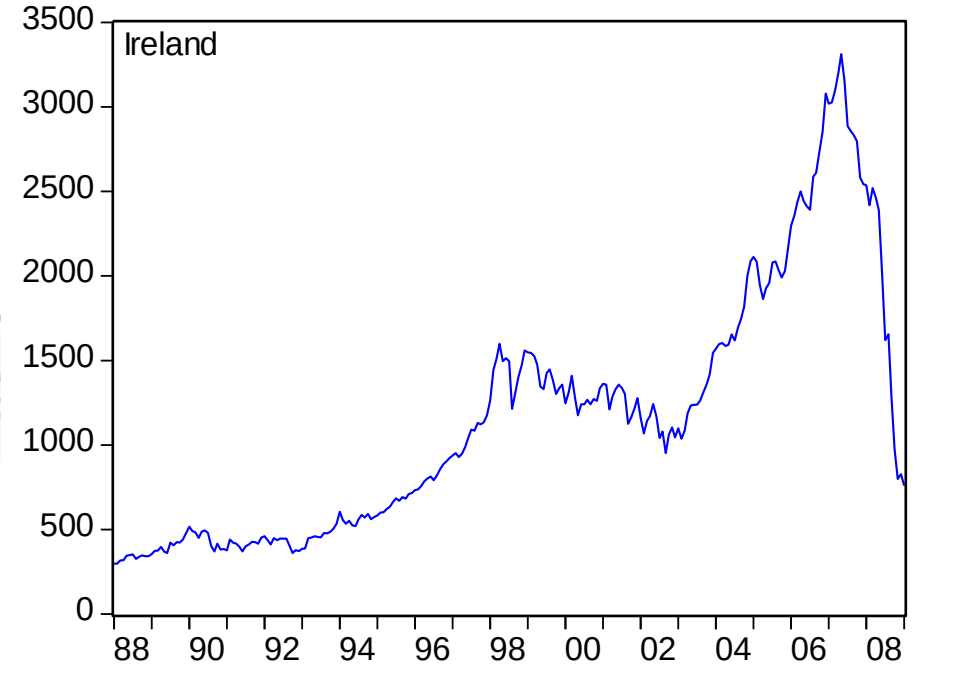
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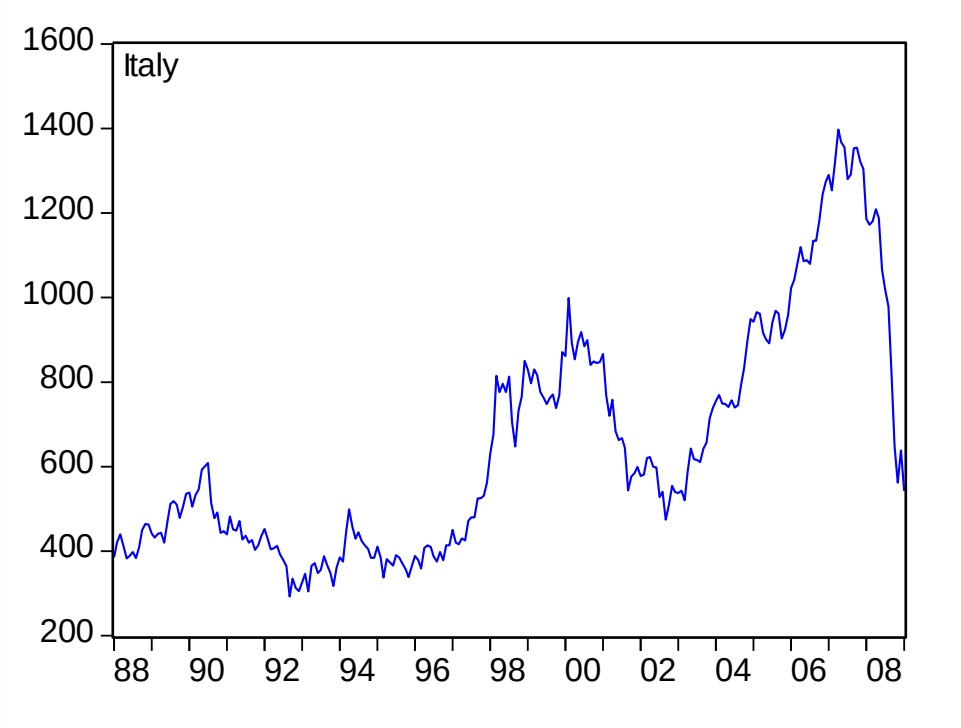
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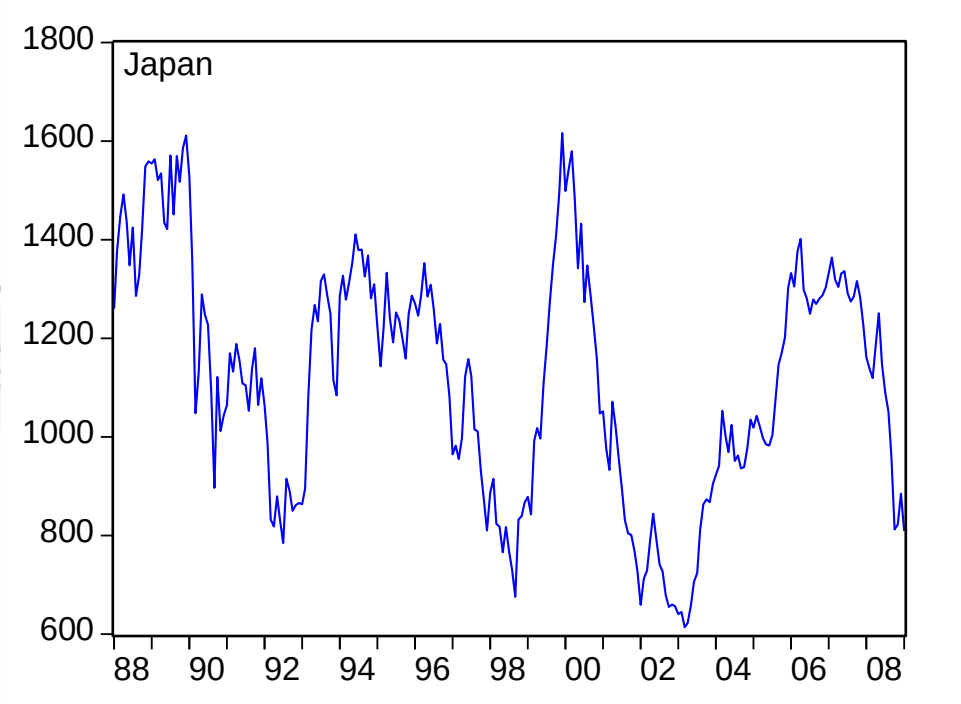
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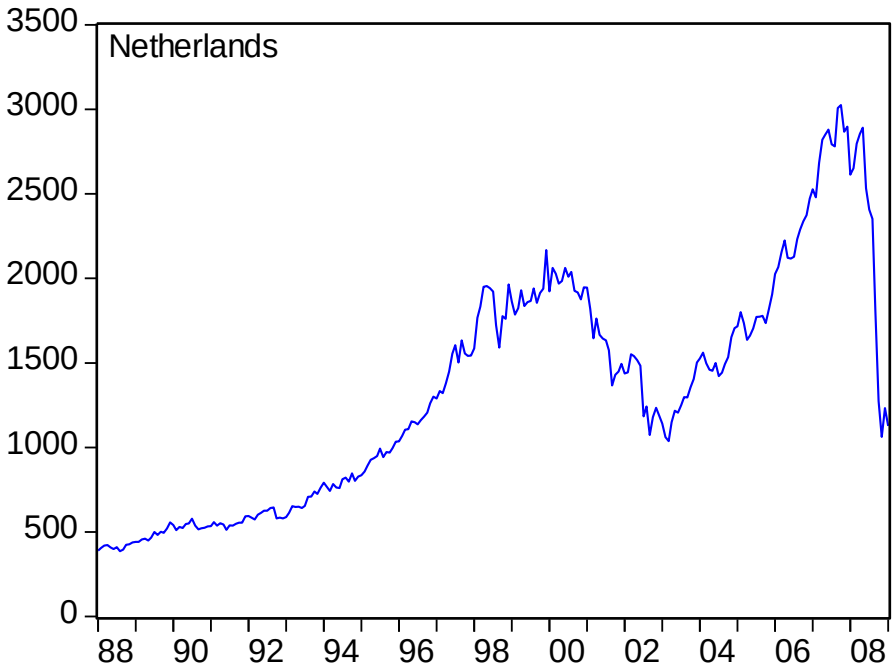
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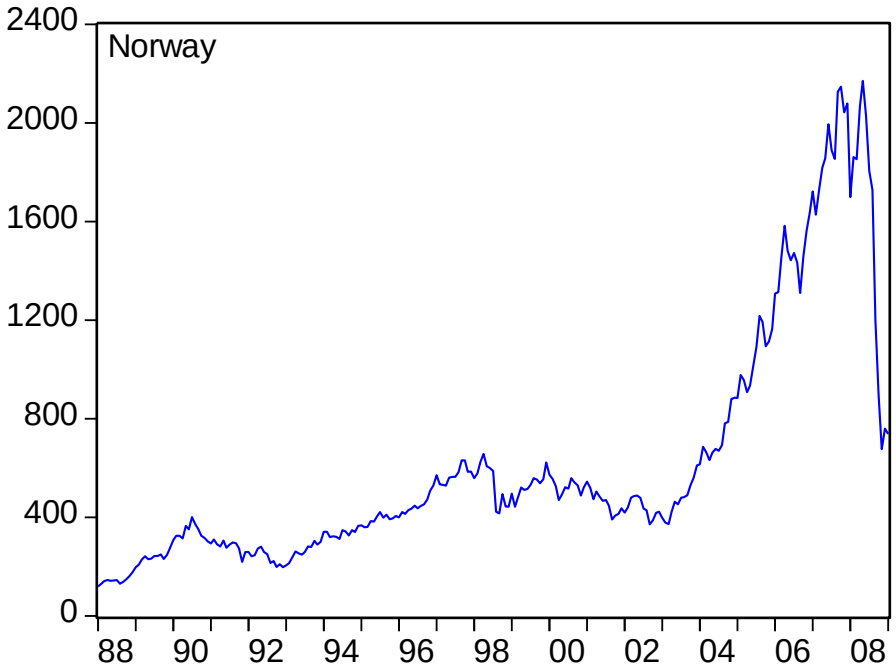
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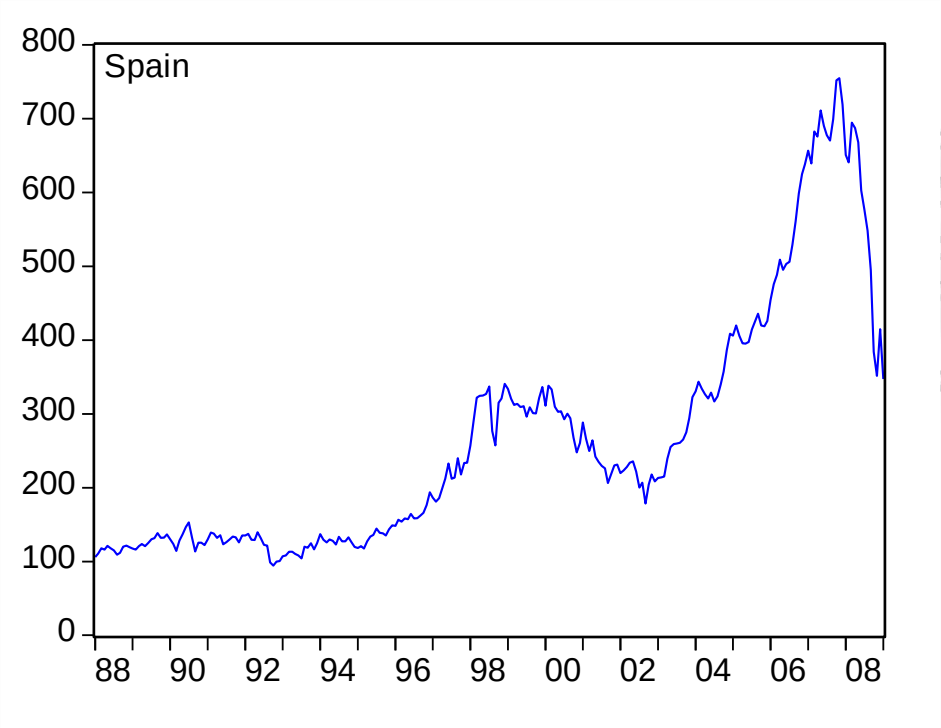
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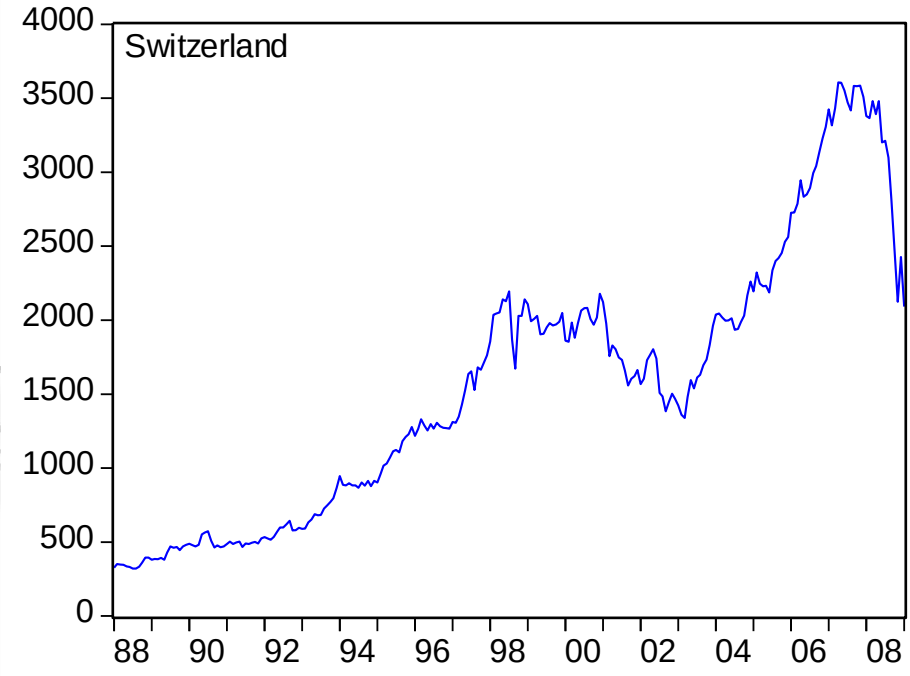
Switzerland
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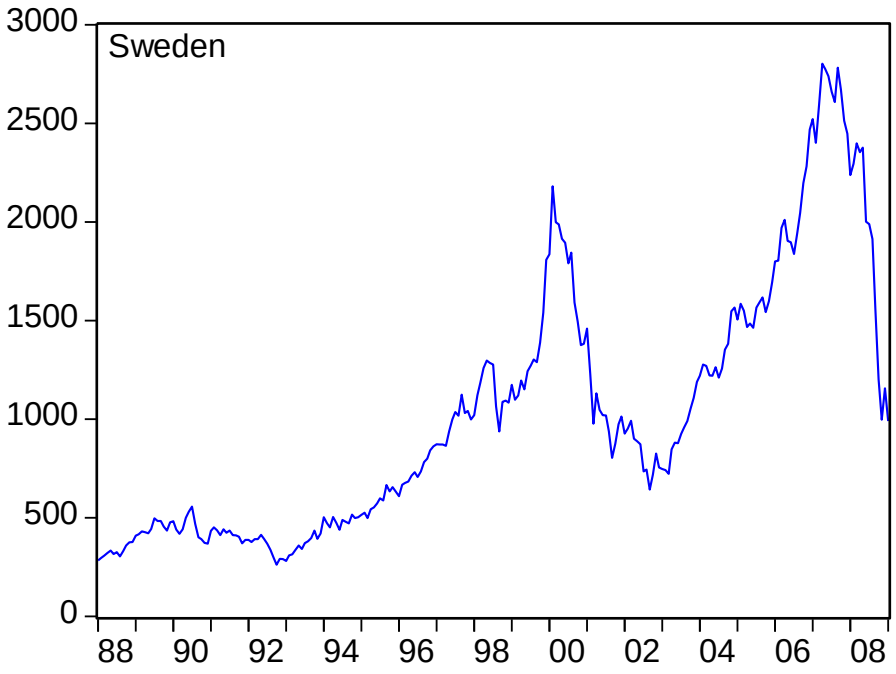
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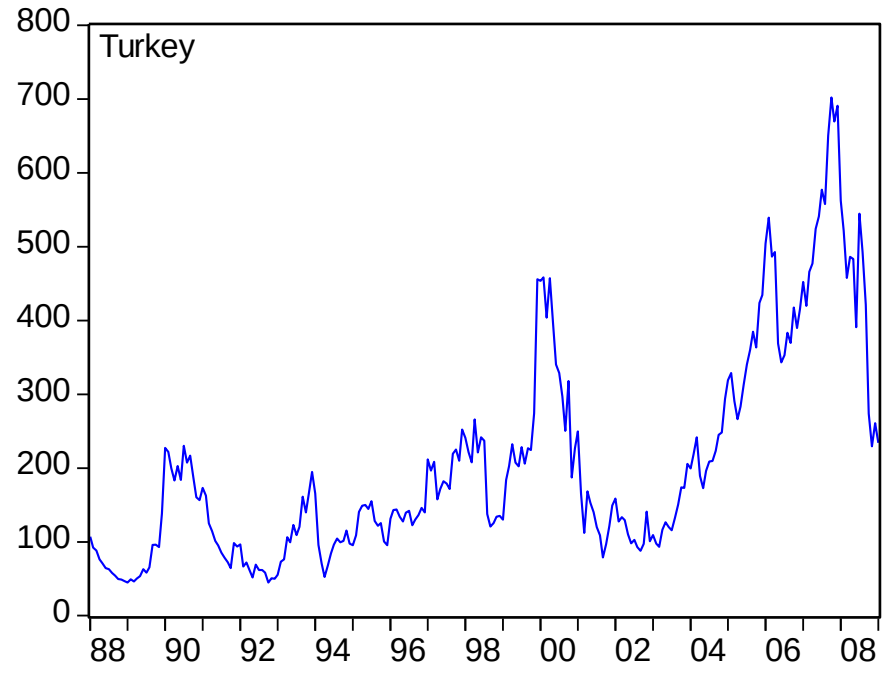
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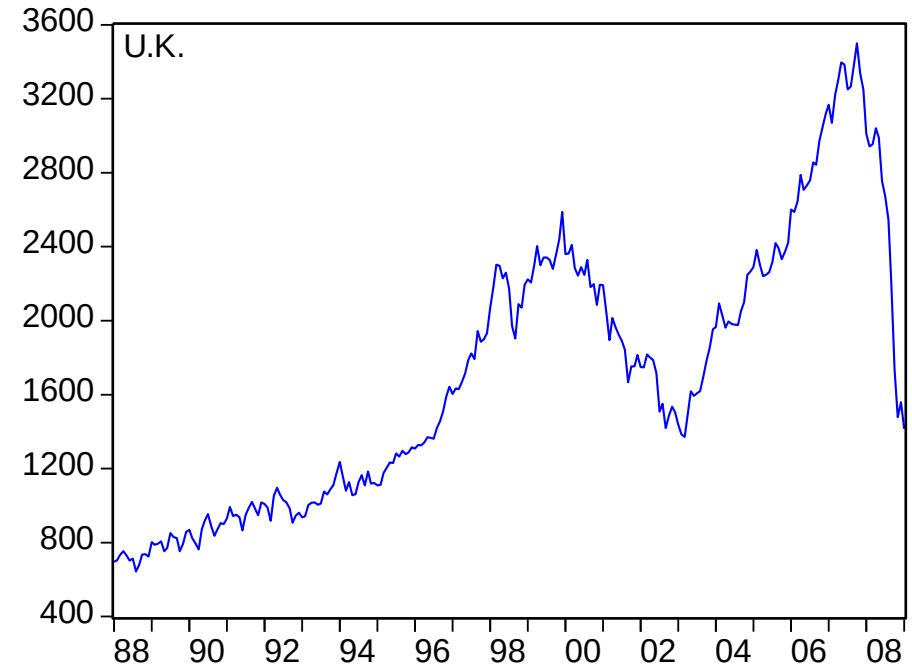
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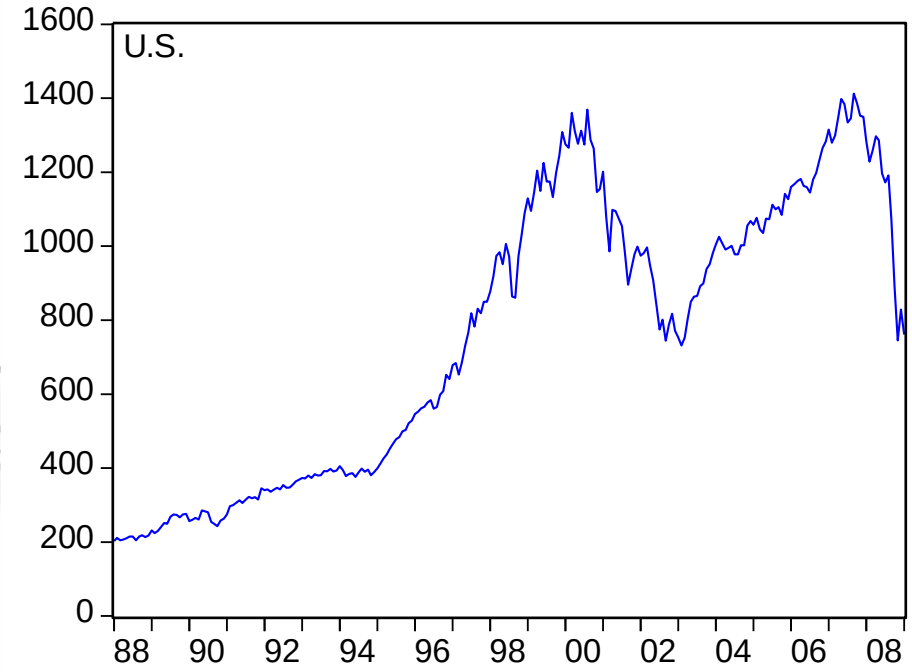
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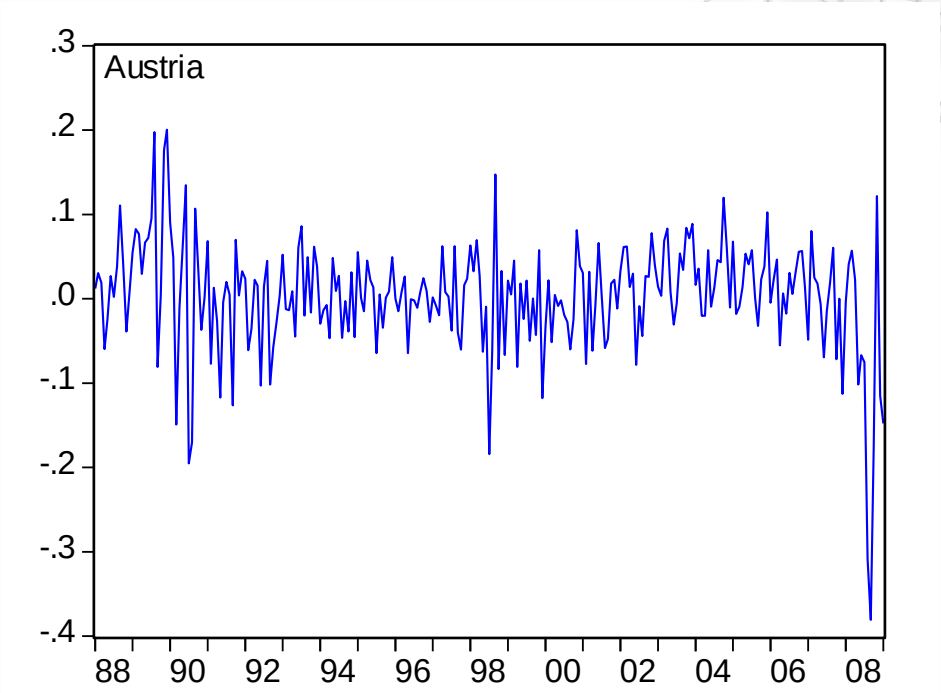
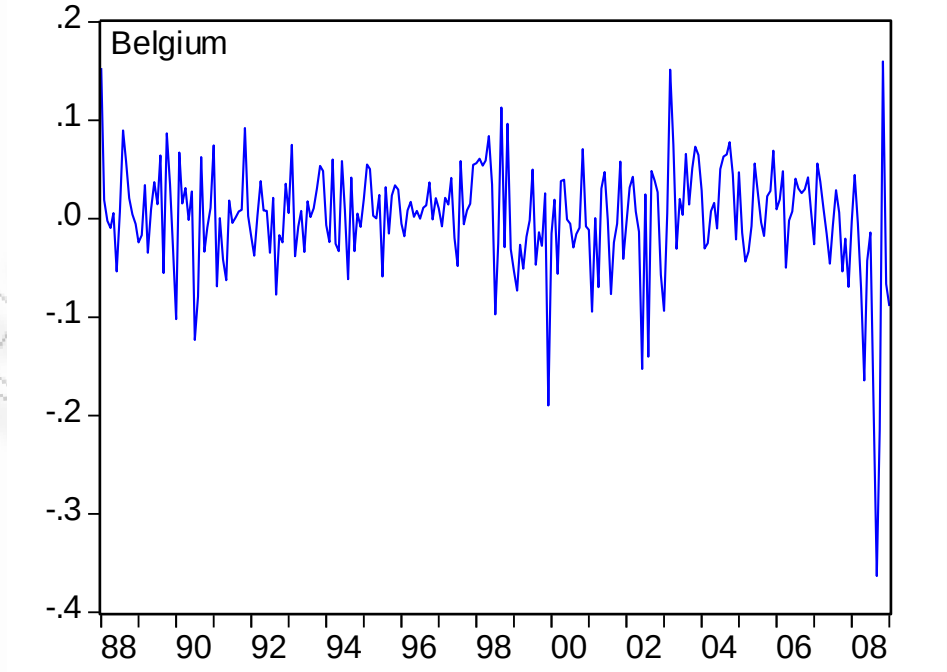
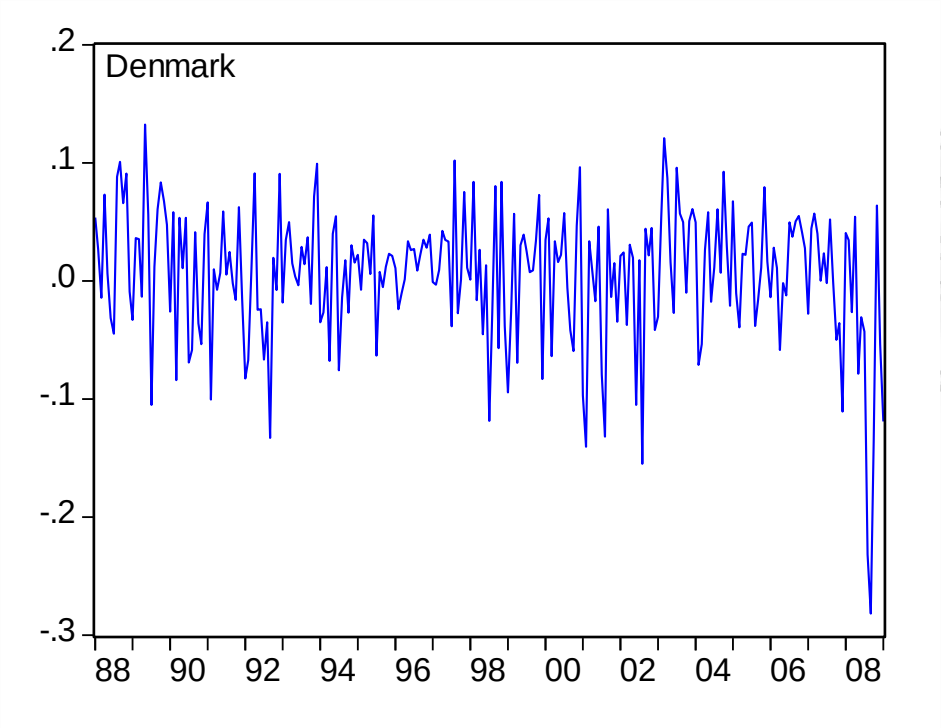
11. APPENDIX B

➢ Graphs of Real Returns of the sixteen Stock Markets
1/2/1988 - 1/3/2009



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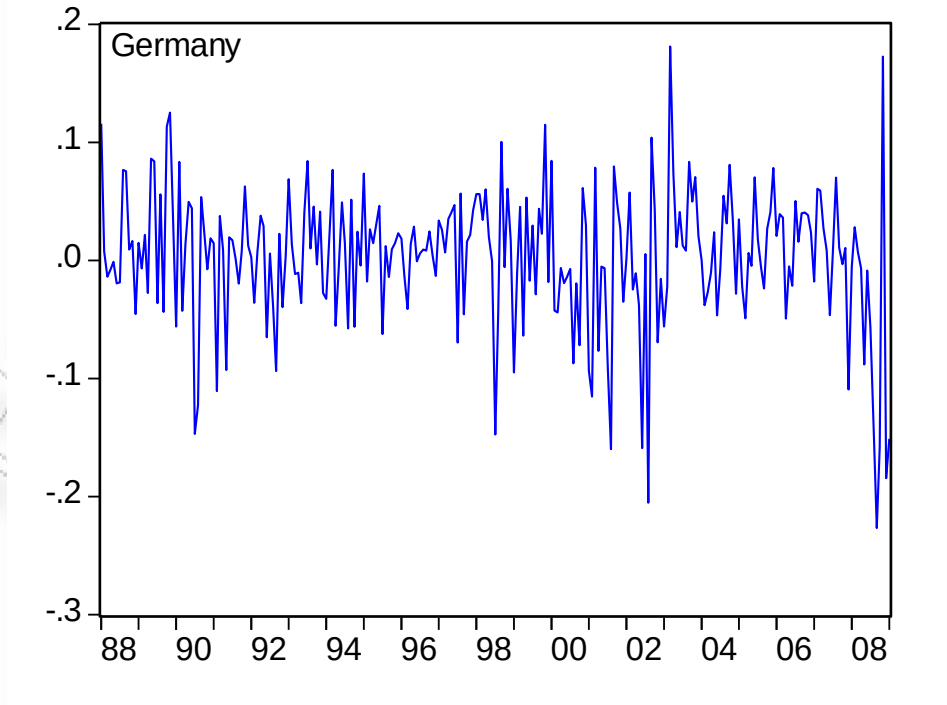
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-.1
-.2
-.3
88
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94
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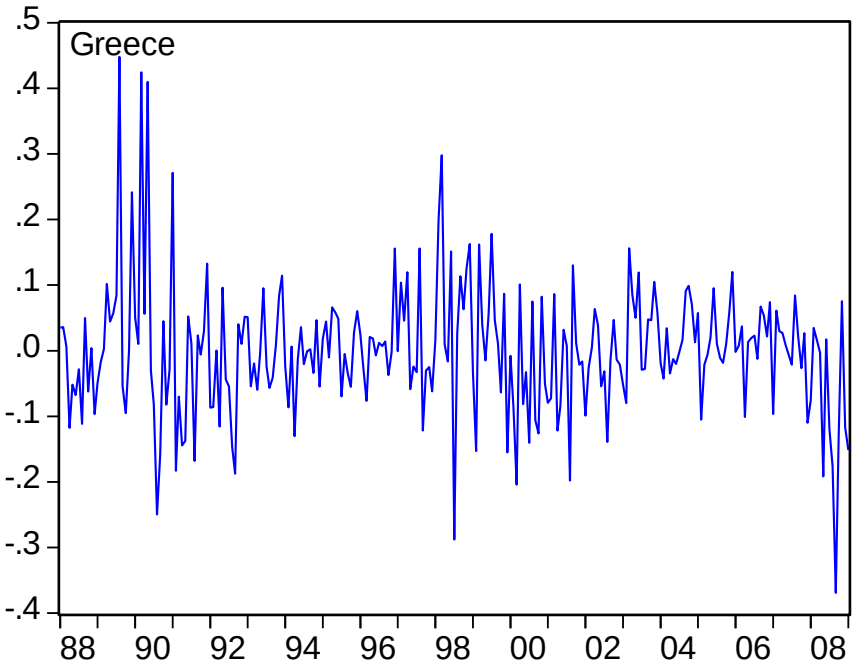
Greece
.5
.4
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.2
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-.1
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-.3
-.4
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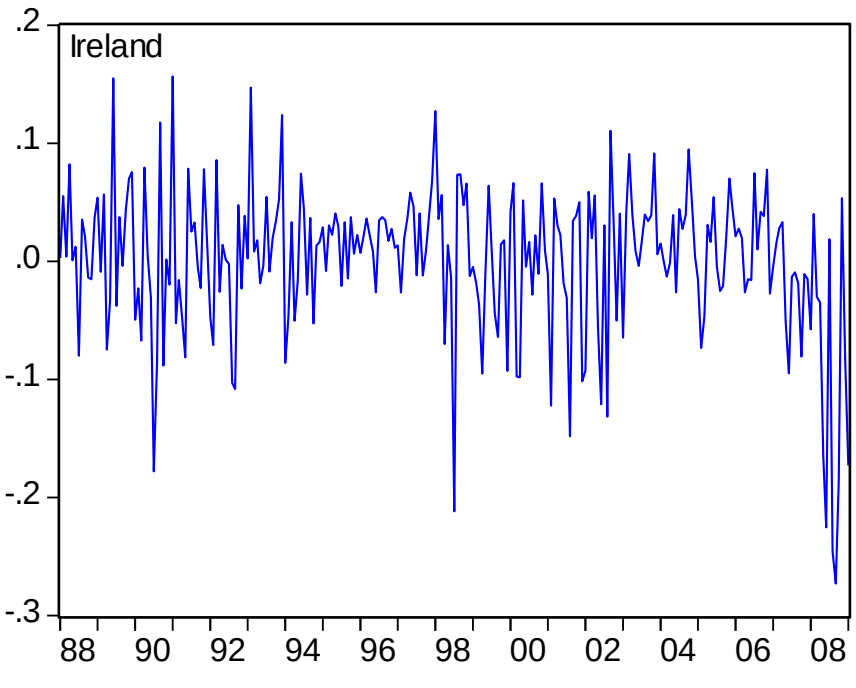
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.0
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-.2
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88
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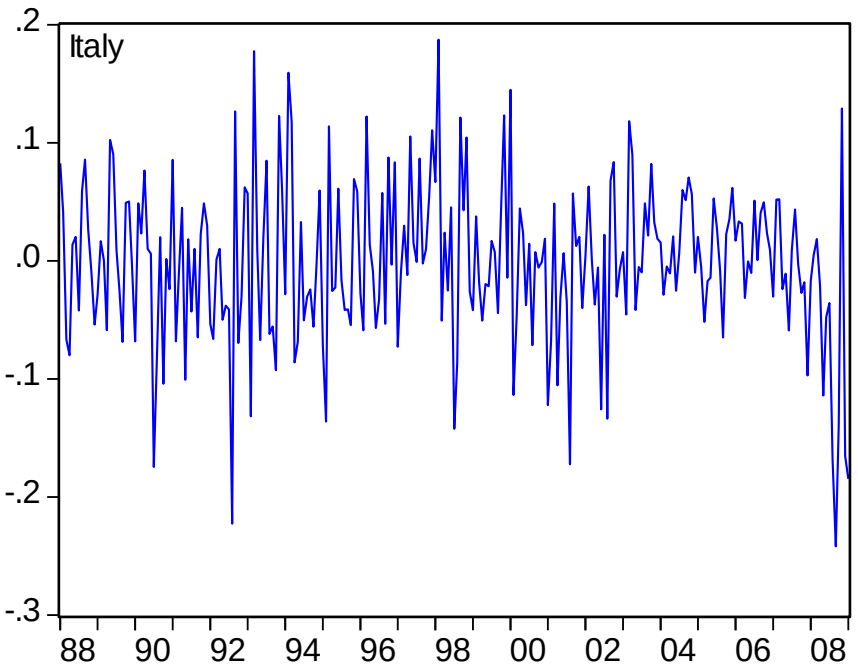
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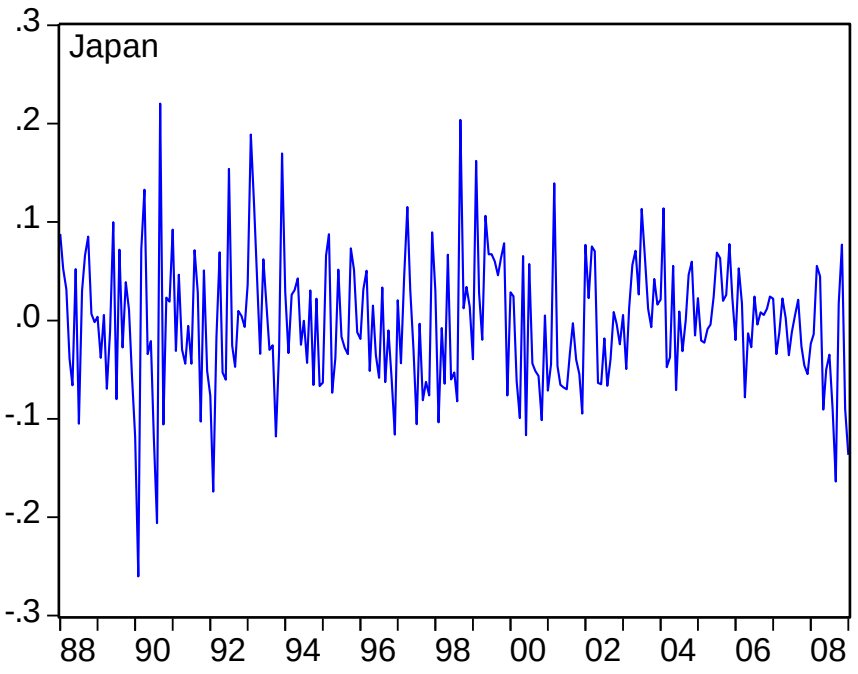
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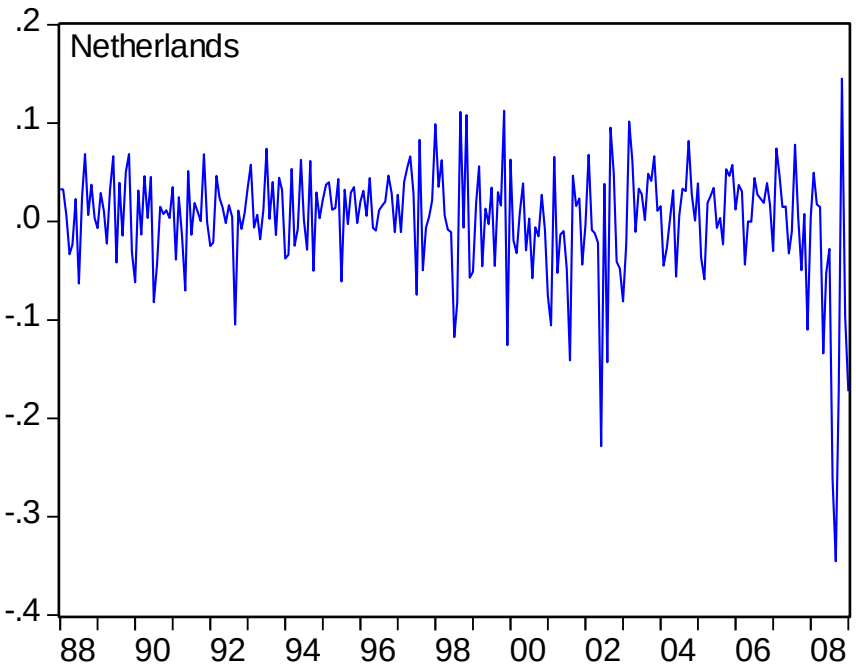
Netherlands
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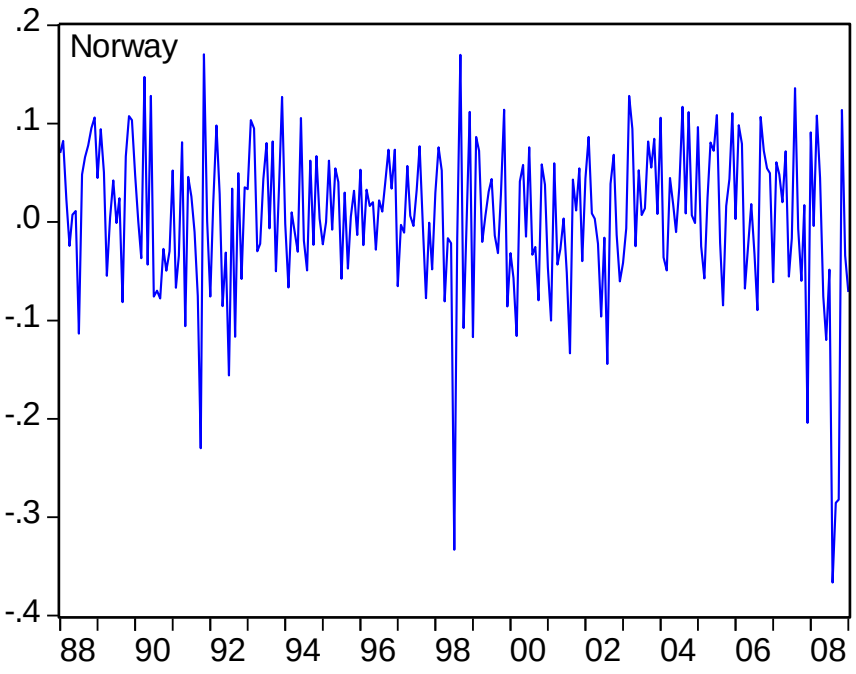
Norway
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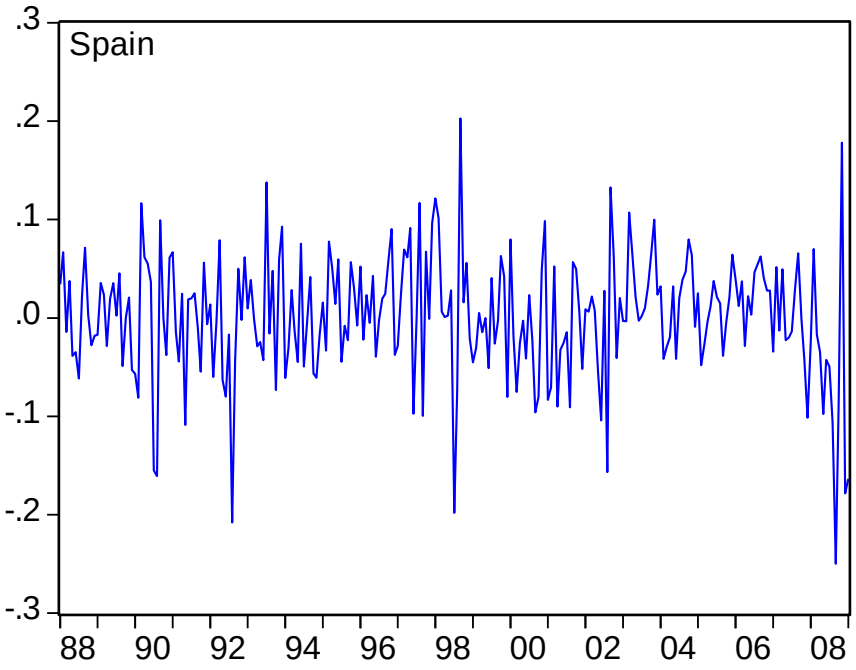
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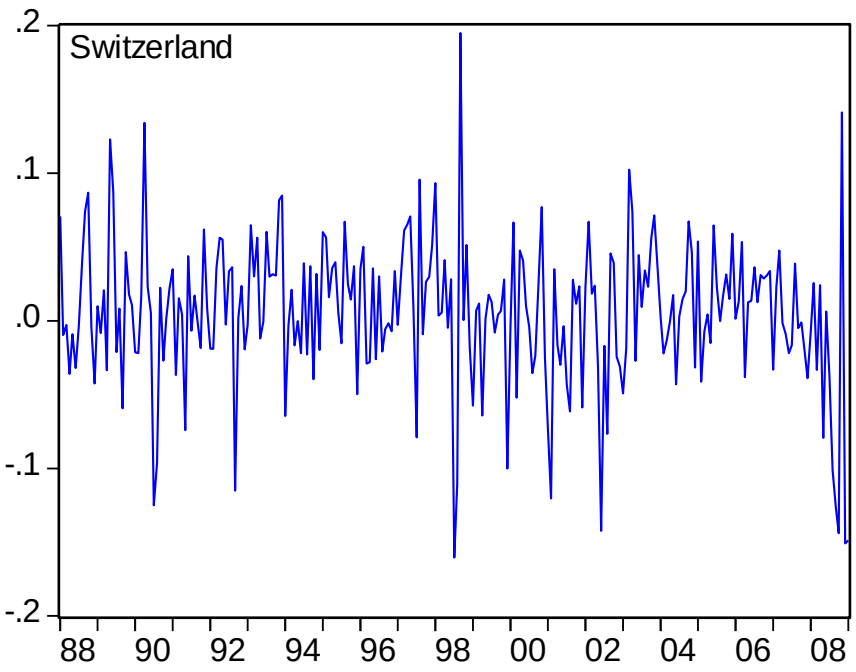
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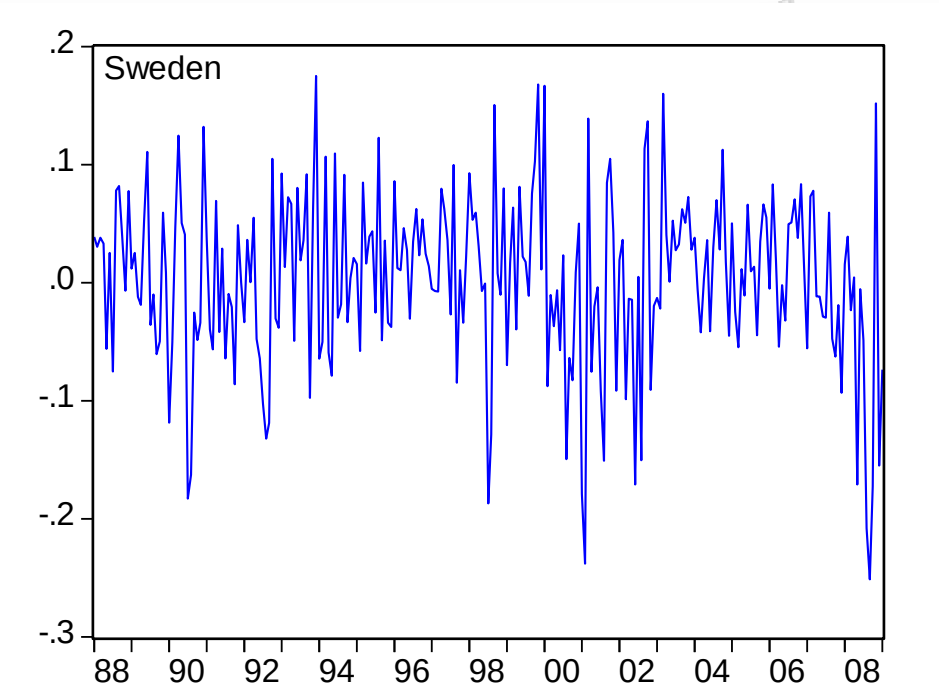
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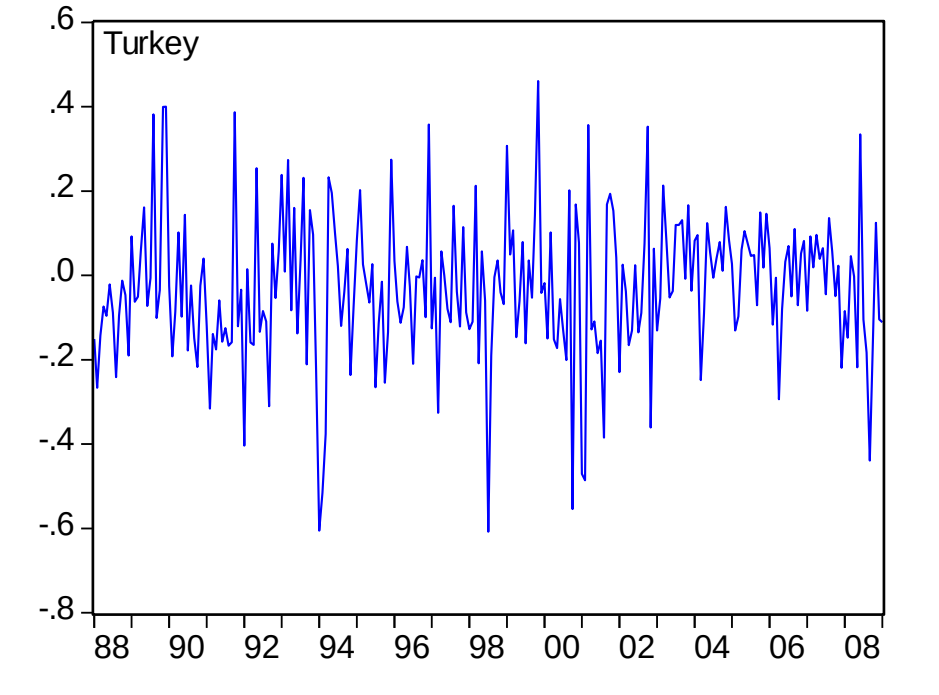
Turkey
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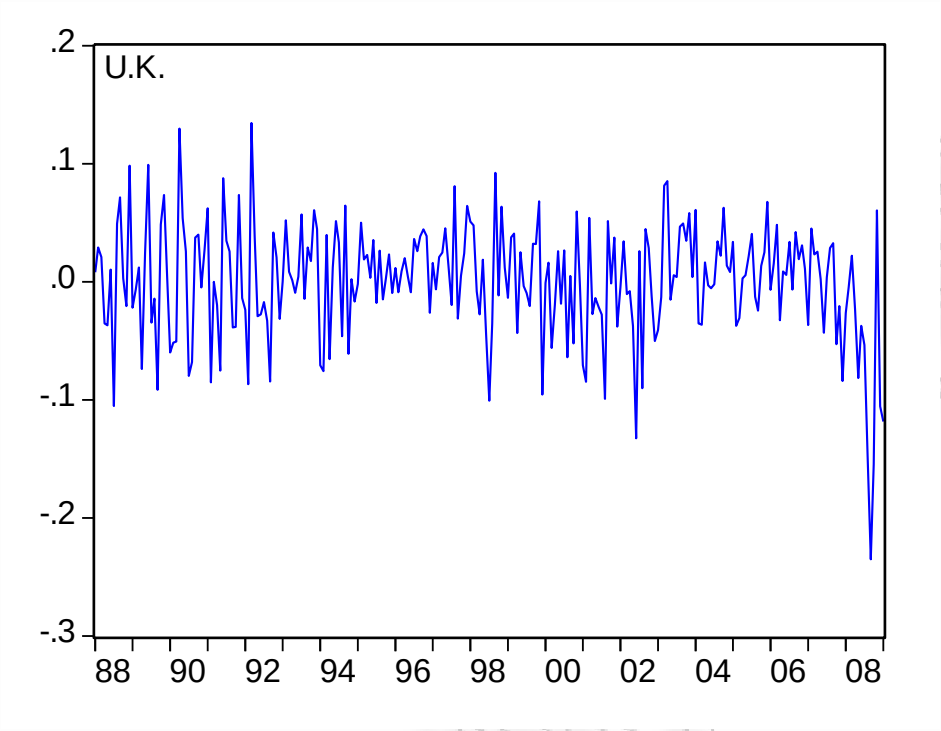
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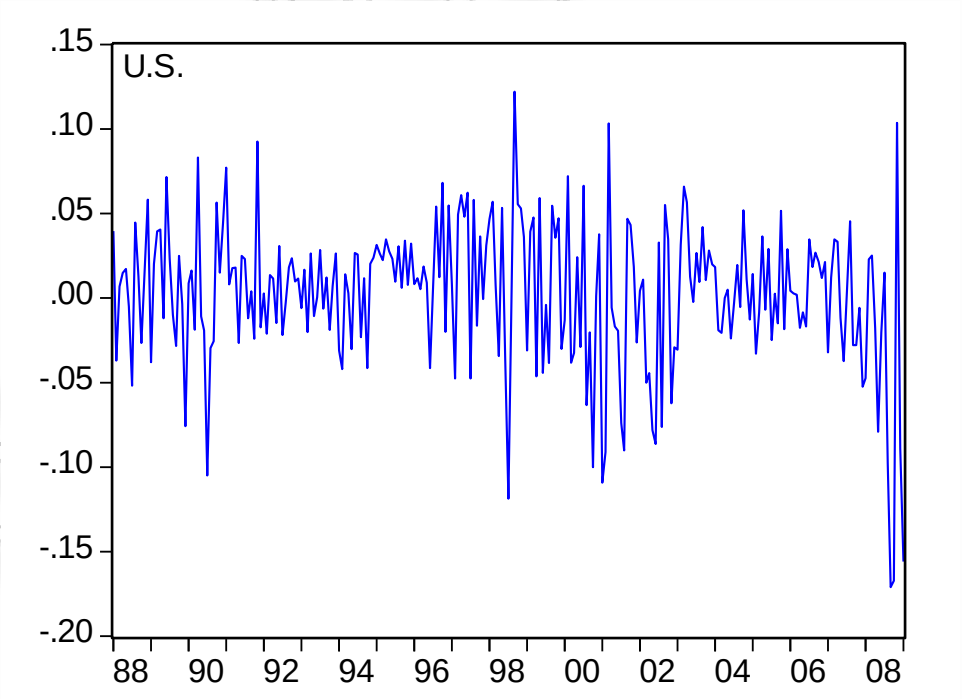
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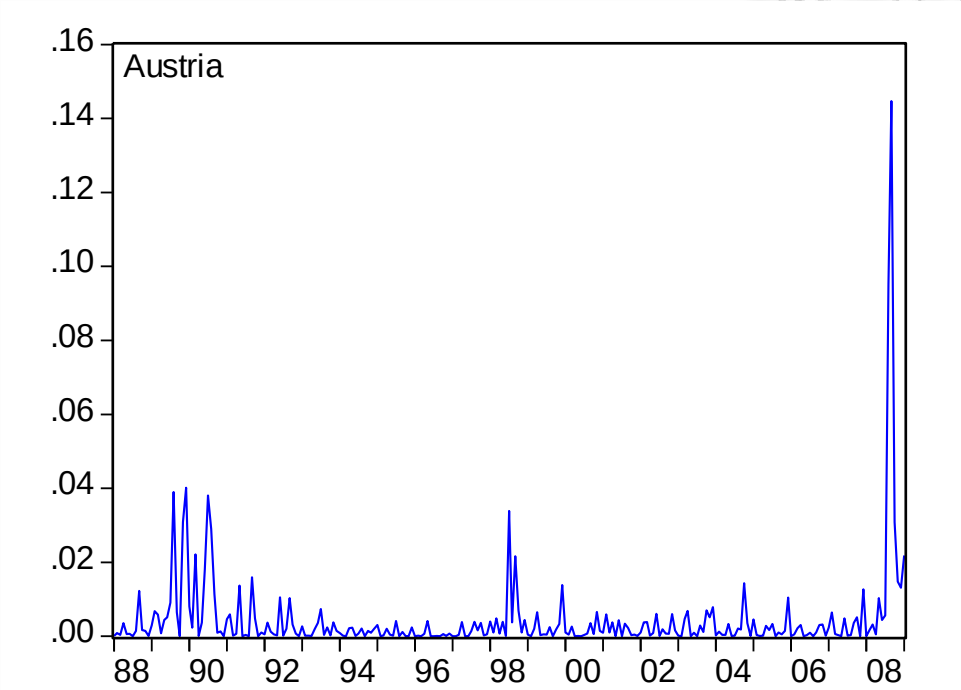
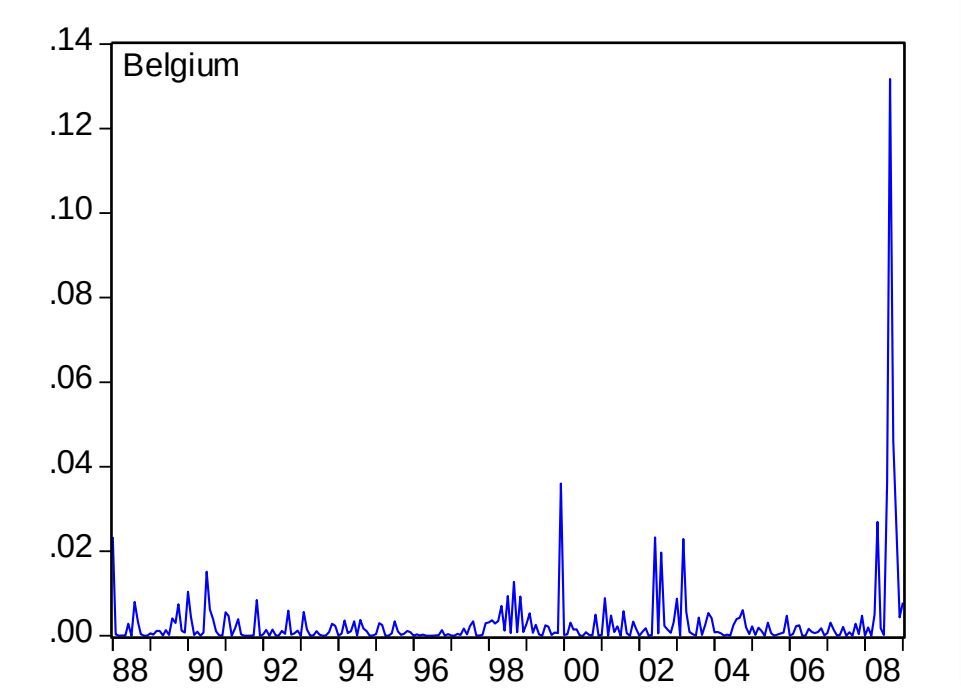
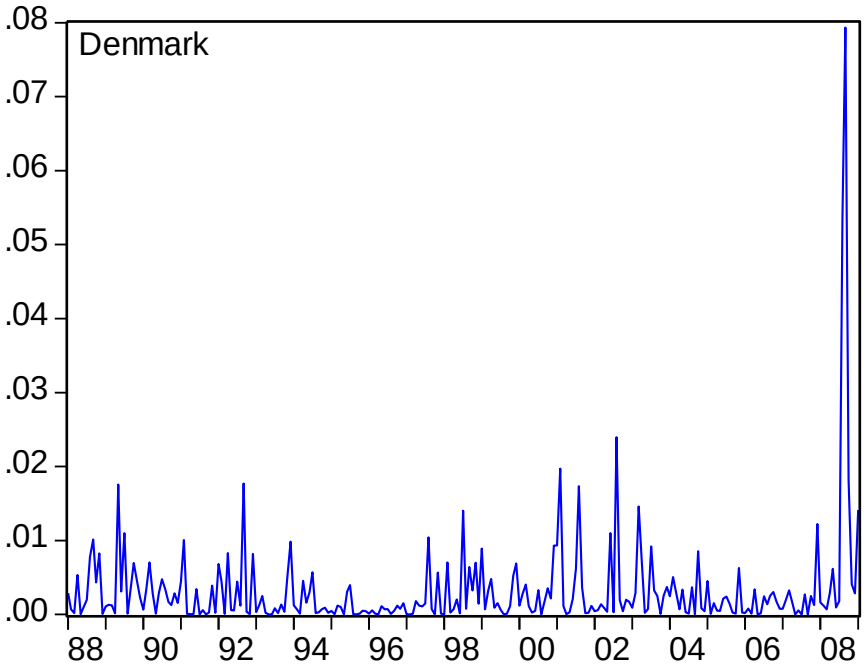
12. APPENDIX C

- Graphs of Squared Real Returns of the sixteen Stock Markets
1/2/1988 - 1/3/2009






Denmark
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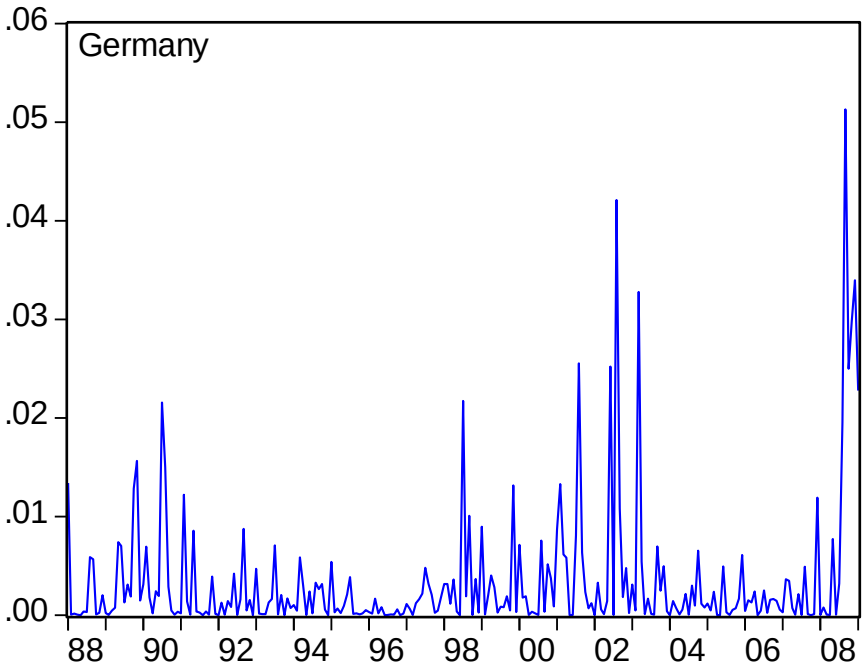
Germany
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96
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02
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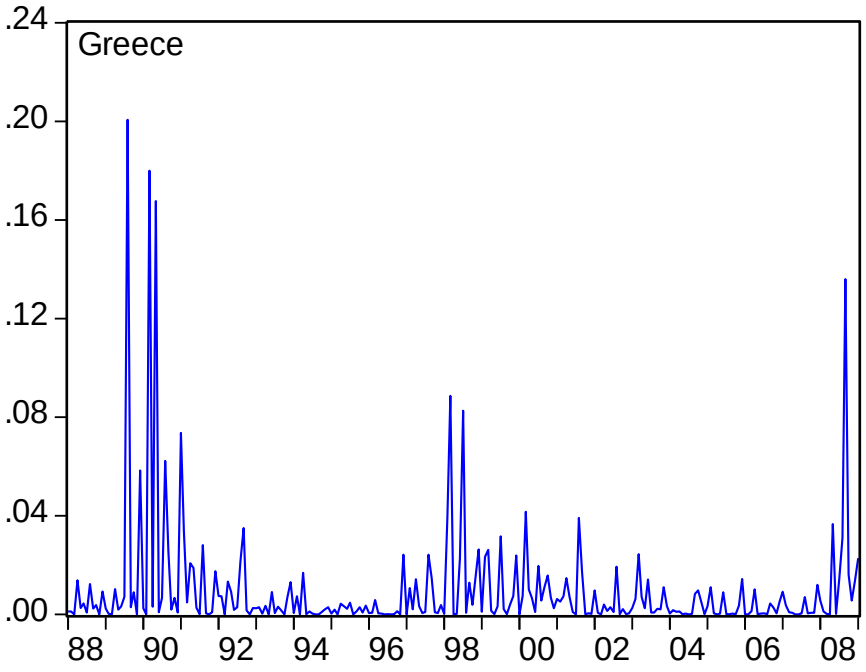
08


Greece
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02
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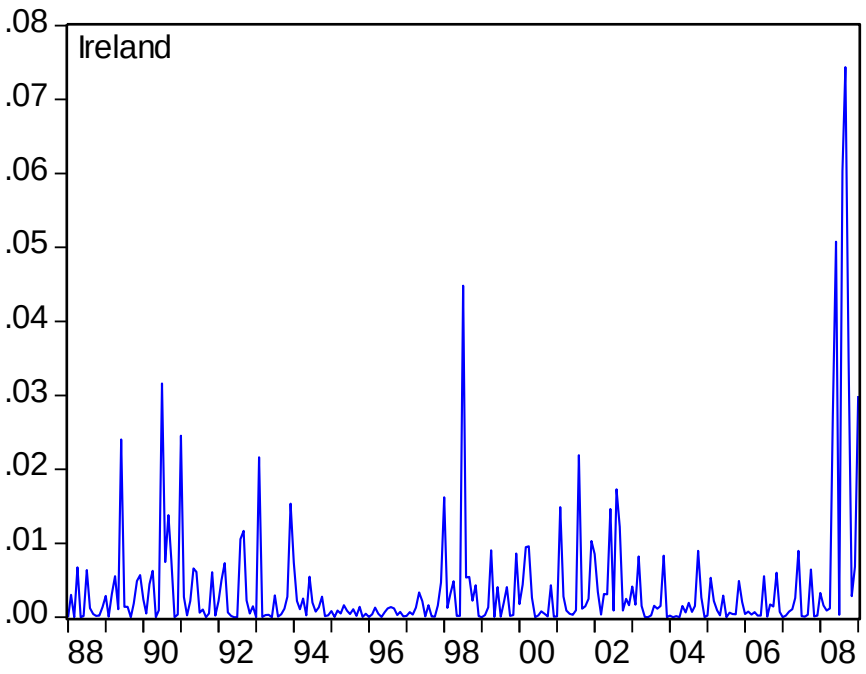
08


Ireland
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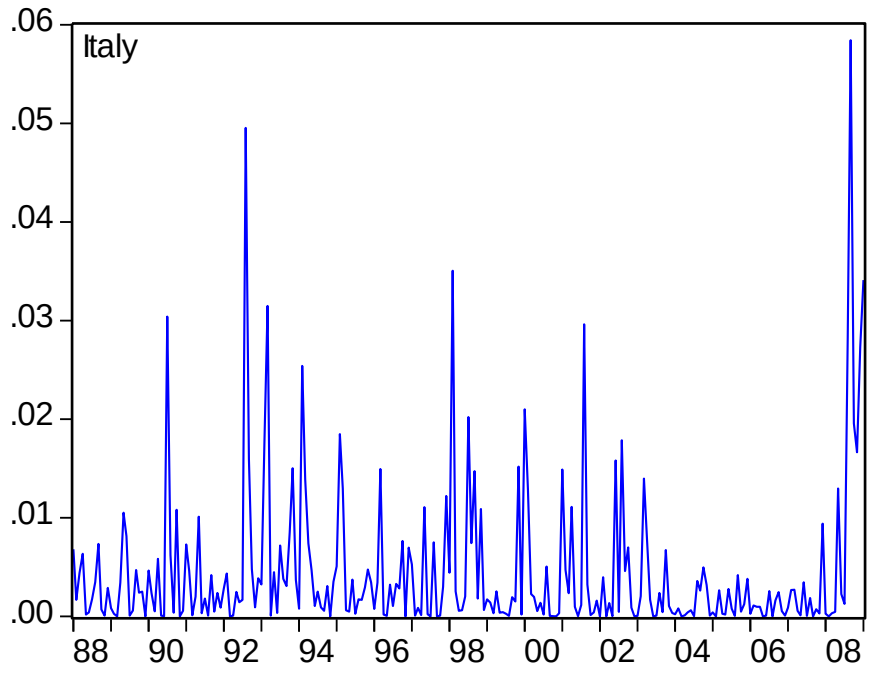
Italy
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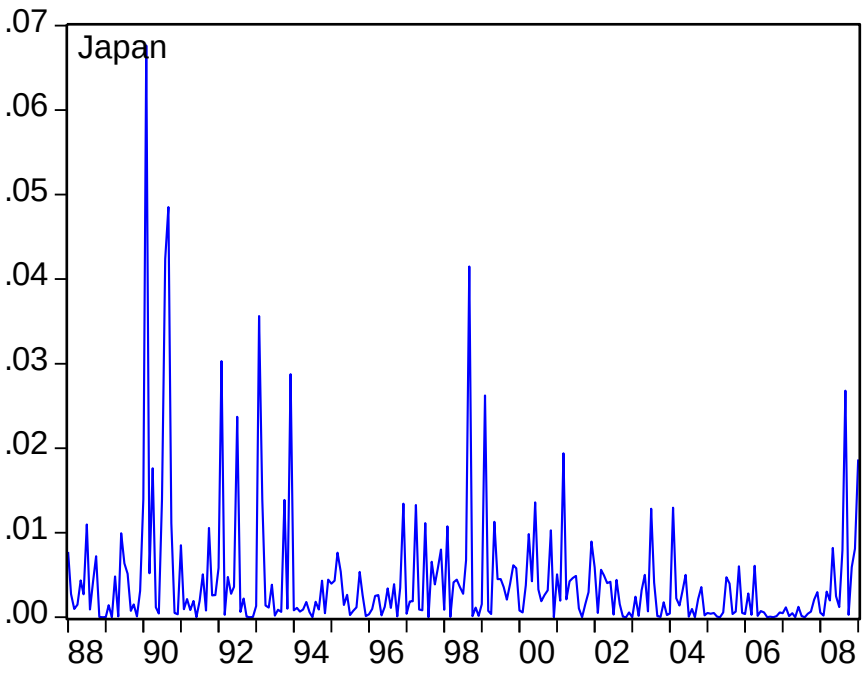
Japan
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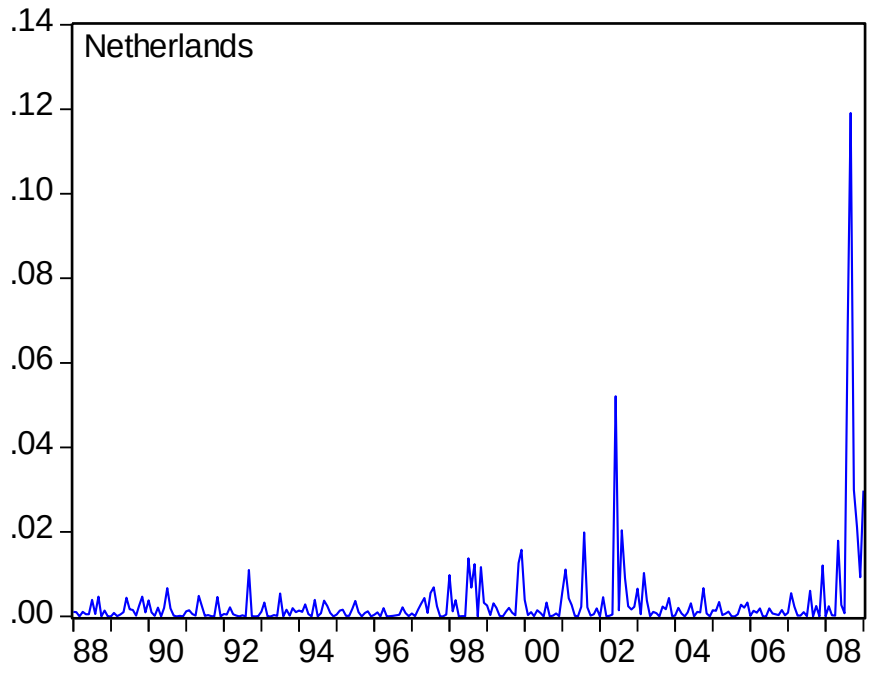
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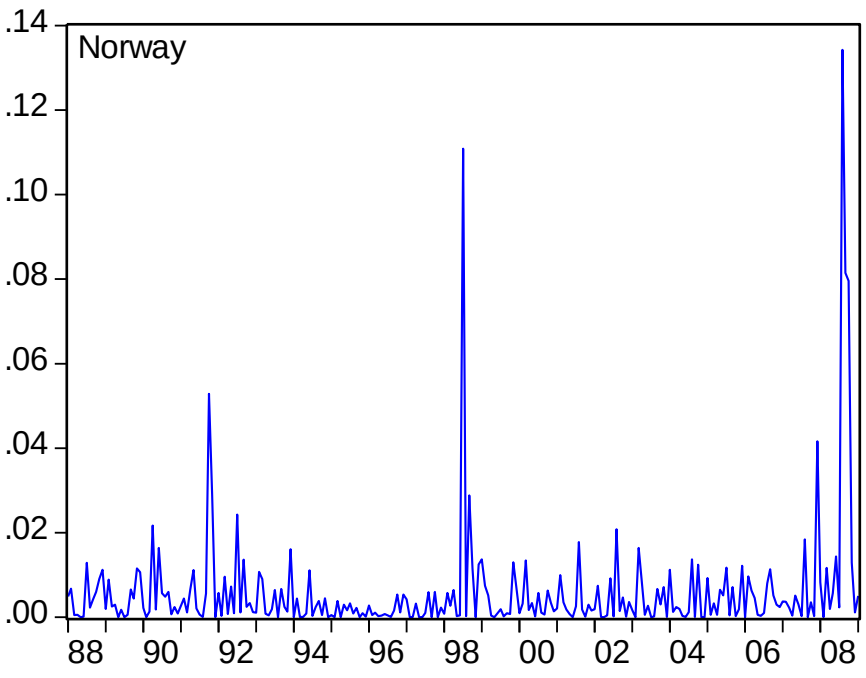
Norway
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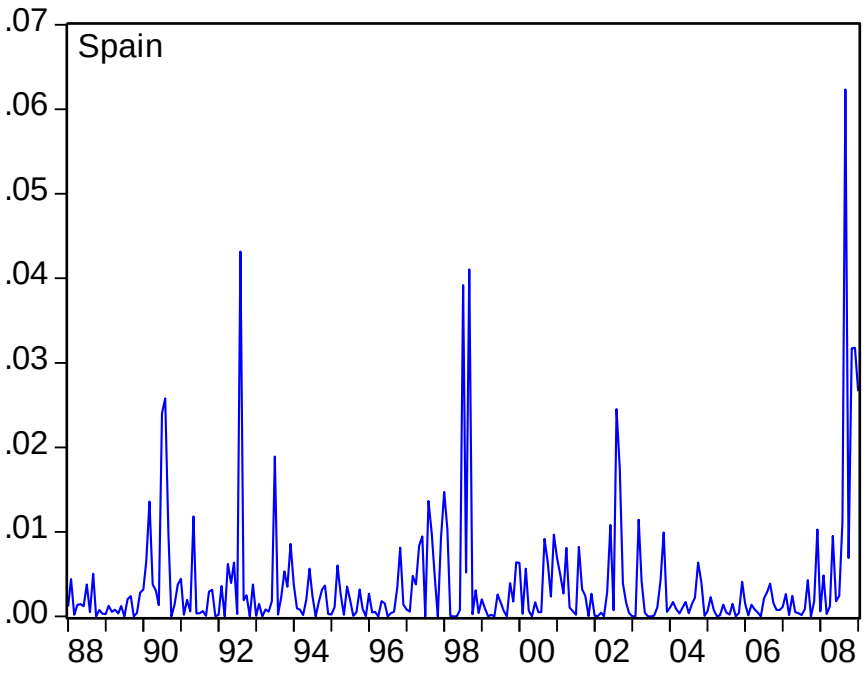
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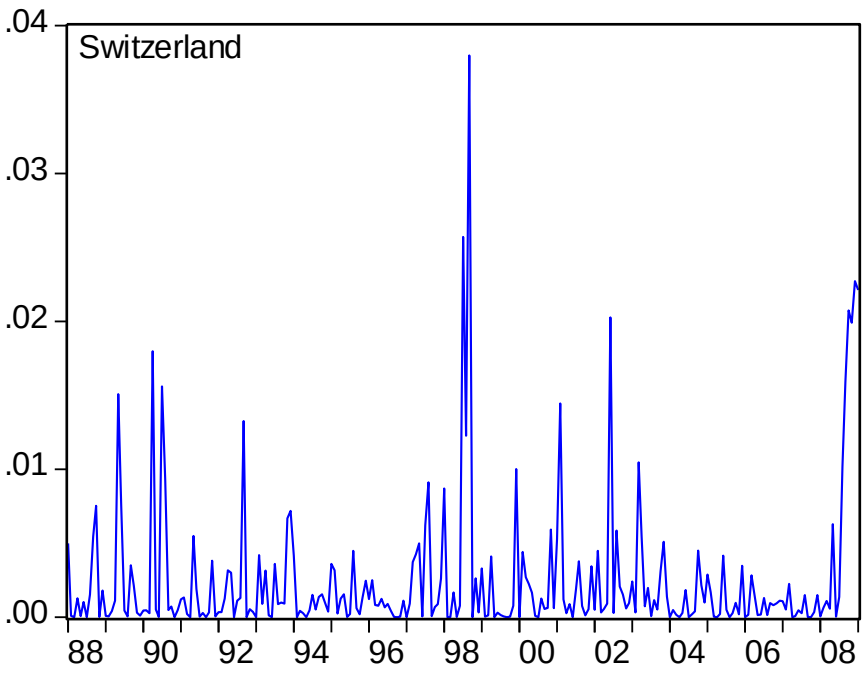
Switzerland
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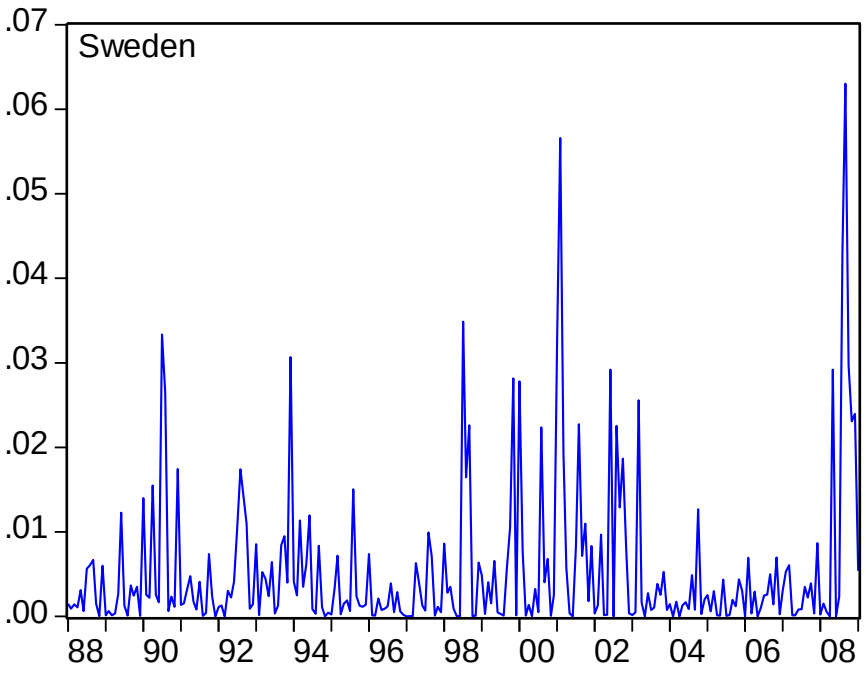
Sweden
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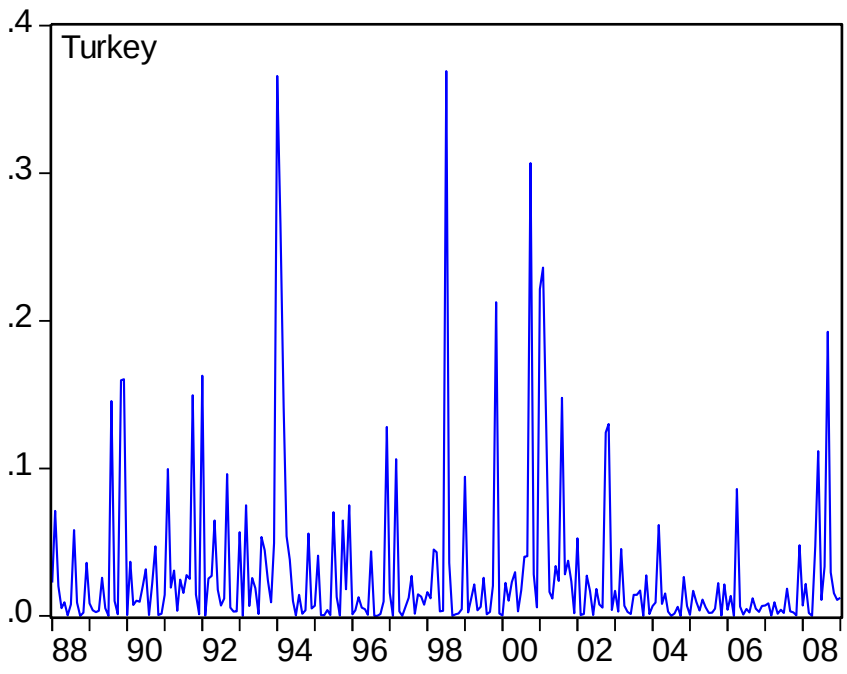
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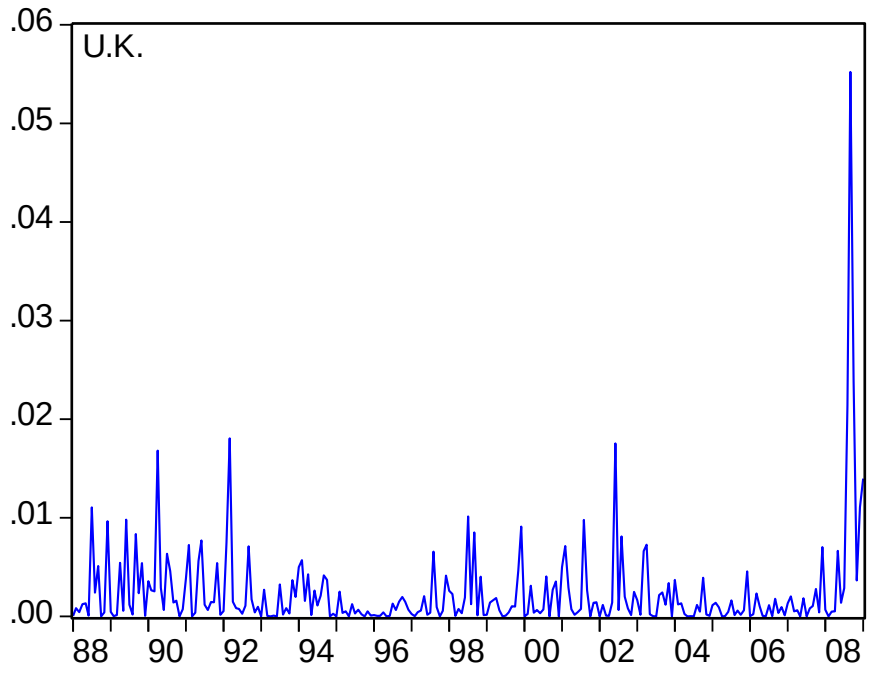
U.K.
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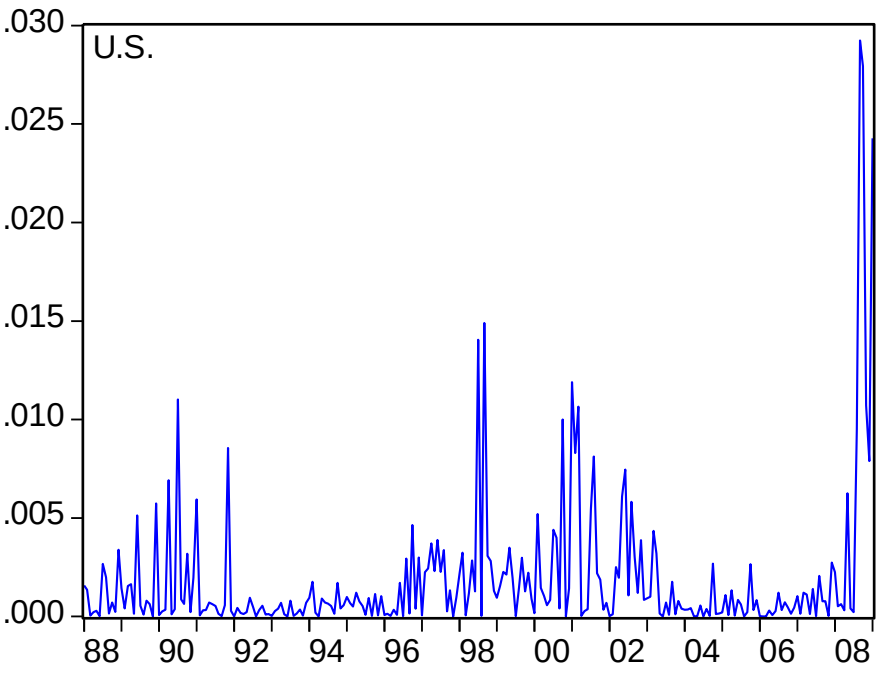
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