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Faculty of Social Sciences
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MASTER'S THESIS

European Stock Markets Integration

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently; using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

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Prague, July 30, 2015

Signature

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Abstract

This thesis examines the integration of European stock markets, focusing on the affect of the EU and Eurozone. Moreover, the thesis analyses whether increasing integration is a local trend possibly caused by the EU and Eurozone, or whether either the Japanese or American stock market gets more integrated with the European ones as well. We study the integration using weekly data of eighteen European stock markets and stock markets of Japan and the US over the horizon of twenty years. The method used is an extension by Klöessner and Wagner (2012) of a method originally introduced by Diebold and Yilmaz (2009). We find a positive effect of the EU on the integration of the stock markets. Also, the integration is rather local as the American and Japanese stock markets are proved to not have a higher increase in integration with the European stock markets that they have with each other. Finally, we find the Eurozone does not have an immediate positive effect on the integration of the stock markets.

Keywords Stock markets integration, Spillovers, EU, Eurozone, Diebold and Yilmaz

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Abstrakt

Tato práce zkoumá integraci Evropských akciových trhů se zaměřením na vliv EU a Eurozóny. Navíc je také zkoumáno, zda je zvyšující se integrace pouze lokální trend nebo jestli se také japonský nebo americký akciový trh více integrují s těmi evropskými. Integraci pozorujeme za použití týdenních dat osmnácti evropských akciových trhů a akciových trhů Japonska a Spojených států v horizontu dvaceti let. Použitá metoda je rozšířením metody Diebolda a Yilmaze (2009) provedené Klöessnerem a Wagnerem (2012). Výsledky ukazují pozitivní efekt EU na integraci akciových trhů. Také se ukazuje, že integrace je spíše lokální, protože se dokazuje, že americký a japonský akciový trh nemají vyšší růst integrace s těmi evropskými, než oni mají mezi sebou. Nakonec výsledky ukazují, že Eurozóna nemá okamžitý pozitivní vliv na integraci akciových trhů.

Klíčová slova Integrace akciových trhů, Spillovers, EU, Eurozóna, Diebold a Yilmaz

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Acronyms

AIC Akaike's Information Criterion

ADF Augmented Dickey-Fuller

CEE Central and Eastern European

CEEC Central and Eastern European countries

CR Czech Republic

EMU European Monetary Union

EU European Union

KPSS Kwiatkowski-Phillips-Schmidt-Shin

SOI Spillovers Index

SOT Spillover Table

UK United Kingdom

US United States

VAR Vector Autoregression

Master's Thesis Proposal

Author:	BSc. Tereza Vildová
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Defense Planned:	June 2015

Proposed Topic:

European region: integration and stock market evaluation

Motivtion:

With regards to the theory of optimum currency areas suggested by Mundell (1961) and also in order for an economic union to be efficient, it is crucial for the certain region to be integrated. The integration is important in many sectors of the economy. Nevertheless, the thesis will focus on the European region and its financial integration, as it is a topic of high interest especially after the recent financial crisis 2007-8 and for countries that are members or are about to become the members of the European Monetary Union.

As Büttner and Hayo (2011) point out, the importance of the integration of the financial stock markets lays in the free flows of capital to places with the highest return, and easier access to foreign capital. Moreover, with higher level of integration, the chances of arbitration decreases and that makes the markets more efficient. However, that comes along with an increase of the level of impact of crisis in other parts of the world. Although there are authors that looked into the issue of the European Region, its integration and its stock markets and how they are influenced from the inside; this thesis will focus on the integration of the European stock markets and also to what extent, if any, the stock markets of other parts of the world (for example, the US stock markets or the Japanese stock markets) affect the European ones, to what extent they are influenced from the outside. And I will be able to compare the level of correlation of the European stock markets between each other to the correlation of the other countries' stock markets with the European region.

To analyse the integration, data from the largest indices of Europe will be collected and as Clare et al. (1995) did in their study, the method of Dickey and Fuller (1979) will be used. To take into account whether the markets have achieved or are achieving convergence, this method will be combined with a method of Brada's et al. (2005), called jumping cointegration.

Hypotheses:

1. Hypothesis #1: The European stock markets continue to integrate, as new countries join the EMU.
2. Hypothesis #2: The European stock markets are more correlated with each other than they are with stock markets of other continents.
3. Hypothesis #3: The major stock markets of other parts of the world affect the major European stock markets.

Methodology:

To test the hypotheses of convergence of any two time-series data, Clare et al. (1995) uses the method of Dickey and Fuller (1979). The long run relationship of the two variables, which will be the various combinations of two of the stock market indices, will be taken into account. This linear relationship is written in the following equation:

$$I_i = \alpha_0 + \alpha_1 I_j + e_i,$$

where I_i and I_j are the stock market indices of two countries and e_i is the country specific factor. The procedure applies an Augmented Dickey Fuller (ADF) (1979) test on each the countries' data and also on the residuals, e_i, from the equation above. The null hypothesis is that, if two variables that are stationary after first differencing, I(1), give a combination of I(0), they are cointegrated (Engle and Granger, 1987). To make visible also the development of the convergence, the thesis will follow Brada's et al. (2005) suggestion of jumping cointegration, which take several sub-periods from the original sample and analyse them separately.

Expected Contribution:

Into the current discussion in the academic literature, I plan to bring more recent results that combine the integration of the EU with influences from the outside world. It is expected to prove the continuing integration within the European stock markets. Moreover, the expectation also is to see a certain level, even an increasing level, of convergence of the European and other stock markets. This, however, should not be as high as the level of convergence on Europe. As the EMU has not existed for long, there is never enough studies focusing on it and testing it as it may be beneficial for both the market participants and the policy-makers.

Outline:

1. Introduction – I will introduce the topic and explain the motivation behind it.
2. Literature Review – I will present the literature that is concerned with these or similar issues. Plus, I will focus on what their methodologies, findings and conclusions were.
3. Data – The data used for the empirical part will be introduced, including their sources, the sizes of the samples and the frequency of the samples.
4. Methodology – I will explain the methods used to test the hypothesis.
5. Empirical Results – I will analyse the data using the method suggested in the section of methodology, and see and comment on what results I will get.
6. Conclusion – I will summarise the thesis, pointing out the findings and their potential effects on market participants and policy-makers.

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Author **Supervisor**

1 Introduction

With regards to the theory of optimum currency areas suggested by Mundell (1961) and also in order for an economic union to be efficient, it is crucial for the certain region to be integrated. The integration is important in many sectors of the economy. Nevertheless, the thesis will focus on the European region and its financial integration, as it is a topic of high interest especially after the recent financial crisis 2007-08 and for countries that are members or are about to become the members of the European Monetary Union.

As Büttner and Hayo (2011) point out, the importance of the integration of the financial stock markets lays in the free flows of capital to places with the highest return, and easier access to foreign capital. Moreover, with higher level of integration, the chances of arbitration decreases and that makes the markets more efficient. However, that comes along with an increase of the level of impact of crisis in other parts of the world. Although there are authors that looked into the issue of the European Region, its integration and its stock markets and how they are influenced from the inside; this thesis will focus on the integration of the European stock markets and also to what extent, if any, the stock markets of other parts of the world (for example, the US stock markets or the Japanese stock markets) affect the European ones, to what extent they are influenced from the outside. And we will be able to compare spillovers from and to the chosen European stock markets with each other.

The thesis begins with a literature review. Papers analyzing the issue of integration of stock markets within Europe are introduced. Their analyses are described as well as what they found out.

The following part of the thesis is about the data used for our analysis. To analyse the integration, data from the largest indices of eighteen European countries, the US, and Japan will be collected. The eighteen European countries are Austria, Belgium, the Czech Republic, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Netherlands, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, and the United Kingdom. We present where the data was accessed, how long is the sample period and the descriptive statistics are given. Furthermore, the data is tested for stationarity.

Then, we get to the part of methodology used for the analysis. As Baruník, et al. (2013) did in their study, the method of Diebold and Yilmaz (2009) will be used. Furthermore, the extension of the method by Klössner and Wagner (2012) will be used. It starts with a detailed description of the method of Diebold and Yilmaz (2009) and then it shows how Klöessner and Wagner (2012) follow their method and improve it. Their methods are based on VAR and its following Forecast Error Variance Decomposition. The result of this method is so called Spillover table, which gives the spillover values going from a country to another country and the other way round for each pair of the twenty stock markets' volatilities used in this analysis.

This brings us to the most important part of the thesis, the results. The results are split into four parts. The first part shows the evolution of the stock markets of each country separately. It is done by using rolling analysis, which is then presented in graphs. The following parts each analyses one hypothesis. The first hypothesis states that during the first two years after becoming a member of the European Union, a country's stock market becomes more integrated with other European countries' stock markets.The second hypothesis says the European stock markets are becoming more integrated with each other than they are with the stock markets of the US and Japan. And the third hypothesis states that Within three years after joining the Eurozone, the level of a country's stock market integration with the other members' stock markets improved more than with the European stock markets as a whole and the stock markets of the EU. In the end, the conclusion is given.

2 Literature Review

This part of the paper reviews the literature concerned with the issue of the integration of European stock markets. It starts with discussing whether the stock markets of Europe are integrated or not. Also, factors influencing the level of integration are given. This is followed by a discussion of to what extent the integration was caused by the establishment of the EMU. Then, the literature review ends with the level of integration between the European stock markets and the US's and Japanese ones.

Schich and Kikuchi (2003) study the level of integration and consolidation of two elements of the financial sector, the first one is banking sector and the second one is stock exchanges. This paper is only concerned with what they find out about the stock exchanges. According to them, the increasing worldwide integration of the financial markets was mostly affected by capital accounts liberalisation, financial deregulation and advances in information and telecommunications technology, as well as the policy action specific to the case of the European Union. Despite of several barriers that still slow down the consolidation of the stock exchanges in the EU, factors that are rather EU-wide than country-specific affect the returns in different European suggesting consolidation of the markets and increasing level of integration. Such an increase of integration of the stock markets in the European sector started with the emergence of an equity culture in this part of the world.

The findings of the study of Bracker et al. (1999) also suggest integration. However, they examine the integration of the stock markets from all over the world. They focus on different degrees of co-movements of different pairs of national equity markets over time. The main idea is that certain macroeconomic variables, specific to two countries being tested, affect the level of integration between these two countries. Greater stock markets integration is assumed when there is a greater degree of co-movement found in the analysis. The analysis is done on nine national equity markets, namely the markets of Japan, Australia, Hong Kong, Singapore, Switzerland, Germany, UK, US and Canada, over 22 yearly samples. They suppose there is a chance the stock market integration for two certain countries varies

systematically and that may be due to the degree of economic integration of these two countries that varies over time. Hence, they first examine how the degree of co-movements for two certain countries' stock markets changes over time and then why the degree of co-movement changes over time.

The results show that over the sample period of twenty-two years, there were apparent mostly same day inter-market responses between all pairs under the measurement. It was found that all possible pairs of national markets show the same significant co-movements on the same day, which means they are highly integrated and also efficient. Some adjustments after the one day periods were found which suggests, for this given measured period, there was potential left for higher degree of integration. Bracker et al. (1999) also point out the tendency of these nine stock markets to become more integrated. The potential macroeconomic factors were analysed to the extent of the same day and leaderlag relationship. It was found that the macroeconomic factors that significantly influence the stock markets integration over time in the same day relationship are "two measures of bilateral import dependence, the geographic distance between markets, the size differential across markets, a time trend, and dummy variables for different blocks of countries whose trading hours overlap" (Bracker et al., 1999, p. 25). Furthermore, there was found a significant influence on the integration only by two variables for the leadrlag relationship across days. The variables were the real interest "differential between markets and the market size differential" (Bracker et al., 1999, p. 25).

Another study that found increasing integration of the European stock markets was written by Caporale and Spagnolo (2012). They looked at the issue from a different point of view as they examined the volatility linkages between stock markets rather than their co-movements. Plus, the focus of the study was not on the largest and strongest markets, but on rather small ones. The markets were three of the Central and Eastern European countries (CEECs), in particular, the Czech Republic, Hungary and Poland. The authors used a model that allowed them to see whether the possible effects of the EU accession on existing volatility spillovers were rather interdependent or contagious. They suppose that if the regional financial integration increases after May 2004, when the three countries joined the EU, it could be

interpreted in a way that the stock markets of the older EU countries have even more common significant influence.

The results provide an evidence for their hypothesis, as they suggest that since the three countries joined the EU in 2004, the regional linkages have become stronger. Substantial shifts in the spillover parameters were found after the accession of the EU. Moreover, because of that, the stock markets of these countries have become less attractive for investment strategies that involve diversification as the diversification is not as effective as before. Also, the markets have become more mature and integrated with the rest of the EU. Hence, as their sensitivity to outside developments has increased, the linkages among their own region itself strengthen as well. Caporale and Spagnolo (2012) therefore suggest there are several changes to the policy responses to shocks originating in this region and for maintaining the stability needed.

On the other hand, Dunis et al. (2013) find that the integration between other small countries and the EU or euro area is rather low or none. They follow with a study about the newest members of the European Monetary Union, namely Cyprus, Estonia, Malta, Slovakia and Slovenia, and their level of integration of euro area. Moreover, the main focus was on the speed of integration between the stock markets of the member states of the EU and the rest of the euro area. The results show that the degree of integration for Malta and Slovenia is increasing. The opposite, however, is found for Estonia, which seems to be rather segmented. Talking about increasing financial integration, joining the EU had a positive effect on Slovakia and Cyprus. Nevertheless, it lasted only till they joined the euro area as well, because since then, their integration started decreasing.

To sum it up, as the Maltese and Slovenian stock markets react more sensitively to shocks from the markets of the mature European countries, they show either stable or increasing integration over the whole sample from 2003 to 2011. The other three countries, Cyprus, Estonia and Slovakia, appear segmented. Jappelli and Pagano (2008) explain few reasons for why that may have happened. It might have been because of the small size of those stock markets or differences in the regulations applying to financial intermediaries, tax treatment, issuance policy or availability of information. Dunis et al. (2013) then conclude that for all the new members, the EU

regulatory framework and currency do not provide stable and increasing degree of integration.

As there are speculations of whether the single currency in Europe was to blame for the increased rate of integration or it was because of other factors, it is also good to look into earlier studies and see what they say about the integration before the launch of euro. Hardouvelis et al. (2006) concentrated on the 1990s. They say this decade was about harmonization, convergence in bond yields and inflation rates, and strict fiscal policy; therefore, they want to find out to what extent the stock markets were integrated. The results confirm that as the launch of euro was approaching, the EU-wide market risk, rather than a country-specific one, was more and more affecting the returns on the stock markets and their integration increased remarkably. Unlike the papers by Dunis et al. (2013) and Bracker et al. (1999), this paper also very much supports the hypothesis that the EMU and its prospects were the reasons for the increase in stock market integration among the countries that joined the euro area. The supporting arguments are that the UK, which has not become a member of the euro area, never converged toward integration with the rest of the European stock markets; and that the integration in the euro area does not follow any, either European or worldwide trends, but it is rather specific to this monetary union. Nonetheless, as mentioned above, Bracker et al. (1999) found that the stock markets of the nine countries from different continents were all integrated, which suggests the integration has nothing to do with the European Union, neither it has anything to do with its monetary union.

However, the study by Chelley-Steeley (2005) offers an opposite argument to the claim that the integration within Europe is only a phenomenon specific to the monetary union. Looking at the integration of the stock markets in Europe with no regards to the euro area, she concentrates on the level of integration, or it is probably more suitable to say segmentation at first, in Hungary, Poland, the Czech Republic and Russia. The aim is to also find out how fast these countries are in getting less segmented. The time range of the data being tested, from 1994 to 1998, let us see that in the early 1990s, these four countries had heavily segmented stock markets. Nonetheless, later on, they have become more integrated. Especially Polish and Hungarian stock markets have become the most integrated ones. External equity

markets started affecting these two markets more than the Czech or Russian one. Although much more slowly than in the case of Poland and Hungary, the Czech stock market has also become more integrated. The Russian one was showing increasing integration until 1997, but then this trend changed. Therefore the Russian stock market remained the most segmented stock market out of these four ones.

Johnson and Soenen (2009) use data from 1980 to 2006 to find out to what extent the returns of the stock markets of fourteen European Union countries co-move with the returns of the stock market of Germany. They found out a high level of co-movement between Germany and twelve out of the fourteen countries. Between the remaining two, Luxembourg and Greece, and Germany, there was found a contemporaneous association to a lesser extent. This paper also provides another argument, agreeing with Hardouvelis et al. (2006), supporting the hypothesis of EMU being the driver of stock markets integration among Europe. The argument is that all of the stock markets under the measurement were showing same-day inter-market responses from 1999, when euro was launched, to 2006, the final year of the sample. This suggests that the markets are both highly integrated and highly efficient, as the integration on the same day is significant. Johnson and Soenen (2009) present the reason for such increase in the degree of co-movements, or what might slow it down. The co-movement is positively affected by the percentage of world equity market share in an EU member country with that of Germany, greater foreign direct investment from Germany to other members of the EU, being a member of the euro area itself, and time. On the other hand, it is slowed down by a higher share of imports by Germany from other EU countries and by an increase percentage change in the level and volatility of the bilateral exchange rate.

Kim et al. (2005) look exactly at the issue discussed in the articles above only as a side result. The aim of their paper is to examine to what extent the dynamic process of stock market integration is influenced by the European Monetary Union. They use the time framework from 1989 to 2003. The result of this analysis was pretty much the same as the result of the study by Hardouvelis et al. (2006). In the first, half of the 1990s, the intraregional and inter-regional stock market integration could be defined as highly volatile. Then, with the approaching year of the introduction of euro, the stock markets showed a significantly higher level of integration. After 1999 to the

end of their data sample, they confirm stronger and more stable process of integration than before for all the countries that were member of the EMU during this period. This and the unidirectional causality from the political creation of the European currency union that was found, suggests that the EMU was the reason for the stock markets' integration. The findings also suggest that the higher degree of integration could be rather explained as caused by the monetary union and the macroeconomic convergence that followed it, than by the elimination of the risk of foreign exchange rate. Nevertheless, they note that the integration depends on the current state and development of the financial sectors. This applies to the case of EMU as well, as the currency stability was significant in defining the stock market integration only within the smaller members that were experiencing historically different economic structures.

Kim et al. (2005) also discuss a global level. Since 1979, when the European Monetary System was introduced, the stock market integration between EMU and the US was significantly strengthened by the commitment to price stability. The EMU integrated more with Japan as well, that was due to the convergence of the industrial production.

Savva and Aslanidis (2010) concentrate in their study on five Eastern European countries and the euro area, when measuring the stock market integration. These five stock markets, namely the Czech, Slovakian, Slovenian, Polish and Hungarian ones, have undertaken important processes of financial reform and development and therefore, the authors consider the analysis to be of high interest, mainly for investors and diversification. The study found out the degree of correlation between the Czech, Slovenian and Polish stock markets and the euro area's one had increased significantly in the period between 1997 and 2008. This, however, does not apply to all the Eastern European countries. Hungary show a high correlation without any increase in that period and the stock markets of Slovakia are correlated very purely with the euro area. The study also shows the integration is rather due to the EU factors and its development than that it would be driven by world-wide phenomenon of integration.

As well as Savva and Aslanidis (2010), Syllignakis and Kouretas (2010) are concerned in their study with the Central and Eastern Europe. They examine the

relationships of Czech Republic, Poland, Hungary, Slovakia, Slovenia, Estonia and Romania with two more developed countries – Germany and the US. For the period under this analysis of local stock price indices, 1997 to 2008, the stock markets, in the long run, have more common trends than cointegrating relations, and therefore, they show partial integration. Moreover, it was found out that as the EU began the accession process, the CEE stock markets and the world stock markets started to be more linked with each other. Another outcome of the paper says there is a significant common permanent component for the Czech Republic, Hungary, Slovakia, Slovenia, Romania, Poland, Germany and the US, which drives the system of stock exchanges in the long run. However, in the case of Estonian stock market, segmentation is apparent. Both, the Estonian and Romanian markets are more variable in deviations from the common trends or permanent component than the other markets under examination. Regarding the common trends, the majority of these stock markets show significant deviations from them. One exception to such deviations from common trends is, for example Slovenian market, which is partly influenced by the same factors as the stock markets of the US and Germany.

It is also worth to mention, the German stock markets was found to have larger portion of influence on the CEE markets and their deviations from the long run trends than the US market. Nonetheless, the convergence process between the stock markets of the CEE countries with those of the Euro area countries was slowed down during the period of the financial crisis 2007. In that period, the transitory deviations from the common trends have opposite directions for all the countries apart from Slovenia. Syllignakis and Kouretas (2010) say it is due to several problems the CEE countries were facing. Those were increasing external debt, increasing current account deficits and depreciating currencies. Then they argue that, although Slovenia suffered as well, the suffering was eased by the membership in the EMU for it and therefore, the other countries did not have to face so many negative consequences of the crisis if they became members too.

Yang et al. (2003) agrees with Kim et al. (2005), Savva and Aslanidis (2010) and Syllignakis and Kouretas (2010) and their findings about the linkage between the establishment of the euro area and increase of integration among the countries belonging to the monetary union. Their study focuses on eleven European stock

markets, namely German, French, Italian, Dutch, Austrian, Belgian, Finnish, Irish, Portuguese, Spanish and British, and the US stock market and how much they are integrated in the long-run and the short-run, especially in regards to the launch of euro and its influence on the integration of the stock markets. The effect is visible when considering the two major stock markets that are not members of the EMU as it may show whether or not being a member of the EMU is the reason for higher or lower integration. Yang et al. (2003) mention previous studies, namely Taylor and Tonks (1989), Corhay, Rad and Urbain (1993), Dickinson (2000), and Leachman and Francis (1995), that found two cointegrating vectors both before and after the launch of euro. The result of the study by Yang et al. (2003) confirms those findings; however, they also suggest stronger relationships and linkages between the stock markets of the members of the euro area after its establishment in the long-run. They say the equilibria of the markets are reset more quickly after shocks that are system-wide.

The analysis of the short-run dynamic structure of international market integration shows there is a higher degree of integration among the stock markets of Germany, France, Italy and the Netherlands which suggests that the larger the stock markets, the higher the level of integration. It was also found that the larger stock markets may affect the smaller ones and there is therefore a certain level of integration between the larger and several smaller ones. Nevertheless, the smallest stock markets from this study by Yang et al. (2003), the Austrian, Belgian and the Irish ones, have been more segmented from the rest of the members of the EMU and their stock markets after the EMU was established.

Further findings of Yang et al. (2003) are based on focusing on macroeconomic environments and they imply that as a small size of a market may be the reason for certain barriers and limitations of the market to attract international investors because of possible concerns of market liquidity, the stock markets interrelationships of, for example, Austria, Belgium and Ireland and other stock markets may not adequately reflect the situation of the macroeconomic linkages between these small countries and other ones.

The paper by Yang et al. (2003) also comes to a conclusion of the studies by Hardouvelis et al. (2006) and Johnson and Soenen (2009) already mentioned above. That is, there is an implication suggesting the significant impact of the euro area on the stock market integration of the member countries. This implication again comes from the lower degree of integration found between the euro area stock markets and the UK one. Their results did not find any pattern that would clearly show the linkage between the stock markets of the euro area and the US market. The analysis of the contemporaneous structure showed very similar results. The euro area is again found to be the reason for higher level of integration among the stock markets of the members of it as well as the UK stock market is found to have been less integrated with the markets of the member countries since the launch of the euro. They also point out that the reason for the increase in the level of integration within the European stock markets may be the technological advances, consolidations and mergers of European stock exchanges as this may have led to faster information transmission and processing. Plus, they say there are several of these channels affecting the integration of the European stock market integration and it is very difficult to distinguish between them.

Hanousek and Kocenda (2011) agree with Caporale and Spagnolo (2012). They anaylze foreign news and spillovers in three of the EU stock markets, namely the Czech Republic, Hungary, Poland. They use intra-day data on stock market index returns and EU and US macroeconomic announcements in the period between the years 2004 and 2007. They include the analysis of the effect of the announcements from the excess impact perspective. This means they distinguish between the market expectations and each announcement. Then they analyze the volatility of the returns. The main aim of their study is to distinguish between individual sources of the macro news spillovers from the developed countries to the countries with the emerging stock markets in Europe. The results show several differences when analyzing each of the three countries. Nevertheless, there were some general issues that can be assigned to all three countries under measurement found. They say the New York stock market appears to have a smaller influence on the stock markets of the three countries, while the influence of the Frankfurt stock exchange dominates the others. They point out the process of European integration itself together with narrow time window of the overlap of the European and US stock markets affect the any results

found regarding the integration of the financial markets. Spillovers from these three countries to one another are rather small. The strongest spillover effects are found from Budapest, Hungary, as the volume of foreign investors there is the largest one. The second one in the size of the spillover effects is Prague, the Czech Republic, and the third one is Warsaw, Poland. Moreover, all three markets are strongly affected by the macroeconomic news of the EU region. They, as emerging markets, are strongly determined by the mature stock markets of the EU. That is even after the macroeconomic announcements were accounted for in the analysis. They say the real economy is then affected and the reason for this is that emerging markets are sensitive to both changes in the economic situation in developed markets and also to perception changes transferred through the macroeconomic news.

3 Data

3.1 Data description

This thesis uses raw data of daily nominal local-currency stock market indices of 18 European countries and Japan and the United States of America (US) collected from Datastream. The period of the data is from 27th February 1995 to 5th December 2014. The European countries that had available data for this period and hence could be used for the analysis are: Austria, Belgium, the Czech Republic (CR), Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Netherlands, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom (UK).

The raw data are then used to calculate the volatility of their returns as for the empirics, the volatility is used. First, natural logarithms are taken from the close prices, and then the returns are calculated as the difference of the log price with its value from the previous period (in our case, the previous day). To get the volatility, the standard deviation of the logarithmic returns is calculated and multiplied by the square root of the number of periods in a year to get it annualised, in this case the square root of 252 (as there is 252 working days in a year). The standard deviation calculation is done for the five working days in each week as it is assumed the volatility is fixed within a week which consistent with what Diebold and Yilmaz (2009) assume when calculating volatility. The descriptive statistics of the log return volatilities of the stock markets can be found in Table 3.1.1.

Table 3.1.1: Descriptive statistics, Stock Market Volatility, 27/02/1995-05/12/2014

	Austria	Belgium	CR	Finland	France	Germany	Greece
Mean	0.172491	0.155170	0.170090	0.205834	0.194241	0.198067	0.232298
Median	0.138356	0.126407	0.144075	0.171936	0.162589	0.166567	0.191083
Maximum	1.362821	1.110499	1.621505	0.998483	1.185734	1.123400	1.237375
Minimum	0.015295	0.020083	0.000000	0.000000	0.016168	0.017160	0.021435
Std. Dev.	0.127307	0.110881	0.129562	0.131630	0.124428	0.130816	0.154760
Skewness	3.044592	2.592987	3.656780	1.796418	2.207211	1.932057	1.698270
Kurtosis	18.77107	14.98314	28.70547	7.898387	10.88256	8.539223	7.171719

	Hungary	Iceland	Ireland	Netherl.	Poland	Portugal	Slovakia
Mean	0.217961	0.113573	0.163827	0.182360	0.193308	0.147798	0.154786
Median	0.182554	0.083443	0.130640	0.144191	0.165582	0.124003	0.129037
Maximum	1.766452	7.858120	1.348726	1.118430	1.055934	0.947422	1.045578
Minimum	0.010304	0.009086	0.012710	0.013879	0.020954	0.008948	0.000000
Std. Dev.	0.158246	0.267188	0.121771	0.135330	0.118517	0.105140	0.121855
Skewness	3.516433	24.51561	2.696661	2.323936	2.142083	2.368726	2.097897
Kurtosis	24.54732	692.8209	16.26370	10.41553	10.79282	13.05014	10.80344

	Spain	Sweden	Switzerland	UK	US	Japan
Mean	0.195837	0.203758	0.153324	0.153658	0.156931	0.181386
Median	0.167985	0.166443	0.126037	0.125803	0.128230	0.159414
Maximum	1.231236	0.842894	1.099778	1.071539	1.187133	1.303063
Minimum	0.025056	0.026889	0.008935	0.018084	0.011156	0.012842
Std. Dev.	0.126567	0.129082	0.106920	0.107107	0.115219	0.112873
Skewness	2.155415	1.705457	2.470978	2.468972	2.933732	3.170362
Kurtosis	11.48413	6.765733	13.22185	13.31466	17.51313	22.88845

Note: Volatilities are for Monday-to-Friday returns.

3.2 Stationarity testing

In order to avoid a spurious regression and infinite persistence of shocks, we are now about to test whether our data is stationary or not. A time series process is said to be covariance stationary if it satisfies the following conditions:

1. $E(y_t) = \mu$
2. $E(y_t - \mu)^2 = var(y_t)$
3. $E[(y_t - \mu)(y_{t-T} - \mu)] = cov(y_t, y_{t-T})$.

The first condition requires the mean to be constant for all t, the second one requires constant variance for all t, and the third one requires the autocovariances to be independent of time.

If any of the assumptions does not hold, the process is not stationary and cannot be used for modelling as all the typical results from classical regression analysis is

invalid. Therefore, the data that are diagnosed not to be stationary need to be transformed to become stationary. There are several ways of how to transform non-stationary and trended data into stationary ones. Non-stationary processes identified as a random walk with or without drift need to be differenced, i.e. $y_t - y_{t-1}$, processes having deterministic trend need to be detrended, and random walks with a drift and also a deterministic trend need to be differenced as well as detrended (Brooks, 2008).

Nevertheless, some important information might be lost during the differencing and detrending procedures. Therefore, we should be careful whether they are necessary, and stationarity tests should be done beforehand.

In this thesis, we use the Augmented Dickey-Fuller test (ADF) and the Kwiatkowski-Phillips-Schmidt-Shin test (KPSS). The null hypothesis of the ADF test states there is a unit root present in a series, i.e. series in not stationary. On the other hand, the null hypothesis of the KPSS test states a series is stationary. We reject the null of the ADF test implying a unit root in favour of an alternative hypothesis of stationarity as shown in table A.1 in the appendix. However, the KPSS test show we need to reject the null of stationarity in cases of Austria, the CR, Greece, Iceland, Ireland, Poland, Portugal, and Slovakia as shown in table A.2 in the appendix. Therefore, we use first differences of the volatilities.

4 Methodology

4.1 The Spillover Table

The measurement of the volatility spillover effects is done using the method first suggested by Diebold and Yilmaz (2009). In their study, they extended the method of Engle et al. (1990), in which spillovers are measured by vector autoregressive (VAR) models. However, as there were certain issues with the ordering of the variables in the method of Diebold and Yilmaz (2009), which are going to be discussed later in this paper, this paper is going to use yet another extension of it. This was presented by Kloessner and Wagner (2012) in their study.

To understand the method, it is worth to first look at the method of Diebold and Yilmaz (2009). It is very different from the traditional approach. The information about spillover effects across markets are generated using the variance decompositions. As a result, we get a single spillover measure. First, VAR of N variables is calculated. The following process basically involves adding the shares of the forecast error variance coming from shocks to asset j for each asset i, for all j ≠ i.

To explain this, we first look at the VAR model, in our case a covariance stationary first-order two variable one:

$$x_t = \Phi x_{t-1} + \varepsilon_t$$

where $x_t = (x_{1t}, x_{2t})$ and Φ is a 2×2 parameter matrix. For the purposes of this thesis, let x be a vector of stock return volatilities. Since there is a covariance stationarity in the process, there exists the moving average representation of the VAR. The equation is as follows:

$$x_t = \Theta(L)\varepsilon_t$$

where $\Theta(L) = (I - \Phi L)^{-1}$. This can be written in a form of

$$x_t = A(L)u_t$$

where $A(L) = \Theta(L){Q_t}^{-1}$, $u_t = Q_t\varepsilon_t$, $E(u_t{u'}_t) = I$, and $Q_t^{-1}$is the lower-triangular Cholesky factor of the covariance matrix of ε_t (Diebold and Yilmaz, 2009).

When we have a look at forecasting, we can get the variances of how ever many-steps-ahead error in forecasting x_{1t} and x_{2t}. For example, for the 1-step-ahead forecasting, the optimal forecast is as follows

$$x_{t+1,t} = \Phi x_t$$

and its 1-step-ahead error vector can be denoted in the following way

$$e_{t+1,t} = x_{t+1} - x_{t+1,t} = A_0 u_{t+1} = \begin{bmatrix} a_{0,11} & a_{0,12} \\ a_{0,21} & a_{0,22} \end{bmatrix} \begin{bmatrix} u_{1,t+1} \\ u_{2,t+1} \end{bmatrix}$$

the covariance matrix of the error vector is

$$E\left(e_{t+1,t}, e'_{t+1,t}\right) = A_0 A'_0.$$

Therefore, the variance of 1-step-ahead error in forecasting x_{1t} is the sum of $a_{0,11}^2$and $a_{0,12}^2$, and for x_{2t}, the variance of 1-step-ahead error in forecasting is the sum $a_{0,21}^2$and $a_{0,22}^2$.

Thanks to the variance decomposition we are able to say to what extent the 1-step-ahead error variance in forecasting x_1 is affected by the shocks to x_1 and to what extent it is affected by the shocks to x_2. Likewise, for x_2, we are also able to say to what extent the 1-step-ahead error forecasting is affected by the shocks to x_2 and to what extent the shock to x_1 had an effect. Generally, for each variable, we are able to distinguish between the fractions of the forecast error variances that were due to different system shocks (Diebold and Yilmaz, 2009).

It is now the right time to make two important definitions as they will be the kez to understanding the results of this method. The two definitions are of the term own variance shares and cross variance shares. Diebold and Yilmaz (2009, p. 159) define them as follows: the own variance shares are "fractions of the 1-step-ahead error variances in forecasting x_i due to shocks in x_i, for $i = 1,2$", and the cross variance shares, which are basically the spillovers, are "fractions of the 1-step-ahead error variances in forecasting x_i due to shocks $to\ x_j$, for $i, j = 1,2$, $i \neq j$". Looking at our two-variable VAR and its variance decomposition, there are two spillovers that can occur, first, those shocks to x_{1t} that affect the forecast error variance of x_{2t}, denoted as $a_{0,12}^2$, and second, those shocks to x_{2t} that affect the forecast error variance of x_{1t} (denoted as $a_{0,21}^2$). Therefore, the total spillover is the sum of $a_{0,12}^2$ and $a_{0,21}^2$.

To get the spillover index, which is easy to interpret, we combine this total spillover with the total forecast error variation, which can be written as $a_{0,11}^2 + a_{0,12}^2 + a_{0,21}^2 + a_{0,22}^2 = trace(A_0 A'_0)$. Then, the spillover index, as a percentage, is

$$S = \frac{a_{0,12}^2 + a_{0,21}^2}{trace(A_0 A'_0)} \times 100.$$

From that equation, the spillover index can be easily generalised into a case of p[th]-order and N-variable VAR, although with the only 1-step-ahead forecast:

$$S = \frac{\sum_{\substack{j,i=1 \\ i \neq j}}^{N} a_{0,ij}^2}{trace(A_0 A'_0)} \times 100.$$

This equation of p[th]-order and N-variable VAR written for an H-step-ahead forecast would then look as follows

$$S = \frac{\sum_{h=0}^{H-1} \sum_{\substack{j,i=1 \\ i \neq j}}^{N} a_{h,ij}^2}{\sum_{h=0}^{H-1} trace(A_h A'_h)} \times 100 \qquad (1)$$

(Diebold and Yilmaz, 2009).

4.2 The extension by Klössner and Wagner (2012)

As there are several issues to the method of that Diebold and Yilmaz (2009) introduced, there need to be some adjustments done to it. Although, for example, Baruník et al. (2013) use the extension by Diebold and Yilmaz (2012), we use for our purposes the extension by Klöessner and Wagner (2012). Klöessner and Wagner (2012) point out issues with respect to the length of the rolling window, the forecast horizon H, and the order in which variables enter the model. They are concerned the most with the last one. They say the ordering of the model variables matter as it affects the results of the spillover measurement. According to them, the reason for this is that "there is no obvious connection between the Cholesky decomposition of the original forecast errors' covariance matrix and the one emerging after a renumeration of the variables" (Klöessner and Wagner, 2012, p. 6). They find out that the method of Diebold and Yilmaz (2009) puts more weight on the spillovers from the countries that are on the first places in the table, meaning that the spillovers from those countries are more likely to be higher than they are in reality.

Hence, they came up with a new approach. To get a deeper understanding of the issue, they developed algorithms for computing both maximum and minimum of the spillover index over all renumeration of the variables, i.e. SOI_{max} and SOI_{min}, respectively, as well as the matrices with the maximal and minimal entries in the spillover table, i.e. SOT_{max} and SOT_{min}, respectively. The new approach that provides a solution to the issue of the ordering and dependency on it involves computation of the average spillover measure and spillover table, i.e. SOI_{avg} and SOT_{avg}, respectively. To get the SOI_{avg} and SOT_{avg}, the variables are reordered as many times as many combinations of the countries exist and then, the average is taken. When N is the number of countries used in the method, the number of their possible combinations is N! (Klöessner and Wagner, 2012).

In order to show how to apply the new approach, it will prove useful to rewrite equation (1) into the following form:

$$S = \frac{\sum_{h=0}^{H-1}\sum_{\substack{j,i=1 \\ i\neq j}}^{N}(B_h C)_{ij}^2}{\sum_{h=0}^{H-1} trace(B_h \Sigma_\varepsilon B'_h)} \times 100 = \left(1 - \frac{\sum_{h=0}^{H-1} trace(B_h C)^{\boxed{2}}}{\sum_{h=0}^{H-1} trace(B_h \Sigma_\varepsilon B'_h)}\right) \times 100$$

where $a_{h,ij}^2$ was replaced by $(B_h C)_{ij}^2$, where B_h is the matrix of coefficients of ε_{t-h} and $C = Q_t^{-1}$, i.e. the lower-triangular Cholesky factor of Σ_ε, and $A_h A'_h$ was replace by $B_h \Sigma_\varepsilon B'_h$, where Σ_ε denotes the covariance matrix of ε_t. The operator $(.)^{\boxed{2}}$ squares a matrix elementwise.

With this notation, the spillover table formula can be written as:

$$sot_{ij} = \frac{\sum_{h=0}^{H-1}(B_h C)_{ij}^2}{\sum_{h=0}^{H-1}(B_h \Sigma_\varepsilon B'_h)_{ii}} \times 100$$

To keep it as simple as possible, Klöessner and Wagner (2012) suggest that $\sum_{h=0}^{H-1}(B_h \Sigma_\varepsilon B'_h)_{ii}$ would equal unity for all i, which means the forecast error variances would be unity. Therefore, they simplify the equation simply by replacing $X_{i,t}$ with $\bar{X}_{i,t} = d_i X_{i,t}$ and d_i is defined as:

$$d_i = (\sum_{h=0}^{H-1}(B_h \Sigma_\varepsilon B'_h)_{ii})^{-0.5}.$$

The model is then considered for $\bar{X}$. Hence, from now on, the assumption is that $\sum_{h=0}^{H-1}(B_h \Sigma_\varepsilon B'_h)_{ii} = 1$ for all i as the variables are assumed to be rescaled.

Now, the easier equations can be written as:

$$sot_{ij} = \sum_{h=0}^{H-1}(B_h C)_{ij}^2 \times 100,$$

and when the values $(sot_{ij})_{i,j=1,\dots,N}$ are put together, they become a SOT matrix, i.e. the spillover table:

$$SOT = \sum_{h=0}^{H-1}(B_h C)^{\boxed{2}} \times 100. \tag{2}$$

And the spillover index is the:

$$S = \frac{\sum_{h=0}^{H-1}\sum_{\substack{j,i=1 \\ i\neq j}}^{N}(B_h C)_{ij}^2}{N} \times 100$$

$$S = \left(1 - \frac{\sum_{h=0}^{H-1} trace(B_h C)^{\boxed{2}}}{N}\right) \times 100 = 100 - \frac{\sum_{i=1}^{N} sot_{ii}}{N} = 100 - \frac{tr(SOT)}{N}. \tag{3}$$

To explain the algorithms, it is necessary to define a matrix P and its properties as there is a way of representation of each rearrangement of the N variables in X using P. For this representation P is used as a pre-multiplier. P is a permutation matrix for which $P_{ij} = 1$ in a state in which j appears at position i within the rearranged vector and $P_{ij} = 0$ in any other state. As P is a classical permutation matrix, P is orthogonal and hence $P'P = PP' = I_N$. Moreover, there exists the moving average representation of the pre-multiplied vector $X_{t,P} = PX_t$, which is given as:

$$X_{t,P} = \varepsilon_{t,P} + B_{1,P}\varepsilon_{t-1,P} + B_2\varepsilon_{t-2,P} + \cdots$$

where $\varepsilon_{t,P} = P\varepsilon_t$ and it is the multivariate white noise with covariance matrix $\Sigma_{t,P} = P\Sigma_\varepsilon P'$ and $B_{h,P} = PB_hP'$ for all h. This is a significant saver of time as the VAR model does not have to be estimated for every reordering of the computation of spillover measures with many variables. The VAR model is necessary to estimate only once. Then, the formulas (2) and (3) are used; however, with B_h replaced for $B_{h,P}$ and C replaced C_P, i.e. the lower triangular Cholesky factor of $\Sigma_{\varepsilon,P}$ (Klöessner and Wagner, 2012).

4.2.1 Algorithms for the Spillover Index

The equation for the spillover index that is written with regards to a permutation matrix P, S_P, looks as follows:

$$S_P = \left(1 - \sum_{h=0}^{H-1} trace(B_{h,P}C_P)^{\boxed{2}}\right) \times 100 = \left(1 - \sum_{h=0}^{H-1} trace(PB_hP'C_P)^{\boxed{2}}\right) \times 100$$

Hence, it is easy to see the maximum, minimum, and the average need to be calculated for the following part of the notation over all permutation matrices P:

$$\sum_{h=0}^{H-1} trace(PB_h P' C_P)^2 \quad (4)$$

Now, the next step is to introduce $D_h = 0$ for all $h = 0, \dots, H-1$ and compute (4) as a special case of

$$\sum_{h=0}^{H-1} trace(PB_h P' C_P + PD_h P' (C'_P)^{-1})^2. \quad (5)$$

For this special case, a "divide and conquer"-strategy was developed by Klöessner and Wagner (2012). There is a proposition[1] underlying this strategy.

Proposition 1 suggests that for the same variables of N_1 that come first, it does not matter what order the first N_1 variables as presented by P_1 are in as it does not affect the calculations for the remaining N_2 variables. Likewise, this applies to N_2 as well, the order of the last N_2 as presented by P_2 does not affect the calculations for N_1 variables that come first. It then follows from (6) that, for the same, unchanged, first N_1 variables, (5) can be rewritten in regards to the N_1 dimension as

$$\left(\sum_{h=0}^{H-1} trace(P_1 \tilde{B}_{11,h} P_1' C_{P_1} + P_1 \tilde{D}_{11,h} P_1' (C'_{P_1})^{-1})^2\right) \quad (7)$$

depending only on P_1, and then with regards to the N_2 dimension as

$$\left(\sum_{h=0}^{H-1} trace(P_2 \tilde{B}_{22,h} P_2' C_{P_2} + P_2 \tilde{D}_{22,h} P_2' (C'_{P_2})^{-1})^2\right) \quad (8)$$

depending only on P_2. Now, as (7) and (8) are structurally equivalent to (5), (5) can be solved by:

- decomposing $N = N_1 + N_2$ (chosen $N_1 = floor(N/2)$),
- determining all subsets of $\{1, \dots, N\}$ with N_1 elements,
- for each subset M_1 of $\{1, \dots, N\}$ with N_1 elements,
    - rearranging the variables in such way where the first N_1 variables in $X_{t,P}$ are the elements of M_1,
    - then, solving (7) of dimension N_1 and (8) for dimension N_2, which means computing maximal, minimal, and average values for both (7) and (8),
    - also, computing the maximal, minimal, and average values for M_1, which are the sums of the maximal, minimal, and average values of (7) and (8),
- and, determining maximum, mminimum, and average of (6). This is done by computing the maximum, minimum, and average of the maximal, minimal, and average values over all subsets M_1, which has N_1 elements (Klöessner and Wagner, 2012).

[1] The proof of the proposition can be found in Klöessner and Wagner (2012).

4.2.2 Algorithms for Spillover Tables

The equation for the spillover table that is written with regards to a permutation matrix P, SOT_P, is written as follows

$$SOT_P = P' \sum_{h=0}^{H-1} (B_{h,P} C_P)^{\boxed{2}} P = \sum_{h=0}^{H-1} (B_h P' C_P P)^{\boxed{2}}. \quad (9)$$

In order to get rid of the dependency on ordering that is present in the spillover table measures, Klöessner and Wagner (2012) suggest to compute the maximal, minimal, and average values of the spillover tables, with minimum, maximum, and average taken over all $N!$ permutations. Even though it seems very hard to compute this, there is a way how to do so. This is thanks to the j-th column not being dependent neither on the ordering of the variables preceding it nor on the ordering of the variables succeeding it. The j-th column only depends on the set of variables preceding variable j in the renumeration of the variables. Again, as in the previous case of the spillover index, it is based on the following proposition.

Klöessner and Wagner (2012) point out that the spillovers from j to the other variables only depend on which variables come into $X_{t,P}$ before and after j. Having a variable j entering $X_{t,P}$ at position k, the spillovers from j do not depend on the order of those $k-1$ variables preceding j neither they depend on those $N-k$ variables succeeding j. For every j and for every k, it is necessary to consider only the possible subsets of the variables preceding j. Therefore Klöessner and Wagner (2012) come up with the following algorithm:

- going through all positions k in $1, \dots, N$
- for every variable j, going through all subsets of $\{1, \dots, N\} \backslash \{j\}$ with $k-1$ elements and computing the corresponding j-th column of (9)
- and then, calculating maximum, minimum, and average over all values obtained. The columns being weighted by $\frac{(k-1)!(N-1)}{N!} = \frac{1}{N\binom{N}{k-1}}$, while calculating the average.

5 Results

In this part of the thesis, the results of the analysis introduced above are given. In order to present them as clearly as possible, they are split into several parts. The first part presents the results in a more general manner without directly aiming each hypothesis separately. It focuses on each of the countries individually. The remaining parts focus on the three hypotheses.

5.1 Contribution

This part of the results does not seek for answers to concrete questions, it rather seek to give a general outlook to the issue with all the data it has, the particular method of analysis and for each of the country individually. We strongly believe, this is useful as it may provide us with the first steps towards the understanding the problem as well as give us a first glance at the issue which may lead to either a preliminary confirmation or a preliminary disproval to certain expectations. Moreover, in order to avoid confusion that might have been the case if we skipped right to the hypothesis analysis, we compare all the countries' stock markets in this way with each other, in which the same results throughout the same periods with the same sample periods are introduced.

Hence, all the figures from this part show the same for each country separately. They show the contribution either from the given country's stock market to the others or to the country's stock market from the others. What we mean when we say "contribution" is the extent to which it is influenced by the others and the extent to which a country influence the others, respectively. It is calculated from the Spillover Tables mentioned above in the methodology part. For the contribution from a stock market A to another one is given by the sum of the column A and for the contribution to a stock market A from another one is given by the sum of the row A. In order not to include the impact of the stock market A, the values on the diagonal are subtracted from the sums.

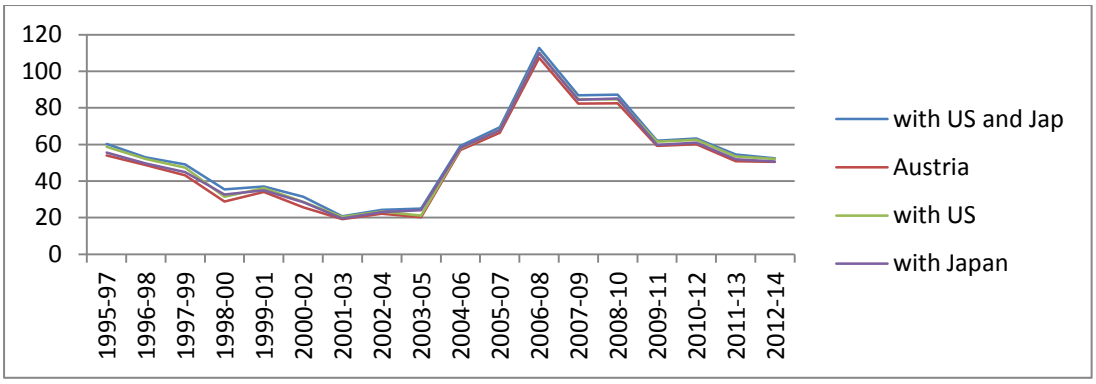
In the legend of the figures, there are lines called "with US and Jap", "with US", and "with Japan". These are included as part of the analysis of the second hypothesis, which focuses on the impact of the stock markets of the US and Japan. The line

named only after the country itself includes only the contribution from or to the country mentioned within the framework of the other European countries only. The line “with US and Japan” shows either the contribution from or to the other European countries and both, the US and Japan. Similarly, the line “with US” leaves out the contribution from or to Japan and only includes the US into the framework as well as the line “with Japan” only includes Japan into the framework and not the US. This suggests that the larger the spread between the red line, a country’s stock market’s contribution within the Europe only, and the other lines, the larger the contribution from or to the US or Japan.

In the manner of Diebold and Yilmaz (2009), we use rolling analysis. Separate sample periods are taken and Spillover tables are calculated for each of them. The sample periods are each three years long and start at the beginning of each of the years of the entire data sample. Therefore, we have eighteen subsample periods each measuring the spillovers for three given years.

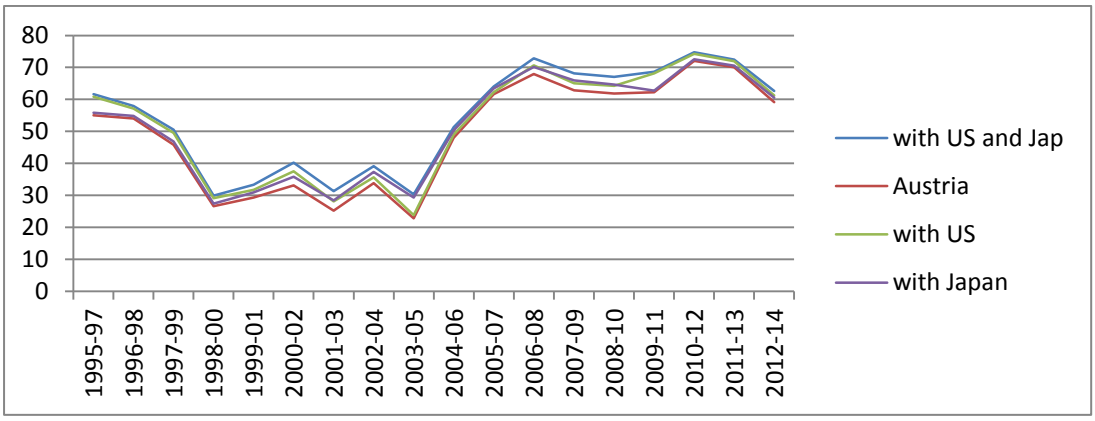
At first sight through the figures 5.1 to 5.36, there is an obvious upward-sloping trend in the contribution both from and to most of the countries during the years right before the financial crisis of 2007-08 and also during the crisis. In most of the cases, the contribution drops down after the crisis, which is not anything we did not anticipate. Following the alphabetical order, we start our comments with the contribution from and to Austria, which is depicted in figures 5.1 and 5.2. Austria became a member of the EU in 1995 and was one of the founders of the Eurozone that was established in 1999. We can see from the figure that the Austrian stock market was getting quite isolated during the first ten years of the data sample. This may mean that joining the EU and the Eurozone did not have a straight positive effect as expected, however we need to keep in mind that not all the other countries included in the sample were members of those unions in those years. In the subsample 2004-06, there is an improvement to the contribution from as well as to Austria, which may be given by the fact that there were four new members to the EU in May of 2004. Moreover, the graphs show that the contribution from the Austrian stock market to the American and Japanese one is quite negligible throughout the entire period while the contribution to the Austrian stock market from those of the US and Japan are more significant.

Figure 5.1: Austria – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

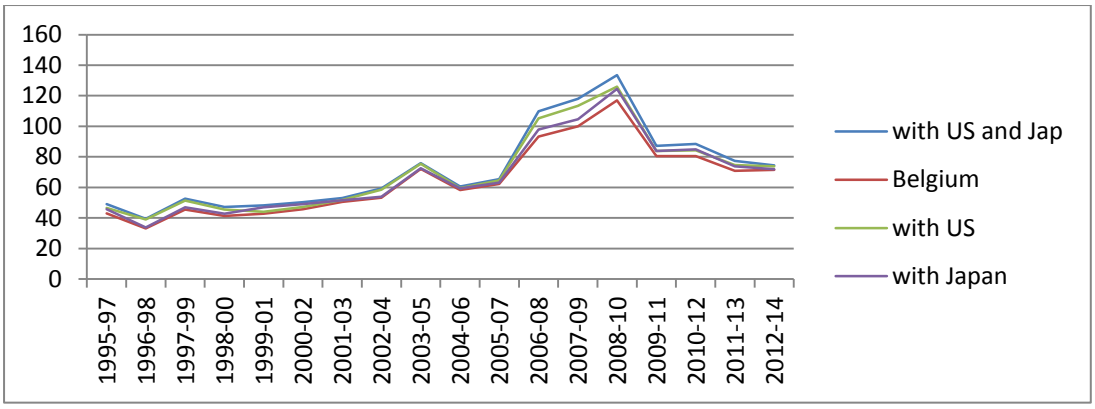
Figure 5.2: Austria – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

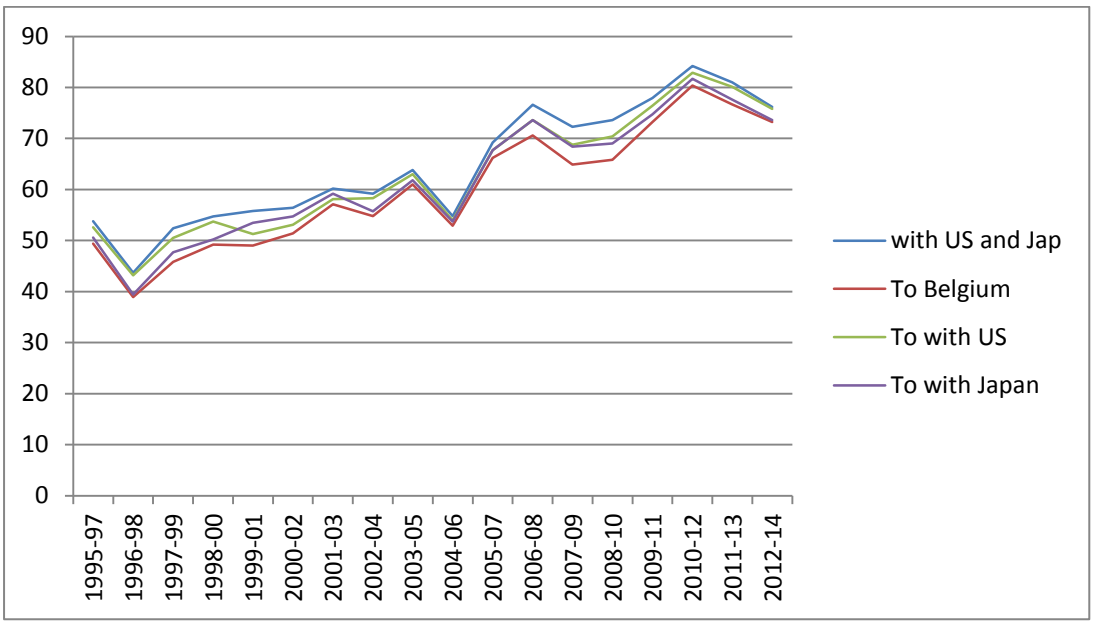
In figures 5.3 and 5.4, we can see the contribution from and to the Belgian stock market. Belgium was in the EU from its very beginning and was one of the founding countries of the Eurozone. The graphs show a rather stable upward-sloping trend of the contribution from and to Belgium until the crisis. While the contribution to Belgium keeps this trend, the contribution from Belgium grows faster in the years of the crisis 2007-08 and then in the subsample of 2009-11 starts decreasing until the end of the entire period. The influence of the US and Japan is apparent in both figures especially during the years of the crisis. Likewise, there is a higher contribution from the US and Japan to Belgium apparent in the first ten years of the data sample. The other subsamples do not show such a high spread between the lines.

Figure 5.3: Belgium – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

Figure 5.4: Belgium – Contribution To

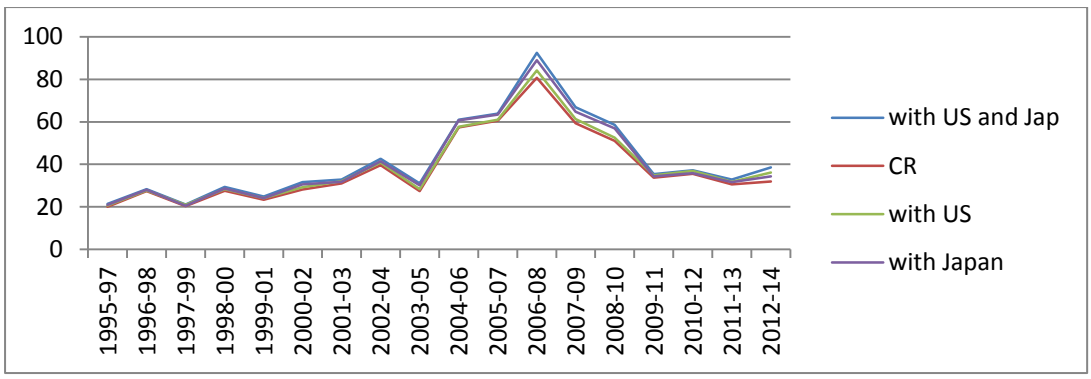


Source: Author.
Notes: We use raw data from Datastream.

Now, to the Czech Republic and its stock market contributions, which are presented in figures 5.5 and 5.6. The Czech Republic joined the EU on 1st May 2004 and it has not accepted the euro for its currency yet. We can see that the contribution both from and to the Czech stock market is mainly stable and almost not growing until the subsample beginning in 2003, suggesting the Czech stock market used to be very isolated from the others. In the one beginning in 2004, there a significant change to the slope and until the years of the crisis, the contribution keeps growing. This may most probably be assigned to the EU accession. However, ever since the crisis, the

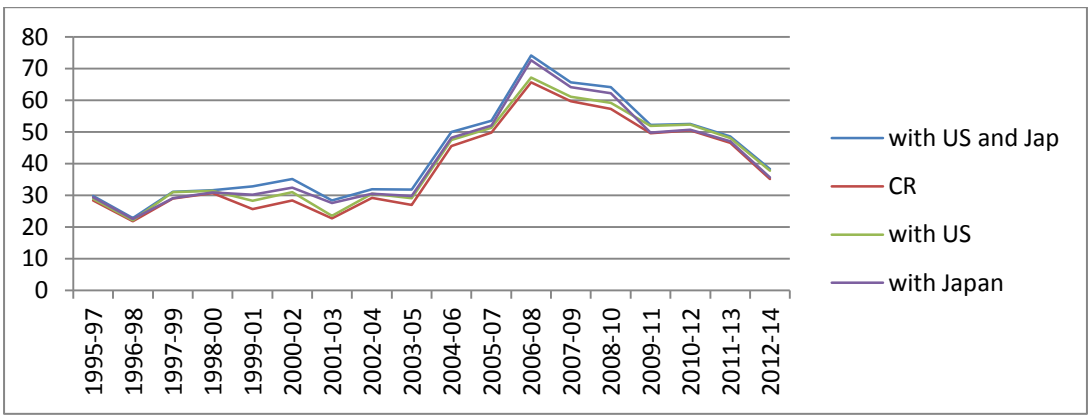
contribution decreases. As in the cases of the two previous countries, the influence of the US and Japan is more apparent in the graph of the contribution to the Czech Republic. Nonetheless, during the crisis there seems to be a contribution from the Czech Republic to those countries as well.

Figure 5.5: The Czech republic – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

Figure 5.6: The Czech republic – Contribution To

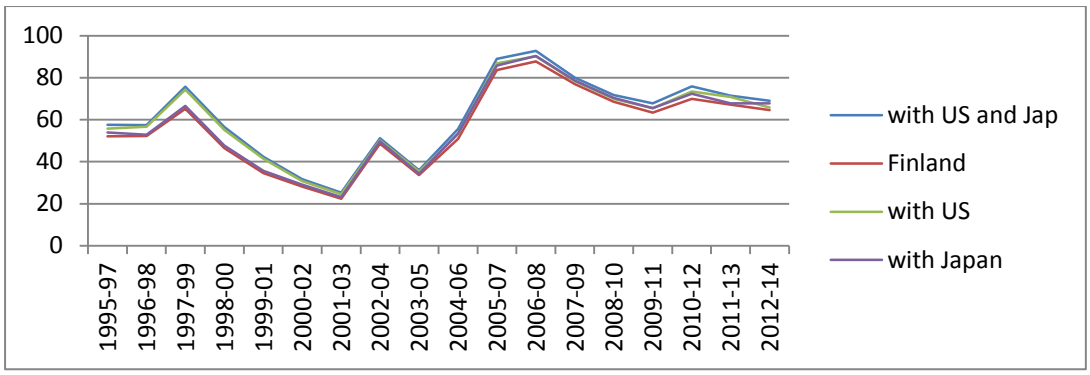


Source: Author.
Notes: We use raw data from Datastream.

In figures 5.7 and 5.8, we see the contribution of Finland's stock market. Finland joined the EU in 1995, as Austria did, and in the Eurozone, it was from the very beginning. Similarly to the case of Austria, there is a downward-sloping trend after joining the EU in both contributions until the subsample 2001-03. Then it takes the opposite direction. The contribution from Finland drops slightly after the crisis and then remains on rather stable level. While the contribution to Finland just stops growing during the crisis and remains on a stable level right away. In regards to the US and Japanese impact, it is not as apparent as in the previous cases. However, in

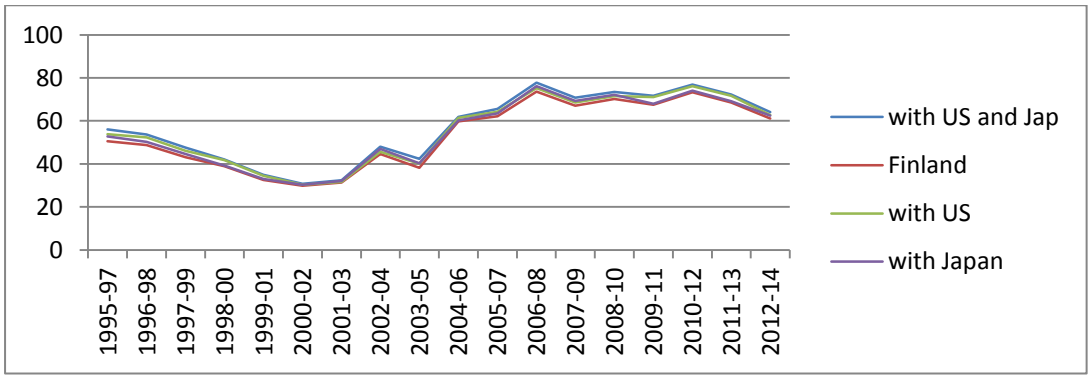
the second half of the 1990s and at the turn of the millennium we can notice slightly higher contribution from Finland to the US.

Figure 5.7: Finland – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

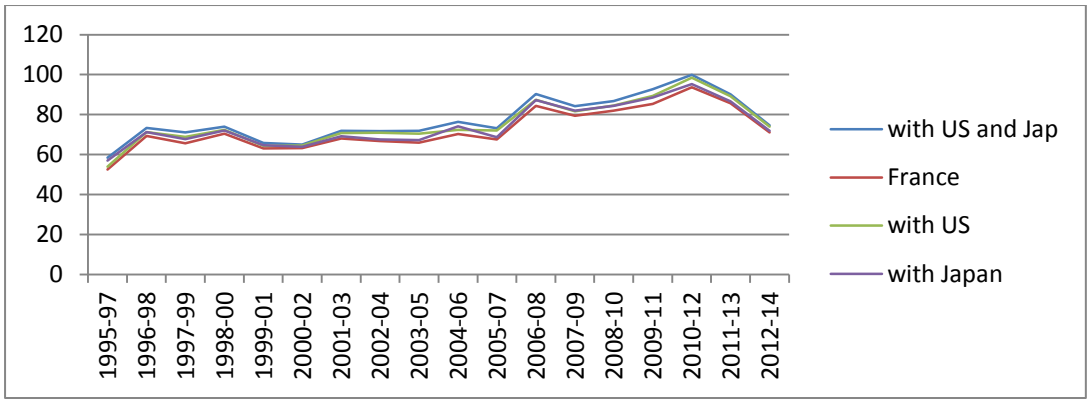
Figure 5.8: Finland – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

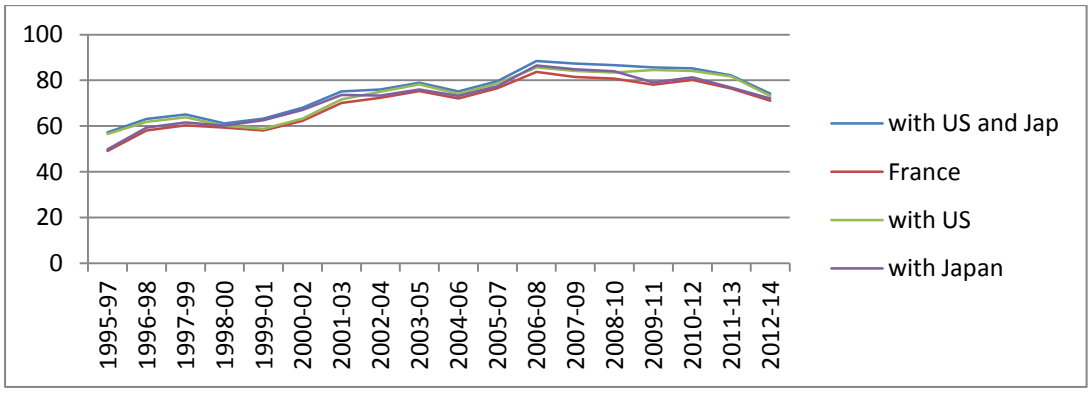
The contribution from and to the French stock market is depicted in figures 5.9 and 5.10. France was one of the founders of the EU as well as the Eurozone. We can see that throughout the entire period there are not any significant changes. The contributions are on fairly high level with a moderate but very stable upward-sloping trend. Although not as significant change as in the case of the previous countries, there is a slightly decreasing tendency after the crisis. The contribution from and to the American and Japanese stock markets are visible more or less in all the subsamples. We can see that the US has quite higher impact on France in the years after the crisis, while Japanese impact drops.

Figure 5.9: France – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

Figure 5.10: France – Contribution To



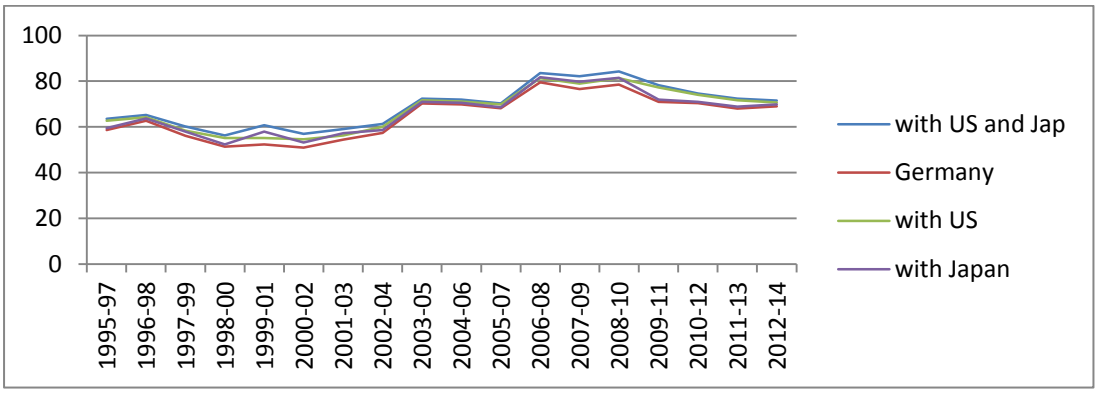
Source: Author.
Notes: We use raw data from Datastream.

In the figures 5.11 and 5.12, we can find the contribution from and to Germany, respectively. As well as France, Germany was also one of the founders of both, the EU and the Eurozone. Moreover, their graphs of the contributions look reasonably similar. There are few more apparent changes in the evolution of the contribution from Germany; however, it still stays on the fairly higher levels. The influence of the US and Japan is not very visible, there is only a wider spread between the lines in the years during and after the crisis.

Figure 5.11: Germany – Contribution From

Source: Author.
Notes: We use raw data from Datastream.

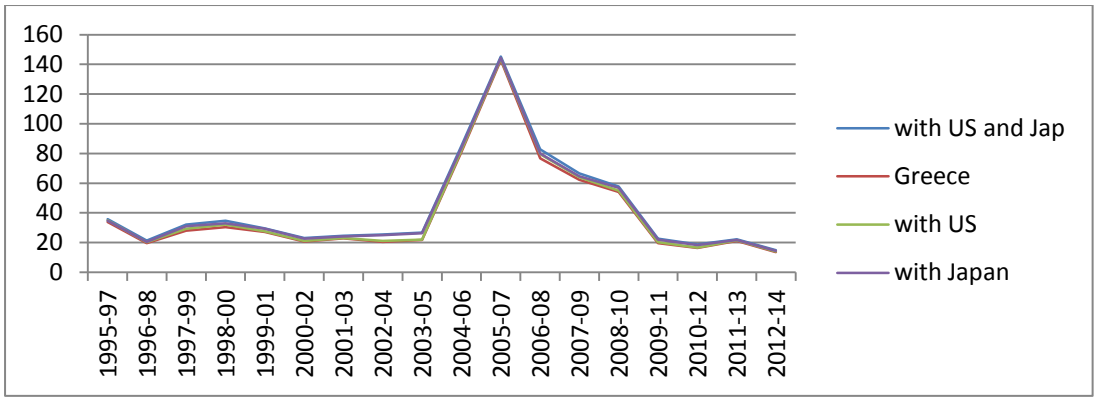
Figure 5.12: Germany – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

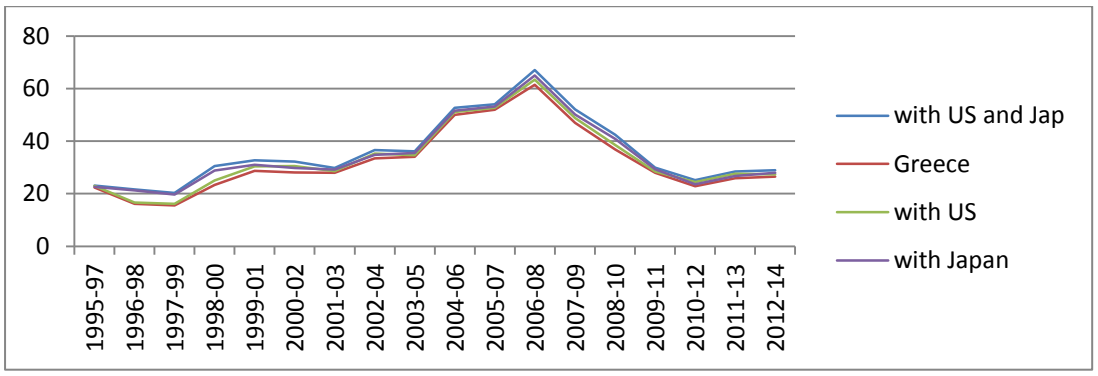
Figures 5.13 and 5.14 show the contribution from and to Greece, respectively. Greece joined the EU in 1981, and in 2001, it joined the Eurozone. Figure 5.13 shows that there is almost no contribution from Greece until the subsample 2003-05, then there is very significant increase which reaches its peak in the subsample 2005-07. After that, it rapidly decreases to even a lower level it was in before 2003. The contribution to Greece keeps growing until the subsample 2006-08. Then it drops rapidly. Generally, there is not much of a contribution from the Greek stock market to either the American or Japanese one. Nonetheless, we can see there is some contribution to Greece from those countries.

Figure 5.13: Greece – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

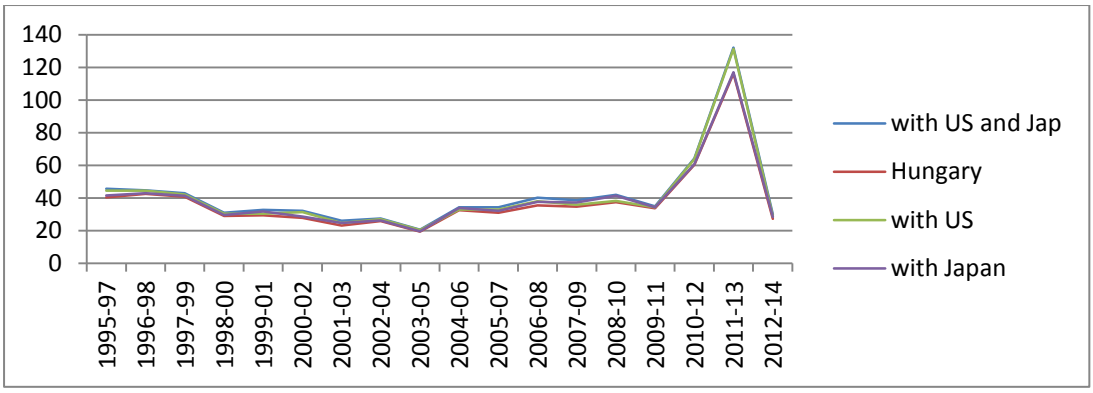
Figure 5.14: Greece – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

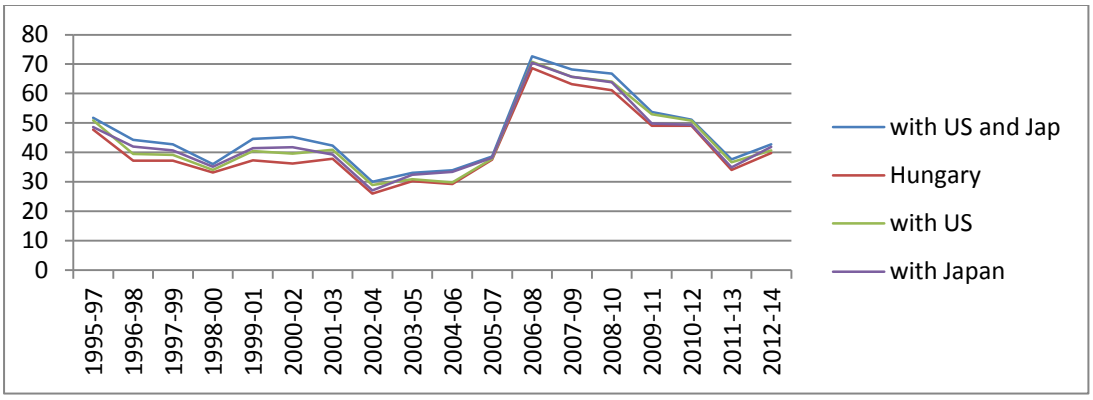
We can find the Hungary's contributions in figures 5.15 and 5.16. As the Czech Republic, Hungary joined the EU in May of 2004 and is not a member of the Eurozone. The contribution from Hungary is generally very moderate, not growing. Only in the subsample 2010-13 it starts growing and the peak is in the following subsample, where it reaches quite high values. Nevertheless, it then drops to the previous values. The contribution to Hungary is rather surprisingly slightly decreasing in the first decade of the data. Before the crisis, it increases to higher level, however, it does not last and it decreases again to the previous values. Furthermore, there is almost non contribution from Hungary to the US or Japan. On the other hand, the contribution from those countries is visible throughout most of the entire sample.

Figure 5.15: Hungary – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

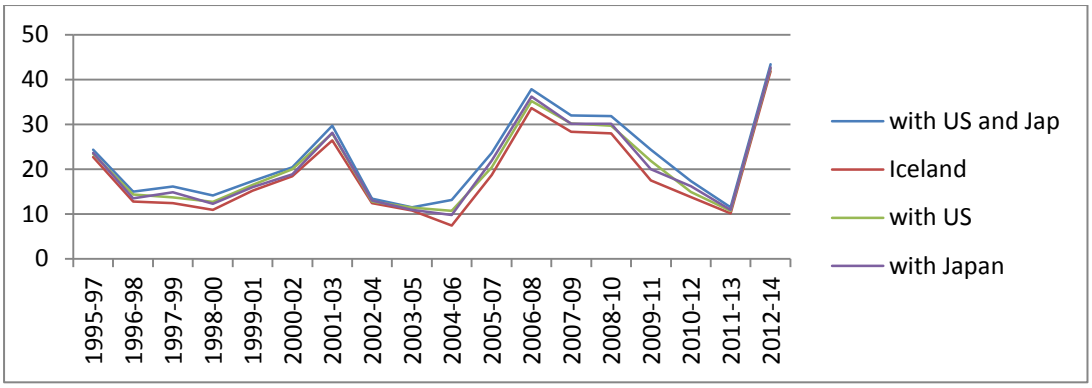
Figure 5.16: Hungary – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

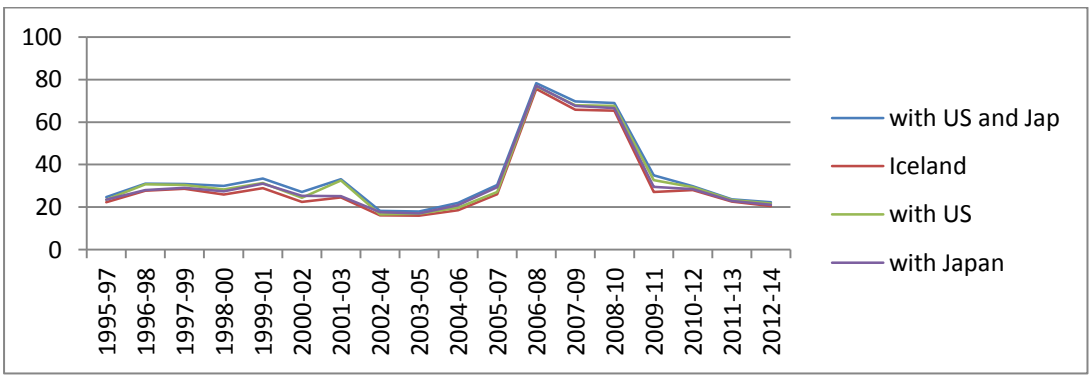
Figures 5.17 and 5.18 present the contribution from and to Iceland. Iceland has not become a member of neither the Eurozone nor the EU. The contribution from Iceland is rather unstable and occurs in rather lower levels. We can find the contribution to Iceland in lower levels as well, without any apparent growth. Well, at least until the subsample 2005-07. During the crisis, it increases, but then it drops to the same low levels almost immediately. What is worth noticing is that the contribution from Iceland to Japan and the US is larger than the contribution from those countries to Iceland.

Figure 5.17: Iceland – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

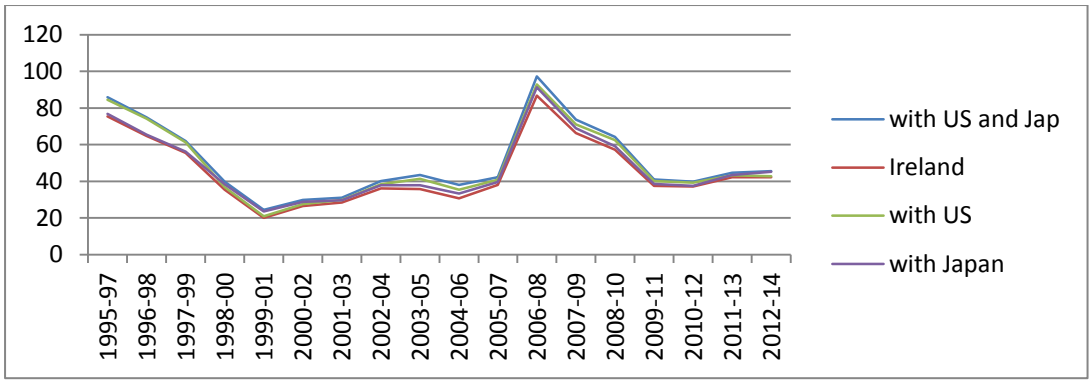
Figure 5.18: Iceland – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

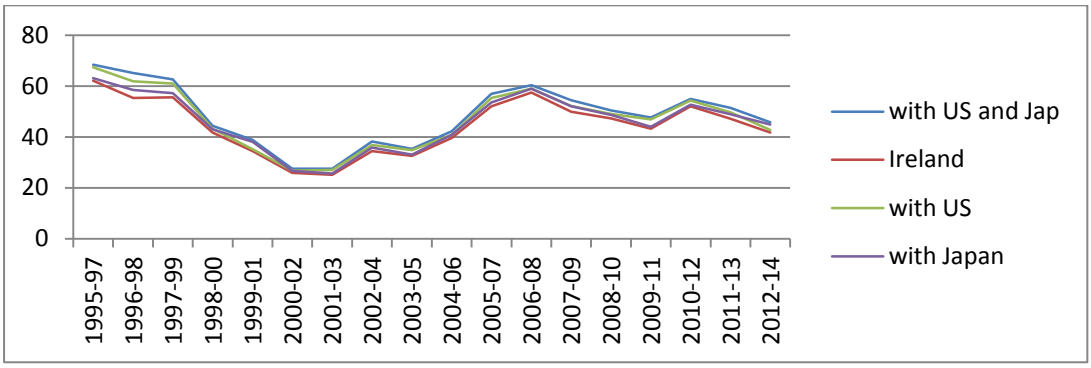
Ireland's stock market contributions can be found in figures 5.19 and 5.20. Ireland joined the institution of the EU in 1973 and was one of the founding countries of the Eurozone. Both, the contribution to and from Ireland, are decreasing in the second half of the 1990s. However, it is just around the time when Ireland accepted the euro for its currency, when the contributions start increasing. The contribution from Ireland increases rapidly before the crisis and then it drops to the pre-crisis level after the crisis. The contribution to Ireland neither increases as rapidly before the crisis nor it decreases as much as the contribution from Ireland. Furthermore, there is more apparent the contribution from Ireland to the US and Japan, than the contribution to Ireland from the US and Japan.

Figure 5.19: Ireland – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

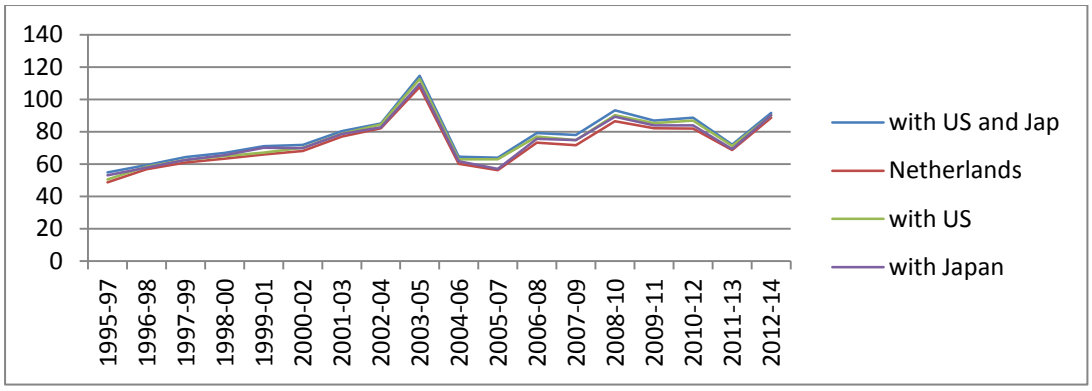
Figure 5.20: Ireland – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

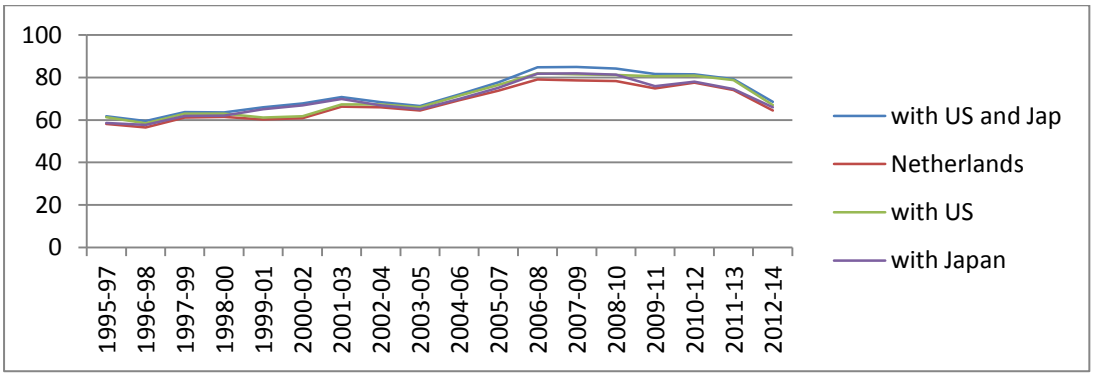
We now continue with the Netherlands, whose contribution is presented in figures 5.21 and 5.22. From all the countries included in this thesis, Netherlands is the last one that was the founder of the both the EU and the Eurozone. The contribution is quite steadily growing throughout the entire sample, especially the contribution to Netherlands. The only larger violation of this steady growth is visible in within the contribution from Netherlands around the sub-sample 2003_05, when it increases a little more than usual, and then it drops more than it increased beforehand. Since the subsample 2005-7, the spread between the lines becomes wider, suggesting higher influence from and on the US and Japanese stock markets.

Figure 5.21: Netherlands – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

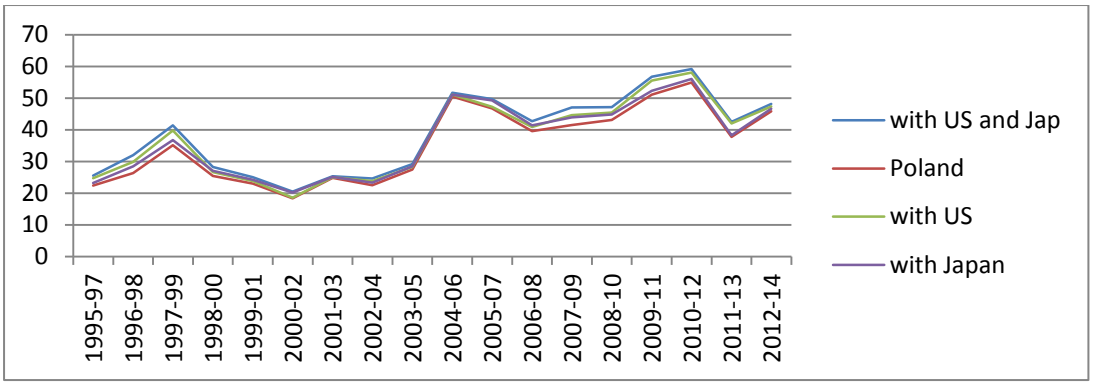
Figure 5.22: Netherlands – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

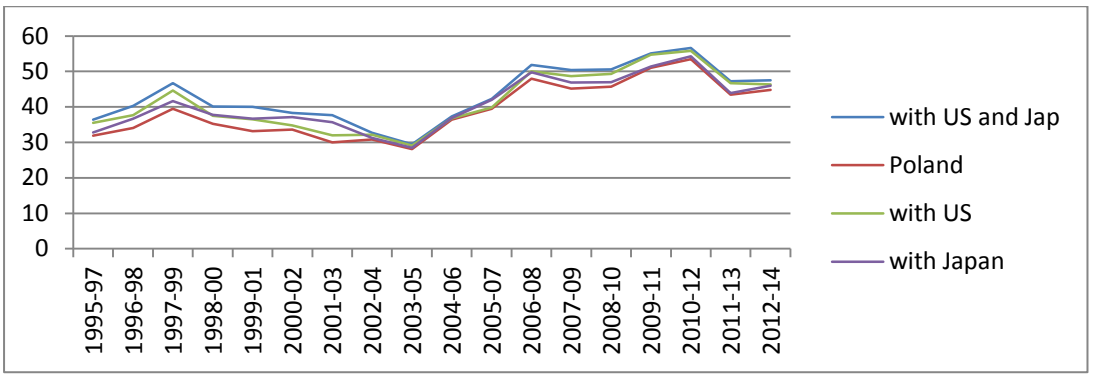
The contribution from and to Poland is depicted in figures 5.23 and 5.24. Poland is one of the four countries in our analysis that joined the EU in May 2004. It has not become the member of the Eurozone as well as the Czech Republic and Hungary. Poland's contribution is generally lower. Nonetheless, it is growing and we can even say the growth is rather steady, although moderate. The growth occurs mainly after the subsample 2003-05, which is probably connected with becoming an EU member. It decreases slightly in the last few subsamples. The contribution from and to the US and Japan is most visible during the crisis. However, the graph shows quite high contribution to Poland from those countries before the subsample 2003-05.

Figure 5.23: Poland – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

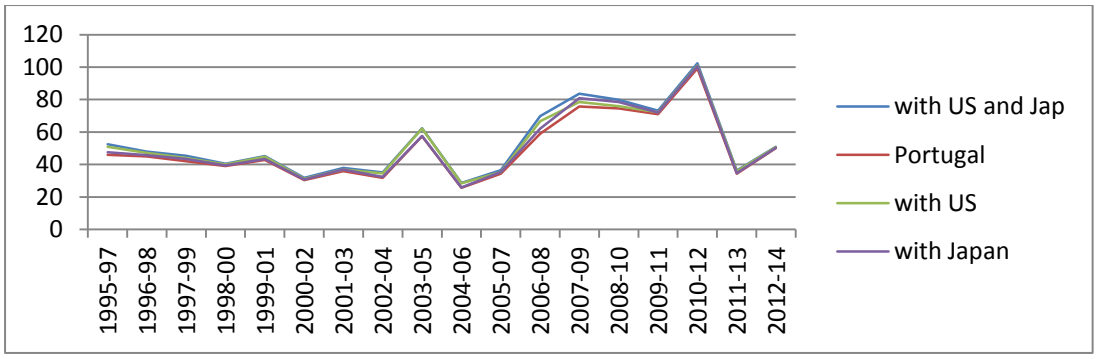
Figure 5.24: Poland – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

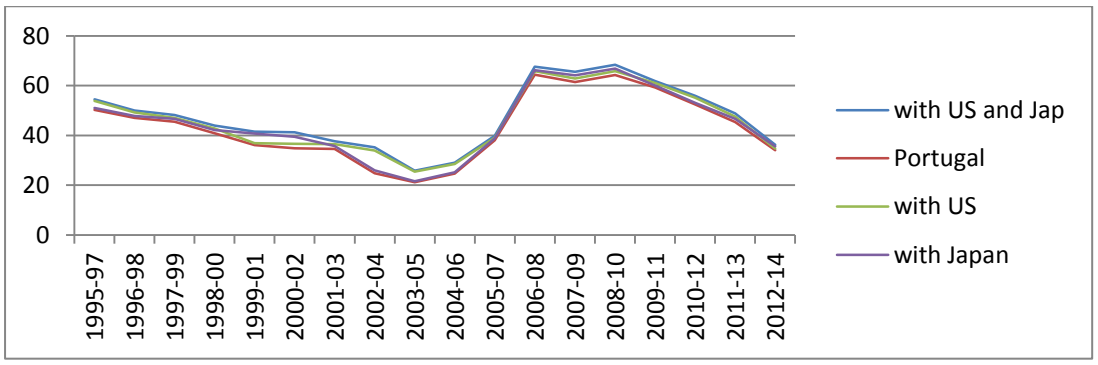
Figures 5.25 and 5.26 show the contribution from and to Portugal. Portugal joined the EU in 1986 and was one of the founders of the Eurozone in 1999. The contribution from and to Portugal steadily decreases until the subsample 2002-04 and 2003-05, respectively. Afterwards, there is a growth which does not last long and the contribution again returns to declining. The contribution from Portugal to the US and Japan is hardly visible apart from the period of the crisis. This applies to the contribution to Portugal as well, but there is also a contribution from the US between the subsamples 2002-04 and 2004-06.

Figure 5.25: Portugal – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

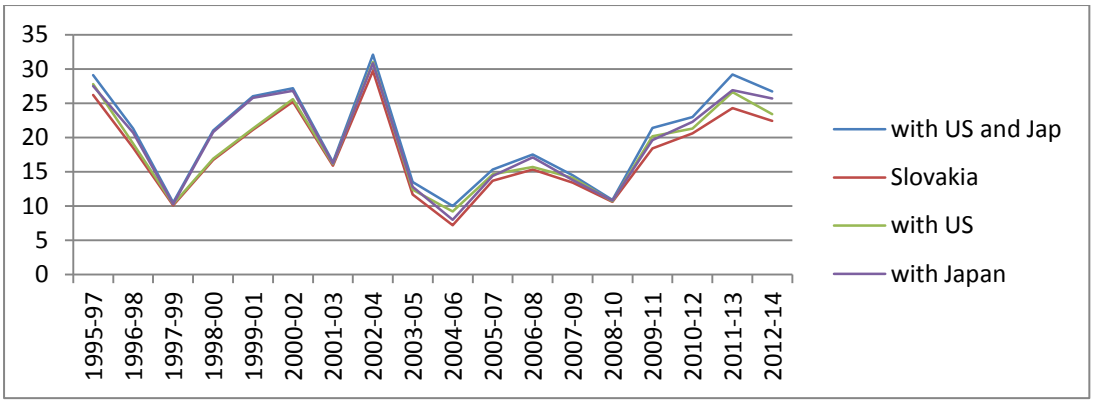
Figure 5.26: Portugal – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

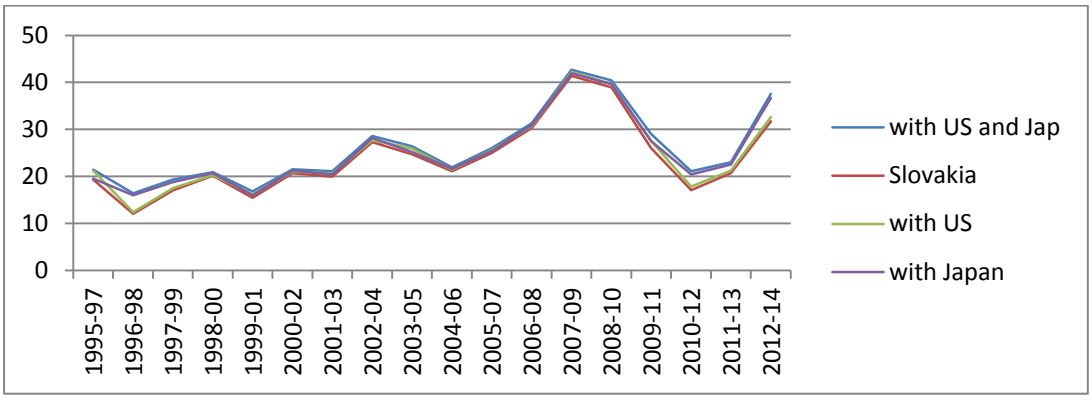
The graphs of Slovakian stock market contributions are given in figures 5.27 and 5.28. Slovakia joined the EU in May 2004 together with its neighbours, the Czech Republic, Hungary and Poland. But, unlike the neighbours, in 2009, it became a member of the Eurozone as well.

Figure 5.27: Slovakia – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

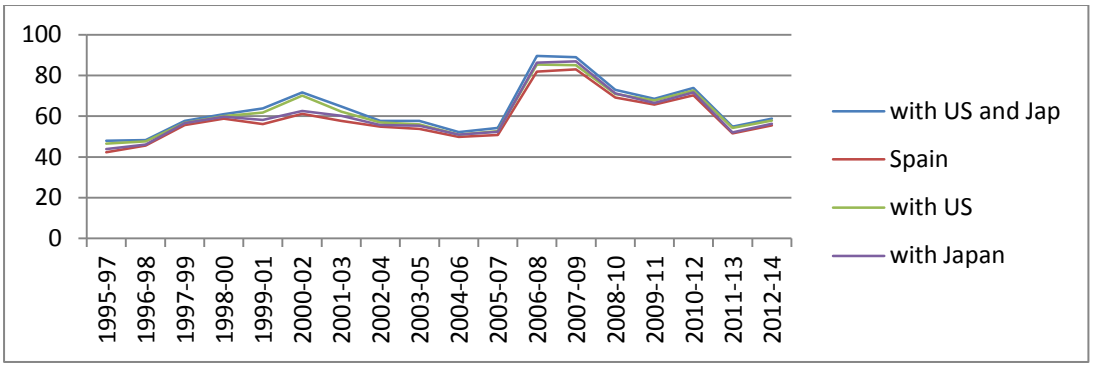
Figure 5.28: Slovakia – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

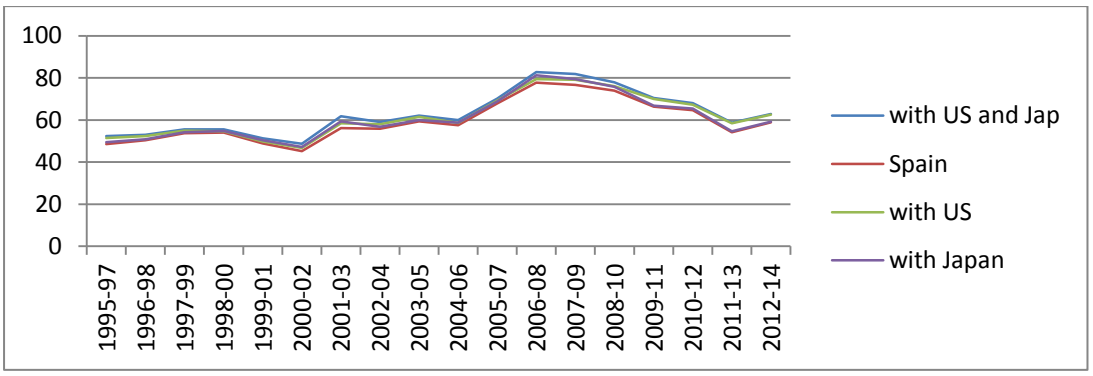
Spain's contributions can be found in figures 5.29 and 5.30. Spain joined the EU in 1986 as well as Portugal did. Also, it was one of the founding countries of the Eurozone. Spanish stock market's contribution is generally rather stable; it only increases more and then decreases again around the years of the crisis. The contribution to Spain from the US and Japan is slightly lower than the contribution of the other way round. Figure 5.29 also shows higher impact that Spain had on the US stock market in the subsample 2000-02.

Figure 5.29: Spain – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

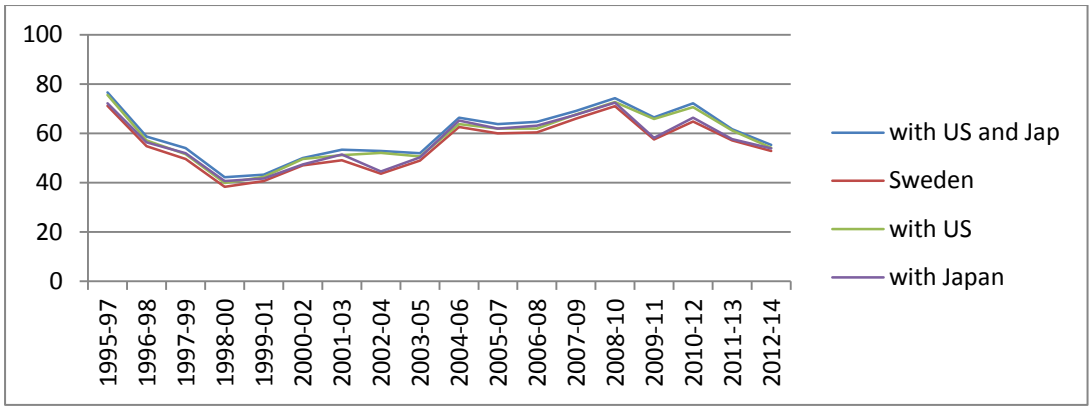
Figure 5.30: Spain – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

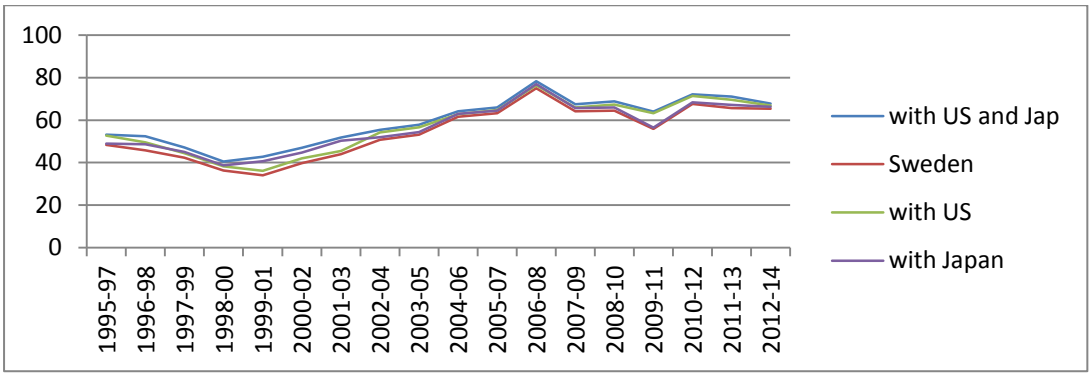
Figures 5.31 and 5.32 belong to Sweden and its stock market contributions. Sweden joined the EU in 1995 as Finland and Austria did. It has not become a member of the Eurozone. In the beginning of the sample, the contribution decreases. That changes and it starts rising again and it keeps rising, once more, until the crisis. Nevertheless, the decrease after the crisis is not as rapid as in the cases of most of the other countries. There is some contribution visible rather from and to the American stock market than the Japanese one.

Figure 5.31: Sweden – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

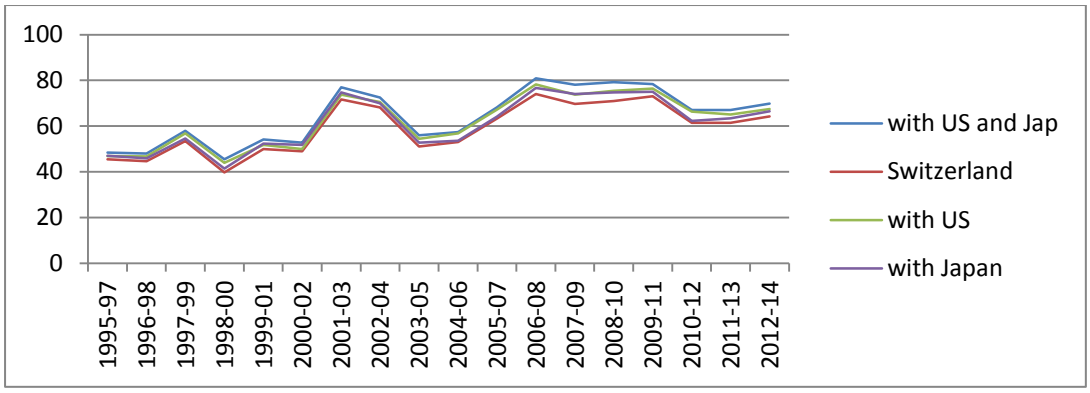
Figure 5.32: Sweden – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

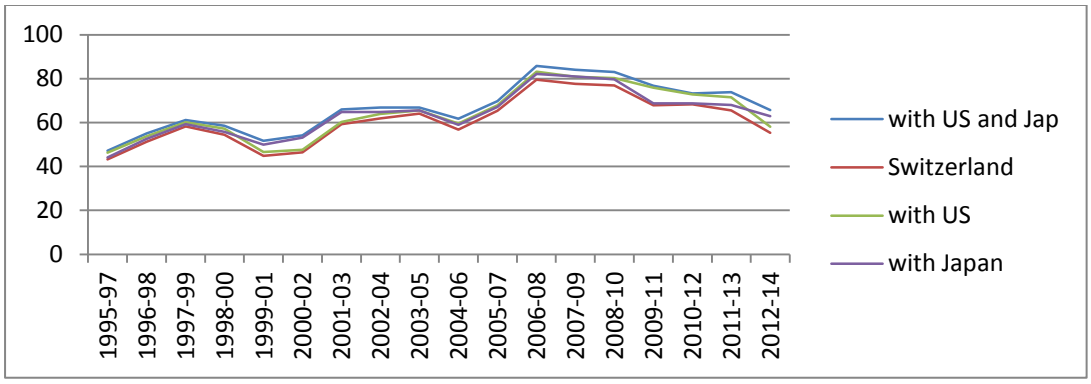
Switzerland and its stock market's contributions are depicted in figures 5.33 and 5.34. Same as Iceland, Switzerland has not become a member of neither the Eurozone nor the EU. We can see that, apart from the years after the crisis, Switzerland's contribution shows an increasing trend throughout the entire sample. The decrease after the crisis is not so dramatic. The contribution to and from the US and Japan is present for the whole period.

Figure 5.33: Switzerland – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

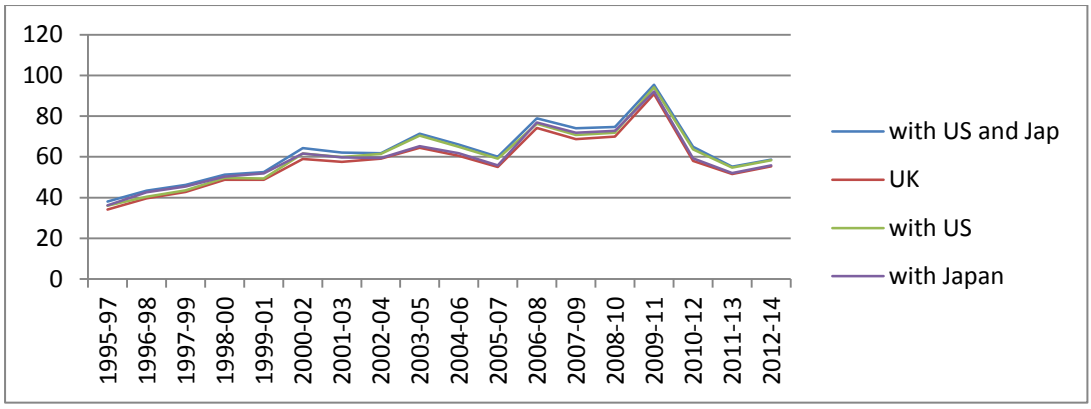
Figure 5.34: Switzerland – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

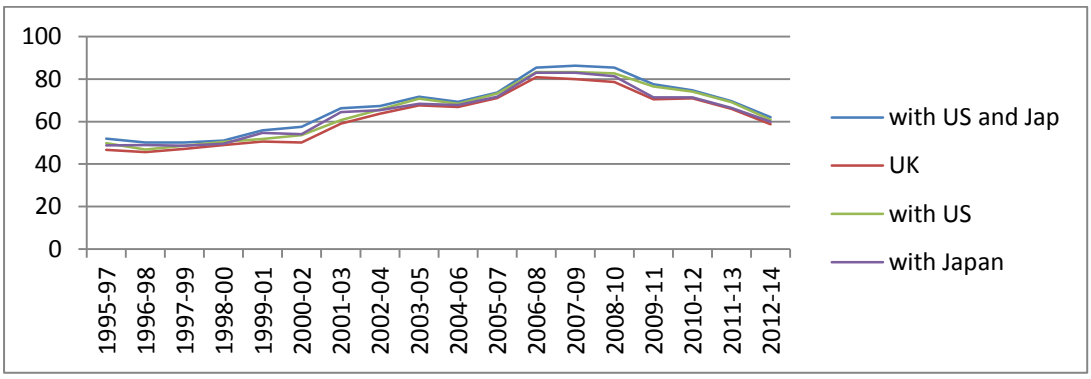
The contribution from and to the United Kingdom is shown in figures 5.35 and 5.36. Together with Ireland, the UK joined the EU in 1973. However, it did not accept the euro. Similarly to the case of Switzerland, the contribution from and to the UK has an upward-sloping trend with a no so dramatic drop in the end as well. The American and Japanese influence is also apparent, although not as high as in the case of Switzerland.

Figure 5.35: The United Kingdom – Contribution From



Source: Author.
Notes: We use raw data from Datastream.

Figure 5.36: The United Kingdom – Contribution To



Source: Author.
Notes: We use raw data from Datastream.

5.2 Hypothesis 1

During the first two years after becoming a member of the European Union, a country's stock market becomes more integrated with other European countries' stock markets.

Out of our sample, we can use four countries to look into that hypothesis. This is because only these four countries, out of the twenty included in this thesis, joined the EU during the sample. We have several countries included that joined in January of 1995, which we do not use for the analysis of this hypothesis as we do not have the data prior the accession and therefore, we would not be able to compare the spillovers before and after it. Those four countries we use all joined the EU at the same time fairly long before the crisis, which allows us to measure the spillovers without having to worry about some major events that would affect the results. The countries are the

Czech Republic, Hungary, Poland, and Slovakia, which all joined the EU on 1st May 2004, as mentioned above.

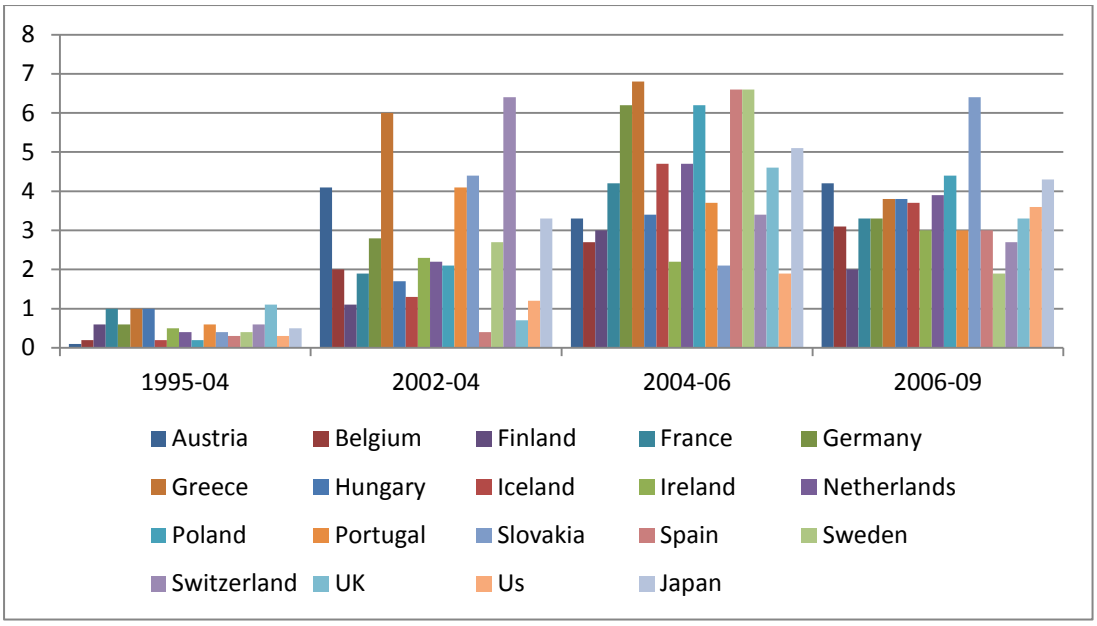
Figures from 5.37 to 5.44 all represent a graphical depiction of spillovers to and from those four countries from and to the other countries for our subsamples. To analyse hypothesis 1, a spillover table with all the countries is calculated for several periods. There are four subsample periods chosen and they are: subsample A is from 06/03/1995 to 25/04/2004, subsample B is from 31/12/2001 to 25/04/2004, subsample C is from 26/04/2004 to 28/04/2006, and subsample D is from 01/05/2006 to 01/05/2009. Subsample A is in the analysis to provide us with an overview of the situation in the period before the EU accession. Subsample B allows us to avoid a misleading result that we could get if we had only subsample A, which reaches too back to the past. Subsample C represents the two years after the countries joined the EU. And subsample D shows what the situation after those two years is like.

The figures allow us to compare, for each country's stock market, the spillovers from and to the other countries' stock markets between each subsample. This is a useful way of how to get a general preview of the situation. Tables from 5.2.1 to 5.2.4 then give us the minimum, maximum, and average values as well as the contribution values. We can say a stock market becomes more integrated with other stock markets, when the spillovers from and to this stock market get higher. To be able to compare the spillovers between the periods, we use the average value of spillovers going from and to the given stock market and the contribution of the stock market, given by the sum of either the column, for the contribution from, or the row, for the contribution to, of a spillover table. The higher the spillovers the higher is the integration.

The Czech Republic

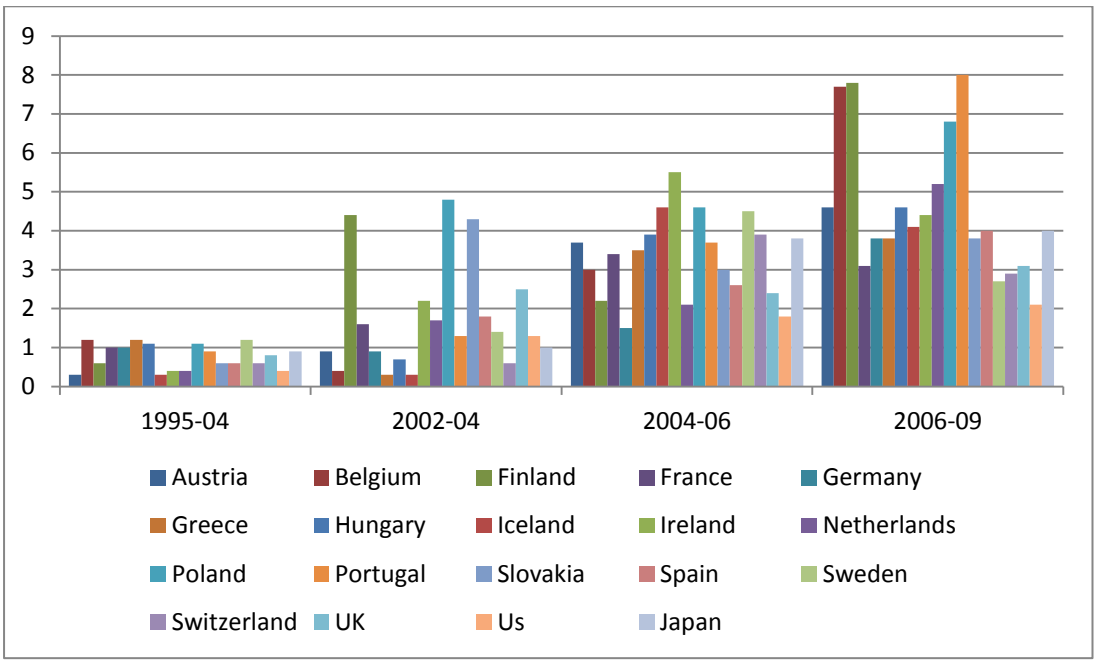
Following the alphabetical order, we start with the Czech Republic. In figures 5.37 and 5.38, we can compare the periods before and after the Czech Republic accessed the EU. The first look at the two figures suggests the spillovers from and also to the CR increased in general from the subsample 2002-02 to the one 2004-06. In the subsample 2006-09 then, are the spillovers generally lower for the spillovers going from the CR, unlike the spillovers going to the CR.

Figure 5.37: The Czech Republic – Spillovers From



Source: Author.
Notes: We use raw data from Datastream.

Figure 5.38: The Czech Republic – Spillovers To



Source: Author.
Notes: We use raw data from Datastream.

Table 5.2.1: The Czech Republic – Spillover Minimum, Maximum, and Average

	From				To			
	1995-04	**2002-04**	**2004-06**	**2006-09**	**1995-04**	**2002-04**	**2004-06**	**2006-09**
Minimum	0.1	0.4	2.1	1.9	0.3	0.3	1.5	2.7
Maximum	1.1	6.4	6.8	6.4	1.2	4.8	5.5	8
Average	0.54	2.72	4.38	3.46	0.78	1.77	3.42	4.73
Contribution	9.2	46.2	74.4	58.8	13.3	30.1	58.1	80.4

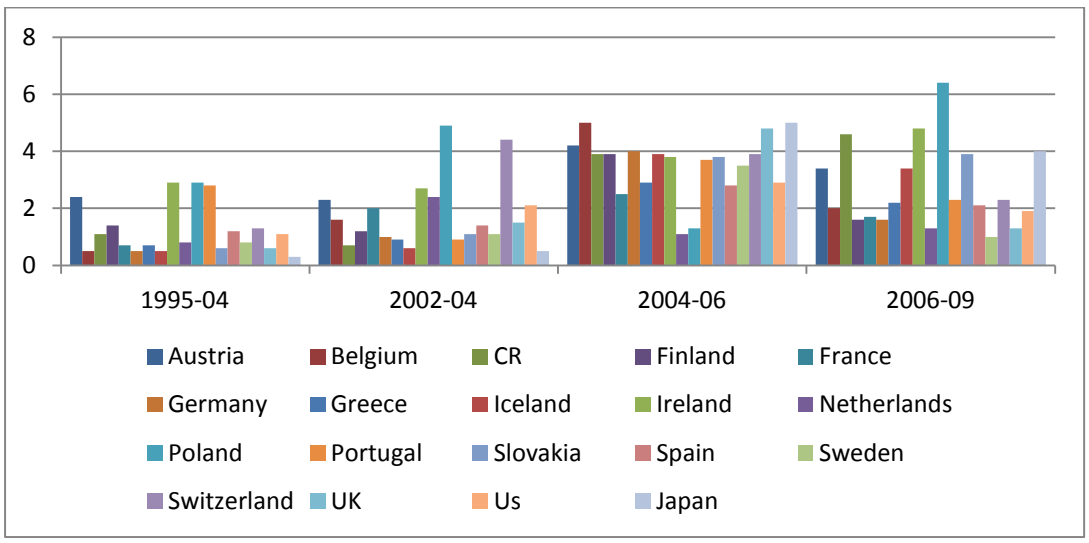
Source: Author.
Notes: We use raw data from Datastream.

Table 5.2.1 tells us, the average values for both spillovers from and to the Czech stock market are higher in the periods after the Czech Republic joined the EU. This applies to the contribution values as well. Therefore, in this case, the stock market becomes more integrated with other European stock markets during the first two years after becoming a member of the EU.

Hungary

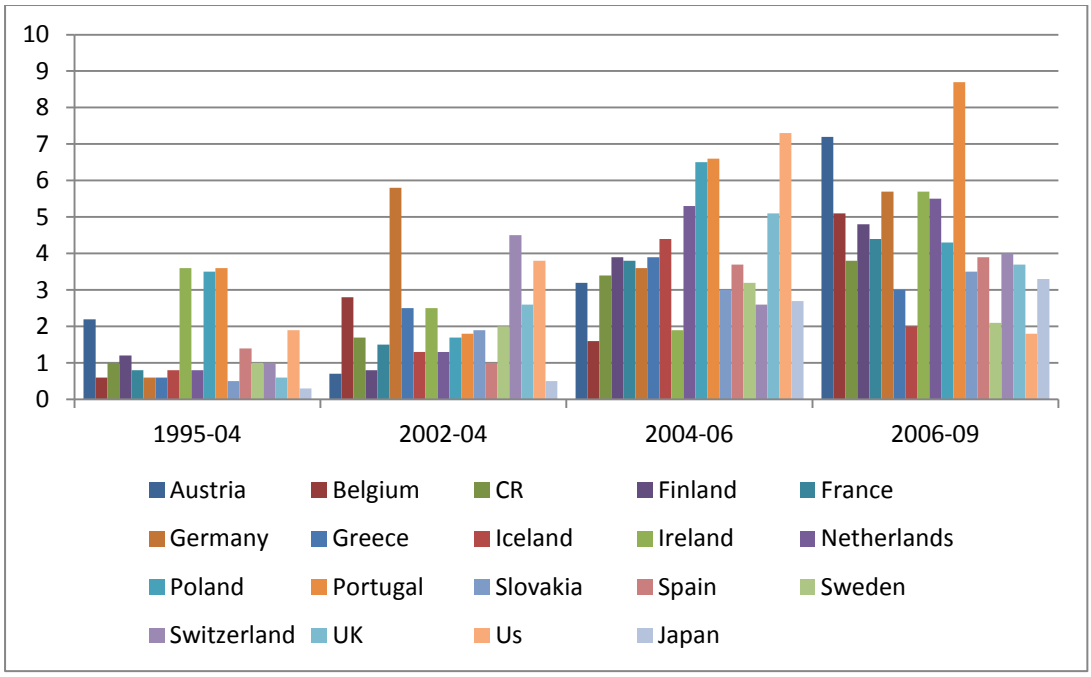
Comparing the periods before and after the accession to the EU in figures 5.39 and 5.40, we get similar results as for the CR. Nonetheless, there are several differences. The Hungarian stock market is generally more isolated than the Czech one, plus, the real or bigger change actually came with the EU accession, which is apparent from the subsample 2002-04, where the spillovers are not much higher than in the subsample 1995-04 suggesting just a slowly increasing trend until 2004.

Figure 5.39: Hungary – Spillovers From



Source: Author.
Notes: We use raw data from Datastream.

Figure 5.40: Hungary – Spillovers To



Source: Author.
Notes: We use raw data from Datastream.

Table 5.2.2: Hungary – Spillover Minimum, Maximum, and Average

	From				**To**			
	1995-04	**2002-04**	**2004-06**	**2006-09**	**1995-04**	**2002-04**	**2004-06**	**2006-09**
Minimum	0.5	0.6	1.1	1	0.5	0.7	1.6	2
Maximum	2.9	4.9	5	6.4	3.6	5.8	6.6	8.7
Average	1.28	1.81	3.47	2.70	1.40	2.14	3.86	4.55
Contribution	21.7	30.7	59	45.9	23.8	36.4	65.7	77.4

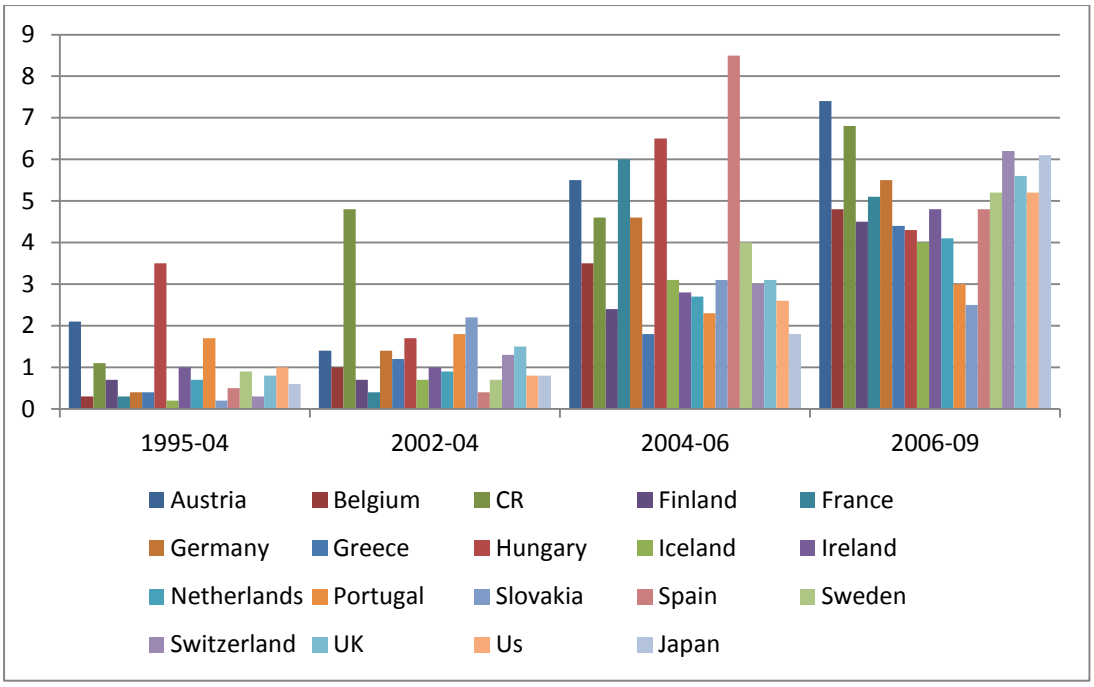
Source: Author.
Notes: We use raw data from Datastream.

Table 5.2.2 basically confirms what we understand from figures 5.39 and 5.40. As in the case of the CR, the average and contribution values of both from and to the Hungarian stock market are higher for the periods after the May of 2004. This suggests higher integration during the two year after joining the EU.

Poland

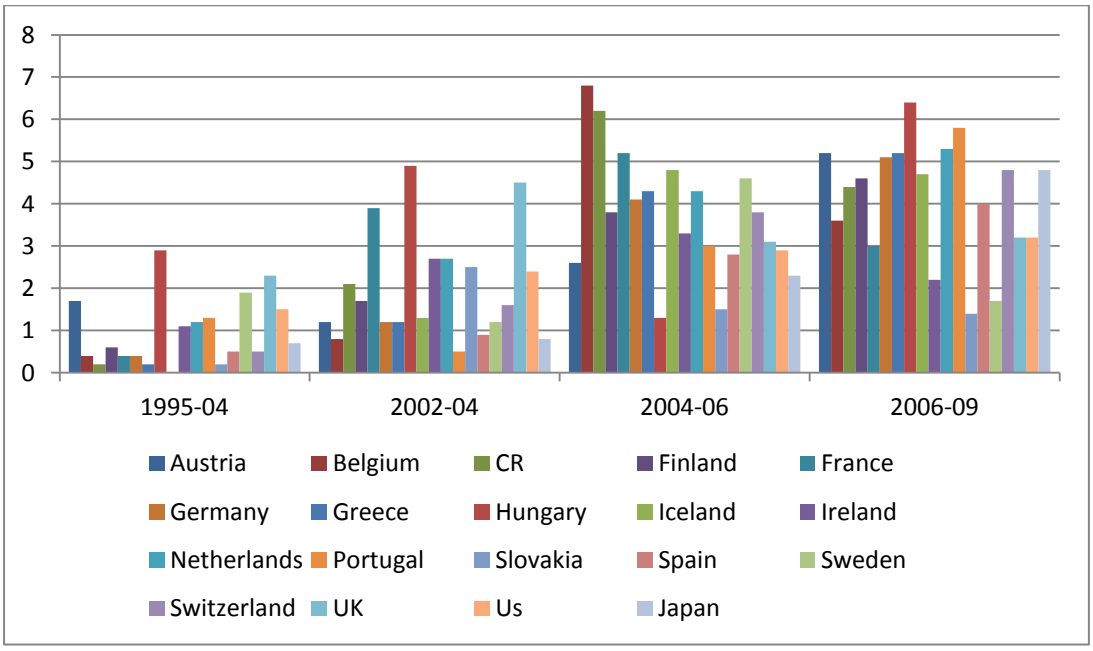
The case of Poland is shown in figures 5.41 and 5.42. The first two subsamples in both figures reveal quite high isolation, again, suggesting just a slowly increasing trend until 2004. In the following subsamples, the spillovers are generally higher. This leads us to believe there is also a higher integration after Poland joined the EU.

Figure 5.41: Poland – Spillovers From



Source: Author.
Notes: We use raw data from Datastream.

Figure 5.42: Poland Spillovers To



Source: Author.
Notes: We use raw data from Datastream.

Table 5.2.3: Poland – Spillover Minimum, Maximum, and Average

	From				To			
	1995-04	**2002-04**	**2004-06**	**2006-09**	**1995-04**	**2002-04**	**2004-06**	**2006-09**
Minimum	0.2	0.4	1.8	2.5	0	0.5	1.3	1.4
Maximum	3.5	4.8	8.5	7.4	2.9	4.9	6.8	6.4
Average	0.89	1.36	3.97	4.88	0.93	2.05	3.85	4.15
Contribution	15.1	23.1	67.5	83	15.8	34.9	65.5	70.6

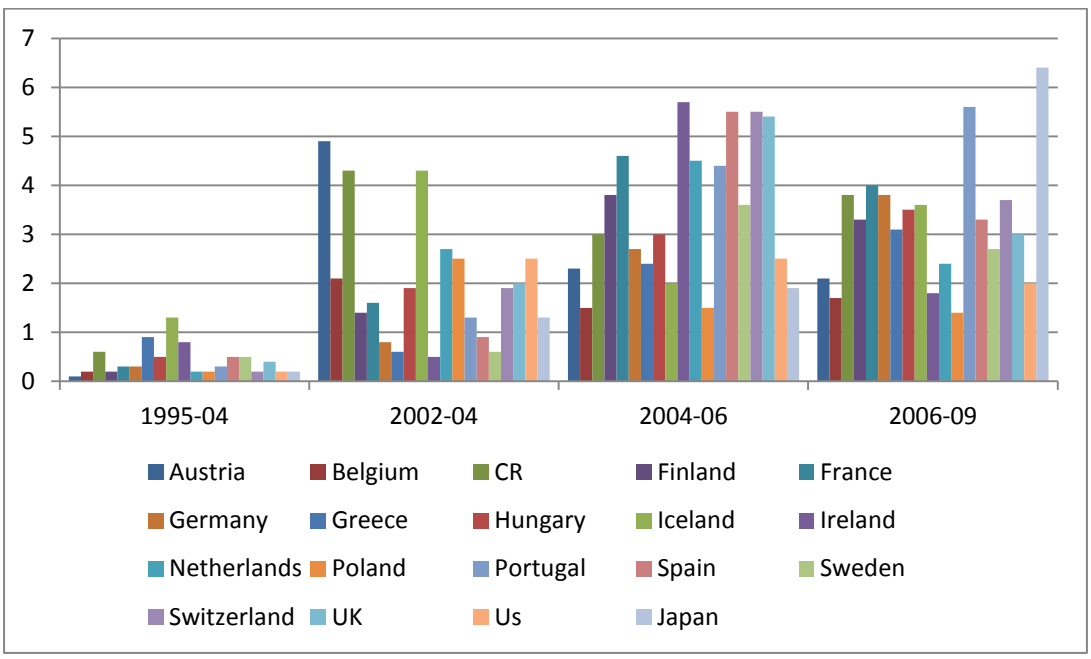
Source: Author.
Notes: We use raw data from Datastream.

Poland's stock market's average and contribution values from table 5.2.3 tell what we see in figures 5.41 and 5.42. Again, the values for the periods after the EU accession are higher than those before it. The integration wither other European stock markets does get higher during the first two years after joining the EU.

Slovakia

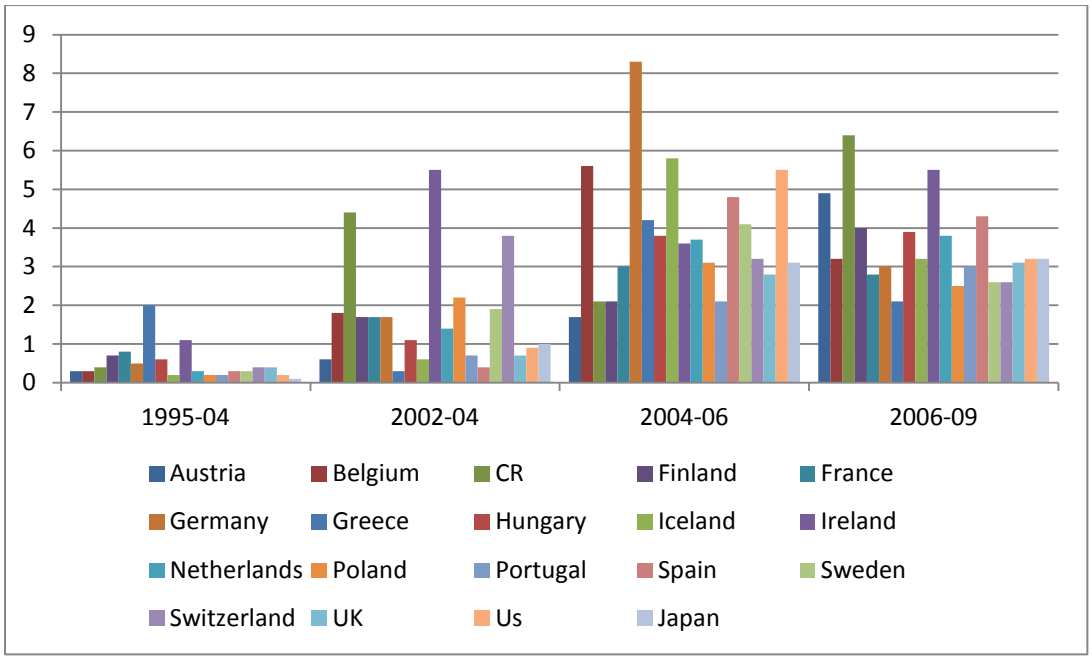
The spillovers from and to the Slovakian stock market grow even before Slovakia joined the EU, as we can see in figures 5.43 and 5.44. Then, they grow more after May 2004, but in the subsample 2006-09, they again appear to be lower.

Figure 5.43: Slovakia – Spillovers From



Source: Author.
Notes: We use raw data from Datastream.

Figure 5.44: Slovakia – Spillovers To



Source: Author.
Notes: We use raw data from DataStream.

Table 5.2.4: Slovakia – Spillover Minimum, Maximum, and Average

	From				**To**			
	1995-04	**2002-04**	**2004-06**	**2006-09**	**1995-04**	**2002-04**	**2004-06**	**2006-09**
Minimum	0.1	0.5	1.5	1.4	0.2	0.3	1.7	2.1
Maximum	1.3	4.9	5.7	5.6	2	5.5	8.3	6.4
Average	0.44	2.02	3.61	3.11	0.53	1.79	3.76	3.58
Contribution	7.5	34.3	61.4	52.8	9	30.5	64	60.9

Source: Author.
Notes: We use raw data from DataStream.

One more time, we get a confirmation of our intuition we get from looking at figures 5.43 and 5.44. During the two years after Slovakia joined the EU, its stock market becomes more integrated with other European stock markets.

Therefore, in all for cases, we can say that during the first two years after becoming a member of the European Union, a country's stock market becomes more integrated with the other European countries' stock markets.

5.3 Hypothesis 2

The European stock markets are becoming more integrated with each other than they are with the stock markets of the US and Japan.

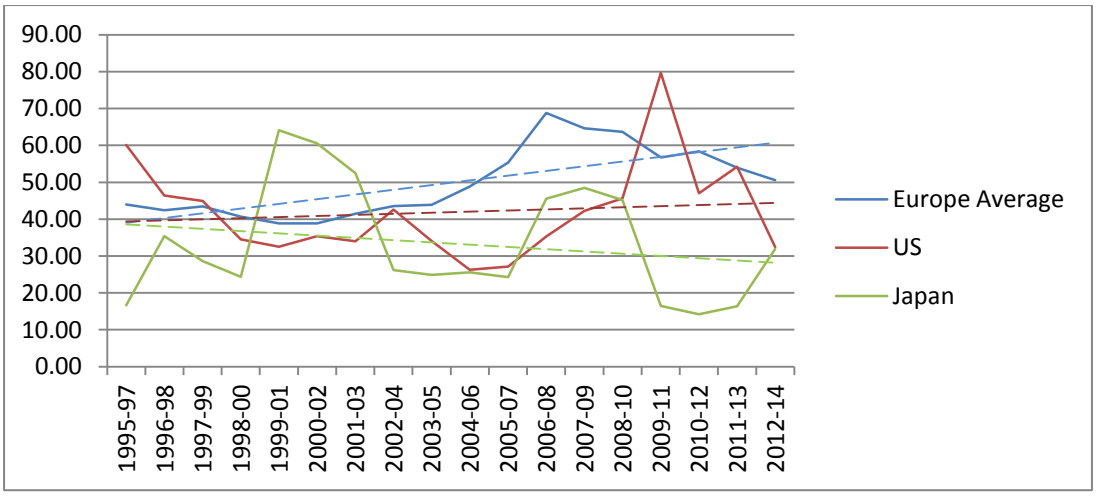
We choose to interpret the results of the analysis of hypothesis 2 using graphs, which are very handy as the results can be read very well. For the analysis we first calculate the average of the contributions of all the European countries included in this thesis for each subsample separately. This is done by first calculating the contribution from and to each European country to and from the other European countries. For the contribution from a country we compute the sum of a column of that country and for the contribution to a country we add up the row of that country. Then, having all these contributions we calculate the average of both, contribution from and to. And we get the European average. Figures 5.45 and 5.46 show the comparison of the contribution from and to the European average, the US, and Japan together with their linear trends. The contributions of the US and Japan are calculated as described above. The curves show us a general level of contribution of the stock markets, as well as their evolution through time. Their linear trends, depicted by the dashed lines of the same colour as a given stock market, give us information of how much or whether the contribution increases though time. This is crucial for the purposes of this analysis. As we need to find out, whether the European stock markets are becoming more integrated with each other than they are with the stock markets of the US and Japan, which is not a static process, it is intuitive to use the linear trend line. Therefore, we can say that as the linear trend of the contribution increases, the integration increases as well. Moreover, the steeper the linear trend line is, the more a country is becoming integrated with the others. To apply it to our case, we can say up front that if the European average linear trend line is steeper than either the American or Japanese linear trend, the European stock markets are becoming more integrated with each other.

Looking at the curves in figures 5.45 and 5.46, we see the European average of the contribution from and to the European countries is generally higher than the contribution from and to the US and Japan to and from the European countries. The US influence on the European stock markets also appears to be bigger than the one of Japan. In the first three subsamples and in subsample 2009-11, the contribution from the US is higher than the average one of Europe. Similarly, the contribution to the US is slightly higher also only in the first three subsamples, and in subsamples 2003-05 and 2011-13. On the other hand, the contribution from Japan is higher than the European average in from subsample 1999-01 to subsample 2001-03. The average

contribution to Europe from its countries shows the European countries generally affect each other more than they affect Japan.

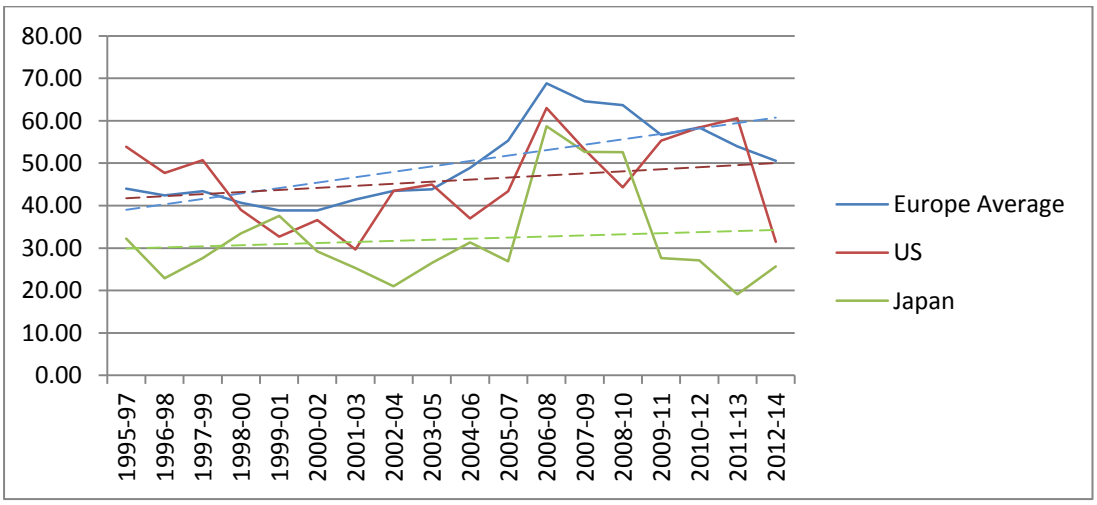
Now, getting to the linear trend lines, we can see the trend line of both average European contributions from and to its countries are steep. Moreover, they are steeper than the trend lines of the contribution from and to both the American and Japanese stock markets. As described above, this means the European stock markets affect each other more and more, and hence becoming more integrated with each other, than they are with the stock markets of the US and Japan.

Figure 5.45: The contribution from the US, Japan and Europe



Source: Author.
Notes: We use raw data from Datastream.

Figure 5.46: The contribution to the US, Japan and Europe



Source: Author.
Notes: We use raw data from Datastream.

5.4 Hypothesis 3

Within three years after joining the Eurozone, the level of a country's stock market integration with the other members' stock markets improved more than with the European stock markets as a whole and the stock markets of the EU.

Out of our sample, we can analyse this hypothesis on eleven countries. As the euro was introduced in 1999 and our data reach back to 1995, the founders of the Eurozone are suitable. They are Austria, Belgium, Finland, France, Germany, Ireland Netherlands, Portugal, and Spain. The two remaining countries that joined the Eurozone later, in 2001 and 2009, are Greece and Slovakia, respectively.

In order to see whether accepting the euro really was an improvement in regards to the integration with the other members of the Eurozone; we once more look at the contributions of each of the eleven countries in different subsamples. In this case, the subsamples are different for the founders, Greece, and Slovakia. For the founders, they are 1995-98, 1999-01, and 2002-04. For Greece, they are four to see what the situation right before the acceptation is and they are, 1995-00, 1998-00, 2001-03, and 2004-06. For Slovakia, we have subsamples 1995-08, 2006-08, 2009-11, and 2012-14. The contribution is again calculated as sum of either a column of a Spilloover table for the contribution from a country, or a row for the contribution to that country, while subtracting the values on the diagonal, which are the contributions that a country has from or to itself. For the purposes of this analysis, we add contributions of a country with the EU and the Eurozone. This is done by subtracting from the original contribution also the countries that, for the given subsample, do not belong to either the EU or the Eurozone. If the contribution from or to the Eurozone show a higher change from the subsamples before the accession to the subsamples after, there an improvement of the integration.

Founders 1999

After Austria joined the Eurozone, the contribution within Europe, the EU, and also the Eurozone decreased. We can see this in table 5.4.1 in subsample 1999-01. The contribution from Austria keeps decreasing in the following subsample, the most within the Eurozone framework; while the contribution to Austria increases back in subsample 2002-04. The most it increased within the Eurozone. This would however suggestthere is no improvement in terms of the integration.

Table 5.4.1: Austria – Spillover Minimum, Maximum, and Average and Contribution

	From			To		
	1995-98	**1999-01**	**2002-04**	**1995-98**	**1999-01**	**2002-04**
Minimum	0.40	0.40	0.10	0.50	0.50	0.30
Maximum	5.80	4.80	4.80	5.90	6.60	5.00
Average	2.72	2.01	1.30	2.94	1.72	1.99
Contribution	46.30	34.10	22.10	50.00	29.30	33.80
% change		-0.26	-0.35		-0.41	0.15
Contribution EU	32.00	20.70	16.80	34.40	19.50	27.80
% change		-0.35	-0.19		-0.43	0.43
Contribution EMU	25.60	16.70	8.90	22.60	13.20	23.50
% change		-0.35	-0.47		-0.42	0.78

Source: Author.
Notes: We use raw data from DataStream.

From the first subsample to the second one, the change of the contribution from Belgium to the Eurozone is smaller than to the EU and Europe. In the following subsample, it is still significantly lower than the contribution to the EU. The contribution change to Belgium is the highest from the Eurozone; nonetheless, it is decreasing in the following subsample. Therefore, the suggestion again is no improvement of the integration.

Table 5.4.2: Belgium – Spillover Minimum, Maximum, and Average and Contribution

	From			To		
	1995-98	**1999-01**	**2002-04**	**1995-98**	**1999-01**	**2002-04**
Minimum	0.20	0.40	0.20	0.20	0.20	0.10
Maximum	3.90	7.50	9.10	5.60	9.00	11.20
Average	1.87	2.51	3.14	2.31	2.88	3.22
Contribution	31.80	42.70	53.30	39.30	49.00	54.80
% change		0.34	0.25		0.25	0.12
Contribution EU	25.60	30.90	43.00	25.70	38.60	41.60
% change		0.21	0.39		0.50	0.08
Contribution EMU	22.00	25.50	31.70	18.40	30.00	28.70
% change		0.16	0.24		0.63	-0.04

Source: Author.
Notes: We use raw data from DataStream.

In subsample 1999-01, the change of contribution from and to Finland to and from, respectively, Eurozone is the highest, i.e. the least negative. However, the following subsample shows no integration improvement that would be attributable to the Eurozone.

Table 5.4.3: Finland– Spillover Minimum, Maximum, and Average and Contribution

	From			To		
	1995-98	**1999-01**	**2002-04**	**1995-98**	**1999-01**	**2002-04**
Minimum	0.50	0.40	0.50	0.20	0.20	0.70
Maximum	5.30	6.60	6.90	5.10	4.30	8.10
Average	2.62	2.04	2.85	2.50	1.91	2.62
Contribution	44.50	34.60	48.50	42.50	32.50	44.60
% change		-0.22	0.40		-0.24	0.37
Contribution EU	34.30	27.90	33.30	27.60	23.50	35.40
% change		-0.19	0.19		-0.15	0.51
Contribution EMU	28.00	23.30	22.30	19.30	19.00	28.70
% change		-0.17	-0.04		-0.02	0.51

Source: Author.
Notes: We use raw data from DataStream.

As we can see in table 5.4.4, the change of the contributions within the Eurozone is the highest only in case it goes from France to the Eurozone and in subsample 2002-04. This shows no improvement of the integration.

Table 5.4.4: France – Spillover Minimum, Maximum, and Average and Contribution

	From			To		
	1995-98	**1999-01**	**2002-04**	**1995-98**	**1999-01**	**2002-04**
Minimum	0.40	0.90	0.40	0.20	0.30	0.40
Maximum	9.30	8.50	10.10	7.20	11.10	16.60
Average	3.45	3.71	3.92	2.90	3.42	4.26
Contribution	58.70	63.10	66.70	49.30	58.10	72.40
% change		0.07	0.06		0.18	0.25
Contribution EU	50.00	49.80	53.40	32.60	32.60	52.60
% change		0.00	0.07		0.00	0.61
Contribution EMU	39.20	38.00	41.40	23.60	26.70	38.10
% change		-0.03	0.09		0.13	0.43

Source: Author.
Notes: We use raw data from DataStream.

Germany does not show the highest numbers of the change of the contributions from and to the Eurozone in any subsample, as can be seen in table 5.4.5. As well as in the other cases, there is no improvement of of the integration within the three years.

Table 5.4.5: Germany – Spillover Minimum, Maximum, and Average and Contribution

	From			To		
	1995-98	**1999-01**	**2002-04**	**1995-98**	**1999-01**	**2002-04**
Minimum	0.40	0.40	1.10	0.20	0.40	0.40
Maximum	7.20	9.00	8.10	9.30	6.60	8.10
Average	3.21	3.62	3.89	3.41	3.08	3.38
Contribution	54.60	61.50	66.10	57.90	52.40	57.40
% change		0.13	0.07		-0.09	0.10
Contribution EU	45.70	46.30	48.60	33.90	36.40	38.10
% change		0.01	0.05		0.07	0.05
Contribution EMU	36.90	37.50	34.90	27.50	26.40	28.20
% change		0.02	-0.07		-0.04	0.07

Source: Author.
Notes: We use raw data from DataStream.

Apart from the change of the contribution to Ireland in subsample 1999-01, which however still shows a decrease in the contribution; there is no sign of a higher improvement of the level of integration between Ireland and the members of the Eurozone, than the one between Ireland and the EU and Europe.

Table 5.4.6: Ireland – Spillover Minimum, Maximum, and Average and Contribution

	From			To		
	1995-98	**1999-01**	**2002-04**	**1995-98**	**1999-01**	**2002-04**
Minimum	0.90	0.30	0.40	0.10	0.70	0.30
Maximum	5.90	4.10	5.70	5.80	4.30	4.40
Average	3.57	1.18	2.12	3.01	2.03	2.03
Contribution	60.70	20.10	36.10	51.20	34.50	34.50
% change		-0.67	0.80		-0.33	0.00
Contribution EU	46.30	14.40	17.30	37.80	25.10	25.70
% change		-0.69	0.20		-0.34	0.02
Contribution EMU	35.80	11.50	9.50	23.90	21.40	19.90
% change		-0.68	-0.17		-0.10	-0.07

Source: Author.
Notes: We use raw data from DataStream.

Table 5.4.7 shows that in each subsample, the change of the contributions from and to the Eurozone is somewhere in between those from and to the EU and Europe. Therefore, Netherlands is not getting integrated any faster with the Eurozone than with the EU and Europe.

Table 5.4.7: Netherlands – Spillover Minimum, Maximum, and Average and Contribution

	From			To		
	1995-98	**1999-01**	**2002-04**	**1995-98**	**1999-01**	**2002-04**
Minimum	0.20	0.70	0.40	0.20	0.70	0.70
Maximum	6.60	8.50	16.60	7.00	8.50	10.10
Average	2.94	3.88	4.83	3.09	3.55	3.88
Contribution	49.90	65.90	82.10	52.50	60.30	65.90
% change		0.32	0.25		0.15	0.09
Contribution EU	40.40	50.60	70.50	35.10	36.70	45.40
% change		0.25	0.39		0.05	0.24
Contribution EMU	31.80	40.00	54.10	26.40	29.00	34.50
% change		0.26	0.35		0.10	0.19

Source: Author.
Notes: We use raw data from DataStream.

The change of the contribution from Portugal to the Eurozone is smaller in both subsamples. While the Eurozone at first has a more increasing affect on Portugal. But the following subsample shows, it loses its effect. Hence, there is not a significant improvement of the integration.

Table 5.4.8: Portugal – Spillover Minimum, Maximum, and Average and Contribution

	From			To		
	1995-98	**1999-01**	**2002-04**	**1995-98**	**1999-01**	**2002-04**
Minimum	0.30	0.40	0.30	0.20	0.40	0.10
Maximum	4.40	4.70	7.20	6.10	5.10	3.70
Average	2.42	2.52	1.87	2.43	2.12	1.46
Contribution	41.20	42.80	31.80	41.30	36.10	24.80
% change		0.04	-0.26		-0.13	-0.31
Contribution EU	29.00	35.60	25.90	22.20	24.00	26.50
% change		0.23	-0.27		0.08	0.10
Contribution EMU	25.10	25.10	15.40	14.90	17.90	15.10
% change		0.00	-0.39		0.20	-0.16

Source: Author.
Notes: We use raw data from DataStream.

The contribution from Spain to the Eurozone increases the less in subsample 1999-01 and decreases the most in subsample 2002-04. On the other hand, the contribution to Sapin from the Eurozone increases the most in subsample 1999-01 and almost the same in 2002-04. Therefore, it is not that straight forward whether we should or not reject the hypothesis in this case. But considering the differences between the changes of the contributions within Europe and the Eurozone, and the differences

between the changes of the contributions within the EU and the Eurozone; the differences are larger for the contributions from Spain. Hence, it means that the higher contributions to Spain form the Eurozone, suggesting higher integration with it, are offset by those from Spain. The integration, therefore, was not improved any significantly.

Table 5.4.9: Spain – Spillover Minimum, Maximum, and Average and Contribution

	From			To		
	1995-98	**1999-01**	**2002-04**	**1995-98**	**1999-01**	**2002-04**
Minimum	0.40	0.80	0.20	0.30	0.30	0.30
Maximum	6.10	11.10	9.60	5.50	7.70	9.50
Average	2.52	3.30	3.22	2.60	2.87	3.28
Contribution	42.90	56.10	54.80	44.20	48.80	55.80
% change		0.31	-0.02		0.10	0.14
Contribution EU	33.30	44.30	44.50	32.20	35.00	45.40
% change		0.33	0.00		0.09	0.30
Contribution EMU	28.20	35.10	33.90	24.40	28.10	36.30
% change		0.24	-0.03		0.15	0.29

Source: Author.
Notes: We use raw data from DataStream.

2001

In table 5.4.10, we can see the changes of the contributions in the first subsample after Greece joined the Eurozone are all negative, apart from the one of the contribution heading to Greece from Europe. This implies there is still more improvement of the integration with Europe as a whole than with the Eurozone in the first three years after Greece accepted the euro.

Table 5.4.10: Greece – Spillover Minimum, Maximum, and Average and Contribution

	From				**To**			
	1995-00	**1998-00**	**2001-03**	**2004-06**	**1995-00**	**1998-00**	**2001-03**	**2004-06**
Minimum	0.10	0.30	0.30	1.00	0.30	0.30	0.30	0.30
Maximum	2.50	3.70	3.90	9.50	1.50	3.20	5.60	7.80
Average	0.84	1.58	1.31	4.72	0.83	1.38	1.63	3.03
Contribution	13.40	25.20	21.00	75.50	13.30	22.00	26.00	48.40
% change		0.88	-0.17	2.60		0.65	0.18	0.86
Contrib. EU	6.30	18.80	12.60	64.90	9.00	15.60	14.80	32.40
% change		1.98	-0.33	4.15		0.73	-0.05	1.19
Contrib. EMU	4.30	11.80	9.50	53.00	8.10	13.40	11.60	26.10
% change		1.74	-0.19	4.58		0.65	-0.13	1.25

Source: Author.
Notes: We use raw data from DataStream.

2009

Table 5.4.11 represents the result for Slovakia. The change of the contribution from Slovakia to the Eurozone is at least twice as big as the one of the contribution to both, Europe as a whole and the EU. Although the change of the contribution to Slovakia from the Eurozone is not the highest one, the differences from those from the EU and Europe are not very significant. Therefore, we can see there is an improvement of the stock markets integration with the other members more than with the Europe as a whole and the EU.

Table 5.4.11: Slovakia – Spillover Minimum, Maximum, and Average and Contribution

	From				To			
	1995-08	**2006-08**	**2009-11**	**2012-14**	**1995-08**	**2006-08**	**2009-11**	**2012-14**
Minimum	0.10	0.20	0.30	0.30	0.20	0.60	0.40	0.50
Maximum	0.50	2.30	2.40	2.80	1.40	5.10	3.20	5.90
Average	0.22	0.90	1.08	1.32	0.48	1.78	1.53	1.86
Contribution	3.70	15.30	18.40	22.40	8.20	30.30	26.00	31.70
% change		3.14	0.20	0.22		2.70	-0.14	0.22
Contrib. EU	3.50	13.90	16.90	18.20	7.50	27.00	22.50	26.70
% change		2.97	0.22	0.08		2.60	-0.17	0.19
Contrib. EMU	2.00	8.10	12.00	11.60	5.20	17.70	14.70	12.90
% change		3.05	0.48	-0.03		2.40	-0.17	-0.12

Source: Author.
Notes: We use raw data from DataStream.

To conclude the analysis of hypothesis 3, the integration was not improved within the first three years after joining the Eurozone in all of the cases apart from the last one, Slovakia. This means that becoming a member of the Eurozone does not improve the integration of the stock markets with the other members more than with the Europe as a whole and the EU. However, it should be noted that it may be because the founders of the Eurozone and Greece might have needed more time to adjust as the euro was completely new and they accepted it at once, which could have possibly been shock to the integration for longer period. Nevertheless, the case of Slovakia shows some immediate improvement, but the contributions to and from the Eurozone decrease in subsample 2012-14, while the ones to and from Europe and the EU both increase.

6 Conclusion

This thesis examined the integration of the stock markets among Europe in a twenty-year horizon, from 1995 to 2014. It focused on the effect that the EU and the Eurozone has on the integration as well as on the extent to which the European stock markets are affected by the stock markets of the US and Japan and the other way round. In the beginning, the literature on this topic was reviewed and a discussion about which authors are unanimous and which are not was given. This was followed by the data description with stationarity testing. Then, the method of Diebold and Yilmaz (2009) extended by Klöessner and Wagner (2012) used for the analysis was explained in detail.

In the part of results, we first looked at each country's stock market separately. In particular, we saw how the contributions of those stock markets of all the countries evolve throughout time, which was thanks to the rolling analysis. From those graphs, we were able to summarize that what affected the contributions of all the countries was unambiguously the crisis 2007-08. Regarding the EU accession, we could have seen some improvements after a country did accessed the EU straight away from the figures. The contributions from and to the stock markets of Japan and the US were, in most cases, more significant only during and around the crisis. And, there was no immediate improvement of the integration visible after the countries joined the Eurozone, even transient stagnation was nothing unusual.

Analysing the first hypothesis, we found out that during the first two years after becoming a member of the European Union, a country's stock market really becomes more integrated with the other countries' stock markets. The analysis was done on four countries and in different subsamples, we could have seen how the contribution grew after the country joined the EU. We also found out that the European stock markets are becoming more integrated with each other than they are with the stock markets of the US and Japan. Here, we used the average contribution of the European countries, and the contributions of Japan and the US, and again run a rolling analysis. It turned out the European average contributions has a higher slope of its linear trend than the contributions of the US and Japan. When we analysed the third hypothesis, which stated that within three years, for those countries that joined the Eurozone, the implementation of the single currency improved the level of stock markets integration with the other members more than with Europe as a whole and the EU; we did not

found higher improvement in most of the cases. As already mentioned, the improvement usually comes within more years after a country joins the Eurozone.

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DATA SOURCES:

www.reuters/com/wealthmanager

Appendix

A. Stationarity Testing

Levels

Table A.1: ADF - Levels

	Value of test statistic	P-Value
Austria	-7.000064***	0
Belgium	-7.31582***	0
CR	-8.123756***	0
Finland	-6.703049***	0
France	-7.001884***	0
Germany	-6.621425***	0
Greece	-8.019381***	0
Hungary	-12.1637***	0
Iceland	-7.311123***	0
Ireland	-5.73084***	0
Netherlands	-6.654686***	0
Poland	-7.58031***	0
Portugal	-8.391531***	0
Slovakia	-18.64462***	0
Spain	-7.800705***	0
Sweden	-7.536962***	0
Switzerland	-7.303961***	0
UK	-7.032842***	0
US	-6.7739***	0
Japan	-10.40475***	0

Notes: H_0: time series has a unit root and the series is non-stationary; number of lags = 2; asymptotic critical values with no intercept, no trend are: 1% : -2.56;5% : -1.95; 10% : -1.62; an asterisk (*) denotes signi_cance at 10% significance level.

Table A.2: KPSS - Levels

	Value of test statistic
Austria	0.863672***
Belgium	0.277012
CR	0.405064*
Finland	0.20885
France	0.127319
Germany	0.213532

Greece	0.891969***
Hungary	0.174235
Iceland	0.844096***
Ireland	0.756635***
Netherlands	0.177413
Poland	0.852487***
Portugal	0.650364**
Slovakia	0.824917***
Spain	0.225036
Sweden	0.254898
Switzerland	0.210335
UK	0.210335
US	0.159479
Japan	0.202797

Notes: H_0: time series is stationary; number of lags = 2; asymptotic critical values with no trend are: 10% : 0.347; 5% : 0.463; 1% : 0.739; three asterisks (***) denote the significance at 1% significance level.

1st difference

Table A.3: ADF – 1st difference

	Value of test statistic	P-Value
Austria	-21.1459***	0
Belgium	-20.7202***	0
CR	-27.3597***	0
Finland	-20.0333***	0
France	-30.3773***	0
Germany	-23.8477***	0
Greece	-16.5467***	0
Hungary	-16.3656***	0
Iceland	-25.9517***	0
Ireland	-22.5336***	0
Netherlands	-27.481***	0
Poland	-19.0129***	0
Portugal	-17.2572***	0
Slovakia	-20.8486***	0
Spain	-23.4482***	0
Sweden	-20.301***	0
Switzerland	-29.1368***	0
UK	-28.8374***	0
US	-26.7092***	0
Japan	-18.9382***	0

Notes: H_0: time series has a unit root and the series is non-stationary; number of lags = 2; asymptotic critical values with no intercept, no trend are: 1% : -2.56;5% : -1.95; 10% : -1.62; an asterisk (*) denotes significance at 10% significance level.

Table A.4: KPSS - Levels

	Value of test statistic
Austria	0.025728
Belgium	0.033905
CR	0.031249
Finland	0.084613
France	0.041406
Germany	0.045139
Greece	0.07233
Hungary	0.033033
Iceland	0.220213
Ireland	0.033994
Netherlands	0.038444
Poland	0.100127
Portugal	0.096472
Slovakia	0.071774
Spain	0.042285
Sweden	0.362544*
Switzerland	0.05112
UK	0.055555
US	0.064913
Japan	0.189079

Notes: H_0: time series is stationary; number of lags = 2; asymptotic critical values with no trend are: 10% : 0.347; 5% : 0.463; 1% : 0.739; three asterisks (***) denote the significance at 1% significance level.

Appendix

B. Propositions

Proposition 1

If the permutation matrix P is partitioned as

$$P = \begin{pmatrix} P_1 & 0 \\ 0 & P_2 \end{pmatrix}$$

where P_1 and P_2 are permutation matrices of dimensions N_1 and $N_2 = N - N_1$, respectively; then Σ_t, B_h, and D_h $(h = 0, \dots, H-1)$ can be written with respect to this as

$$\Sigma_t = \begin{pmatrix} \Sigma_{\varepsilon,11} & \Sigma_{\varepsilon,12} \\ \Sigma_{\varepsilon,21} & \Sigma_{\varepsilon,22} \end{pmatrix}$$

$$\mathrm{B}_h = \begin{pmatrix} B_{11,h} & B_{12,h} \\ B_{21,h} & B_{22,h} \end{pmatrix}$$

$$\mathrm{D}_h = \begin{pmatrix} D_{11,h} & D_{12,h} \\ D_{21,h} & D_{22,h} \end{pmatrix}$$

and hence, (5) can be written as

$$\begin{aligned} \sum_{h=0}^{H-1} trace(PB_hP'C_P + PD_hP'(C'_P)^{-1})\boxed{2} \\ = \left(\sum_{h=0}^{H-1} trace(P_1\tilde{B}_{11,h}P_1{}'C_{P_1} + P_1\widetilde{D}_{11,h}P_1{}'(C'_{P_1})^{-1})\boxed{2}\right) \\ + \left(\sum_{h=0}^{H-1} trace(P_2\tilde{B}_{22,h}P_2{}'C_{P_2} + P_2\widetilde{D}_{22,h}P_2{}'(C'_{P_2})^{-1})\boxed{2}\right) \end{aligned} \tag{6}$$

with

- $\tilde{B}_{11,h} = B_{11,h}$, $\widetilde{D}_{11,h} = D_{11,h} + B_{12,h}\Sigma_{\varepsilon,21}$, and the Cholesky lower factor C_{P_1}, for which $C_{P_1}C'_{P_1} = P_1\Sigma_{\varepsilon,11}P'_1$
- $\tilde{B}_{22,h} = B_{22,h}$, $\widetilde{D}_{22,h} = D_{22,h} + B_{21,h}\Sigma_{\varepsilon,11}^{-1}\Sigma_{\varepsilon,12}$, and the Cholesky factor C_{P_2}, for which $C_{P_2}C'_{P_2} = P_2(\Sigma_{\varepsilon,22} - \Sigma_{\varepsilon,21}\Sigma_{\varepsilon,11}^{-1}\Sigma_{\varepsilon,12})P'_2$.

Proposition 2

If the variable j remains unchanged and a permutation permutes $1, \dots, j-1$ and $j+1, \dots, N$ separately, then the permutation matrix P is partitioned as

$$P = \begin{pmatrix} P_1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & P_3 \end{pmatrix}$$

where P_1 and P_3 are the permutation matrices for the first $j-1$ and the last $N-j$ variables, respectively. When we partition

$$\Sigma_\varepsilon = \begin{pmatrix} \Sigma_{\varepsilon,11} & \sigma_{\varepsilon,12} & \Sigma_{\varepsilon,13} \\ \sigma_{\varepsilon,12} & \sigma_{\varepsilon,22} & \sigma_{\varepsilon,32} \\ \Sigma_{\varepsilon,12} & \sigma_{\varepsilon,32} & \Sigma_{\varepsilon,33} \end{pmatrix}$$

with $\sigma_{\varepsilon,12}$, $\sigma_{\varepsilon,32}$vectors and $\sigma_{\varepsilon,22}$, we get

$$P'C_P P = \begin{pmatrix} P'_1 C_{11,P_1} P_1 & 0 & 0 \\ \sigma'_{\varepsilon,12} P'_1 \left(C'_{11,P_1}\right)^{-1} P_1 & c_{22} & 0 \\ \Sigma'_{\varepsilon,13} P'_1 \left(C'_{11,P_1}\right)^{-1} P_1 & c_{32} & P'_3 C_{33,P_3} P_3 \end{pmatrix}$$

where

- C_{11,P_1} is the lower triangular Cholesky factor $P_1 \Sigma_{\varepsilon,11} P'_1$,
- $c_{22} = \sqrt{\sigma_{\varepsilon,22} - \sigma'_{\varepsilon,12} \Sigma^{-1}_{\varepsilon,11} \sigma_{\varepsilon,12}}$ is a scalar,
- $c_{32} = \left(\sigma_{\varepsilon,32} - \Sigma'_{\epsilon,13} \Sigma^{-1}_{\varepsilon,11} \sigma_{\varepsilon,12}\right) \frac{1}{c_{22}}$ is a vector,

and the j-the columns $P'C_P P$ and $B_h P' C_P P$ are independent of P_1 and P_3.