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Impact of sovereign debt crisis in Greece on its neighboring countries

Bachelor thesis

Prague 2015

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Academic year: **2014/2015**

Bibliographic note

Papoušek Radan. *Impact of sovereign debt crisis in Greece on its neighboring countries.* Praha 2015. 52 p. Bachelor thesis (Bc.) Charles University in Prague, Faculty of Social Sciences, Institute of Economic Studies. Supervisor: doc. PhDr. Adam Geršl, Ph.D.

Character count: 56 235

Abstract

In this thesis, I analyze contagious effects stemming from Greece to Bulgaria, Cyprus, Italy, and Turkey during the Greek sovereign debt crisis. Using the VAR framework, I estimate adjusted cross-market correlation coefficients, and then test them on contagion. My research is based on examination of 10-year sovereign bonds and stock market indices in time period spanning from December 2004 to August 2012. The thesis finds that contagious impacts arising from the Greek crisis were present in all the examined countries. I also find significant interdependence among some of the examined countries. The existence of transmission channels suggests that the crisis could spread easily from Greece.

Keywords: financial contagion, interdependence, VAR model, Greece, sovereign bonds, stock indices
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Abstrakt

V této práci se zabývám vlivem finanční nákazy šířící se z Řecka v době řecké dluhové krize do následujících zemí: Bulharska, Kypru, Itálie a Turecka. Pomocí upravených korelačních koeficientů získaných z VAR modelu se snažím odhalit nákazu do výše zmíněných zemí. K výzkumu používám 10leté vladní dluhopisy a akciové indexy v období od prosince 2004 do srpna 2012. Tato bakalářská práce odhaluje šíření nákazy způsobené řeckou dlouhovou krizí do všech zkoumaných zemí. Analýza ukazuje, že existuje velmi silná vzájemná závislost mezi některými zkoumanými trhy. Existence přenosových kanalů naznačuje, že krize se z Řecka mohla šířit jednoduše.

Klíčová slova:	finanční nákaza, vzájemná závislost, VAR model, Řecko, státní dluhopisy, akciové indexy
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Declaration of Authorship

1. The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

2. The author hereby declares that all the sources and literature used have been properly cited.

3. The author hereby declares that the thesis has not been used to obtain a different or the same degree.

Prague, July 30, 2015

Radan Papoušek

Acknowledgment

I would like to thank doc. PhDr. Adam Geršl, Ph.D., for supervising my thesis and for his time, advice, and guidance.

Acronyms

ADF	Augmented Dickey-Fuller test
(A-)DCC	(Asymmetric-) Dynamic Correlation Coefficient [model]
Eonia	Euro Overnight Index Average
ECB	European Central Bank
EC	European Commission
EFSF	European Financial Stability Facility
EFSM	European Financial Stabilisation Mechanism
ESM	European Stability Mechanism
EU	European Union
EVT	Extreme Value Theory
(FA)VAR	(Factor Augmented) Vector Autoregressive [model]
(G)ARCH	(Generalized) Autoregressive Conditional Heteroskedasticity [model]
Leonia	Lev Overnight Index Average
IMF	International Monetary Fund
OMT	Outright Monetary Transactions
SMP	Securities Markets Programme
TRLIBOR	Turkish Lira Reference Interest Rate

Bachelor Thesis Proposal

In 2010, it became evident that Greece was experiencing serious financial problems and had to ask for international help. Greek government officials asked for a bailout in order to prevent default on its government debts. The EC, the ECB, and the IMF have provided bailout plans, which have been supplying Greece with hundreds of billions euros, and hundreds of billions euros of its loans were written off. Still after such an enormous international help, the Greek economy has been recovering very slowly. Overall unemployment rate is around 25 %, and unemployment among age group of 15-24 is around unbelievable 55 %. From 2008 to 2012, its nominal GDP felt almost by 30 %.

The aim of my thesis will be to examine the impact of the Greek economic meltdown on its neighboring economies with the focus on financial contagion. I will investigate, if financial contagion occurred in all the examined countries, why occurred, and how strongly occurred. Also, I will look into, in which sectors of economy occurred.

Hypotheses

1. Contagion occurred in all the neighboring countries (i.e., Albania, Bulgaria, Cyprus, Italy, Macedonia, and Turkey).
2. Contagion was stronger in the EMU member countries.
3. Contagion occurred only in the financial sector, the non-financial one was intact.

Methodology

I will work with the term "financial contagion" as it is defined by Forbes & Rigobon (2002). For testing hypotheses, I will use the VAR model introduced by Forbes & Rigobon (2002). For testing first two hypotheses, I will use daily data from 2003 to 2012 on 10Y government bonds. For the third hypothesis, I will use daily data from 2003 to 2012 on financial and non-financial stock market indices.

Content:

1. Introduction
2. Literature Review
3. Methodology

4. Empirical Part

5. Results

6. Conclusion

References

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Contents

Chapter 1

Introduction

The Greek sovereign debt crisis began in late 2009, and since then, it has been affecting whole the EU and mainly the eurozone. Risk perception of the European countries quickly changed, driving yields of some sovereign bonds incredibly high. Several countries had to even seek external help to be able to repay their liabilities and to refinance their debts. Even the Greek economy represented only ca. 2,6 % of the eurozone's GDP at its brightest periods, it has caused serious troubles to all European leaders.

Because of the severe economic turmoil, which has been happening in Greece, many have feared that contagion could spread from Greece to other countries, eventually infecting the eurozone and consequently the whole EU. Thus extensive research has been done on possible spread of contagion from Greece to the eurozone countries. But almost none research has been conducted on contagious capacity of the Greek meltdown to its neighboring countries. When having such a crumbling economy as the neighboring one, it is not very likely to pass the critic period intact. My thesis targets such topic.

I focus on contagious effects to the neighboring countries, how strong they are, and what the main determinants for magnitude of contagion are. For measuring contagion, I use one of the most common methods, which was firstly introduced by Forbes & Rigobon (2002). It is based on comparison of the correlation coefficients obtained from the VAR framework. For my estimation method, I use yields on 10-year government bonds, because it can be seen as a proxy for risk perception of a country in the long term. The riskier investment, the higher yield demanded. If there are contagious effects from Greece, sovereign yields should correlate with the Greek ones significantly more than before the crisis started. I also use stock market data to distinguish any impact of the Greek crisis on the financial and the non-financial sector in terms of contagion.

The remainder of the thesis is structured in the following way: Background, Literature review, Data & Model, Results, and Conclusion.

The second part, Background, gives a look at the overall situation around Greece. The third part firstly summarizes theoretical literature and secondly empirical one. The fourth part introduces the data used for this research and describes the employed model in detail. The fifth part reports results obtained from the model and analyzes them. The sixth part summarizes and concludes the thesis.

Chapter 2

Background

This part is divided into two sections. In the first section, I provide the reader with a basic overview of the development of the Greek crisis. I also briefly discuss tools introduced to firstly stop the spreading of the crisis, and secondly to help the Greece to get out of it. In the second section, I provide some basic figures about the Greek economy to complete the whole picture about the Greek government-debt crisis.

2.1 Situation development

Since the beginning of the Greek crisis, the EU and the ECB have introduced many extraordinary measures to prevent the crisis from spreading out of Greece, and to preclude any possibility of contagion. In 2010, the EU introduced the EFSF and the EFSM. The EFSF was merged with the ESM in 2012 and was capable of financing up to €440 billion. The ESM is capable of financing another €500 billion. These funds have been put together in order to bring confidence back to the market and to convince investors that the EU, hence the eurozone, is strong and can prevent member countries from default. Nevertheless, these facilities were not enough to calm the investors down, leaving the interest rates on government bonds too high for some countries. Therefore in May 2010, the ECB launched the SMP – a program for purchasing sovereign bonds in secondary markets of countries in need aiming to lower interest rates of concerned bonds. The SMP was running from May 10, 2010, until September 6, 2012[1]. Liquidity provided by the SMP is sterilized through fine-tuning operations such as auctions of fixed-term deposits. So it should not affect monetary policy (Panico & Purificato 2013). Although lawfulness of this program is questionable, together with stability mechanisms, it has succeeded in

[1] On September 6, 2012, the SMP was replaced by the OMT. Since the OMT has not been used yet and has not directly influenced the bond yields, it is not in the scope of this thesis.

calming the situation. All troubled countries, except of Greece, have the access on the bond market.

These measures only aimed to stop the panic and to stop possible spreading of contagion from Greece; nevertheless, it did not aim to help Greece directly. To help Greece to stand on its own feet again, a broader consensus had to be reached. The fact that Greece had bigger problems, which was not able to solve on its own, became apparent in the fourth quarter of 2009. In April 2009, Greece estimated that its debt-to-GDP ratio for the year would be 99,6 %. Nevertheless in November 2009, Greece changed the figure to 126,8 %, after international pressure questioning verity of such data. Greece had to also adjust other figures such as budget deficit. Adjusted budget deficit for 2009 soared to 12,7 % of GDP. Such adjustments together with uncertainty about accuracy of the rest of the Greek data stood at the beginning of the Greek crisis.

On May 2, 2010, the EC, the ECB, and the IMF, together known as Troika, introduced a bailout plan of €110 billion (€80-billion finance support provided by the eurozone countries on a bilateral basis, €30 billion provided by the IMF as a stand-by arrangement), which aimed to help Greece to cover its financial needs for period May 2010 – June 2013. The program was conditional on passing needed structural reforms to increase productivity, implementing austerity measures, and on privatization of governmental assets of value €50 billion by the end of 2015. €80 billion provided by the eurozone countries were later reduced by €2,7 billion for two reasons. Firstly, Ireland and Portugal did not contribute because they were experiencing severe economic conditions and were forced to request financial support themselves. Secondly, the Slovak parliament refused to contribute the required amount of €800 million for political reasons.

Another wave of financial support was agreed upon in March 2012, when Troika approved additional €130-billion support for period 2012 – 2014 on grounds of worsened economic conditions. Anticipated financial aid totaled €165 billion until December 31, 2014, of which €140 billion was financed through the EFSF, and the rest was granted by the IMF. Again, release of the funds was conditional on passing economic reforms and fulfilling economic criteria[2].

Moreover, Troika with Greek political leaders forced private creditors to accept inferior debt conditions – a face-value cut off of 53,5 %, longer maturity, and lower interest rates. Nevertheless already in the 4Q 2012, Troika approved condition softening of the second-wave support such as lower interest rates and maturity extensions; furthermore, the IMF granted additional €8,2 billion to Greece due to –

[2] see detailed in Council Decision 2011/734/EU of 12 July 2011 (as amended in November 2011, 13 March and 4 December 2012) and the Memorandum of Understanding setting the economic policy conditionality (with the last update signed on 7 December 2012)

yet again – worsened economic conditions.

The program was running without major issues, and the Greek problem seemed to be dealt with until parliamentary snap election in January 2015. The opposition party Syriza won the election and since then has been trying to re-arrange the terms and conditions of the program. The Greek situation is again uncertain.

2.2 Overview of the Greek economy 2000-2014

The Greek economy has never exceeded more than 3 % of the eurozone in terms of nominal GDP. According to Eurostat, it reached its peak in 2008 at value ca. €242 billion (for comparison the Czech GDP at that time was ca. €161 billion, and in 2014, the Greek economy was still larger than the Czech one). Since then, it has lost more than 26 % (comp.: Czech -3,75 %). However, GDP per capita is at the same levels as it was in 2000; this surely does not sound so badly as the 26% drop in GDP. Nevertheless due to the sharp decline of GDP, debt-to-GDP ratio has changed dramatically. It reaches almost 180 %, which is extremely high; still, the debt alone is not the reason, why the Greek economy is not able to operate on its own. Japan's debt-to-GDP ratio is around ca. 220 %, Italian is around ca. 130 %, and U.S. around ca. 120 %. All mentioned countries have serious problems with their debts, but unlike Greece, they do not need billion-euro support as described above.

The main cause, why Greece needs external help, is that its economy is very inefficient and has very low productivity. Greece suffers from massive corruption and tax evasion; it has also very large public sector (Bouvet et al. 2013). Corruption with large public sector contributes to low effectiveness, and tax evasion again with large public sector puts great pressure on public finances. Resulting indebtedness is just the outcome of poor economic efficiency; debt alone could not cause such a large-scale crisis. This is the reason, why financial help from Troika is conditional on structural reforms, and why Troika gives such importance to it.

To put my words to some perspective, I provide the reader with several figures. Unemployment has remained above 25 % for more than 2 years, reaching its peak 27,9 % in the 3Q 2013. Since 2009, Greek GDP has been declining. Import dropped by one third. Even though the Greek path has been drastic for more than 6 years now, it seems that it is somehow stabilizing. If you look at the figures, unemployment has been mildly declining for more than a year, year-to-year changes in GDP are heading to zero from such depth as -8 %, and overall export seems to be in a good condition relative to its past development.

Chapter 3

Literature review

Literature regarding contagion has one unique characteristic – no unequivocal definition of contagion. This phenomenon is discussed in the first section of this part. Following sections sum up theoretical frameworks and approaches used for detecting contagion. This part concludes with a summary of the recent research about the European sovereign debt crisis.

3.1 Definition of the term contagion

There is not a clear agreement about the definition of financial contagion. Pericoli & Sbracia (2001) identify five the most commonly used definitions at that time:

1. "Contagion is a significant increase in the probability of a crisis in one country, conditional on a crisis occurring in another country."

2. "Contagion occurs when volatility spills over from the crisis country to the financial markets of other countries."

3. "Contagion is a significant increase in co-movements of prices and quantities across markets, conditional on a crisis occurring in one market or group of markets."

4. "Contagion occurs when the transmission channel is different after a shock in one market."

5. "Contagion occurs when co-movements cannot be explained by fundamentals."

   (Pericoli & Sbracia 2001, p.9)

Since then, the view on contagion has changed. Second definition does not exclude a possibility of interdependence. According to Forbes & Rigobon (2002), interdependence can be defined as: "strong linkages between the two economies that exist in all states of the world" and "the co-movement [between the two markets] does not increase significantly [after a shock to one of the economies]" (Forbes & Rigobon 2002, p.2224). In another words, when magnitude of the co-movement remains unchanged or the change can be explained by other external factors, it is not contagion. In the second definition, the increased volatility could be explained by e.g. similar fundamentals; in the majority of the recent papers, this is not considered as contagion. All other definitions exclude interdependence. At first sight, it might appear that the first and the third definition may include also interdependence, but the difference is in the word "significant"; that is such increase that cannot be explained by rational means. The fourth definition represents "structural" view on contagion. That is: contagion occurs, when the structure of the way, how movements in one economy are transmitted to the other economy, is altered.

Philippas & Siriopoulos (2013) group definitions of contagion into three types:

1. The wake-up-call contagion – "Contagion in which the crisis initially restricted to one country, providing new information that prompts investors to reassess the default risk of other countries."

2. The shift contagion – "The normal cross-market channel intensifies after a crisis in one country with an increased sensitivity to global risk factors instead of country-specific factors."

3. The pure contagion – "Any instance of contagion that is completely unrelated to the level of fundamentals."

   (Philippas & Siriopoulos 2013, p.162)

So-called the wake-up-call contagion (also referred as the wake-up-call effect) is not perceived as contagion in many papers referring to the European sovereign debt crisis and will not be understood as contagion in this thesis as well. The wake-up-call effect is rather a rational re-assessment of facts. Some facts might be assigned with greater or lower importance due to various reasons, and after a shock to at least one country, the level of importance is reasonably adjusted for better corresponding with the new state of the world. It differs greatly from all other definitions, because this type of contagion does not exclude a possibility of explanation solely based on rational behavior. Thus I do not consider it as contagion.

To see how differently a definition of contagion can be constructed, I pick three of them from the recent papers. Kaminsky et al. (2003) define contagion as "an episode in which there are significant immediate effects in a number of countries following an event – that is, when consequences are fast and furious and evolve over a matter of hours or days" (Kaminsky et al. 2003, p.3). Gorea & Radev (2014) construct the following definition: "an increase in a joint probability of default after a shock to one country" (Gorea & Radev 2014, p.78). Gomez-Puig & Sosvilla-Rivero (2014) use the following definition: "an abnormal increase in the number or in the intensity of causal relationships, compared with that of tranquil period, triggered after an endogenously detected shock" (Gomez-Puig & Sosvilla-Rivero 2014, p.14).

The unclear concept of contagion makes sometimes difficult to compare various papers on contagion. The definition used greatly influences the result of a paper. It is beneficial to use one of the more frequent definitions for the sake of better comparability with existing research. One of the most influencing and cited works on contagion was conducted by Forbes & Rigobon (2002). Thus in this thesis, I use their definition – "a significant increase in cross-market linkages after a shock to one country (or group of countries)" (Forbes & Rigobon 2002, p.2223).

Use of this definition is wise for several reasons. It clearly rules out a possibility of interdependence. It fulfills the concept of contagion as I understand it: a change in relationships between two markets, which cannot be solely explained by fundamentals, i.e. some kind of irrational behavior is involved in influencing the process. And finally, it fits well with the method used in this thesis for detecting possible contagion – the method will be discussed in more detail in the part 4.

3.2 Estimating methods

When estimating contagious effects, there are several ways how to tackle the problem. Gomez-Puig & Sosvilla-Rivero (2014) summarize the most common methods in their paper. They list following ones: probability analysis, cross-market correlations, VAR models, latent factor/(G)ARCH models, and extreme value/co-exceedance/jump approach.

To expand the list above, I add some other techniques used: copula functions, co-integration technique, extreme value theory approach, and granger causality.

Forbes & Rigobon (2002) declare that "[the methodology of cross-market correlation coefficients] is the most straightforward approach to test for contagion" (Forbes & Rigobon 2002, p.2227). Indisputable advantage of the model introduced by Forbes & Rigobon (2002) is in its simplicity. It compares correlation coefficients during two periods; if the correlation coefficients from the post-shock period show significant increase in comparison with the pre-shock coefficients, then it can be concluded that contagion occurred.

Nevertheless, it has several drawbacks. Correlation coefficients capture only linear dependence between variables (Stove et al. 2014). If the relationship is not linear, the measurement is inaccurate. Favero & Giavazzi (2002) states that many country-specific shocks have non-linear impacts on other countries. Moreover, correlation is not invariant of non-linear transformations. Further, it prioritizes the central part of the distribution and disregards extreme values (Rocco 2011). This is not a good property, when examining contagion, because it is a phenomenon that occurs after extreme events. Methods based on correlation coefficients presume that examined data follow the Gaussian distribution (Pais & Stork 2011). According to Rocco (2011) financial time series have often heavy tails.

Moreover, a sample under examination must be divided into two sub-samples. It must be done arbitrarily and before actual testing. As it is stated above, the analysis is based on comparing two periods – a tranquil period and a crisis period. For such comparison a break point, where the tranquil period ends and the crisis period begins, must be picked. Also, presence of such tranquil period is a necessity for this method. Thus to be able to examine contagious effects of a shock, researchers must be able to collect enough data prior the shock. The two periods are distinguished by different volatilities. In the stable period, volatility is low; after a shock, volatility often rises, and turmoil period is characterized by high level of volatility compared to the stable period.

Correlation-coefficient analysis suffers from heteroskedasticity issue. As stated by Forbes & Rigobon (2002) "Cross-market correlation coefficients are conditional on market volatility" (Forbes & Rigobon 2002, p.2225). Since volatility is often dependent on time, heteroskedasticity is present, thus correlation coefficients are biased and inaccurate without proper adjustments – discussed in more detail in the part 4.

Drawbacks of the correlation coefficients can be among the reasons, why EVT has gained popularity in recent years. It examines tail events and disregards others. By the definition, extreme events are rather rare and large in magnitude (Rocco 2011), after these events contagion may arise. Since EVT focuses on such events, the approach seems very suitable for examination of contagious effects. According to Pais & Stork (2011) "EVT is particularly well-suited to analyze extreme negative events represented by large decreases in stock prices and how they propagate across institutions and sectors" (Pais & Stork 2011, p.683). Nevertheless, very high number of observations is needed, and threshold defining extreme values must be picked carefully, otherwise it can lead to misleading results. When employed with copula functions, it is able to detect different patterns of dependence, and it can determine causality. When non-parametric form of EVT is employed, no assumptions has to be made about the probability distribution of the variables (Aloui et al. 2011).

Another very popular method employed, when estimating contagion, is GARCH framework, because it removes the problem with heteroskedasticity. The paper written by Grammatikos & Vermeulen (2012) states clearly: "the GARCH model is well known for its ability to deal with time varying stock market volatility" (Grammatikos & Vermeulen 2012, p.518). Nevertheless, it has its own shortcoming. Forbes & Rigobon (2002) declare that GARCH framework does not explicitly test for contagion. Pechova (2010) also comes to a similar conclusion: "[GARCH] is not primarily focused on detection of contagion" (Pechova 2010, p.20). Although GARCH itself is not suitable for detecting contagion, when put together with other estimating tools, it is very helpful. For instance, GARCH is used in the DCC model introduced by Engle (2002). According to Pragidis & Chionis (2014), the advantage of the DCC-GARCH model is that researchers do not need to divide the sample into the two sub-samples.

According to Forbes & Rigobon (2002), Granger-causality approach is often used when the source of contagion is not obvious, or when issues with endogeneity arise. This method is able to detect feedbacks from the infected countries to the source country.

GARCH, correlation coefficients, and Granger causality are the most widespread methods employed regarding research about the European sovereign debt crisis. There have been some new methods introduced such as A-DCC model or copula functions, but they have not been in wide use yet, given their novelty.

3.3 Contagion propagation mechanisms

There are many ways, how contagion can spread. Bouvet et al. (2013) state that it can propagate through trade linkages and international capital markets. Contagion through trade linkages may happen, when firms from one country experience a shock, thus may be unable to repay its obligations to their trading partners abroad. This would lead to lower tax revenues and other possible negative effects in the foreign economy, and therefore worsening fiscal balance, hence impairing ability to repay sovereign debt. The other way of spreading contagion could be explained in the following way: when country's debt is downgraded, some financial institutions (domestic and foreign) may be force to dispose such debt instruments in order to meet financial-regulation requirements. This disposal can lead to increase in sovereign bond yield and possible further downgrading. The financial institutions may then lack sufficient collateral or capital volumes. Governments may then need to step in and inject additional capital into those institutions. Similarly to the example above, such actions may affect fiscal balance of such countries and impair ability to finance their debt.

Given high level of integration in the eurozone, many banks outside of a troubled country may hold its debt. This suggests that issues from one country can spread quickly to the whole eurozone. Pragidis & Chionis (2014) add to these two mechanisms also "similarities in macro fundamentals, liquidity, and irrational behavior of investors" (Pragidis & Chionis 2014, p.3). Similar macro fundamentals usually cause only the wake-up-call effect, which may not be considered as contagion – see the section 3.1.

Contagion via liquidity means that when a financial institution realizes losses due to toxic financial instruments, it may find itself cut from further funding, because investors may exhibit fly-to-quality pattern. Even if the institutions are not cut from external funding, it can cause serious troubles. When bonds lose their value, it lowers an amount of collateral available to the institutions, therefore it directly affects their functioning.

3.4 Empirical literature

The majority of the papers tends to the conclusion that there was no (or very limited) contagion spreading from Greece.

For instance, Pragidis & Chionis (2014) find no contagion from the Greek 10Y government bonds to the sovereign bonds of the following countries: Portugal, Ireland, Spain, Italy, Germany, and France. They use Forbes's & Rigobon's (2002) correlation coefficients and DCC methodology. For the first methodology, they define the crisis period from October 20, 2009, to March 16, 2012. Not even that they find no contagion, they find that correlation coefficients decreased among countries suggesting that investors began looking more closely on each country's macro fundamentals and economic indicators. Furthermore, they discover flight-to-quality pattern among German and French bonds.

This conclusion is in line with Bhanot et al. (2012), who also find no evidence of contagion to Portugal, Ireland, Italy, and Spain using VAR and ARCH frameworks. The paper also suggests that correlation coefficients actually decreased during the crisis. Their definition of the turmoil period is from July 2007 to March 2011.

Claeys & Vasicek (2014) test for contagion 16 EU countries finding only very limited contagion. They claim that contagion occurred only when financial assistance to troubled economies – Greece, Ireland, and Portugal – was discussed at EU level. Besides that, no contagion was present. They employ FAVAR framework.

Samitas & Tsakalos (2013) test for contagion using A-DCC model and copula functions. They find that a limited contagion occurred mainly among Italy, Ireland, Portugal, and Spain. Nevertheless, the most of contagion is probably caused by the wake-up-call effect. The paper does not state clearly its definition of contagion, therefore it is not obvious, what they mean as they are referring to contagion. All of the detected so-called contagion could be probably explained by the fundamentals.

Although they are in a minority, there exist papers suggesting that contagion from Greece occurred. For instance, Arghyrou & Kontonikas (2011) test[1] for contagion using OLS-HAC (OLS adjusted for heteroskedasticity and autocorrelation) and find evidence that contagion was spreading from Greece in period March 2009 – February 2010. Moreover, they claim that in period March 2010 – August 2011 contagion had several sources: Greece, Ireland, Portugal, and Spain.

Gomez-Puig & Sosvilla-Rivero (2014) identify "clear evidence of contagion" (Gomez-Puig & Sosvilla-Rivero 2014, p.1) among 11 eurozone countries[2]. They use Granger-causality approach to identify new connections and to detect intensification of existing ones. The authors find that contagion did not spread only among the peripheral[2] countries, but it was also spreading to the core[2] countries. This study does not select a break point between tranquil and turmoil period a priori based on researchers' knowledge; instead, they run Quandt-Andrews test to detect them. Since their interest is the whole eurozone, not just Greece, I state only relevant break points for my purpose: November 2009 – admission made by Greek authorities of questionable adjustments of public-finance statistics; later in that month correction of such data followed; and April 2010 – Greece made a request for international support.

Philippas & Siriopoulos (2013) also confirm the hypothesis of spreading contagion from Greece to other countries[3]. Similarly to Gomez-Puig & Sosvilla-Rivero (2014), they do not set a break point purely exogenously. With help of Markov switching model, they identify December 2009 as the break point. Unlike the majority of papers, they do not base their computations directly on daily data of 10Y government bond yields, but they base it on "the average weekly realized volatility" (Philippas & Siriopoulos 2013, p.167) of these instruments.

Bouvet et al. (2013) find evidence of contagion in the following way: when Greek (and Spanish) sovereign spreads[4] increased, it significantly affected other countries'[5] debt-to-GDP ratios. They use panel VAR framework for such testing; defining the pre-crisis period from 2000 to 2007 and the crisis one as 2008 – 2011.

Definitions of turmoil periods differ among papers. Some papers define the beginning of the period somewhere around the collapse of the investment bank Lehman Brothers; other somewhere at the end of 2009, when the Greek issues became evident. This may also have an effect on the results presented in the papers.

It is worth mentioning also papers, which do not base their examination on gov-

[1] They performed the tests on 10 eurozone countries: Austria, Belgium, Finland, France, Greece, Ireland, Italy, the Netherlands, Portugal, and Spain. Germany is not among the countries, since they use 10Y sovereign bonds yield spreads relative to Germany.

[2] core countries: Austria, Belgium, Finland, France, Germany, the Netherlands; peripheral countries: Greece, Ireland, Italy, Portugal, Spain

[3] France, Germany, Italy, Portugal, Spain, the Netherlands

[4] Sovereign spread is defined as a difference between country's 10Y bond yield and yield on U.S. treasury notes

[5] Countries under examination: eleven founding countries of the eurozone

ernment bonds. For instance, Mink & de Haan (2013) employ event study approach to analyze the relationship between news about Greece and the Greek bailout on the one hand and 48 European bank[6] stock prices in 2010 on the other hand. They conclude that the possibility of the Greek default was not considered as a serious source of contagion by international investors. Still, news about the Greek economic situation and about the Greek bailout had impact on government bonds of Ireland, Portugal, and Spain. The offered explanation by the authors is the wake-up-call effect, therefore supporting hypothesis of no contagion as it is defined in this thesis. Another conclusion, published in the paper, is that news about the Greek bailout had significant effect on all bank stock prices, no matter how large the exposure to Greece was. This suggests contagious effects spreading from Greece to other European countries.

Kalbaska & Gatkowski (2012) use CDS spreads instead of sovereign bonds. They test for contagion among GIIPS[7], France, Germany, and the United Kingdom. Although the paper is more focused on examination of contagion during the global financial crisis of 2007-08, it also touches early stages of the European sovereign debt crisis[8]. It reveals that Greece had actually the lowest triggering capacity of contagion after the first Greek bailout – May 2010. The authors' explanation is that "it became obvious that the Greek crisis is the European Union crisis" (Kalbaska & Gatkowski 2012, p.671), therefore attention moved to the core countries – mainly Germany and France, since they had the biggest decision power regarding the Greek crisis; also their economies are significantly larger and more important for the whole continent. For these reasons, they had much higher capacity of triggering contagion than Greece had.

Gorea & Radev (2014) also examine the European contagion phenomenon based on CDS spreads. They find that contagious effects through financial channel were present only among the eurozone periphery countries[9], while contagion via trade linkages spread also to the core countries[9], though in a very limited way.

[6]Banks under examination are from the following countries: Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Spain, Sweden, the United Kingdom

[7]Portugal, Italy, Ireland, Greece, Spain

[8]The period under examination ends in September 2010 – approximately a year after the beginning of the Greek crisis

[9]core countries: Austria, Belgium, Finland, France, Germany, Luxembourg, the Netherlands, Malta; periphery countries: Greece, Ireland, Italy, Portugal, Spain

Chapter 4

Data & Model

This part is divided into three sections. In the first one, I briefly discuss the motivation behind countries picked for my research together with introduction of my main variables. The second section analyzes the data and the estimation technique in detail. The third one focuses on sensitivity analysis of the model.

4.1 Data

Since Greece is a coastal country, it may be ambiguous, what by neighboring countries is meant. In this thesis, I analyze Greek relationships with following countries: Bulgaria, Cyprus, Italy, and Turkey. Obviously, I pick Bulgaria and Turkey, because they share land border with Greece. Although Cyprus does not have land borders with Greece, it is very connected to it. Greece is the main import and export partner for Cyprus, therefore any shock experienced in Greece may be well transmitted to Cyprus. Italy is included in my research for following reasons: its distance from Greece is less than 200 kilometers, it has been the largest import partner of the sample countries for Greece for many years, and it was the main export partner until 2012, when Turkey took the lead. Furthermore, it has many similar macro-economic indicators such as: high level of debt-to-GDP ratio, high public expenditures, high unemployment – mainly among the youth, high bank exposition to the domestic debt, poor tax collection, and instable political environment. The last reason is comparability; whether the thesis belongs to the group, which rejects contagion to Italy, or if it belongs to the other group.

Moreover, it adds one more perspective, how to look at the presented results. There are two cases, in which the Italian results would have greater information value. If the model rejects contagion for Italy, but detects contagion for other examined countries, the results with contagion will have greater weight in comparison to the case, when contagion is detected for all countries including Italy; similarly, when it confirms contagion for Italy, but rejects contagion for others, the soundness of rejection would be stronger compared to the case, when contagion is rejected for all.

Albania and Macedonia are excluded from the examination, despite they both share land border with Greece. The data available on these two countries are not sufficient for my research. Examination of the impact of the crisis on these two countries may be the focus of a next research using different estimating methods and requiring different type of data.

I use daily data on 10Y government bond yields for Bulgaria, Cyprus, Greece, Italy, and Turkey. Data are acquired from several sources. All data on 10Y government bond yields, but Turkish, are acquired from Eurostat. Bloomberg serves as the source for Turkish government bonds. All other data come from Thomas Reuters Eikon, unless indicated differently. Time period under examination begins on December 17, 2004, and ends on August 10, 2012. For Cyprus, the examined period is adjusted and begins from January 11, 2008. Cyprus became a member of the eurozone on January 1, 2008, therefore to avoid any influences arising from such transition, I alter the period. Similarly, the examined period for Turkish bonds begins also on January 11, 2008. I found no data on Turkish 10Y government bonds in 2007, therefore I have to begin my research from January 2008. Discussion about time-period selection follows in the section 4.2.

I also examine stock indices in daily frequency of such countries. I use the same time period for comparison with results based on sovereign bonds. I compare impacts of the Greek crisis on whole stock markets and on the bank stocks separately. As it is stated in the section 3.3, banking sector is one of the transmission channels of contagion. Thus such contagion may be stronger and may be better detectable on bank indices than on government bonds or on indices representing whole markets.

From my examination, I have to drop two variables. The first one is bank stock index for Bulgaria because of its non-existence. The second one is Cypriot 10Y government bond yield. Eurostat reports only primary market yield for Cyprus. The effective yield is fixed to the latest sovereign bond issuance and its yield, therefore this indicator has the exactly same value for long periods of time. Such property makes this variable unsuitable for my testing. The development of the variable is depicted in Figure 4.1 for illustration. Thus I do not test my hypotheses on Cypriot bonds and Bulgarian bank stock index.

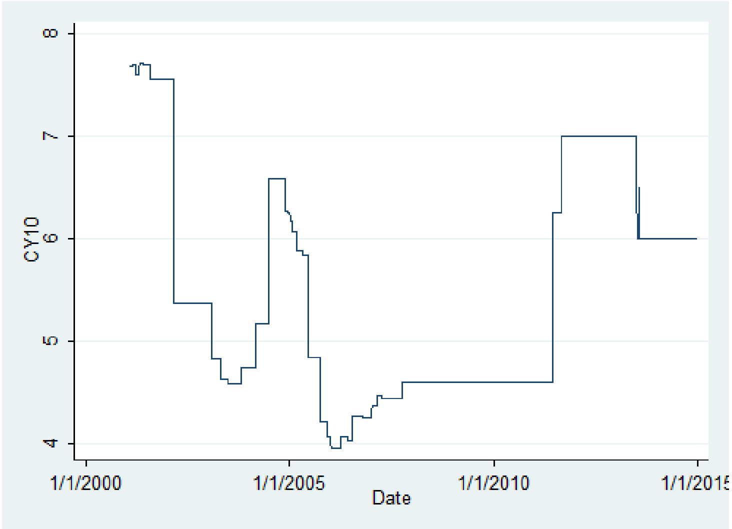

Figure 4.1: Cypriot 10Y sovereign bond yield

Financial data often follow a unit root process; to test for this possibility, I run an ADF test. The test does not exclude the possibility of a unit root existence, therefore transformation of the data is needed. I apply the following transformation:

$$r_t = 100 * log\left(\frac{r_t}{r_{t-1}}\right) \tag{4.1}$$

(Pragidis & Chionis 2014). After the transformation, the test strongly rejects unit root and the data are stationary. The transformation turned the data on bond yields into rate of returns of bond yields and the data on stock indices into stock returns.

4.2 Introducing the model

I test the following three hypotheses:

1. Contagion did not occur in all the examined countries.
2. Contagion was not stronger in the eurozone countries.
3. Contagion occurred only in the financial sector, the non-financial one was intact.

I employ the methodology introduced by Forbes & Rigobon (2002) with several adjustments based on latter literature. As it is stated in the section 3.2, Forbes's & Rigobon's (2002) methodology is one of the most straightforward methods, how to test for contagion. It is well-known and often used. The problem with heteroskedasticity is dealt with well as it is shown below in this section. Secondly, I have enough data to establish both a stable and a turmoil period, so the necessity of existence of the stable period is not an issue here. Thirdly, I can set a break point to divide the sample into the stable and the turmoil period easily, since there exists sufficient amount of literature identifying such point. I am aware that only linear dependencies can be revealed by the model. Still, the existing literature on the Greek sovereign debt crisis exploit heavily methods connected with correlation coefficients. I contribute to the existing research by examining countries, which have not been under examination yet.

Forbes's & Rigobon's (2002) approach compares cross-market correlation coefficients, which are acquired from the VAR model. The VAR framework, which I use, has the following structure:

$$X_t = \phi(L)X_t + \Phi(L)I_t + \eta_t \tag{4.2}$$

$$X_t = \{x_t^j\}' \tag{4.3}$$

$$I_t = \{x_t^G, i_t^G, i_t^{us}, i_t^j, z_t^{VIX}, z_t^{ECB}\}' \tag{4.4}$$

, where x_t^G is rate of returns of the Greek government bond yields in time t in the first part, and return of the selected Greek stock index in time t in the second part of the estimation. x_t^j is the same indicator for country j.

$\phi(L)$ and $\Phi(L)$ are vectors of lags. i_t^G is the short-term interest rate in Greece. As Greece has been a member of the eurozone, since January 1, 2001, I use Eonia for this purpose. As defined by the ECB (2015): "It is calculated as a weighted average of the interest rates on unsecured overnight lending transactions denominated in euro".

i_t^j is the same indicator for country j. For Italy and Cyprus, it would be again Eonia, thus i_t^j is not present in the model for these two countries. For Bulgaria and Turkey, it is Leonia and TRLIBOR, respectively. Leonia is the same as Eonia, but regarding Bulgarian Lev. It is sponsored by the Bulgarian central bank and several other institutions. TRLIBOR[1] is sponsored by the Banks Association of Turkey. I use its overnight values, therefore it can be thought as the Turkish equivalent to Eonia and Leonia. For the variable i_t^{us}, I use the federal funds effective rate, which in its logic is similar to the Eonia rate.

z_t^{VIX} is the Chicago Board Options Exchange (CBOE) Market Volatility Index. As it is defined by CBOE (2015) "a key measure of market expectations of near-term volatility conveyed by S&P 500 stock index option prices".

Since the ADF test does not reject the hypothesis of a unit root presence, I transform all the variables according to the above mentioned formula 4.1. All variables

[1]data on TRLIBOR acquired from www.trlibor.org; the web page is run by the Banks Association of Turkey

and their transformations are depicted in Appendix A.

The motivation behind employing interest rates and volatility index in my model is following. Interest rates control for changes in monetary policy (Claeys & Vasicek 2014) and for aggregate shocks to an economy (Forbes & Rigobon 2002), which both can influence the bond yields. VIX is used as a proxy for fundamentals (Bhanot et al. 2012). As stated by Claeys & Vasicek (2014), VIX "is often used to measure risk aversion on global markets" (Claeys & Vasicek 2014, p.15). It can be thought that interest rates control for fundamentals on a regional level and VIX controls for fundamentals on the global one. Some papers use VSTOXX instead of VIX (European variation of VIX) – for instance Pragidis & Chionis (2014). However, I think, VIX is a better choice, since VSTOXX could suffer from possible endogeneity as it measures volatility on European stock markets.

z_t^{ECB} is a dummy variable. It controls for effects arising from interventions on bond markets conducted by the ECB through the SMP – as stated in the section 2.1. For periods of high activity of the SMP, $z_t^{ECB} = 1$; when the SMP is inactive or the activity is low, $z_t^{ECB} = 0$. Periods of high activity are following: May 10, 2010, – June 6, 2010, (total amount purchased[2]: €28,5 billion; weekly average: €5,7 billion); September 27, 2010, - October 1, 2010, (T: €1,4 billion; W: €1,4 billion); November 1, 2010, - February 21, 2011, (T: €16,5 billion W: €1,1 billion); August 8, 2011, - January 23, 2011, (T: €145 billion W: €6 billion). The highest amount of bonds held by the SMP was €219,5 billion; purchases in the defined high-activity periods constitute more than 87 % of the amount. The impact of the SMP on the Greek bond yields is confirmed by e.g., Eser & Schwaab (2013), Trebesch & Zettelmeyer (2014).

η_t is a vector of reduced-form disturbances. X_t and I_t are transpose vectors of the variables.

To account for the fact that exchanges have different opening hours, moreover that some variables come from the U.S. market, I compute 2-day moving averages of the variables. I also adjust the data for non-trading days; since they differ among exchanges, the number of observations is not identical for individual datasets. All variables are thought to be exogenous. Only x_t^j is thought to be endogenous; based on literature review, 4 lags of x_t^j should be sufficient to capture any effect.

One of the main issues to solve is heteroskedasticity. Methodology introduced by Forbes & Rigobon (2002) removes such issue. They firstly estimate conditional correlation coefficients – coefficients, which are biased, when heteroskedasticity is present – then they estimate impact of heteroskedasticity and correct for it deriving unconditional coefficients.

[2]at market price, not face value

Their argumentation is following. The authors come with simple model

$$y_t = \alpha + \beta x_t + \epsilon_t,$$

, where

$$E[\epsilon_t] = 0,$$

$$E[\epsilon_t^2] = c < \infty$$

$$E[x_t, \epsilon_t] = 0.$$

They prove that with increasing variance in x, the estimated correlation coefficient between x and y increases as well, even if the real correlation remains constant. Thus correlation coefficient is conditional on volatility (Forbes & Rigobon 2002).

Given ρ^* as a conditional coefficient and

$$\delta \equiv \frac{\sigma_{xx}^h}{\sigma_{xx}^l} - 1$$

as an expression of the relative increase in the variance of x. Forbes & Rigobon (2002) propose the unconditional correlation coefficient in this way:

$$\rho = \frac{\rho^*}{\sqrt{1 + \delta[1 - (\rho^*)^2]}}.$$

To come to this coefficient, two strong assumptions have to be made. First one is no endogeneity, the second one is no omitted variable (Forbes & Rigobon 2002).

I have dealt with both of the assumptions. It is almost unanimously accepted that the Greek sovereign debt crisis originated in Greece (inter alia, Bouvet et al. (2013), Arghyrou & Kontonikas (2011), Philippas & Siriopoulos (2013) and has had the strongest impact on the country (inter alia, Samitas & Tsakalos (2013), Grammatikos & Vermeulen (2012), so feedback (if any) from the neighboring countries should be negligible. Therefore I can allow x_t^G to be exogenous variable. Any other effect should be covered by variables for interest rates, by the variable for the volatility index, and by the dummy variable.

Nevertheless, the unconditional coefficients as proposed by Forbes & Rigobon (2002) are under criticism that they are biased towards rejecting contagion (e.g. Pragidis & Chionis (2014). I construct correlation coefficients as they are stated in Pechova (2010). The author modifies the construction of the coefficient slightly, which lowers the bias. The adjustments are in the definition of δ and in a restatement of the null hypothesis. New definition of δ is:

$$\delta \equiv \frac{\sigma_{xx}^h - \sigma_{xx}^l}{\sigma_{xx}^l}$$

Forbes & Rigobon (2002) in their hypotheses compare the conditional coefficient for a whole period with the unconditional one for a crisis period. I compare the conditional coefficient for a stable period and the unconditional one for the crisis period. There can be the conditional coefficient used in the hypothesis, since it is assumed that the stable period is a period of low volatility, and the crisis period is a period of high volatility, thus there is no need to adjust the coefficient for the low-volatility period. Put it mathematically, the hypotheses are:

$$H_0 : \rho_s^* = \rho_t$$

$$H_1 : \rho_s^* < \rho_t$$

, where upper index * indicates conditional coefficients, and lower indices "s" and "t" indicate the stable and the crisis period, respectively.

In another words, the null hypothesis says that no contagion occurred after the shock; after accounting for fundamentals and heteroskedasticity, the coefficient remained the same.

T-statistic is:

$$FR_1 = \frac{\hat{\rho}_t - \hat{\rho}_s^*}{\sqrt{\frac{1}{T_h} + \frac{1}{T_l}}}.$$

, where T_h and T_l is number of observations in the turmoil and the stable period, respectively. After applying Fisher transformation, the test statistic is following:

$$FR_2 = \frac{\frac{1}{2}\log\left(\frac{1+\hat{\rho}_t}{1-\hat{\rho}_t}\right) - \frac{1}{2}\log\left(\frac{1+\hat{\rho}_s^*}{1-\hat{\rho}_s^*}\right)}{\sqrt{\frac{1}{T_h-3} + \frac{1}{T_l-3}}} \sim N(0,1).$$

As stated in the section 4.1, the examined period spans from January 11, 2008, to August 10, 2012, for Cyprus and for Turkish bonds. For the rest of the countries, the period begins from December 17, 2004, and ends also on August 10, 2012. The beginning for the second group is chosen arbitrarily well enough before the beginning of the Greek crisis. When examining the Greek sovereign debt crisis, the majority of papers agrees that the crisis began at the end of 2009. As my brake point, I choose November 13, 2009. In that time, the real Greek figures about its economy became public and Greek bond yield started to rise. The development of the Greek 10Y sovereign bond yield is shown in Figure 4.2 for illustration. I also pick the end date of the crisis period – August 10, 2012, even though the data are available further beyond this point. The yield after that date dramatically fell, indicating that severe crisis period was calming down, so any ability to create contagion decreased.

Figure 4.2: Greek 10Y sovereign bond yield

To sum up: the tranquil period spans from December 17, 2004, (January 11, 2008, for Cyprus and Turkish bonds) to November 13, 2009. The turmoil period is from November 16, 2009, to August 10, 2012.

4.3 Sensitivity analysis

I run a set of sensitivity tests to see whether changes in model specification have significant effect on reported results. For instance, varying number of lags from 1 to 4, dropping variables for interest rates, VIX, and the dummy variable, or changing dates for beginnings and endings of the stable and the turmoil period.

The alternative beginning date of the stable period is set to match the beginning date for the analysis of Cyprus and Turkish bonds, i.e. January 11, 2008. I pick May 2, 2010, as the alternative breakpoint date. As discussed above, there were two major events at the early stages of the Greek crisis – first one occurring in November 2009, and the second one occurring in May 2010. I work with November 13, 2009, as my primary date and May 2, 2010, as the alternative date. The alternative end date of the turmoil period is set to October 25, 2013, more than one year after my primary end date. Rate of returns of the Greek bond yields (tGR10) remain still quite volatile after the primary end date – see Figure 4.3, therefore from this point of view, the alternative end date suits better than the primary one.

I assume that the alternative beginning date of the stable period should not have significant effect on the final results. It is included in the primary stable period – a period of low variance and no shocks, therefore shortening the stable period should not affect results, because the nature of the period does not change significantly.

Nevertheless, the alternative dates regarding the turmoil period may have an impact on the results. As depicted in Figure 4.3, behavior of tGR10 is changing dramatically throughout the turmoil period, therefore when I include or exclude some part of it, such action may influence results. Regardless the length of the turmoil period, its nature is still quite different from any of the stable ones. There are some basic characteristics about the periods presented in Table 4.1. Notice that standard deviations differ greatly between stable and crisis periods no matter on picked dates. P and A denote primary and alternative dates, respectively. S denotes a stable period and T denotes a turmoil one.

However, our result should be stable enough not to change after dropping some variables, or when different number of lags is utilized.

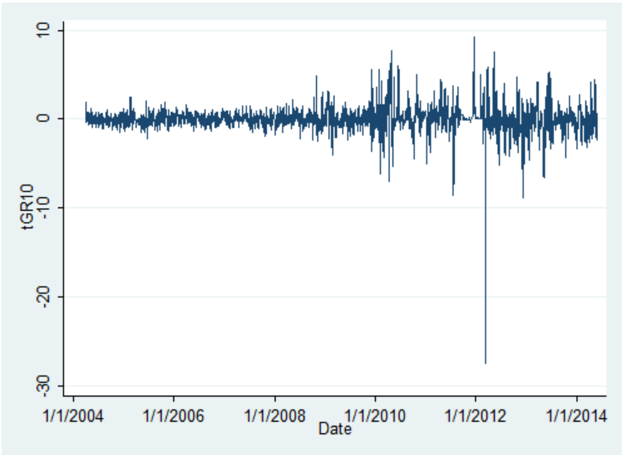

Figure 4.3: Rate of returns of Greek 10Y sovereign bond yields

Table 4.1: Basic characteristics of different periods of tGR10

Period		Obs	Mean	SD	min	max
PPP	S	1220	0,02181	0,766	-3,988	4,907
	T	656	0,24641	2,341	-27,484	9,175
PAP	S	1326	0,06665	1,032	-7,039	7,692
	T	549	0,18148	2,302	-27,484	9,175
APP	S	461	0,01686	0,969	-3,988	4,907
	T	655	0,24641	2,341	-27,484	9,175
AAP	S	567	0,12264	1,410	-7,039	7,692
	T	549	0,18148	2,302	-27,484	9,175
PPA	S	1220	0,02181	0,766	-3,988	4,907
	T	940	0,06102	2,223	-27,484	9,175
PAA	S	1326	0,06665	1,032	-7,039	7,692
	T	834	-0,00528	2,175	-27,484	9,175
APA	S	459	0,01488	0,969	-3,988	4,907
	T	942	0,06189	2,221	-27,484	9,175
AAA	S	567	0,12264	1,410	-7,039	7,692
	T	834	-0,00528	2,175	-27,484	9,175

Chapter 5

Results

In this part, I present results of the model as described by formulae (4.2) – (4.4). I analyze results of each of the countries in a separate section, and then provide details about robustness check, thus 5 sections follow in this part.

In each section, I present tables of results. Notation is the same for all tables. Conditional correlation coefficients have upper index *, coefficients for stable period have lower index "s", and the ones for turmoil period have lower index "t". σ denotes standard deviation of the variable tGR10, tGRx, or tGRb depending on the instrument under examination – 10Y sovereign bonds, all stock indices, bank stock indices, respectively. I use σ as a proxy for market volatility. FR1 and FR2 values for rejecting the null hypothesis (no contagion) at various confidence levels are stated in Table 5.1. The values for FR1 and FR2 are the same, since number of observation is well above 100. The null hypothesis at a specific level is rejected, when both of the FR statistics are higher than the corresponding value. When FR statistics give contradicting verdicts, the situation is treated individually.

Table 5.1: Values for FR statistics

Confidence level	Value
1%	2,326
5%	1,645
10%	1,282

From now on, if not stated otherwise, all results concerns division PPP, 4 lags, and all exogenous variables included in the model. When results obtained from the sensitivity analysis are not in line with the ones for the default division PPP and for 4 lags, I provide additional tables summarizing findings from the sensitivity analysis.

Table 5.2: Graphical illustration of confidence levels in sensitivity-analysis tables

Confidence level	Value
1%	2,326
5%	1,645
10%	1,282
otherwise	

5.1 Greece and Italy

Results for Italy are the most straightforward. The model does not detect contagion at any level between any variables – bonds, stock market index, bank stock index. Table 5.3 shows that both FR statistics are well below zero, thus any confirmation of contagion can be hardly expected. Not only that ρ_t did not increase significantly, it actually dropped compared to ρ_s^*. Even ρ_t^* decreased in comparison to ρ_s^*.

Table 5.3: Results for Italian 10Y government bonds

Period	Obs	σ	conditional ρ	unconditional ρ
S	1220	0,766	0,900	0,646
T	656	2,339	0,392	0,143
W	1876	1,518	0,580	0,246
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	-15,627	no	no	no
FR2	-27,336	no	no	no

ρ_s^* is very high – correlation between the yields was at 0,9. This is in line with the known fact that yields of sovereign bonds issued by eurozone countries were converging and moving alike (inter alia, Kocenda et al. (2005), Cote & Graham (2004). At least this was the case before the Greek sovereign debt crisis. These results suggest that after the crisis started, correlation between these two countries dropped much – from 0,900 to 0,143.

A similar situation is on the stock market – see Table 5.4 and Table 5.5. Although FR statistics for both of the examinations – all stocks and bank stocks – are greater than for the bond yields, contagion could hardly occur. Greater values of FR statistics suggest that the drop in correlation between the stable and the turmoil period was not as large as it was experienced on the bond market. Since there was fear that contagion could spread through banking sector, one might expect that values of FR statistics for banking sector would be greater than those for the whole stock market. Surprisingly, the opposite is true. Both FR statistics for the whole Italian stock market are greater than those for banks.

As it is assumed, dropping variables and/or changing number of lags has no effect whatsoever on the final results. Similarly, alternative sets of periods have no effect on the verdict.

Table 5.4: Results for the Italian stock market

Period	Obs	σ	conditional ρ	unconditional ρ
S	1220	1,187	0,818	0,661
T	656	2,040	0,506	0,329
W	1876	1,544	0,692	0,503
Statistics	Value	1%	5%	10%
FR1	-10,096	no	no	no
FR2	-16,678	no	no	no

Table 5.5: Results for Italian bank stocks

Period	Obs	σ	conditional ρ	unconditional ρ
S	1220	1,690	0,798	0,558
T	656	3,687	0,427	0,217
W	1876	2,577	0,602	0,344
Statistics	Value	1%	5%	10%
FR1	-11,992	no	no	no
FR2	-17,967	no	no	no

Note that the results, indicating that no contagion occurred, are not in a contradiction with Italy experiencing hard times during the Greek crisis and the possibility that the hard times were triggered by the crisis. It may be explained by e.g., interdependence, by similar macro fundamentals, or the wake-up-call effect might occur.

5.2 Greece and Turkey

Results for Greece and Turkey are similar to those for Greece and Italy. There was not found enough evidence to reject the null hypothesis at any level on any market. Again, the results are persistent no matter how many lags, which periods, or how many variables are employed in the model.

For reasons stated in the section 4.1, I cannot estimate contagious effects on Turkish bonds in division PPP, therefore reported results are based on APP division – see Table 5.6. I report results on stocks also in APP for the sake of comparability with the Turkish bond market – see Tables 5.7, and 5.8. Nevertheless, values of FR statistics for stocks during PPP are very similar to those for APP. In order to preserve clarity of the text, results based on division PPP are not reported here, but can be found in Appendix B.

It should not be surprising that the Turkish ρ_s^* for the bond market is much lower compared to the Italian ρ_s^*. Greece and Italy are much more linked together through the eurozone; moreover, they have many similar macro fundamentals. Turkey has definitely very different economic development than Greece. For basic illustration: Turkish GDP shrank only in 2009; in all the following years, it grew. Its debt-to-GDP ratio has been steadily declining since 2002 with the only exception in 2009. The ratio is now below 40 %. Unemployment is just below 10 %. Turkey has experienced very different path after the crisis compared to Greece; global markets are aware of it, thus ρ_t dropped so low. It seems that Turkey has been untouched by the Greek turmoil.

Evidence from the stock market is in compliance with the previous findings. Again, values of FR statistics for bank stocks are smaller than those for all stocks. It suggests that Turkish banks were immune against the Greek contagion. Very high correlation during the stable period almost disappeared after the crisis started.

Table 5.6: Results for Turkish 10Y government bonds for division APP

Period	Obs	σ	conditional ρ	unconditional ρ
S	448	1,065	0,411	0,203
T	636	2,380	0,182	0,083
W	1084	1,951	0,232	0,107
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	-5,308	no	no	no
FR2	-5,705	no	no	no

Table 5.7: Results for the Turkish stock market for division APP

Period	Obs	σ	conditional ρ	unconditional ρ
S	441	1,709	0,926	0,914
T	661	1,875	0,413	0,382
W	1102	1,811	0,683	0,649
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	-8,844	no	no	no
FR2	-19,918	no	no	no

Table 5.8: Results for Turkish bank stocks for division APP

Period	Obs	σ	conditional ρ	unconditional ρ
S	441	2,515	0,906	0,850
T	661	3,446	0,313	0,235
W	1102	3,110	0,572	0,458
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	-10,919	no	no	no
FR2	-20,518	no	no	no

5.3 Greece and Bulgaria

Firstly, I remind that I analyze only Bulgarian bonds and index for the whole Bulgarian stock market. There is no Bulgarian bank index. Nevertheless, the lack of such data should not make any difference, since bank indices exhibit very similar behavior to those, which represent the whole market. Results for Bulgaria are presented in Tables 5.9 and 5.10.

Contagion is detected on the bond market – both FR statistics reject the null hypothesis at 5 % level – ρ_s^* is negative and ρ_t is close to zero. So bond yields between these two countries went from slightly negative correlation to almost none correlation at all. By the definition, it is surely contagion – the correlation increased, and increased significantly as the FR statistics indicate. But I hesitate to draw any strong conclusions from such results. During the crisis period, there was no serious relationship between the two countries in terms of bond yields, so even the model detects contagion, ρ_t is too small to cause any significant effects regarding Bulgarian bonds. Results based on SOFIX, the Bulgarian stock index, do not provide evidence of contagion. Bulgarian stocks show small correlation with the Greek ones during the stable period and the increase in the turmoil period is negligible.

Table 5.9: Results for Bulgarian 10Y government bonds

Period	Obs	σ	conditional ρ	unconditional ρ
S	1227	0,767	-0,167	-0,055
T	649	2,366	-0,239	-0,080
W	1876	1,527	-0,168	-0,056
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	1,775	no	cont	cont
FR2	1,800	no	cont	cont

Table 5.10: Results for the Bulgarian stock market

Period	Obs	σ	conditional ρ	unconditional ρ
S	1179	1,227	0,118	0,072
T	646	2,013	0,196	0,121
W	1825	1,556	0,123	0,075
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,071	no	no	no
FR2	0,072	no	no	no

Sensitivity analysis does not affect stock market results at all. Actually, FR statistics depicted in Table 5.10 are the highest among all periods. The analysis for the bond market is not so straightforward, therefore I provide the sensitivity-analysis table as described in the beginning of this part. Figures in Table 5.11 represent FR1 statistic. Both statistics give identical verdicts, thus I do not report table for values of FR2 statistic here. It can be found in Appendix C (Table C.1).

Table 5.11: Results based on the sensitivity analysis for Bulgarian 10Y government bonds: values for FR1 statistic

no. of lags/division	PPP	PAP	APP	AAP	PPA	PAA	APA	AAA
4 lags	1,775	6,005	4,176	9,118	1,930	7,018	4,419	10,170
3 lags	1,609	5,354	2,111	6,887	1,754	5,089	2,218	6,414
2 lags	-0,023	4,312	2,960	7,770	-0,100	3,405	3,093	6,876
1 lag	-0,576	2,021	0,839	4,480	-0,245	2,248	1,284	4,848

The strongest evidence of contagion is found in divisions AAP and AAA. Enough evidence to confirm contagion at 5 % level among all lags is in divisions PAP and PAA. Although in division APP, the null hypothesis cannot be rejected for 1 lag, evidence from other lags supports rejection quite strongly. The only two divisions, where contagion cannot be confirmed, are PPP and PPA, because the evidence is weak. I can surely confirm contagion for divisions starting from January 2008. Nevertheless, the real impact is low, since ρ_t does not exceed value of 0,2 in any of the divisions. The reason, why divisions starting from 2004 give ambiguous results, may be in behavior of rate of returns of the Bulgarian bond yields (tBG10) – see Figure 5.1. The period of 2006-2008 can be hardly defined as stable, the model is probably influenced by this heavily, thus gives the different conclusions.

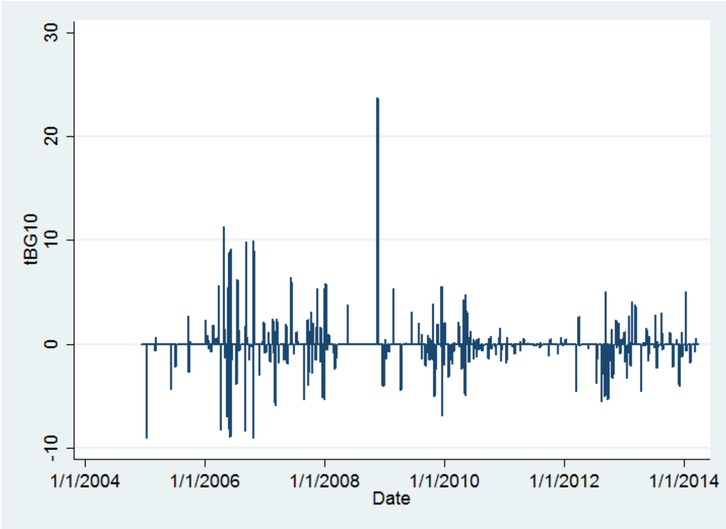

Figure 5.1: Rate of returns of Bulgarian 10Y sovereign bond yields

5.4 Greece and Cyprus

5.4.1 Contagion among stocks

For detecting possible contagion from Greece to Cyprus, I have to rely only on data from stock markets. Data from the bond market cannot be used for reasons stated in the section 4.1. The analysis for Cyprus begins on January 11, 2008. Reasoning for such decision can be also found in the section 4.1.

Cyprus is the only country, where FR statistics do not come to the same verdicts – see Tables 5.12 and 5.13. The difference is so severe that while FR1 statistic finds no evidence for rejecting the null hypothesis at 10 % level, FR2 statistic reject it at 1 % level. The different claims are probably caused by values of correlation coefficients. FR2 statistic, based on Fisher transformation, does not work well with small samples and with high coefficient values (Dungey et al. 2003). Thus FR1 statistic seems as a better indicator here, since the values are around 0,9. Nonetheless, an increase in the coefficients is apparent and given their high values in the stable period, there was not much space to increase any further.

Table 5.12: Results for the Cypriot stock market for division APP

Period	Obs	σ	conditional ρ	unconditional ρ
S	450	1,706	0,886	0,872
T	268	1,832	0,936	0,927
W	719	1,752	0,912	0,901
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,530	no	no	no
FR2	3,015	cont	cont	cont

Table 5.13: Results for Cypriot bank stocks for division APP

Period	Obs	σ	conditional ρ	unconditional ρ
S	450	2,531	0,879	0,866
T	268	2,700	0,963	0,958
W	719	2,595	0,905	0,894
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	1,021	no	no	no
FR2	7,072	cont	cont	cont

Both FR statistics find no evidence of contagion to the whole stock market in division AAP, APA, and AAA – see Tables 5.14 and 5.15. Note that values for periods ending in August 2012 are much higher than those for periods ending in October 2013 (particularly for FR2 statistic). As stated above, FR2 statistic is not a good indicator here, thus we should take its values with reserve. Although FR2 statistic claims that contagion occurred in division APP, I consider it as a false signal. Results for bank stocks are similar to the ones for the whole market and are reported in Appendix C (Tables C.2 and C.3). I interpret such results as in support of the idea of no contagion to Cyprus, especially for periods ending in October 2013.

Table 5.14: Results based on the sensitivity analysis for the Cypriot stock market: values for FR1 statistic

no. of lags/division	APP	AAP	APA	AAA
4 lags	0,530	-0,357	-1,927	-2,678
3 lags	0,069	-0,059	-2,088	-2,622
2 lags	0,190	-0,101	-2,176	-2,795
1 lag	0,188	-0,014	-1,324	-1,726

Table 5.15: Results based on the sensitivity analysis for the Cypriot stock market: values for FR2 statistic

no. of lags/division	APP	AAP	APA	AAA
4 lags	3,015	-1,711	-6,419	-9,246
3 lags	0,759	-0,692	-11,283	-14,372
2 lags	3,162	-1,496	-13,144	-17,215
1 lag	6,143	-0,392	-12,790	-17,515

Though the model fails to reliably find contagion to Cyprus, there is a large potential for spillover effect from Greece to Cyprus. There was enormous correlation between stock markets prior the crisis: $\rho_s^* = 0,886$ for the whole stock market and $\rho_s^* = 0,879$ for bank stocks. Correlation after the shock even increased: $\rho_t = 0,927$ and $\rho_t = 0,958$ for the whole stock market and bank stocks, respectively. FR statistics and ρ_t are greater for the bank stocks than for the whole market. This was not the case for the previous countries.

This could be explained by very large exposure of the Cypriot banks to Greece. Two largest Cypriot banks (as at December 31, 2011), Bank of Cyprus (BC) and Marfin Popular Bank[1] (MFB), which managed more than 70 %[2] of the total bank assets at that time, had the largest exposure to Greece except Greek banks among all examined banks in the paper by Mink & de Haan (2013). Measured as % of core tier 1 capital, MFB had 122 % and BC 75 %. To put it into perspective, the next one was a German bank with 27 % (Mink & de Haan 2013). All of the above mentioned suggests that the crisis could easily transmit from Greece to Cyprus.

5.4.2 Cross contagion among Greek bonds and Cypriot stocks

Given ambiguous results about contagion to Cyprus, I perform cross-contagion analysis to acquire more information. Results reported in Tables 5.16, 5.17, and 5.18 show relationship between Cypriot stock indices and Greek government bonds. Note that negative correlation means that increase in bond yield corresponds with decrease in value of stock indices. The logic is inverted here, i.e. contagion is detected, when correlation falls significantly. FR statistics regarding this subsection are already adjusted to it.

Table 5.16: Results for the Cypriot stock market and Greek bonds for division APP

Period	Obs	σ	conditional ρ	unconditional ρ
S	432	0,974	-0,123	-0,058
T	267	2,098	-0,323	-0,159
W	700	1,510	-0,150	-0,071
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,464	no	no	no
FR2	0,472	no	no	no

[1]today known as Cyprus Popular Bank

[2]figure acquired from The Banker Database; www.thebankerdatabase.com; the site is sponsored by The Financial Times Limited

Table 5.17: Results for Cypriot bank stocks and Greek bonds for division APP

Period	Obs	σ	conditional ρ	unconditional ρ
S	432	0,974	-0,118	-0,055
T	267	2,098	-0,323	-0,159
W	700	1,510	-0,146	-0,068
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,531	no	no	no
FR2	0,539	no	no	no

Even though for 4 lags in division APP and APA, the null hypothesis cannot be rejected at 10 % level, and in division AAP the null hypothesis cannot be rejected at 5 % level, evidence of contagion among the rest of lags is strong – see Table 5.18. Nevertheless, I cannot confirm contagion in division AAA, because the evidence is rather weak. Results for the banks are very similar to those for the whole stock market. Unlike in the former case, FR statistics agree with one another in each verdict, thus tables, which report results for banks and for the whole stock market with values for FR2 statistic, can be found in Appendix C (Tables C.4, C.5, and C.6). Note that the model compares two different instruments, which are traded on separate markets. This may be the reason, why the verdicts are not unequivocal. The model may not cover all effects, thus these estimates may be a little inaccurate. Nevertheless in all cases, ρ_s^* is smaller than ρ_t. 3 out of 4 divisions provide strong evidence of contagion. Given high correlation among Greek and Cypriot stocks, it can be drawn that the Greek crisis spread easily to Cyprus and had a large influence on the whole Cypriot economy.

Table 5.18: Results based on the sensitivity analysis for the Cypriot stock market and Greek bonds: values for FR1 statistic

no. of lags/division	APP	AAP	APA	AAA
4 lags	0,464	1,419	0,306	1,598
3 lags	4,437	5,584	3,625	3,427
2 lags	5,600	4,480	3,367	-0,007
1 lag	7,477	4,262	4,064	-1,059

5.5 Robustness check

Until now, I have tested for contagion among long periods of time. As stated in the section 3.1, definition of contagion used by Kaminsky et al. (2003) presumes that it is a phenomenon occurring during much shorter intervals, than I examine. One of the reasons, why there is no contagion detected for Italy and Turkey, can be in the length of the crisis period. During short turmoil intervals, country-specific (i.e. idiosyncratic) factors may be suppressed and may have lower influence than during longer periods of time. In Italy and Turkey, country-specific factors might inhibit the impact of the Greek crisis more than in Bulgaria and Cyprus. For instance, one of the factors, which might cover evidence of contagion to Italy and Turkey, may be the size of economies. When comparing sizes with the Greek economy, as at December 31, 2008, well before the Greek crisis, the Italian economy was ca. 6,7x larger, the Turkish one was 3,9x larger; on the opposite side, the Bulgarian one was 3,4 smaller and the Cypriot one was 12,9x smaller. The contagious effects might have persisted longer in the smaller economies. Nevertheless, in short periods of time, right after a shock occurs, such factors may not play a role.

To test for this possibility, I define the following stable and the crisis period: the stable period ranging from April 5, 2010, to May 2, 2010; the crisis one ranging from May 3, 2010, to June 1, 2010. I choose May 2, 2010, over November 13, 2009, because the first bailout plan was introduced on May 2, 2010, and shortly after, the ECB got involved in the crisis for the first time. In November 2009, it might not be so apparent how severe the crisis would be. Thus I assume that contagious effect should be stronger after May 2, 2010, than after November 13, 2009.

I have to modify the model slightly. As stated in the section 4.2, the methodology assumes that during the turmoil periods, volatility is higher. Nonetheless, the period under examination in this section shows opposite behavior. According to Eser & Schwaab (2013), volatility on bond markets was lower during periods of the ECB interventions "due to less extreme (tail) movements occurring when the Eurosystem is active in the market" (Eser & Schwaab 2013, p.29). Since the SMP was highly active during May 2010, and was not active during April 2010 at all, volatility during the turmoil period is lower than during the stable one.

Nothing changes in the construction of δ; the only difference is that I consider the stable period as the one of high volatility and the turmoil period as the one of low volatility. The only change made is in the hypotheses and in the definitions of FR statistics. ρ_t has been replaced by ρ_t^*, and similarly ρ_s^* has been replaced by ρ_s. The logic remains the same. I correct for the bias caused by volatility; since volatility is higher in the stable period, I adjust the coefficient for the stable period, the coefficient for the turmoil period can be left unadjusted.

Due to the length of the examined periods, it was possible to employ only 1 lag in the model. The critical values stated in Table 5.1 are not applicable for FR1 statistic, since there is a low number of observations, and FR1 follows t-distribution. Verdicts reported in tables below do respect critical values for t-distribution; nevertheless, since the differences with Table 5.1 are minimal[3], I do not report the critical values in

[3]the maximal difference is 0,115; mean value of differences is 0,057 and median is 0,042

the thesis. As stated in the subsection 5.4.1, FR2 statistic is not a good indicator, when the sample is small. Thus if FR2 statistic indicates differently than FR1 statistic, I will follow the verdict of FR1 statistic.

5.5.1 Greece and Italy

Contagion is detected only for the all-stock index. The model does not reveal an existence of contagion in the bond market nor for the bank stock index – see Tables 5.19, 5.20, and 5.21. Unlike in the longer periods, the drop in correlation for the bond yields is not so dramatic. ρ_t^* remained quite high suggesting strong interdependence between the bond markets. No evidence of contagion among the bond yields during May 2010 may be explained by different impacts of the SMP on the Greek bonds and on the Italian ones. According to Eser & Schwaab (2013), the impact of the SMP on the Italian yields was ca. "-1 to -2 basis points and up to -17 to -21 basis points (Greece) at a five-year maturity per €1 bn of purchases across euro area countries" (Eser & Schwaab 2013, p.29).

In Table 5.20, FR statistics do not come to the same conclusion at 1 % level, so contagion can be confirmed on 5 % level only. Results for the whole stock market suggest that before the break point, correlation was rather mild; on the other hand bank stock indices exhibited quite strong correlation even during the stable period. The bank stocks did not respond to the shock as much as the whole market. The model suggests that no contagion occurred among the bank stocks. This goes along with the finding in the section 5.1, where FR statistics for the bank stocks are smaller than those for the whole stock market. Still, ρ_t^* is quite high in all three examined sectors, revealing that interdependence between Greece and Italy was strong.

Table 5.19: Results for Italian 10Y government bonds

Period	Obs	σ	conditional ρ	unconditional ρ
S	19	1,657	0,910	0,876
T	22	1,357	0,711	0,641
W	41	1,553	0,891	0,853
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	-0,529	no	no	no
FR2	-1,388	no	no	no

Table 5.20: Results for the Italian stock market

Period	Obs	σ	conditional ρ	unconditional ρ
S	19	1,535	0,342	0,251
T	22	1,085	0,794	0,689
W	41	1,287	0,496	0,378
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	1,736	no	cont	cont
FR2	2,437	cont	cont	cont

Table 5.21: Results for Italian bank stocks

Period	Obs	σ	conditional ρ	unconditional ρ
S	19	2,375	0,656	0,539
T	22	1,716	0,605	0,487
W	41	2,015	0,629	0,510
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,212	no	no	no
FR2	0,291	no	no	no

5.5.2 Greece and Turkey

ρ_t^* is higher than ρ_s in all cases for Turkey – see Tables 5.22, 5.23, and 5.24. Nonetheless, contagion can be confirmed at 10 % level only for the whole stock market. Though the increase for the bank stocks is quite large, given small sample size, it is not statistically significant. FR statistics for the bank stocks are smaller than the ones for the whole stock market; this is in line with the previous finding in the section 5.2. Unlike of those findings, there was strong interdependence among the stocks. So even though the bank stocks did not experience contagion, they were affected quite heavily by the Greek crisis.

Table 5.22: Results for Turkish 10Y government bonds

Period	Obs	σ	conditional ρ	unconditional ρ
S	19	3,769	0,197	0,126
T	19	2,383	0,361	0,240
W	38	3,385	0,274	0,178
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,723	no	no	no
FR2	0,710	no	no	no

Table 5.23: Results for the Turkish stock market

Period	Obs	σ	conditional ρ	unconditional ρ
S	19	2,728	0,315	0,249
T	20	2,103	0,724	0,635
W	39	2,433	0,534	0,440
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	1,486	no	no	cont
FR2	1,904	no	cont	cont

Table 5.24: Results for Turkish bank stocks

Period	Obs	σ	conditional ρ	unconditional ρ
S	19	4,020	0,339	0,244
T	20	2,791	0,607	0,475
W	39	3,459	0,439	0,324
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	1,133	no	no	no
FR2	1,308	no	no	cont

5.5.3 Greece and Bulgaria

Similarly to the results based on longer periods, evidence of contagion is found only on the bond market. Again, any real impact on the Bulgarian economy seems negligible given $\rho_t^* = 0,009$. Though contagion was detected, results indicate that Bulgaria was quite isolated from the Greek economy; it has the lowest values of correlation coefficients among all the examined countries.

Table 5.25: Results for Bulgarian 10Y government bonds

Period	Obs	σ	conditional ρ	unconditional ρ
S	18	4,185	-0,648	-0,452
T	19	2,392	0,009	0,005
W	37	3,623	-0,270	-0,159
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	1,400	no	no	cont
FR2	1,379	no	no	cont

Table 5.26: Results for the Bulgarian stock market

Period	Obs	σ	conditional ρ	unconditional ρ
S	18	3,025	0,074	0,049
T	18	2,007	0,263	0,178
W	36	2,582	0,229	0,155
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,641	no	no	no
FR2	0,603	no	no	no

5.5.4 Greece and Cyprus

Even though no contagion was detected to Cyprus, results are quite consistent with the ones for the longer periods. Increase[4] of correlation is apparent in all sectors. Again, correlation between stock markets is extremely high; and FR statistics are higher for the bank stocks (disregarding FR2 statistic for reasons stated above – small sample size, high coefficient values). Results on cross contagion show that correlation coefficients almost doubled after the break point, though due to the small sample size, it is not enough to reject the null hypothesis.

Table 5.27: Results for the Cypriot stock market

Period	Obs	σ	conditional ρ	unconditional ρ
S	16	3,029	0,976	0,963
T	19	2,349	0,980	0,969
W	35	2,685	0,986	0,978
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,051	no	no	no
FR2	0,863	no	no	no

Table 5.28: Results for Cypriot bank stocks

Period	Obs	σ	conditional ρ	unconditional ρ
S	16	4,537	0,955	0,914
T	19	3,006	0,977	0,954
W	35	3,799	0,974	0,949
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,184	no	no	no
FR2	1,784	no	cont	cont

[4]indeed for results on cross contagion, I mean increase of negative correlation

Table 5.29: Results for the Cypriot stock market and Greek bonds

Period	Obs	σ	conditional ρ	unconditional ρ
S	16	4,416	-0,358	-0,206
T	19	2,392	-0,394	-0,229
W	34	3,659	-0,531	-0,330
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,552	no	no	no
FR2	0,554	no	no	no

Table 5.30: Results for Cypriot bank stocks and Greek bonds

Period	Obs	σ	conditional ρ	unconditional ρ
S	16	4,416	-0,358	-0,206
T	19	2,392	-0,392	-0,228
W	34	3,659	-0,528	-0,328
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	0,548	no	no	no
FR2	0,549	no	no	no

Chapter 6

Conclusion

Contagion was detected on the Bulgarian bond market during November 2009 – October 2013. In the same period, contagion from the Greek bonds was affecting the Cypriot stocks. I found evidence of contagion to Italy and Turkey on the whole stock market during May 2010. In all other cases, the model failed to find any contagion. Detected contagion was rather an isolated phenomenon affecting individual markets in very specific periods. No examined country experienced contagion on its bond and its stock market simultaneously. Nevertheless, I must reject my first hypothesis; contagion was present in all the examined countries.

I cannot reject the hypothesis that contagion was stronger among the eurozone countries. While the Bulgarian bond market experienced contagion from Greece, the Italian one revealed no traces of contagion. Turkish bank stock index exhibited stronger response to the Greek crisis during May 2010 than the Italian one. In all other cases, the Turkish stock market behaved quite similarly as the Italian one in relation to the Greek stock market. Nevertheless, the eurozone countries were much more interdependent with Greece than Bulgaria and Turkey. Correlation between the Bulgarian and the Greek bond market did not exceed value of 0,2. Correlation between Cypriot and Greek stocks was during turmoil periods well beyond 0,9. Bond markets between Italy and Greece in May 2010 showed correlation of value 0,7. So even though, I cannot reject that contagion was stronger among the eurozone countries, it is evident that linkages among Italy and Cyprus on the one hand and Greece on the other hand were stronger than those, which Greece had with Bulgaria and Turkey. Spillovers from Greece could spread easily to Italy and Cyprus. This suggests that the eurozone countries might experience larger negative shocks triggered by the Greek crisis.

I reject the hypothesis that contagion occurred only in the financial sector. For Italy and Turkey in May 2010, contagion was detected on the whole stock market, while among the bank stocks was not detected. The analysis shows that correlation among bank stocks was smaller than the one among the whole markets. The only exception is Cyprus during May 2010 – August 2012, though the difference is small.

Even though that there exists the evidence of contagion, it is noticeable that investors distinguished between the countries very well during the crisis in the long perspective. Many correlation coefficients for stable periods had been very high, but after the turmoil period began, the coefficients dropped dramatically. It applies mainly for Italy and Turkey.

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Appendix A

Graphical illustration of variables

The depicted data are adjusted by two-day moving average, and non-trading dates are removed. The key in naming of the variables is following: the core of the name consists of two letters BG, CY, GR, IT, or TR and denotes the country of the origin of such data. BG for Bulgaria, CY for Cyprus, GR for Greece, IT for Italy, and TR for Turkey. Prefix “t” denotes transformed data of the variables as it is described by the formula (4.1). Prefix “s” denotes data for short-term interest rates. Suffixes “10”, “x”, and “banks” denotes data for 10Y sovereign bonds, whole stock market indices, and bank stock indices, respectively. VIX denotes data on VIX. For instance, tITx represents transformed data on the Italian stock market.

Figure A.1: GR10

Figure A.2: BG10

Figure A.3: CY10

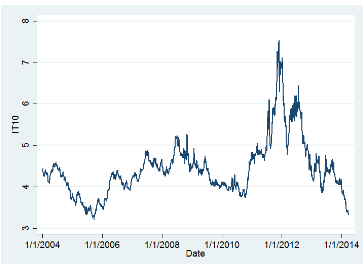

Figure A.4: IT10

Figure A.5: TR10

Figure A.6: GRx

Figure A.7: BGx

Figure A.8: CYx

Figure A.9: ITx

Figure A.10: TRx

Figure A.11: GRbanks

Figure A.12: CYbanks

Figure A.13: ITbanks

Figure A.14: TRbanks

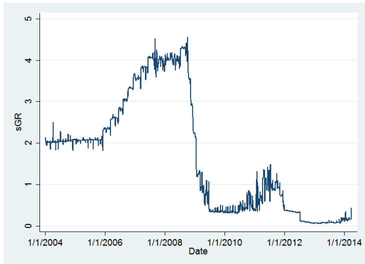

Figure A.15: sGR

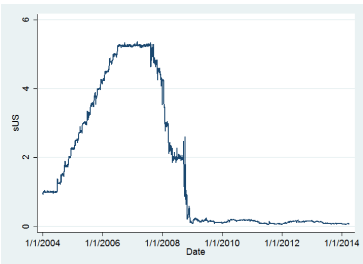

Figure A.16: sUS

Figure A.17: sBG

Figure A.18: sTR

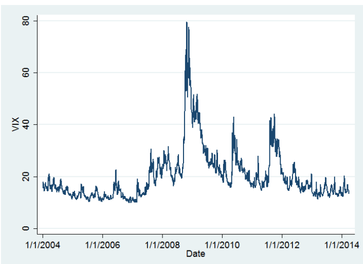

Figure A.19: VIX

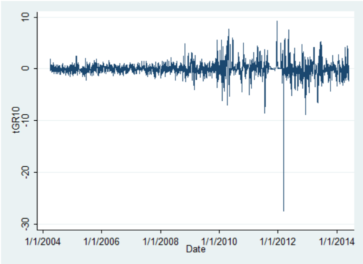

Figure A.20: tGR10

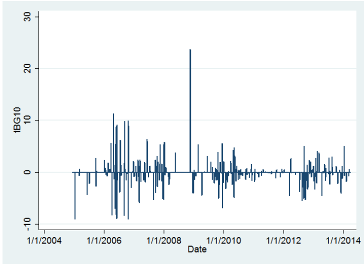

Figure A.21: tBG10

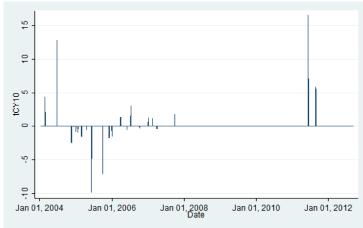

Figure A.22: tCY10

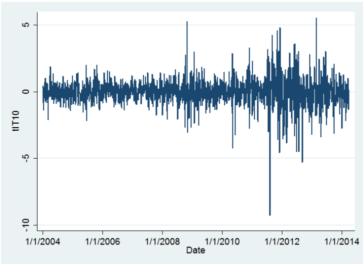

Figure A.23: tIT10

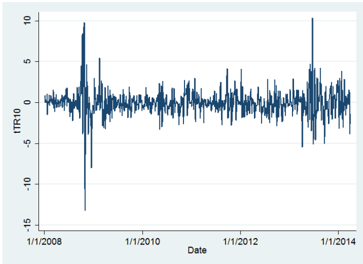

Figure A.24: tTR10

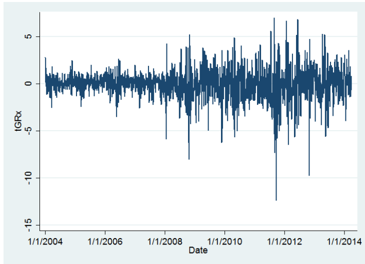

Figure A.25: tGRx

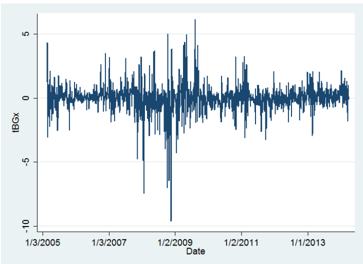

Figure A.26: tBGx

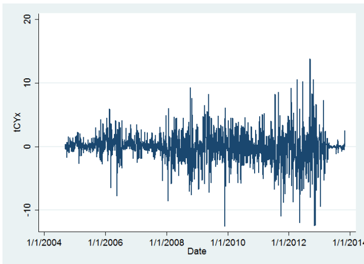

Figure A.27: tCYx

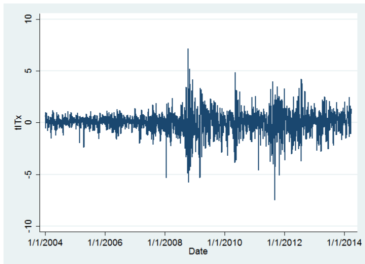

Figure A.28: tITx

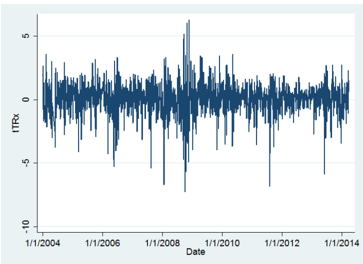

Figure A.29: tTRx

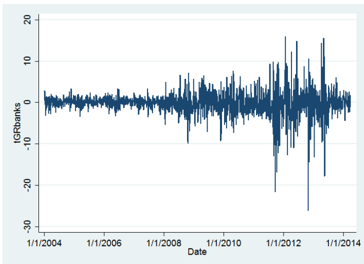

Figure A.30: tGRbanks

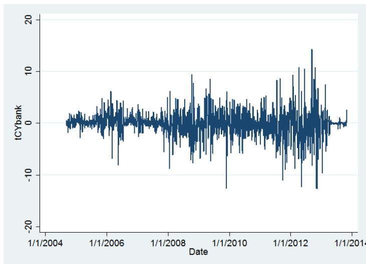

Figure A.31: tCYbanks

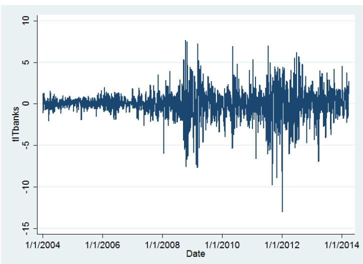

Figure A.32: tITbanks

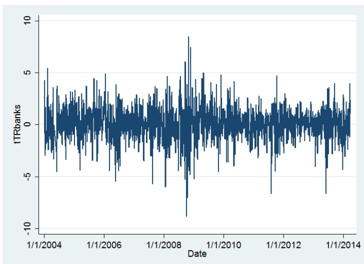

Figure A.33: tTRbanks

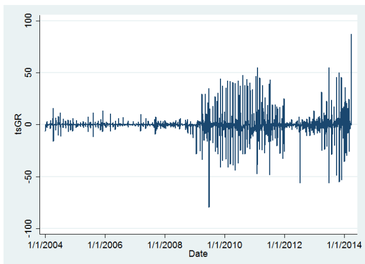

Figure A.34: tsGR

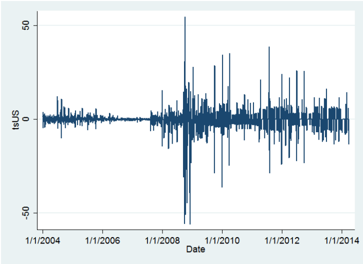

Figure A.35: tsUS

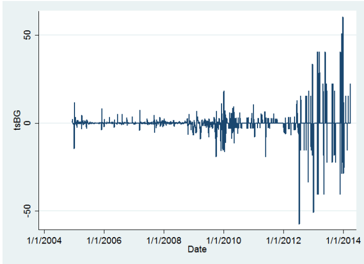

Figure A.36: tsBG

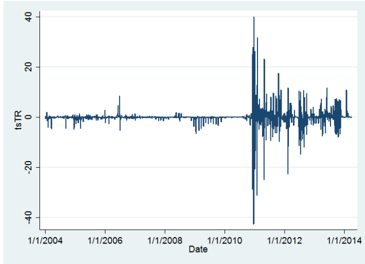

Figure A.37: tsTR

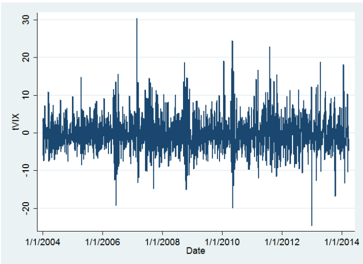

Figure A.38: tVIX

Appendix B

Additional tables – Turkey

Additional information for the section 5.2.

Table B.1: Results for the Turkish stock market for division PPP

Period	Obs	σ	conditional ρ	unconditional ρ
S	1173	1,225	0,875	0,778
T	661	1,875	0,413	0,287
W	1834	1,497	0,687	0,537
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	-12,095	no	no	no
FR2	-21,742	no	no	no

Table B.2: Results for Turkish bank stocks for division PPP

Period	Obs	σ	conditional ρ	unconditional ρ
S	1173	1,738	0,816	0,614
T	661	3,446	0,313	0,166
W	1834	2,499	0,551	0,327
Statistics	**Value**	**1%**	**5%**	**10%**
FR1	-13,361	no	no	no
FR2	-20,034	no	no	no

Appendix C

Additional tables – sensitivity analysis

Table C.1: Results based on the sensitivity analysis for Bulgarian 10Y government bonds: values for FR2 statistic

no. of lags/division	PPP	PAP	APP	AAP	PPA	PAA	APA	AAA
4 lags	1,800	6,095	4,423	9,747	1,959	7,127	4,684	10,866
3 lags	1,612	5,386	2,125	7,020	1,758	5,128	2,233	6,555
2 lags	-0,023	4,326	2,975	7,902	-0,100	3,406	3,110	6,986
1 lag	-0,575	2,020	0,840	4,544	-0,244	2,248	1,284	4,920

Table C.2: Results based on the sensitivity analysis for Cypriot bank stocks: values for FR1 statistic

no. of lags/division	APP	AAP	APA	AAA
4 lags	1,021	0,343	-3,890	-4,837
3 lags	0,088	-0,015	-4,359	-5,169
2 lags	0,242	-0,029	-4,277	-5,145
1 lag	0,284	0,078	-3,045	-3,672

Table C.3: Results based on the sensitivity analysis for Cypriot bank stocks: values for FR2 statistic

no. of lags/division	APP	AAP	APA	AAA
4 lags	7,072	2,024	-10,175	-12,868
3 lags	0,734	-0,131	-14,907	-17,479
2 lags	2,700	-0,315	-15,814	-19,208
1 lag	5,593	1,508	-15,714	-19,553

Table C.4: Results based on the sensitivity analysis for Cypriot bank stocks and Greek bonds: values for FR1 statistic

no. of lags/division	APP	AAP	APA	AAA
4 lags	0,531	1,442	0,362	1,616
3 lags	4,438	5,607	3,632	3,437
2 lags	5,589	4,517	3,348	0,020
1 lag	7,452	4,289	4,032	-1,020

Table C.5: Results based on the sensitivity analysis for Cypriot bank stocks and Greek bonds: values for FR2 statistic

no. of lags/division	APP	AAP	APA	AAA
4 lags	0,539	1,477	0,367	1,652
3 lags	4,490	6,022	3,635	3,457
2 lags	5,739	5,048	3,350	0,020
1 lag	7,849	4,918	4,040	-1,033

Table C.6: Results based on the sensitivity analysis for the Cypriot stock market and Greek bonds: values for FR2 statistic

no. of lags/division	APP	AAP	APA	AAA
4 lags	0,472	1,455	0,311	1,636
3 lags	4,491	6,003	3,629	3,449
2 lags	5,752	5,010	3,368	-0,007
1 lag	7,878	4,895	4,073	-1,073