Charles University in Prague

Faculty of Social Sciences
Institute of Economic Studies

MASTER'S THESIS

Communication of the European Central Bank and contagion on financial markets

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Declaration of Authorship

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

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Prague, May 12, 2016

Signature

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Bibliografický záznam

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Abstract

The aim of this thesis is to assess the effect of central bank communication on joint occurrence of extreme returns and on extreme movements shared by two stock markets. The research concentrates on the following aspects: predictability of increased share of countries experiencing extreme returns in the eurozone based on the nature of policymaker's statement and also a set of control variables, change in probability of extreme returns joint occurrence after president's speech, determinants of joint occurrence when non-standard measures were announced and finally, effect of crisis period. Additionally, determinants of shared extreme movements between particular countries are examined. The results suggest that communication nature or crisis are not significant predictors of extreme returns joint occurrence. Moreover, markets seem to react jointly to ECB president's speech only when they have extremely high returns. Furthermore, markets jointly react on days of nonstandard measures announcement differently. We also found that in the first quantile dovish statements tend to increase returns above their mean in case of Greece and Germany, and Greece and the UK. Rest of the pairs of countries have opposite reaction to dovish tone and communication is significant in the 95th quantile for the pair Germany-UK.

JEL Classification	C22, C25, E58, G15
Keywords	Financial crisis, contagion, interdependence, coexceedance, central bank communication

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Abstrakt

Cieľom tejto práce je posúdiť efekt komunikácie centrálnej banky na súčasný výskyt extrémnych výnosov a na extrémne pohyby zdieľané dvomi akciovými trhmi. Výskum sa zameriava na nasledujúce aspekty: predvídateľnosť zvýšeného podielu krajín v eurozóne vykazujúcich extrémne výnosy na základe povahy výroku predstaviteľa ECB a na základe súboru kontrolných premenných, zmenu pravdepodobnosti súčasného výskytu extrémnych výnosov po prejave prezidenta ECB , determinanty súčasného výskytu, keď neštandardné opatrenia boli oznámené a efekt krízy. Na záver sú skúmané determinanty zdieľaných pohybov medzi dvoma krajinami.Výsledky indikujú nevýznamnosť povahy komunikácie a krízy ako predvídateľov súčasného výskytu extrémnych výnosov. Trhy súčasne reagujú na výroky prezidenta ECB iba v prípade extrémne vysokých výnosov. Avšak reakcia trhovje odlišná, keď boli oznámené neštandardné opatrenia. Zistili sme, že na prvom percentile umiernené výroky zvyšujú výnosy nad priemernú hodnotu v prípade Nemecka a Grécka, Grécka a Veľkej Británie. Zvyšné páry krajín majú opačnú reakciu a komunikácia je významná na 95 percentile pre Nemecko a Veľkú Britániu.

Klasifikace	C22, C25, E58, G15
Klíčová slova	Finanční krize, nákaza, vzájemná závislost, coexceedance, komunikace centralní banky

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Acronyms

CAC Cotation Assistée en Continu

CPI Consumer Price Index

DAX Deutsche Aktienindex

ECB European Central Bank

FED Federal Reserve

FSR Financial Stability Report

FTSE Financial Times Stock Exchange

GARCH General autoregressive conditional heteroskedasticity

UK United Kingdom

US United States

USA United States of America

Master's Thesis Proposal

Author:	Bc. Júlia Jonášová
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Defense Planned:	June 2016

Proposed Topic:

Communication of the European Central Bank and contagion on financial markets

Topic Characteristics:

Financial markets' linkages are of great importance, especially in periods of market turmoil as recent crisis confirmed. Transmission of crisis to other countries is present mainly in financial system characterized by high degree of interdependence and is usually connected with contagion. Transmission strengthens the linkages and this, therefore, decreases investors' benefits resulting from diversification and at the same time, it makes policymakers more attentive towards financial stability. However, it is crucial to differentiate between contagion and interdependence. Forbes et al. (2002) define interdependence as a situation with ‘’high level of comovement during all states of world (during crisis as well as more stable periods)’’, while contagion is according to latest papers (e.g. Beirne et al., 2014) defined as structural break in international propagation mechanism during a crisis period. Therefore, linkages must be assessed before, during and also after the crisis in order to make conclusion about the presence of contagion.

Most of the studies implementing coexceedance as a measure of contagion focuses on identifying its determinants such as conditional volatility, exchange rates and interest rates. However, central bank communication might also play a role to substantial extent. Research proves that various means of central bank communication influence financial stability. Knutter et al. (2011) provide evidence that speeches and press conferences can be considered as one of the most effective channels of central bank communication in maintaining financial stability. In similar manner, Born et al. (2014) show that speeches and interviews do not have a significant impact on stock market returns during tranquil times, but on the other hand, they have substantial effect during the global financial crisis. Beck et al. (2013) analyze comovements of stock and bond markets between the United States and Canada as well as within Canada. Applying diagonal-BEKK models it is found out that communication of the central banks significantly affects correlation of these financial markets. This suggests that contagion could be affected by central bank communication in form of speeches and interviews.

Hypotheses:

1. ECB communication affects contagion immediately.
2. ECB communication has long lasting effect on contagion.
3. Nature of the statement (hawkish or dovish) matters in the manner the contagion spreads.

Methodology:

As suggested in paper by Bae et al. (2003), coexceedance will be used in order to determine periods of contagion despite the possibility of usage of other measures such as correlation coefficient and cointegration analysis, since correlation coefficient is a linear measure sensitive to heteroscedasticity. This thesis will follow the approach by Bae et al. (2003) and apply ordered logit method. This particular method is chosen due to discrete and ordered nature of dependent variable. Moreover, it allows to assess the probability of further spreading contagion to other countries.

To test the first hypothesis, we extend the model by Baur et al. (2005), which incorporates main determinants of coexceedance, e.g. dummy crisis, market returns, conditional volatility and include additional variable *communication* whose coefficient will represent the effect of the European Central Bank's communication on contagion. Since the model includes also conditional volatility, the estimation will be performed in two steps similarly to Chevapatrakul et al. (2014): firstly, conditional volatility will be calculated using general autoregressive conditional heteroscedasticity (GARCH) model, secondly, ordered logit regression will be estimated. Nextly, lagged variable communication will be added to the original model. Therefore, we will be able to assess whether market participants keep in mind content of speeches published during previous days and hence, contagion is affected by current as well as historical communication. This enables to address the second hypothesis. The third hypothesis will be tested by adding another variable *statement* to original model which is equal to 1 if the statement is identified as hawkish or containing tightening surprise with respect to prevailing trends or it is equal to 0, if it is identified as dovish.

Data for variable *communication* and *statement* will be created by coding daily statements of individual representatives of the ECB released on Reuters. If the statement suggests good economic outlook, communication will be equal to 1. On the other hand, speeches indicating neutral outlook, no cut or no rise, will be given value 0. Finally, statements regarding bad outlook will be assigned -1. Moreover, all these statements will be sorted based on their dovish/hawkish nature. Information about the rest of the variables needed for the models is expected to be obtained from Reuters Wealth Manager.

Outline:

1. Introduction – Firstly, transmission mechanism and importance of contagion will be described. Nextly, motivation for the examined hypothesis as well as description of thesis structure will be included.
2. Literature review – In this section, brief summary of the studies will be presented in order to examine what has been done so far in this field. Attention will be paid to different definitions of contagion and its channels as well as determinants of coexceedance.
3. Data description – Data sources, statistical description of the main variables will be presented. Additionally, detailed description of creation of the ECB communication dataset will be included.
4. Empirical methodology – Various methods of measuring contagion, their advantages and drawbacks are expected to be discussed. Furthermore, concept of coexceedance will be described in details. Choice of the particular estimation framework will be supported by arguments following from

econometric theory and econometric model will be presented.

5. Results – Interpretation of the results will be part of this section. Moreover, discussion will follow and possible policy applications will be suggested.
6. Conclusion – Main findings of the thesis will be summarized and recommendation for further research will be made.

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1 Introduction

Financial markets' linkages are of great importance, especially in periods of market turmoil as recent crisis confirmed. Transmission of crisis to other countries is present mainly in financial system characterized by high degree of interdependence and is usually connected with contagion**.**

Investors tend to diversify their portfolios and invest not only in home stocks but also international ones because most of the times, they exert lower levels of comovement. When countries are exposed to different shocks, international diversification enables global investors to share risks. However, portfolios may not remain immune to common shocks. Transmission strengthens the linkages of the markets and this, therefore, decreases investors' benefits resulting from diversification. At the same time, stronger linkages make policymakers more attentive towards financial stability.

However, it is crucial to differentiate between contagion and interdependence. Forbes et al. (2002) define interdependence as a situation with ''high level of comovement during all states of world (during crisis as well as more stable periods)'', while contagion is according to the latest papers (e.g. Beirne et al., 2014) defined as structural break in international propagation mechanism during a crisis period. Therefore, linkages must be assessed before, during and also after the crisis in order to make conclusion about the presence of contagion.

Most of the studies implementing coexceedance as a measure of contagion focuses on identifying its determinants such as conditional volatility, exchange rates and interest rates. However, central bank communication might also play a role to substantial extent. Research proves that various means of central bank communication influence financial stability. Knutter et al. (2011) provide evidence that speeches and press conferences can be considered as one of the most effective channels of central bank communication in maintaining financial stability. In a similar manner, Born et al. (2014) show that speeches and interviews do not have a significant impact on stock market returns during tranquil times, but on the other hand, they have substantial effect during the global financial crisis. The aim of this diploma thesis is to examine the relationship between contagion on financial markets and communication of the European Central bank (ECB). In particular, we focus on testing immediate effect of communication, delayed effect and significance of the ECB president's speech.

Measurements of contagion differ due to various definitions of this phenomenon. In this research coexceedance is used as opposed to correlation coefficient or cointegration analysis since it is shown to have better econometric properties. Correlation coefficient is vulnarable to heteroscedasticity and moreover, it is a linear measure. However, this is not an appropriate measure if contagion is induced by non-linear changes of market association (Bae et al., 2003). This thesis follows the approach by Bae et al. (2003) and applies ordered logit method. This particular method is chosen due to discrete and ordered nature of dependent variable. Moreover, it allows to assess the probability of further spreading contagion to other countries. Data for financial markets were obtained from the Reuters Wealth Management database. Data for variable *Communication* are created by coding daily statements of individual representatives of the ECB released on Reuters. If the statement is hawkish, communication will be equal to 1. On the other hand, speeches indicating neutral outlook, no cut or no rise, will be given value 0. Finally, dovish statements will be assigned -1.

In order to capture also the degree of the contagion, definition by Baur et al. (2005) will be implemented. Quantile regression used to assess the degree has several advantages, mainly no distributional assumptions. This method will examine spreading contagion between two countries. In particular, we will have a closer look at some of the eurozone countries - Greece, France, Germany, and also one of the non-eurozone countries – the United Kingdom (UK). It will allow us to evaluate the effect of the ECB communication on contagion within the eurozone and also between a European country not using euro as their official currency and a eurozone country.

Effect of central bank communication on financial stability has been studied to large extent. However, any research has not been performed on the relationship between communication of the ECB and contagion on financial markets (to the best knowledge of the author of this thesis). Since it is so far unexplored field, this thesis is expected to contribute substantially to the current academic discussion. It proves that there is an additional significant effect of the central bank's communication in particular cases and this could serve as a higher incentive for effective communication and thus, ability to regulate even financial markets' behaviour in a purpose to decrease the joint occurrence of extreme returns. Additionally, by comparing different pairs of countries and their extreme movements we assess the effect also in various percentiles. Focusing not only on the countries of the eurozone, we examine also the effect between the UK and Germany, and the UK and Greece. This enables us to assess the impact of communication nature on returns of two major European players with different national currencies, and on returns of highly indebted country and a strong non-euro country, which makes this thesis unique as well. Moreover, the thesis is extended and effect of the very first statement of the day is analyzed, too. Undoubtedly, this extensive and thourough empirical study represents a large contribution.

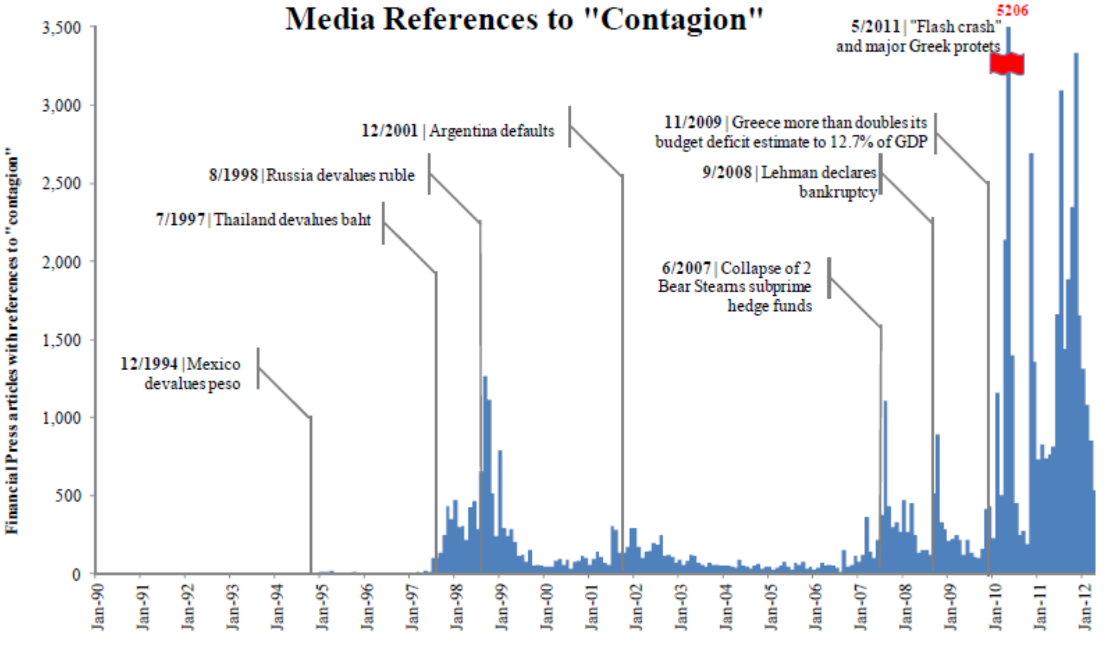
The results suggest that communication nature or crisis are not significant predictors of extreme returns joint occurrence. Moreover, markets seem to react jointly to ECB president's speech only when they have extremely high returns. Furthermore, markets jointly react on days of nonstandard measures announcement differently. We also found that in the first quantile dovish statements tend to increase returns above their mean in case of Greece and Germany, and Greece and the UK. Rest of the pairs of countries have opposite reaction to dovish tone and communication is significant in the 95th quantile for the pair Germany-UK.

This thesis consists of six parts. Introduction is followed by Literature review. In this section, brief summary of the studies will be presented in order to examine what has been done so far in this field. Attention will be paid to different definitions of contagion and its channels as well as determinants of coexceedance. Next, Data description presents data sources and statistical description of the main variables. Additionally, detailed description of creation of the ECB communication dataset will be included. Chapter 4 focuses on empirical methodology, where various methods of measuring contagion, their advantages and drawbacks are expected to be discussed. Furthermore, concept of coexceedance will be described in details. Choice of the particular estimation framework will be supported by arguments following from econometric theory and econometric models will be presented. In the fifth part of the research, interpretation of the results is provided. Moreover, comparison with the existing literature will follow. Lastly, conclusion summarizes main findings of the thesis and recommendation for further research is made.

2 Literature review

Forbes (2012) shows that the notion of contagion as a description of an international transmission of financial turmoil has arisen just recently. Before 1995, the term was barely used, but after that it started to appear in papers focusing on the effect of Mexican peso crisis on the rest of the Latin America. Figure 1 by Forbes (2012) based on data from Factiva depicts monthly uses of the word contagion in economic papers and press aimed at finance and/or commodities. However, only 1997 devaluation in Thailand having impact on other Asian countries and global effect of 1998's devaluation in Russia triggered inclusion of contagion in the standard economic terminology. Furthermore, these events raised awereness of policy makers toward the importance of contagion.

Figure 1: References to Contagion



Source: Forbes (2012)

Even though, the term has become more frequently used since 1995, there seems to be a huge disagreement in its definition. Disagreement concerns various issues. As discussed by Forbes (2012), these issues include economic similarity or close links between 2 countries, types of cross-market linkages constituting contagion. First of all, it has to be considered if the term contagion can be used even in case when markets that are economically similar or have close trade links, such as the United States and Canada. Secondly, there is not unanimous agreement on whether residual transmission of shock not caused by fundamentals should be identified as contagion or whether it should be only transmission of the most extreme negative events. Therefore, in this section we provide review of definitions having appeared in the academic papers as well as channels of contagion. Eventually, research regarding the effects of central bank communication on financial markets is reviewed to further support our main hypothesis.

2.1 Definitions of contagion

As presented above there does not appear to be agreement about unique definition of contagion. Moreover, while many economists prefer restrictive definition in order to enable transmission of crisis and the treatment, most policy-makers are in favour of broader definition. In the Financial Stability Review, the ECB (2005) provides the following definition - “When a crisis in the stock market of one country causes a crisis in the stock market of another country this can be thought of as financial market contagion.” Table 1 provides overview of some of the definitions in chronological order.

Table 1: Definitions overview

Eichengreen et al. (1996, p.481)	“an increase in the probability of a speculative attack on the domestic currency which stems not from domestic “fundamentals” such as money and output but from the existence of a (not necessarily successful) speculative attack elsewhere in the world.’’
Forbes et al. (2002, p.2223)	“a significant increase in cross-market linkages after a shock to one country (or group of countries)”
Baur et al. (2005, p.21)	“contagion is defined as the crisis-specific coexceedance not explained by the covariates for different quantiles“
Boyer et al. (2006, p.957)	‘‘significant increase in cross-market linkages during periods of high

	volatility‘‘
Koehler-Geib (2007, p.1)	“the propagation of crises across countries beyond what would be implied by common shocks“
Kelly (2008, p.1)	“large falls in asset values in one country are sometimes followed rapidly by falls in other countries. To the extent that these falls are too great to be explained by interdependence in trade or exposure to common macroeconomic factors, the process is called contagion“
Dungey et al. (2010, p. 11)	“the effects of contemporaneous movements in asset returns across countries having conditioned on a range of factors as represented by the common factors, regional and idiosyncratic factors”
Bekaert et al. (2011, p. 1)	“the co-movement in excess of that implied by the factor model, i.e. above and beyond what can be explained by fundamentals taking into account their natural evolution over time”

Source: Author

2.2 Channels of contagion

To be able to fully understand the concept of contagion, channels through which it spreads ought to be overviewed. There is a lot of literature aiming at contagion and its channels but most of the papers agrees on four basic channels: trade, banks and other lending institutions, portfolio inverstors and wake-up calls (reassessment of fundamentals). Below, these channels are described based on Forbes (2012).

Wake-up calls are defined as reassessment of risks in other countries caused by additional information or reappraisal of fundamentals of another country. Fundamentals reassessment occurs when investors are unaware of particular vulnerabilities or they do not pay too much of attention to those, or simply, when issues with fundamentals arise during a crisis and thus, they lead to multiple equilibria. There exist many forms of reassessment – macroeconomic, country's financial or political characteristics, functioning of financial markets as well as policies of international financial institutions. Typical example of a wake-up call is a situation of reduction of fundings in other countries due to shock for bank funding in country A. This is very likely to generate reassessment and also bank runs in a country characterized by weaker financial system and more uncertainty, supporting spread of contagion across countries.

Trade affects contagion by two ways: through bilateral trade and competition in third markets. When a country is hit by a crisis, it can lead to reduced income and therefore, decrease in demand for imports and through bilateral trade, exports from other countries are affected. Regarding competition in third markets, devalution of a currency can relatively enhance countries' export competitiveness in third markets.

Banks and other lending institutions represent an extremely important channel of contagion. Not only shocks to financial intermediaries cause contagion, but also their characteristics, such as banks' close relationship to the solvency of their sovereign, their high degree of leverage, and their extensive interconnections. Greenwood et al. (2015) show so called ''liquidation spiral'', when presence of leverage magnifies negative shocks to banks leading to even greater decline in amount of loans and unwinding positions. Another example of bank channel of contagion could be a shock to a country that leads to reduction in supply of credit by financial intermediaries to other countries. Hence, increasing the cost of credit and reducing liquidity. If the initial shock is induced by large amount of bank withdrawals because of increases in non-performing loans and reduction of asset value in a weak economy, then the intermediary might be forced to contract the credit offered to other countries in order to meet regulation rules. Contraction in credit in foreign countries might be caused by three means – reduction of cross border lending by foreign banks, decline of local lending by foreign banks' branches and finally, contraction of credit offered by domestic banks as a reaction to funding shock to their balance sheets.

Portfolio investors represent another channel of contagion. The simplest example how portfolio investors enhance emergence and spread of contagion is when investors start to sell their assets in foreign countries due to decline of value of their portfolios caused by idiosyncratic shock in home country in order to meet margin calls or to rebalance their portfolios. Overeacting, herding behavior and self-fulfilling expectations form important part of this channel as well. If investors are worried that others would sell first and they would have no claim in a limited pool of foreign exchange reserves left, these investors might unexpectedly start withdrawing from a country (Masson, 1999). Furthermore, emergence of new financial instruments, i.e. transfer credit risk, could also worsen contagion by portfolio investors' channel (Allen et al., 2006).

2.3 Effects of central bank communication on financial markets

As proven recently, central bank plays an important role in the overall functioning of the financial markets. Its communication affects decision-making of agents through various means – speeches, interviews, Financial Stability Reports (FSR) as well as voting records.

Findings by Born et al. (2011) show that communication about financial stability by central banks contains relevant information for markets. It is suggested that FSR contributes to reducing market volatility and affects stock market return. Additionally, it is claimed that despite very little effect of speeches and interviews during calm periods, these forms of communication served as a significant mean for volatility reduction.

Ranaldo et al. (2007) bring evidence that interviews and speeches by members of the Swiss National Bank influence to substanstial extent Swiss markets. Studying intraday financial market reaction, they show that markets react promptly to communication of Swiss National Bank. Bond, equity as well as foreign currency markets react significantly, where the most responsive market is the bond market and the stock market is the least responsive.

Study by Briere (2006) presents comparison of communication strategies by the ECB and Federal Reserve (FED). The author examines changes of market expectations as a reaction to the central banks' communication. Results show that speeches by Greenspan are more influential regarding rate levels and market uncertainty than those made by Duisenberg.

Recent paper studying effects of speeches by FED on market returns during 1998-2009 (Hayo et al., 2014) proves that hawkish statements raise bond yields and statements suggesting future rate cut lead to decline in bond yields. Additionally, hawkish statements have less influence on interest rates than dovish speeches. It is shown that markets pay more attention to speeches and make adjustment to their prices in greater extent during crisis times.

3 Data description

This section is divided in two parts – subsection presenting the ECB communication data and subsection introducing evolvement of financial market's variables. In particular, it provides detailed description of the data used for our empirical analysis and it is focused on depicting main variables' evolution over time, data sources and comparisons between countries.

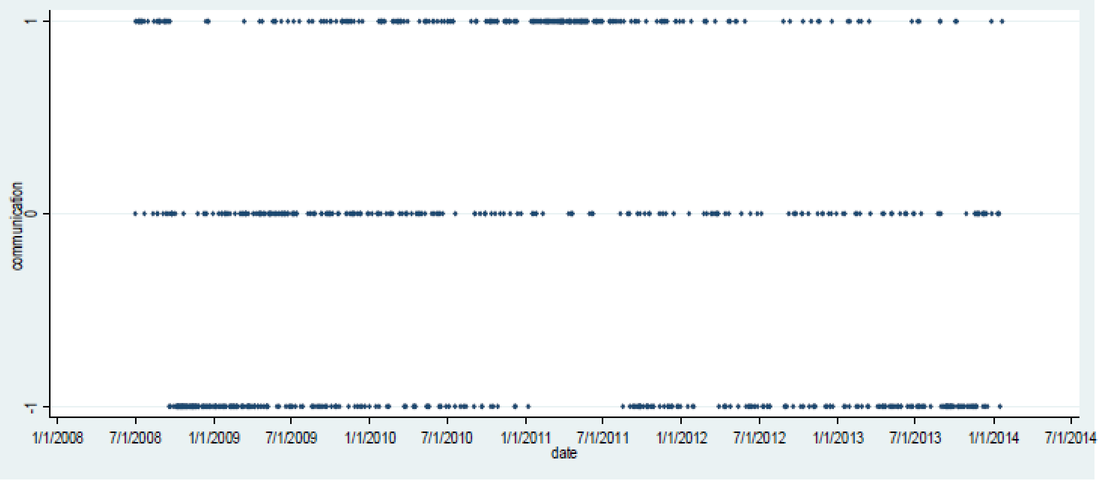
3.1 The ECB communication and analysis of statements

Representants of every national bank make speeches, interviews or publish minutes and reports on a regular basis. In this thesis, we focus on speeches and interviews made by the ECB monetary policy committee members. The ECB communication dataset used covers period from 1st July 2007 until 21st January 2014, therefore the main body of the global financial crisis. Speeches and interviews, that are worked with, were posted on the website of Reuters which served as the main source.

Statements by the ECB during the observation period are coded based on their nature. Firstly, the statement is denoted by 1 if it has hawkish tone. On the other hand, speeches having neutral tone will be given value 0. Finally, dovish statements will be assigned -1.

Since there are many cases when more than one speech or interview was made on a particular day often by two or more ECB representants and we have only daily data on variables from financial market as noted in the next subsection, the average value of the statements is calculated for the day and rounded. For example, on 10th July 2008, three speeches were made – speech by Constancio carried message with hawkish opinion, statement by Hurley was neutral while Smaghi brought hawkish economic outlook. Therefore, on this day the communication variable is assigned 1. On the other hand, if there is communication event having value 1 and another communication event assigned -1 on the same day, we conclude that the ECB sent mixed signal and the markets would react as it was a neutral statement. Another case may be when there are 2 signals – neutral and hawkish. This could be perceived as hawkish by financial markets and thus, communication on that day is assigned 1. Figure 2 depicts time series of independent variable *communication*. Since September 2008 until the second half of 2009 communication events were mostly dovish. This is likely due to the beginning of the global financial crisis. On the other hand, during the first half of 2011, most of the speeches were perceived as having hawkish signs. However, dovish speeches were prevailing again in the second half of 2013. In general, the share of statements with hawkish, neutral and dovish tone is approximately balanced (around 32%, 30% and 38%, respectively) and this conclusion is confirmed also in the statistics of the original coding given in Table 2 indicating that our transformation of the high frequency statement coding did not cause any substantial changes to the original data.

Figure 2: Communication time series



Source: Author’s calculations

Table 2 shows percentage of statements according the nature of the economic outlook they suggest. Statements suggesting easing surprise occurred most frequently during the sample period – almost 39% out of all statements were of dovish nature. Speeches indicating neutral or hawkish policy were made slightly less often – around 30% of the sample speeches were supporting neutral outlook and 31% accounted for hawkish messages. Moreover, approximately 29% of all the statements were about nonstandard measures.

Table 2: Statistics of the nature of the outlook

Nature of the statement	Dovish	Neutral	Hawkish
Total	539	416	429
Percentage	38,92%	30,04%	30,98%

Source: Author's calculations

Table 3 overviews nature of the speeches according to 10 ECB representants who gave the most speeches in our sample. ECB Governing Council member Ewald Nowotny provided most speeches during the observation period. His statements were mostly dovish (45%) on the contrary to the former Chief Economist of the ECB Jurgen Stark whose statements were mostly delivering hawkish messages. The current ECB president gave fewer speeches out of which only 18% suggested hawkish policies.

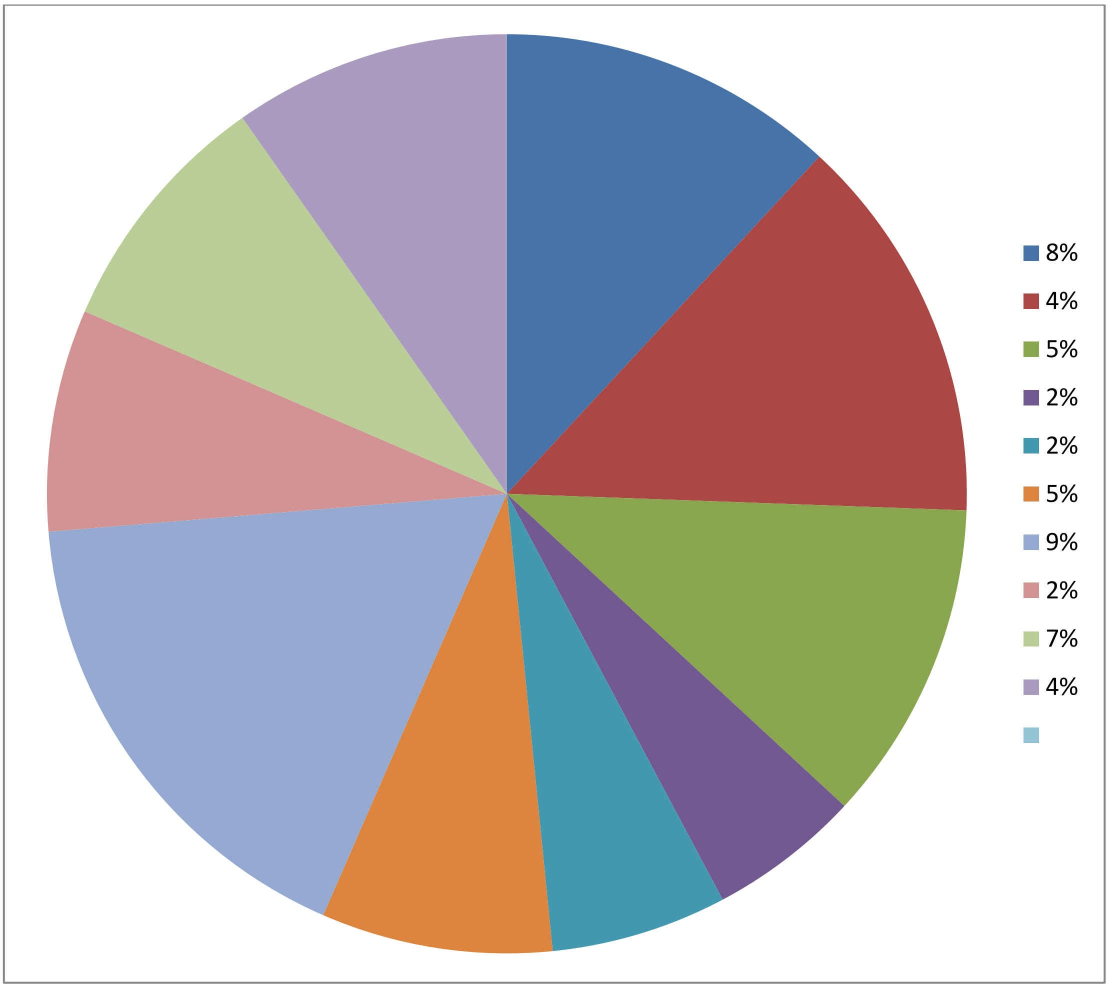
Table 3: Statistics of most talkative representants' statements

	Nature of the statement			Statements given	Percentage		
Name	Dovish	Neutral	Hawkish		Dovish	Neutral	Hawkish
Nowotny	72	56	32	160	45%	35%	20%
Weber	32	29	41	102	31%	28%	40%
Trichet	35	33	33	101	35%	33%	33%
Stark	21	17	57	95	22%	18%	60%
Smaghi	25	28	29	82	30%	34%	35%
Mersch	16	27	35	78	21%	35%	45%
Paramo	32	15	27	74	43%	20%	36%
Draghi	30	23	12	65	46%	35%	18%
Liikanen	29	16	13	58	50%	28%	22%
Noyer	22	19	11	52	42%	37%	21%
Constancio	21	19	10	50	42%	38%	20%
Coeure	25	18	5	48	52%	38%	10%

Source: Author's calculations

It is also noteworthy to examine the content of the speeches (Figure 3). Most of them included issues regarding interest rate changes (20%), growth (17,47%) and inflation (16,17%). Statements aiming at liquidy (8,52%) and nonstandard measures (8,52%) were often subject as well. Rate appropriateness (4,55%), uncertainties (3,03%), long-run accommodation (2,67%), risks to recovery (2,60%) and stance appropriateness (2,17%) occurred less frequently in our sample. Other topics including targetry, quantitative easing, outright monetary transactions, negative rates, forward guidance, recession risks account for 14,30% of all of the statements.

Figure 3: Content of the speeches



Source: Author's calculations

Having look at Table 4, it can be said that 22% of the speeches made by Nowotny concerned growth, while Weber talks about growth even more (28%). Smaghi's statements are most often aimed at interest rate changes (27%) and inflation (20%). 19% of speeches made by member of the Executive Board of the ECB Benoit Coeure are aimed at nonstandard measures. Liquidity is subject of a speech less frequently, with Paramo making around 14% of all his statements about this issue. Statistics for the rest of the ECB representatives included in our sample can be found in Table 4.a in the appendix.

Table 4: Prevailing topics of statements by particular representants

Topic						
name	rate change	growth	inflation	nonstandard measure	liquidity	rate appropriate
Nowotny	21%	22%	16%	6%	9%	8%
Weber	18%	28%	11%	5%	11%	4%
Trichet	17%	16%	19%	10%	9%	5%
Stark	25%	14%	15%	9%	4%	2%
Smaghi	27%	17%	20%	5%	5%	2%
Mersch	18%	22%	18%	4%	6%	5%
Paramo	24%	8%	16%	9%	14%	9%
Draghi	14%	14%	17%	9%	6%	2%
Liikanen	16%	12%	19%	7%	7%	7%
Noyer	8%	17%	21%	15%	8%	4%
Constancio	18%	14%	26%	6%	8%	4%
Coeure	23%	8%	8%	19%	13%	2%

Source: Author's calculations

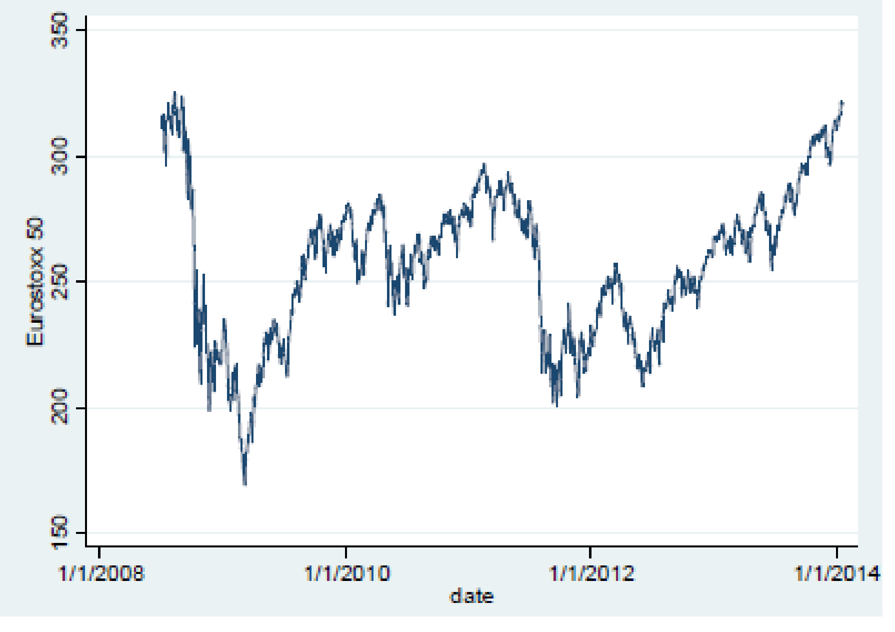
3.2 Financial market's variables

Financial markets react sensitively to various factors and the returns coming from these markets differ across time, especially during financial turmoils. Since this thesis tries to examine potential effect of the ECB communication on contagion spreading on the markets, returns from the stock markets were obtained from Thomson Reuters Wealth Management. This dataset emcompases daily returns of stocks in the eurozone countries (except Luxembourg, whose returns were not available) as well as some of the European countries that do not use euro as official currency during sample period from 1st July 2008 until 21st January 2014. In particular, those stocks include returns for the biggest companies established in given countries, for example for France it is Cotation Assistée en Continu 40 (CAC40). Additionally, since regional market return is also needed for our analysis, daily returns for Eurostoxx 50 are included.

This section is dedicated to describing data constructed from stock returns, spot prices, government bond yields and exchange rate. As our models described in Methodology incorporate volatility, it is useful to study first prices and their transformation.

Figure 4 shows evolution of the Eurostoxx 50 over time. The index reached the highest value at the beginning of August 2008. Sharp decline was observed in the middle of October 2008, which was connected with bankruptcy of Lehman Brothers. However, this is not the point of the lowest value in our sample. This was recorded in March 2009. From this day on, the index started to increase, but then in the third quarter of 2011 it experienced almost as serious drop as in 2008 and returned to values of April 2009. This period was followed by mild increase persisting for a shorter time after which the prices dropped again. Unlike in 2008, the surge did not last for too long and index rebounced faster. At the end of the sample, the values reached were similar to those in August 2008. Figure 4 suggests that there might be a trend in Eurostoxx's time series which leads to non-stationarity.

Figure 4: Evolution of the Eurostoxx 50 over time (in EUR)

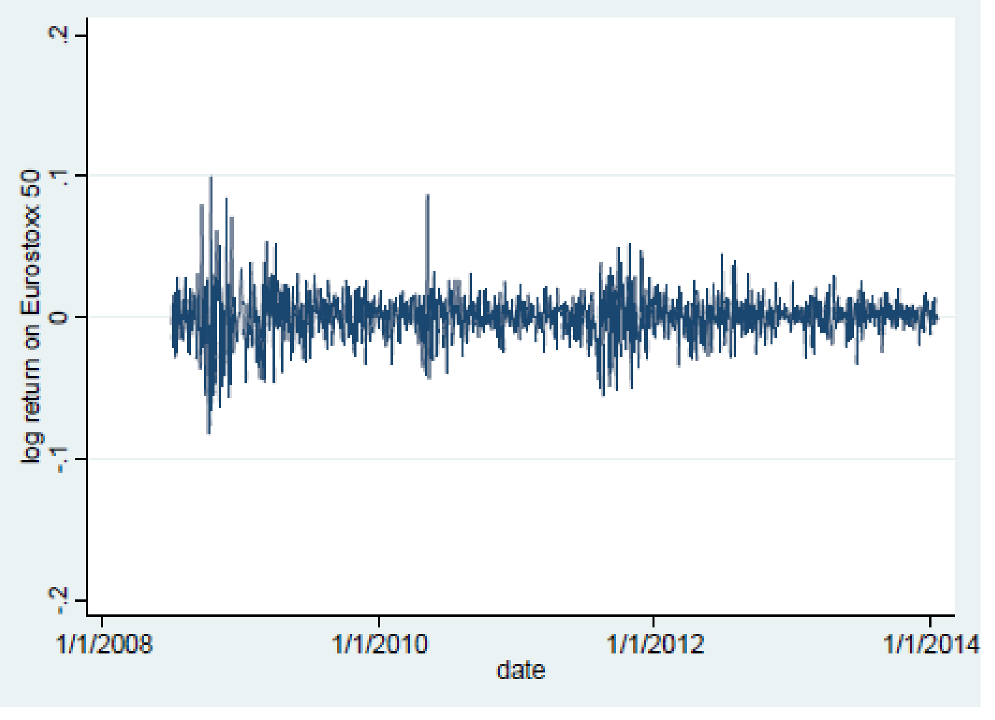


Source: Author's calculations

Since the empirical methodology we decided to apply in this case, as described in the next section, requires stationarity, the original time series have to be transformed so that the potential issue of spurious regression resulting from the non-stationary nature of the data is avoided. Transforming the data into daily percentage change leads to stationarity and this new dataset has constant mean as well as constant unconditional variance. Moreover, the newly created time series is weakly dependent.

Figure 5 depicts evolution of Eurostoxx's log return. It suggests that Eurostoxx 50 does not have constant volatility and indicates periods with increased volatility and volatility clusters. The largest log returns during the observation period were made on 13th October 2008. The lowest log return occurred on 6th October 2008. The same magnitude of log return was present on 10th October 2008.

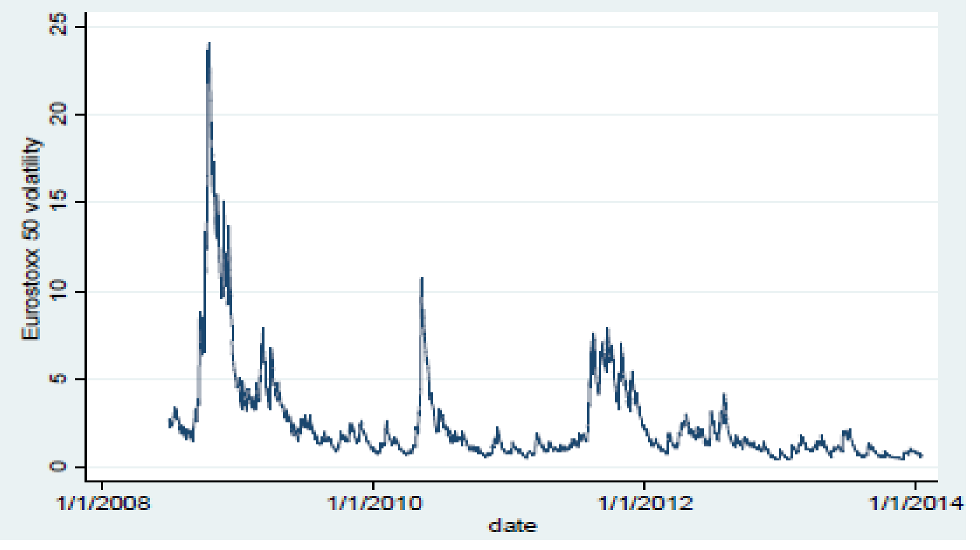
Figure 5: Eurostoxx 50 log return, time series



Source: Author’s calculations

Time series of volatility of Eurostoxx 50 estimated by general autoregressive conditional heteroskedasticity (1,1) (GARCH) is presented in Figure 6. The highest volatility was reached on 17th October 2008 that might be connected with the delayed reaction on economic situation in the United States. Figure 6 also reflects points highlighted in the description of Figure 5, when the difference between the lowest and highest return was just matter of few days. Clearly, the volatility started upsurging on 15th September 2008 when the Bank of Lehman Brothers went bankrupt. On 30th January 2011, volatility reached its lowest value in our sample period.

Figure 6: Volatility of Eurostoxx 50, time series



Source: Author's calculations

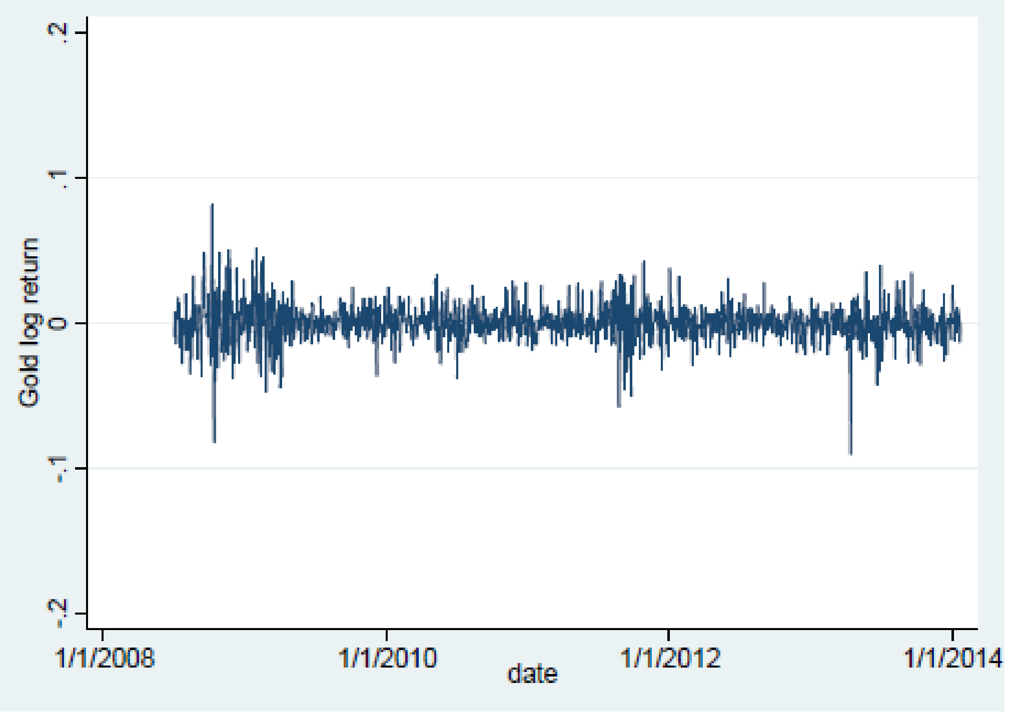
Another important part of our dataset will be spot price of gold. Price data were downloaded from the website of the World Gold Council. Price of gold was rising almost steadily until the beginning of 2013, when substantial decline was recorded and the growth became slower and in the end of 2013, the values returned to the levels of the second quarter of 2010. As Figure 7 shows, there is some substantial trend in the series. Therefore, transformation analogic to the previous one should be performed. Figure 8 depicts transformed time series.

Figure 7: Spot price of gold over time (in EUR/oz)

Source: Author's calculations

Even in this case, returns suggest volatility clusters as well as periods of high volatility.

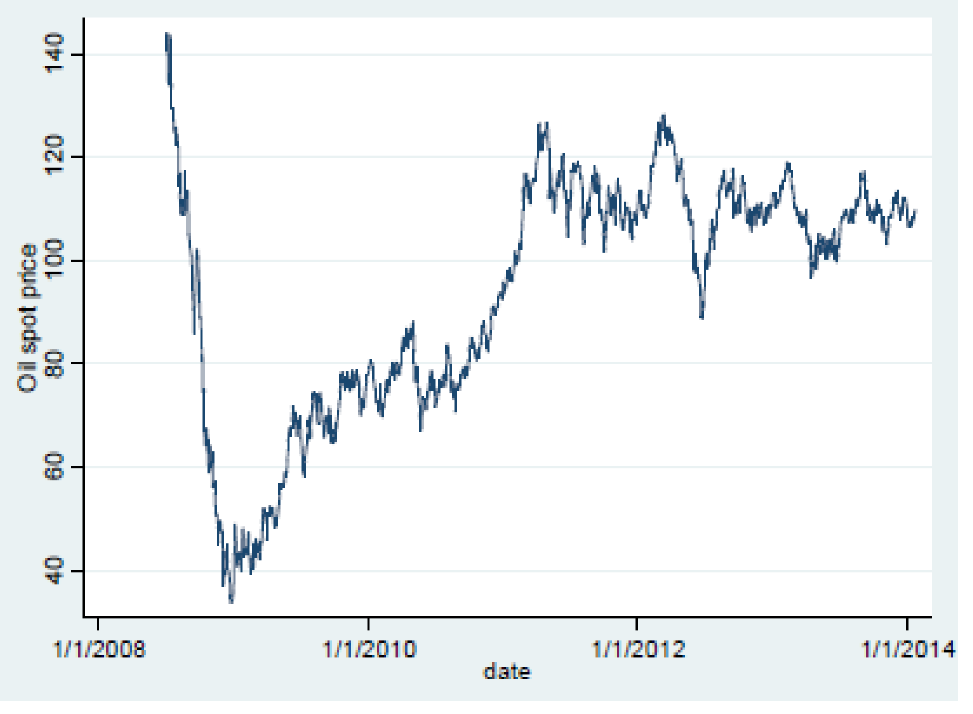
Figure 8: Log returns of gold spot price



Source: Author's calculations

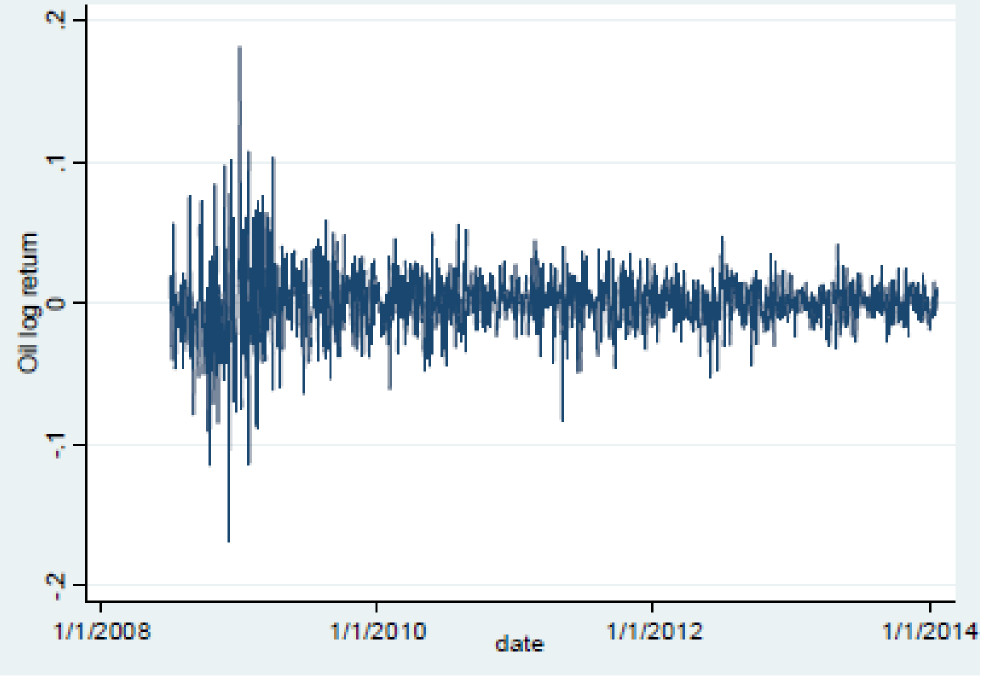
In addition to gold price we include oil spot price as well (Figure 9).Website of the US Energy Information Administration served as the source of the Europe Brent Oil spot price.The highest spot price was recorded at the beginning of July 2008, but since then it was steadily declining until it reached the lowest value in our sample in December 2008. Another substantial decline in oil prices was experienced in the period of March-April 2012. Figure 10 shows evolution of oil returns over time. The highest returns were gained at the very beginning of January 2009 caused by tension in Gaza, while the lowest log returns occurred in December 2008 most likely due to stronger dollar and probable European demand decline.

Figure 9: Oil spot price (in USD), time series



Source: Author’s calculations

Figure 10: Evolution of oil log returns over time



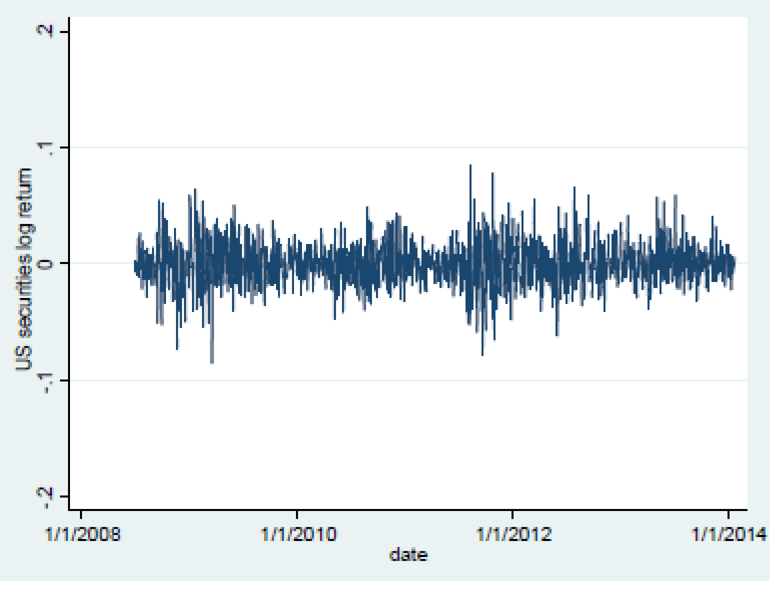
Source: Author’s calculations

Figure 11 depicts evolution of US Tresury securities yield in % over our sample period obtained from the US Federal Reserve Data Releases. As it could be seen from the graph, securities have periods of very low yields and higher yields. An extreme drop in yields was recorded in the last quarter of 2008 very likely to be connected to the global crisis. Yields slowly regained back its magnitudes from the pre-crisis period in the second half of 2009 reaching almost 5%.Other significant declines were observed in 2010 and in the middle of 2011, from where, the yields did not get to the pre-crisis levels until the end of our sample. Also in this case, there is suspicion of trend presence and non-stationarity of the data. Transformation of the data as suggested in the next section leads to time series as shown in Figure 12. It can be concluded that there are clusters of high volatility.

Figure 11: Market yields on U.S. Treasury securities at 20-year constant maturity over time

Source: Author’s calculations

Figure 12: Log returns of US securities over time



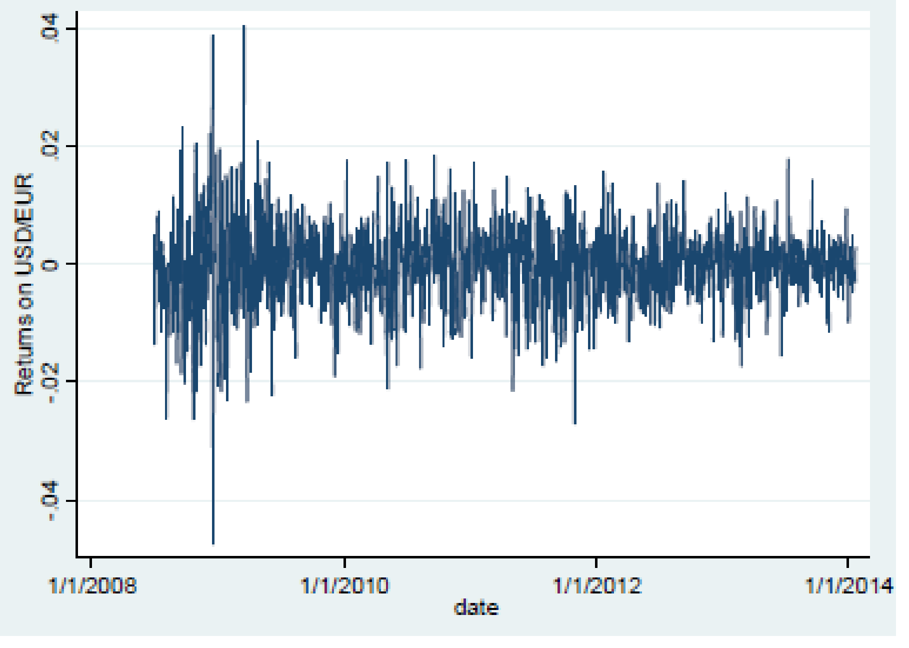
Source: Author's calculations

Figure 13 depicts changes of the exchange rate over the sample period. Euro was the strongest when it reached 1.6 dollars per euro on 15th July 2008. After that it started losing its power until November 2008. This, however, was not the lowest point which occurred in 2010 as euro fell bellow 1.2 dollars. At the end of our sample period euro could be exchanged for approximately 1.35 dollars and therefore, it did not attain or exceed its 2008 value. Log returns are presented in the Figure 14. Even in this case, we expect some volatility clusters and volatility that changes over time.

Figure 13: Evolution of exchange rate USD/EUR over time

Source: Author's calculations

Figure 14: Log returns on USD/EUR



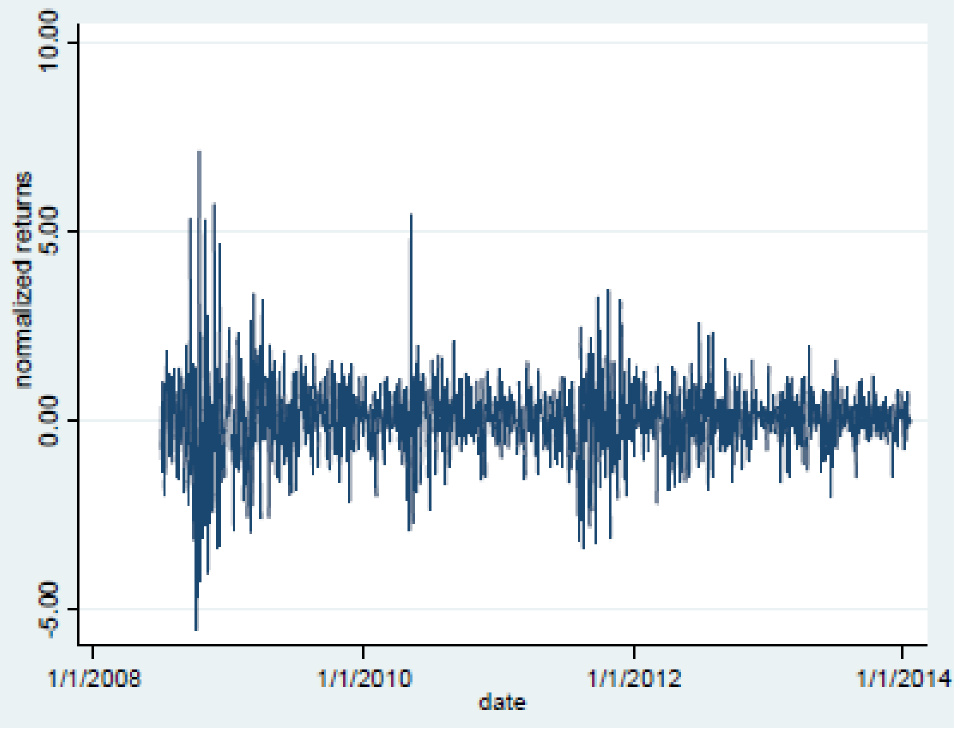
Source: Author's calculations

Note: y axis has smaller scale than previous figures on log returns to enable better visual representation of small fluctuations of currency log returns, data on exchange rate were obtained from Statistical Data Warehouse of the ECB

As suggested in the next section describing econometric methods used for calculation of volatilities, all of the prices are transformed into log returns in order to achieve stationarity and rule out unit root. Firstly, the original series are tested for these issues performing KPSS test, Augmented Dicky-Fuller and Portemanteau test. Due to their results, series are transformed and tested again in order to prove that the issues are no longer present in the data. Results of these tests can be found in the appendix together with the postestimation tests (e.g. GARCH residuals, no-remaining ARCH residuals).

The evolution of normalized French stock returns resembles to the German ones to substantial extent. Returns were 5.5 standard deviations lower than the mean on 6th October 2008, but more than 7 standard deviations above the mean on 13th October 2008. Period of August-October 2011 was marked by increased variance in normalized stock returns (Figure 15). This can be considered as resemblance to the Deutsche Aktienindex (DAX) normalized returns. Importantly, the most visible difference is on 10th May 2010, where the returns were more than 5 standard deviations above the average over the observation period.

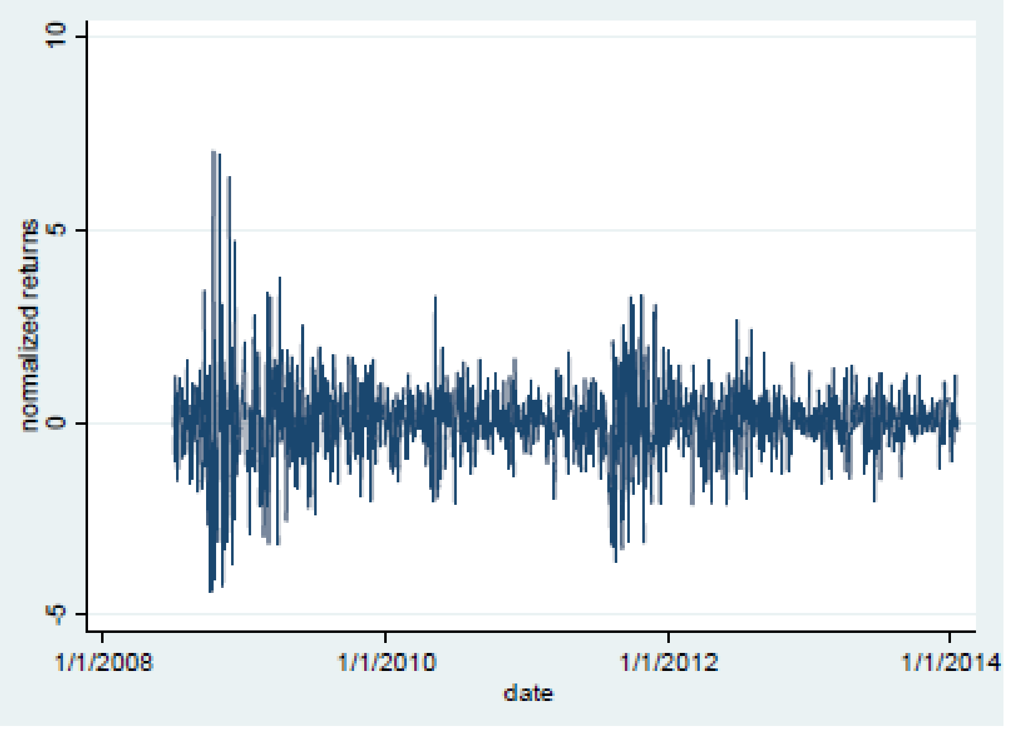
Figure 15: Evolution of normalized returns in France over time



Source: Author's calculations

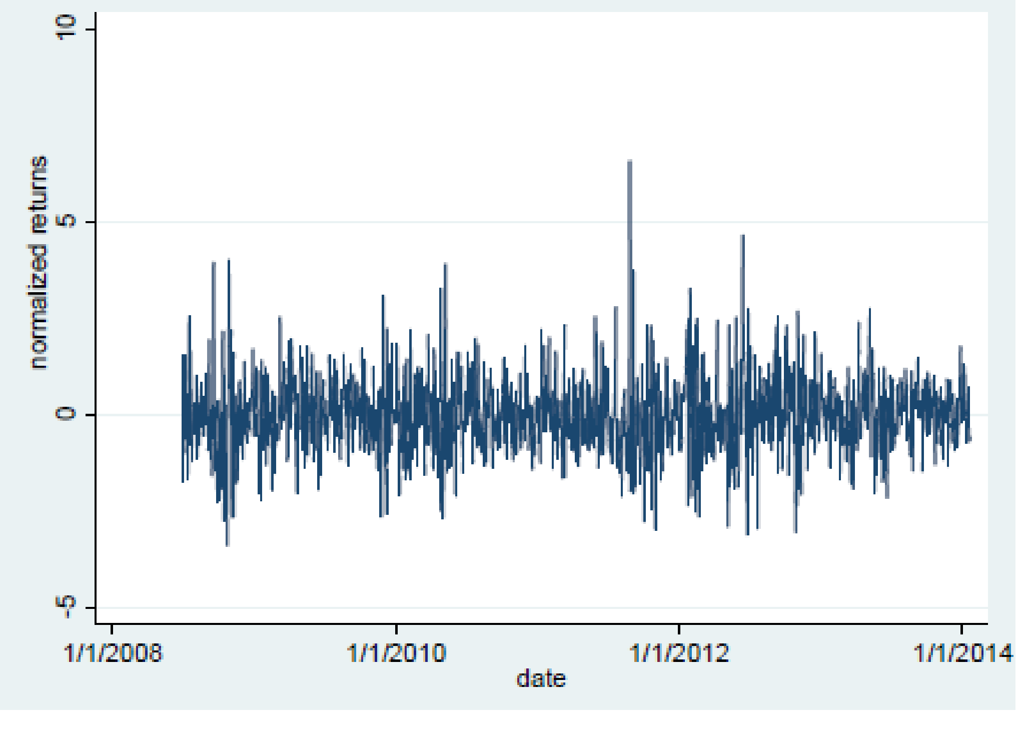
Returns of DAX were more than 4 standard deviations below the mean on 6th October 2008, but on the other hand returns were approximately 7 standard deviations above the mean on 13th October 2008. Even in this case high volatility is suggested to be present in the first half of October. After the third quarter of 2009 variance of normalized returns came back to the pre-crisis levels. However, normalized returns during August-September 2011 indicate increased variance but of much lower magnitude than the variance at the very beginning of the global financial crisis of 2008 (Figure 16).

Figure 16: Evolution of normalized returns of DAX over time



Source: Author's calculations

Figure 17: Evolution of normalized Greek stock returns over time

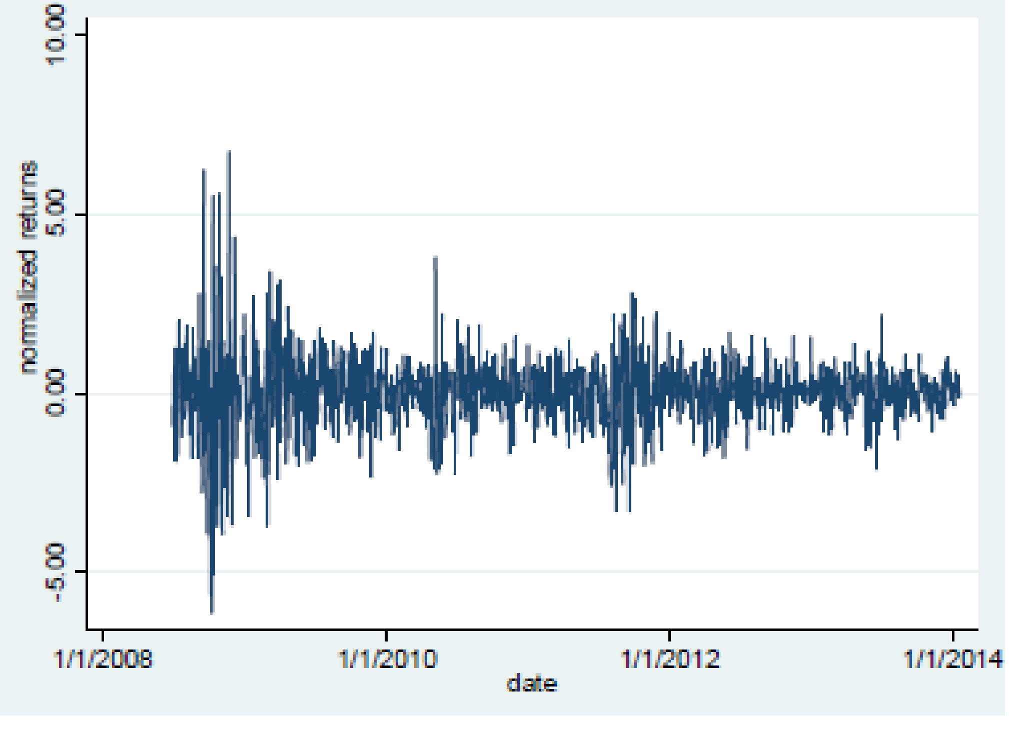


Source: Author's calculations

Undoubtedly, issues regarding repayment of the Greek debt have large influence on the national stock returns. As it can be seen from Figure 17, normalized returns exert increased variance more often than other countries (whose returns are depicted in this section). Unlike France or Germany, the highest normalized returns were not realized in October 2008, but it was on 29th August 2011, when the investors gained returns of more than 6.5 standard deviations above the average. In order to compare returns in October 2008, the maximum and minimum normalized returns of this period are provided – on 29th October normalized returns reached magnitude of almost 4, while on 24th October the returns were 3.4 standard deviations lower than the mean, which is also the lowest value of the normalized return throughout the sample period for Greece.

Figure 18 depicts evolution of normalized returns in the UK. The lowest Financial Times Stock Exchange (FTSE) returns over the sample period were 6 standard deviations below the mean value on 10th October 2008, while the highest values of normalized returns were realized on 24th November 2008 (6.7 standard deviations above the average). In comparison to German DAX, on 13th October 2008 returns were 5.5 standard deviations higher than the mean. The rest of the sample period is relatively more stable.

Figure 18: Evolution of normalized returns in the United Kingdom over time



Source: Author’s calculations

Being aware of the structure and characteristics of the data used is extremely crucial for every empirical analysis in order to be able to choose the most appropriate econometric method and to make some adjustments if nesseccary. In the next section, econometric methods applied in this thesis are described and reasoning for model construction is made.

4 Empirical methodology

In this section we briefly introduce different measures of contagion and discuss their advantages and drawbacks. Afterwards, we describe one particular measure – coexceedance, which is used in this thesis. Furthermore, econometric methods needed for testing our hypothesis are presented. This chapter is concluded by detailed description of econometric methods applied throughout the research.

4.1 Measures of contagion

Since researchers do not agree on one particular definition of contagion, various measures have been proposed. This subsection reviews and discusses measures as in Forbes (2012).

Probability analysis: Probability analysis uses contagion definition such that occurrence of a crisis in a "ground zero'' country affects the probability of crisis in another country. Recently extensions for this method have been developed such as testing for contagion in explaining sharp movements in capital flows (Forbes et al., 2012) and default probabilities derived from credit default swaps. Main drawback of probability analysis is little success in controlling for feedback effects and omitted variables.

Cross-market correlations: This method examines whether correlations in equity returns (or exchange rates, sovereign spreads or interest rates) significantly increased during the crisis across economies. As Forbes et al. (2002) showed this method leads to upward bias in correlation coefficients due to increased volatility during crises. Furthermore, they prove presence of high interdependence of markets in all states of world and bring evidence of more awareness of usual interdependence during high volatility periods. Even if corrected for this heteroscedasticity in returns, correlation method does not control for endogeneity (feedback effects) or omitted variables (common shocks). Most of the researchers ceased using this approach because of the above mentioned drawbacks.

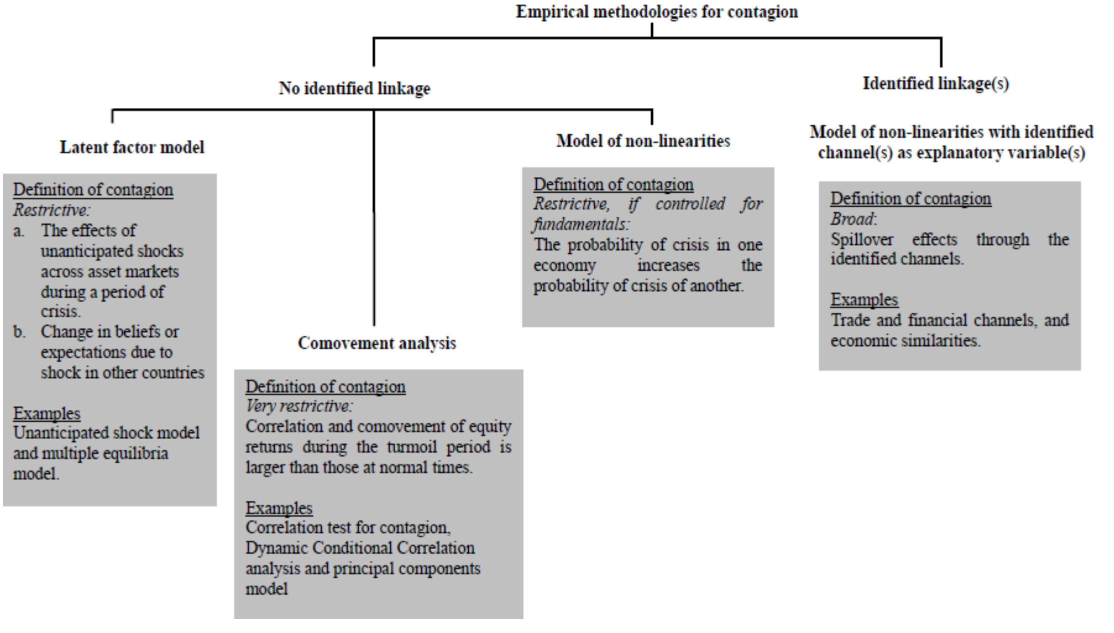
VAR models: This measure is usually used to predict stock market returns or yield spreads controlling for global factors, country-specific factors as well as persistence of these by error correction. Using impulse response functions the impact of a shock, which is not anticipated, to other country is predicted and hence, contagion can be measured. Despite being less conservative, this measure does not include adjustment for heteroscedasticity in returns. Papers employing VAR strategy usually provide more evidence of contagion (e.g. Constancio, 2012, Favero et al., 2002).

GARCH models and Latent factor: Latent factor and GARCH models allow for changing return variances across regimes. The main focus is on the cross-market movements in the second moment of asset prices, therefore spillovers in volatility. Papers implementing these approaches provide evidence of contagion only in certain circumstances. Here, contagion is defined as the excess correlation after controlling for fundamentals. As this approach is grounded on the correlation of the residuals, the main criticism is what residuals capture and whether global shocks or any other omitted variables can cause any contagion.

Extreme values, jump approach and coexceedances: these approaches are based on the probability analysis. Extreme value theory is used to test the correlation of tail events in returns across countries. Extreme events are defined as periods when a particular threshold value is exceeded. Papers use different approaches to define these exceedances. Jump approach focuses on periods of significant price movement. There are several advantages when applying these approaches. Firstly, linearity of shock transmission is not assumed. Moreover, daily relationships between markets are not part of focus and the main attention is paid to the impact of large shocks, which is associated with the broader definition of contagion. Additionally, these approaches exert robustness to different distributional assumptions about returns unlike VAR models or correlation analysis. On the other hand, small sample of extreme events is often present and difficulty of controlling for any global shocks causing exceedances in multiple markets at the same time make these approaches less attractive.

This part provides review of the main measures of contagion. Figure 19 by Cheung et al. (2009) shows brief overview of definitions of contagion together with examples. It is obvious that none of the described measures is perfect and the appropriate method depends also on the chosen definition of contagion. Even though these methods usually identify presence of contagion successfully, they are unable to explain why transmission of negative shocks occurs on the international level and through what channels.

Figure 19: Empirical Strategies



Source: Cheung et al., 2009

4.2 Coexceedance

In order to perform our analysis, definition of contagion is crucial. In this thesis, we define contagion according to latest papers (e.g. Beirne et al., 2014) as structural break in international propagation mechanism during a crisis period. For this particular definition of contagion method of coexceedance is chosen to study this particular phenomenon.

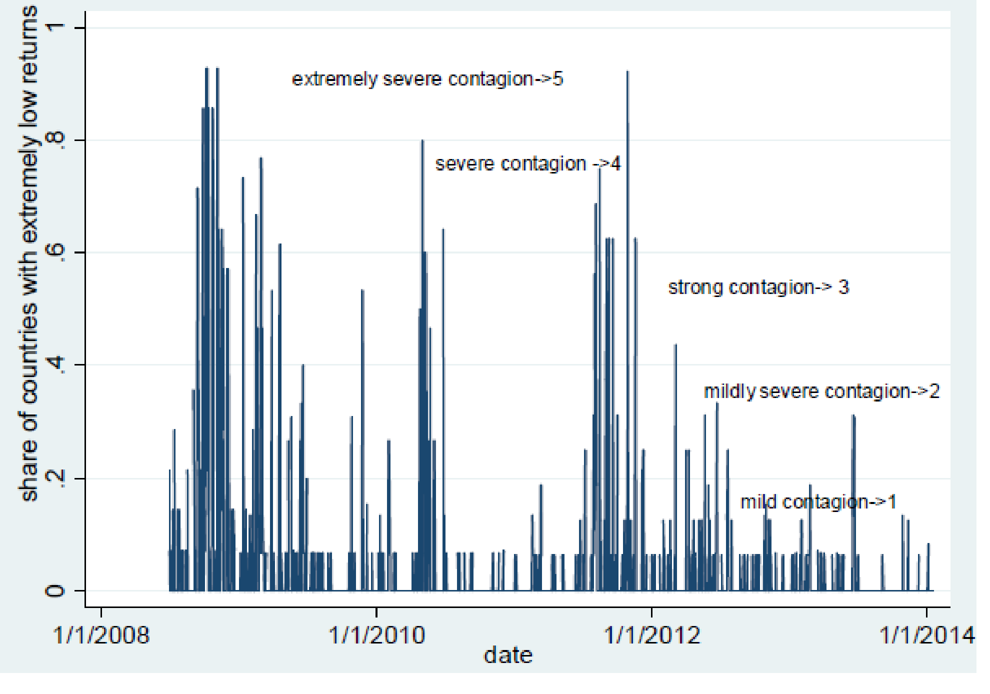
As mentioned in the previous subsection, method of exceedances focuses on the extreme events, more precisely extreme returns. We follow arbitrary definition of an extreme return – exceedance by Bae et al. (2003) as the one which is below (above) the 5th (95th) quantile of marginal return distribution. This leads to notion of coexceedances. Coexceedance represents number of joint occurrences of extreme returns (exceedances) within the eurozone on a particular day, e.g. if returns of three eurozone countries exceed jointly the prespecified threshold at time *t*, the value of coexceedance will be equal to three. As during our sample period the number of the eurozone members changed (new countries entering), it is more convenient to calculate coexceedance values in percentages. Additionally, the dependent variable is stacked in 5 categories and method of ordered logit is implemented (Table 5).

Table 5: Categories of coexceedance

% of the eurozone countries reporting extreme returns	Severness of contagion	Category of dependent variable *coexceedance*
0-20%	mild contagion	1
21-40%	mildly severe contagion	2
41-60%	strong contagion	3
61-80%	severe contagion	4
81-100%	extremely severe contagion	5

Source: Author

Figure 20: Share of countries with extremely low returns

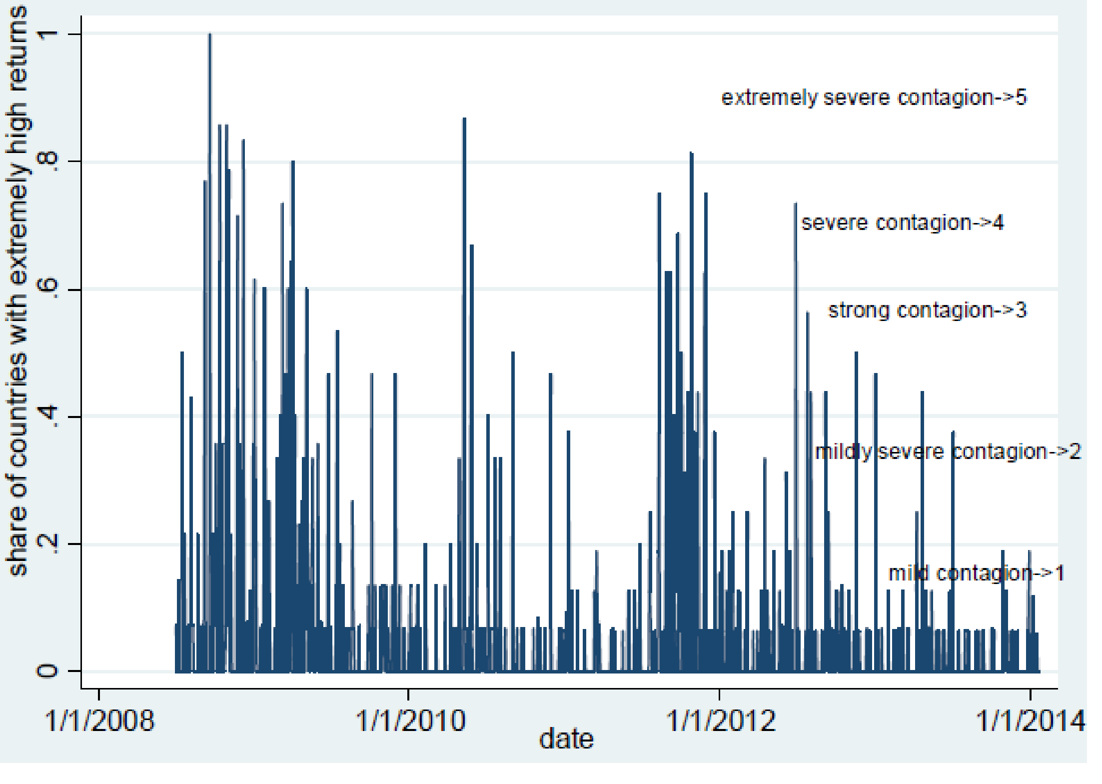


Source: Author's calculations

Figure 20 shows evolution of share of countries experiencing extremely low returns. Moreover, each horizontal region suggests the category of our dependent variable. Extremely severe contagion occurred rarely in the sample mostly during October 2008 and once in November 2011. Coexceedance of 93.33% suggesting that 14 out of 15 eurozone countries had returns in the lower tail of the distribution occurred twice on the day of central banker's speech – 10th August 2008 and 10th October 2008. Severe contagion was present mainly in the second half of 2011 and on the day of the Lehman Brothers' bankruptcy. Even if we exclude all the zero values, mild contagion occured most frequently during the depicted period.

Time series of share of countries experiencing extremely high returns is depicted in Figure 21. Even here, each horizontal region suggests the category of our dependent variable. As in the previous case extremely severe contagion was very rare. Surprisingly, on 19th September 2008 all the eurozone members reported extremely high returns after money market funds had been offered temporary insurance by the U.S. Treasury, stocks short selling had been suspended in the United States of America (USA) and president Bush had announced bailout proposal. Another extreme event was observed on 10th May 2010 when almost 87% of the eurozone members experienced extremely large returns. This was caused by the announcement of rescue package worth 750 billion euros for troubled eurozone economies.

Figure 21: Share of countries with extremely high returns



Source: Author's calculations

4.3 Econometric models

As already mentioned, the aim of the thesis is to examine effect of the ECB on contagion. In particular, we try to assess whether communication of the ECB is significant to contagion and in what direction speeches influence spreading contagion during times of crisis.

In order to test hypothesis that the ECB communication affects contagion immediately, we construct model (1). The variable of interest simultaneously affects coexceedance. Since previous research shows that central bank communication in form of speeches and interviews significantly contributes to maintaining financial stability and has substantial effect on stock market returns during the global crisis (Knutter et al., 2011 and Born et al., 2014), estimated sign of *communication* is expected to be positive since dovish statements would indicate stimulation of economy. Furthermore, the model includes coexceedance (*coex*) in the previous period as it is very likely that high coexceedance is preceeded by times when amount of countries with extreme returns was higher, e.g. if 10 eurozone countries report extreme returns at time t-1, then the likelihood that the contagion will spread further to other eurozone countries at time t is very high. Therefore, β_1 is expected to be positive.

Volatility on the regional stock market has to be considered as well. High volatility, which is one of the main features of crisis times, leads to more uncertainty on the regional market, which in turn would also affect investors' decision making in individual countries. This suggests that volatility increases the probability of further spreading of contagion. Thus, estimate for *volatility_stx* is expected to be positive as well.

Moreover, sudden portfolio re-allocation in period described by flight to quality could be considered as one of the causes for transmission of financial crisis across asset classes (Caballero et al., 2008). Liquidity spirals can even make these effects stronger (Brunnermeier et al., 2009). This indicates substitution effect between safer assets (e.g. bonds) and equities. For example, periods of turmoil on stock markets might be connected with flight to quality, which decrease the yields of low-risk bonds. Declines in the yields of low-risk bonds are accompanied by the declines in the required return and could make investors seek for new investment options. Furthermore, news and monetary policy decisions that are not anticipated by financial markets' participants can create environment for extreme interdependence among equities, currencies as well as bonds with short-term. These arguments serve as a support for price extremes on equity markets being accompanied by substantial price movements of bonds and currencies. Additionally, shock propagation mechanism is more probable when high volatility across all asset classes is observed and not only on the stock markets. In order to account for these facts, market yields on U.S. Treasury securities at 20-year constant maturity, foreign exchange rate between euro and US dollar and their volatilities are also included in our model (*r_bond, r_fx, Volatility_bond, Volatility_fx*, respectively).

Since papers aiming at oil, gold and stock prices show substantial relationship (e.g. Guo et al., 2011 or Baruník et al., 2016), we control for short-term shocks by including continuous daily returns from oil and gold spot price as well as their volatilities in the model (*r_oil, r_gold, Volatility_oil, Volatility_gold*, respectively).

$$Coex_t = \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_t + u_t \quad (1)$$

In this thesis we would like to assess also the possibility of delayed effect on contagion. Stock markets might exert delayed reactions to speeches made by the ECB leaders or they simply may keep in mind words from previous days suggesting different outlook to economic conditions. Many research papers suggest that markets do not often react immediately, especially to news (in our case it could mean sudden change of the view on economic outlook) because of the large amount of information that might create distraction. Therefore, we include lagged *communication* to the first model and we get equation (2). The justification for the expected sign of this variable is similar to the previous case – dovish communication decreases probability of contagion, hence, the β_{12} sign is expected to be positive. Reasoning for the rest of the variables stays the same.

$$Coex_t = \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + u_t \quad (2)$$

So called ‘‘Draghi effect’’ is widely used in journalism to describe the calming effect of Mario Draghi on financial markets (in e.g. The Times, Reuters). Many articles tend to give Draghi’s words credit for making the European sovereign debt crisis look less bleak and global macroeconomy better. It is thanks to the very high credibility that markets assign to the president. Since his statements account only for approximately 10% in our sample, we cannot test this effect directly. Instead, we test for the effect of the ECB president in general. By doing so we will enlarge the sample of president’s statements to around 20% of the whole sample. The third hypothesis of importance of president's words will be addressed by using dummy *President* (when statements are made by the president of the ECB on that day, it is equal to 1) and we get equation (3). It needs to be noted that Trichet was president at the time of the beginning of our sample until 31st October 2011. After this, Draghi became the ECB's president and he keeps his position until today. Additionally, we will also try to examine significance of announcement about non-standard measures by including only those statements which delivered message about this particular type of measures.

$$Coex_t = \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + \beta_{13} President_{t-1} + u_t \quad (3)$$

There might be some concerns regarding the influence of volatility since it is computed using returns of Eurostoxx 50. This index includes 50 stocks from 12 eurozone countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. The first important observation is that it also includes Luxembourg stocks which are not part of our dataset due to their unavailability. Secondly, it does not include Cyprus, Estonia, Latvia, Malta, Slovenia, and Slovakia. Hence, there might occur some cases when the volatility of the Eurostoxx 50 decreases (e.g. when Luxembourg stocks become less volatile) but our dependent variable coexceedance stays the same and therefore, coexceedance does not affect volatility. Additionally, if the coexceedance increases, it might be caused just by the extreme returns experienced in the countries that are not covered in Eurostoxx 50.

4.4 Ordered logit

As described above, the dependent variable attains discrete values, and since the value suggests the severness of the contagion, the ordering in these values is important. Therefore, estimation method must be chosen carefully. In this part, theoretical ground of ordered logit is explained.

Let us denote P_i probability connected to category i out of k possible categories. Then, multinomial distribution is defined as

$$P_i = G(\beta_i' x)/[1 + \sum_{j=1}^{k-1} G(\beta_j' x)] \quad (4)$$

where, β_i is vector of coefficients and x is vector of covariates. Rewriting $G(\beta_i' x)$ as logistic function $exp(\beta_i' x)$ in equation (4), multinomial logit model is obtained. Estimation process is performed by maximum likelihood, where the log-likelihood function with n observations to be maximized is:

$$logL = \sum_{i=1}^{n}\sum_{j=1}^{k} I_{ij} logP_{ij}$$

I_{ij} represents indicator function, such that it is equal to 1 if the *i*th observation belongs to the *j*th category and zero otherwise.

In order to measure goodness of fit, *pseudo*-R^2 as suggested by McFadden (1974) is used. It compares unrestricted likelihood L_U and the restricted one L_R containing constant only:

$$pseudo\ R^2 = 1 - \{\log L_U \,/\, \log L_R\}$$

Additionally, probability of specific level of severness of coexceedance can be calculated by evaluating unconditional covariates:

$$P_i' = exp(\beta_i' x')/[1 + \sum_{j=1}^{k-1} exp(\beta_i' x')]$$

x' represents unconditional mean of *x*. Marginal probability given a unit change can be also obtained following Greene (2000, chap. 19).

4.5 Volatility modelling

As our models include independent volatility variables, this section presents general econometric procedure of estimating volatility values. Additionally, since the empirical methodology we decided to apply in this case, requires stationarity, the original time series have to be transformed so that the potential issue of spurious regression resulting from the non-stationary nature of the data is avoided. Transforming the data into daily percentage change leads to stationarity and this new dataset has constant mean as well as constant unconditional variance. Moreover, the newly created time series is weakly dependent.

Percentage return R_t at time t can be expressed as:

$$R_t = \frac{P_t}{P_{t-1}} - 1$$

P_t represents index or price at time t.

We further make increasing transformation by taking logarithm to obtain log returns:

$$\log(R_t + 1) = log\frac{P_t}{P_{t-1}}$$

Econometric theory provides two estimation procedures that allow for heteroscedasticity and are suitable for the purpose of this thesis –ARCH and GARCH models. The simplest ARCH(1) model was first introduced by Robert Engle (1982):

$$y_t = \rho y_{t-1} + u_t \qquad (5)$$

$$u_t = e_t\sqrt{\alpha_0 + \alpha_1 u_{t-1}}$$

$e_t \sim IID$ (0,1), $\alpha_0 > 0$ and $0 \leq \alpha_1 < 1$.

$$Var(y_t) = \alpha_0 + \alpha_1 y_{t-1}^2 \qquad (6)$$

where mean eq. (5) represents AR(1) process, α_0 and α_1 are constants; $\alpha_0 > 0$ and $0 < \alpha_1 < 1$. Including more lags (q) of y_t leads to ARCH(q) model.

By including lags of E$(u_t)^2$into eq. (6) we obtain GARCH(1,1) model:

$$h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} \qquad (7)$$

where h_t= E$(u_t)^2$= E$(y_t)^2$

These 2 approaches to conditional heteroscedasticity enable modelling volatility clusters, fat tails and also excess volatility. However, ARCH results in estimation of too many parameters and due to this substantial drawback we focus our research only on modelling using GARCH which allows for more flexible lag structure (Bollerslev, 1986.) GARCH(1,1) suggests that the best prediction of the next period variance of y_t is weighted average of long term variance with weight α_0, actual variance in this period with weight α_1 and predicted variance for this period with weight β_1. Including p lags of E$(u_t)^2$ and q lags of u_t, GARCH(p,q) is obtained. If sum of all betas and alphas is strictly smaller than 1, this process is stationary.

4.6 Quantile regression

As already mentioned Bae et al. (2003) we use arbitrary coexceedance thresholds. However, Baur et al. (2005) present different statistical definition of coexceedance for bivariate case:

$$Coex_t = \begin{cases} \min(r_1, r_2) & if \quad r_1 > 0, r_2 > 0 \\ \max(r_1, r_2) & if \quad r_1 < 0, r_2 < 0 \\ 0 & otherwise \end{cases} \tag{8}$$

It is argued that this definition also helps to reveal the precise degree of coexceedance.This measure represents value of extreme movement shared by both markets. Even though this method could be employed to study also multivariate cases, it is not convenient as number of zeros would increase and the regression would yield less efficient estimates.

Since it might not be clear from (8) how this alternative definition of coexceedance is related to tails of the distribution, following explanation is provided:

$$P(Coex_t \leq c) = P(\forall i: r_i \leq c) \tag{9}$$

Expression (9) represents lower tail dependence under condition that scalar c is sufficiently small. It can be shown that it holds also if $a \rightarrow 0$ for $c = F_{Coex}^{-1}(a)$.

Studying bivariate case enables us to examine whether the ECB communication influences significantly the contagion between two markets, e.g. contagion coming from Greece to Germany might be alleviated by statements made by the ECB monetary policy members. On the other hand, it could be shown that the central bank's communication is ineffective when examining France and Germany. Due to large number of the eurozone countries only some of them will be included in the analysis. Having closer look at this relationship might reveal crucial differences how the communication is perceived by national markets in the sense of decreasing volatility, more specifically contagion. As a result, some countries could exploit the ECB communication as one of the measures of mitigating unpleasant crisis characteristics that contagion undoubtedly is. Additionally, we are able to control also for potential effect of the ECB on spreading contagion between the eurozone and non-eurozone countries.

Standardization of both market returns to zero mean and a variance of one before the coexceedance calculation leads to possibility of direct interpretation of coexceedance measure. For example, if the coexceedance attains value 3, both market returns are at least 3 standard deviations above their mean at that time.

Application of quantile regression requires no distributional assumptions unlike logistic regression or application of Extreme Value Theory. Following Baur et al. (2005) simple linear quantile regression model can be written as:

$$\boldsymbol{Coex} = \boldsymbol{X\beta}(\tau) + \varepsilon(\tau) \quad where \;\; Q_{\varepsilon(\tau)}(\tau|\boldsymbol{X}) = 0$$

$\varepsilon(\tau)$ is error term, $\boldsymbol{\beta}(\tau)$ is (*m* x*1*) vector of parameters, **X** stands for (*n* x *m*) matrix of *m* independent variables and $\boldsymbol{Coex}$ represents (*n* x *1*) coexceedance vector. Assuming that the τ-th quantile of error term given all the regressors is equal to zero leads to this expression:

$$Q_{Coex}(\tau|\boldsymbol{X}) = \boldsymbol{X\beta}(\tau)$$

Model 2 estimated by quantile regression will be similar to the one estimated by ordered logit method since there might occur some endogeneity issue in model 1. Here, however, the definition of coexceedance is slightly different as described at the beginning of this section. Lagged coexceedance coefficient is expected to be positive at all levels – the higher the coexceedance of previous day, the higher the current coexceedance. The expectations regarding the volatility sign are not unambiguous. High volatility could lead to positive returns in higher quantiles and negative returns in lower quantiles. Increased volatility during the period of financial turmoil might cause larger extreme coexceedances, even though the stability of the underlying data-generating process is remained (Baur et al., 2005). In addition, the estimate of *communication* is expected to be negative. The reason for the negative sign is that speech sending a message with hawkish tone might lead to returns lower than the mean (e.g. due to fear of high interest rates or aggressive policies), while dovish messages could cause returns to rise above their mean (e.g. due to perception of better future economy or lower interest rates).

5 Results

This section focuses on presenting and interpreting the results. Additionally, deeper analysis is made in order to provide better understanding of usefulness and practical interpretation. Subsection 5.1 includes main results and their description, while subsection 5.2 provides closer look into slightly modified models or definitions.

5.1 Main results

In order to provide as detailed analysis as possible, each model is given three specifications. First, models are estimated using dependent variable describing joint occurrence of extreme returns below 5th percentile of the distribution. Second, coexceedance is defined as share of the eurozone countries jointly gaining stock returns above 95th quantile of the distribution. Eventually, coexceedance represents share of the eurozone members whose stock returns are either below 5th quantile or above 95th quantile.

Table 5.1 shows results of estimation of model 1 by ordered logit, where communication is defined as average nature of a statement on a particular day. Coexceedance of the previous day matters in the last two specifications (5% and 10% level of significance, respectively). However, the sign of its estimate is opposite of what was expected – negative sign suggests that likelihood of increased coexceedance decreases with high coexceedance that occured in the previous day. This might be caused by tendency of investors to reallocate their financial resources if there is an opportunity of larger gains, but herding behaviour may lead to diminishing of benefits. Additionally, communication does not have any effect on coexceedance. In all three specifications, its estimate is not significant and our first hypothesis must be rejected. Returns on currency are not significant in either of the three cases, but closer examination shows that exchange rate volatility affects the probability of joint occurrence of extremely high and extreme returns. Positive sign indicates that likelihood of higher coexceedance increases with increasing volatility. Controlling for short term shocks using returns and volatilities of gold and oil, suggests no effect and hence, these variables cannot help predict joint occurrence of extremely high returns in the eurozone. On the other hand, returns on oil and volatility of gold is significant for predicting extremely low returns in the eurozone – positive relationship leads to the idea that short term shocks may increase the probability of more countries experiencing returns from the lower tail of the distribution. Regional market volatility is significant in all of the cases with positive sign suggesting that the more volatile the stock environment, the higher the probability of larger share of countries having extreme returns. Returns on the Eurostoxx 50 are not significant only in the second specification. However, significant negative relationship between the likelihood of higher coexceedance and stock return is present in the other two specifications. Returns on US Treasury securities are significant for prediction of coexceedances in the first two specifications but the sign of the estimates differs – in the first specification the sign is negative, while the other specification brings positive sign, suggesting that higher returns on securities are connected with higher probability of increasing share of countries jointly experiencing extremely high stock returns, but also with decreasing probability of increasing share of countries jointly experiencing extremely low stock returns. Hence, there seem to be a substantial linkage between these two markets.

Estimates of model 2 are presented in Table 5.2. Even in this case our hypothesis is rejected due to insignificant coefficient of lagged communication. Therefore, it cannot be concluded that the stock market participants react to the nature of the statement and adjust their decisions with delay. As in the previous case, the last two specifications deliver significant and negative estimates of the lagged coexceedance. However, this time, currency volatility matters in the first and the last case but not in the case of extremely high returns indicating a bit of sensitivity for the inclusion of the lagged communication. This is further supported by volatility of oil gaining 1% significance and on the contrary, volatility of gold losing its significance in the case of coexceedance of extremely low returns. Volatility of regional stock market remains to be significant in the first and the last specification. Returns of the US securities are significant and the estimates exert the same sign as in the previous model. Negative sign on regional stock return suggests that better conditions on the regional level lead to decrease in probability of spreading extremely low stock returns within the eurozone.

Table 5.3 shows estimation results of the third model. Coefficients and significance of independent variables are similar to those obtained from model 2 regression. The estimate on dummy *President* exerts negative and significant sign as we expected only in the second specification. Hence, the “calming effect’’is present only in the case of spreading extremely high returns and our hypothesis cannot be rejected due to significant coefficient of the dummy. It can be concluded that the day after president’s speech, probability of higher share of the eurozone countries experiencing extremely high returns decreases.

Result of testing the last hypothesis of stronger communication effect on coexceedance, when speech delivers announcement about a non-standard measure, is presented in Table 5.4. Again, communication does not represent significance regarding influence on coexceedance. The volatilities of currency and oil returns are significant at 1% in the last specification. Unlike volatility of currency, estimate on volatility of oil exerts negative sign indicating that the more volatile the oil market in the previous day the less likely it is to observe joint occurrence of extreme returns. But when the estimations are performed separately for extremely high and extremely low returns, different results are delivered. The first specification leads to four significant variables – return on bond and volatility of currency, oil and bond. While positive sign of estimate on currency volatility leads to the conclusion that increased lagged currency volatility is connected with the higher probability of coexceedance, negative sign on bond return estimate indicates that higher return on the US securities market is accompanied by increased likelihood of joint occurrence of extremely low returns the following day. Volatility of bond and oil exert negative estimates as well and indicate similar relationship. In the second specification, only three of the variables are significant – currency volatility, currency return and return on the U.S. securities. In this case, however, estimates on returns exert positive sign and indicate that higher returns would lead to increase in probability of joint occurrence of extremely high returns.Here, the magnitude of currency volatility is much lower than in the first specification and suggests weaker effect on contagion spread. Even the magnitudes of significant estimates are different than in the model 2. In the first two specifications communication is not significant and therefore, the third hypothesis is rejected and it cannot be concluded that financial markets adopt their behaviour based on the statements' nature when non-standard measure is announced. Therefore, taking all above into account leads to conclusion that in days when non-standard measures are announced markets react substantially differently.

Table 5.1: Model 1, estimation results

Model : $Coex_t = \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_t + u_t$			
Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
$Coex_{t-1}$	-0.31 (0.34)	-0.67* (0.38)	-0.35** (0.17)
r_fx_{t-1}	0.04 (0.26)	0.28 (0.20)	0.02 (0.17)
$Volatility\_fx_{t-1}$	1.24 (1.16)	1.57* (0.83)	1.47** (0.70)
r_oil_{t-1}	0.20** (0.09)	0.02 (0.7)	0.10* (0.05)
$Volatility\_oil_{t-1}$	-0.09 (0.06)	-0.06 (0.04)	-0.08** (0.04)
r_bond_{t-1}	-0.33*** (0.12)	0.28*** (0.09)	0.08 (0.07)
$Volatility\_bond_{t-1}$	-0.13 (0.12)	0.18** (0.08)	0.07 (0.06)
r_gold_{t-1}	0.16 (0.11)	0.02 (0.11)	0.09 (0.08)

Continue Table 5.1

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
Volatility_gold$_{t-1}$	0.51*** (0.20)	-0.14 (0.22)	0.31** (0.15)
Volatility_stx$_{t-1}$	0.13* (0.08)	0.23*** (0.09)	0.21*** (0.06)
r_stx$_{t-1}$	-0.28* (0.15)	0.05 (0.13)	-0.16** (0.08)
Communication$_t$	-0.01 (0.31)	-0.14 (0.26)	-0.09 (0.20)
Pseudo R-sq.	0.22	0.16	0.18
Number of observations	506	506	506

Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses. The first column represents estimation for coexceedance constructed by using returns below 5th percentile, the second column represents estimation for coexceedance constructed by using returns above 95th percentile and the last column represents estimation for coexceedance constructed by using returns below 5th percentile and above 95th percentile. *Coex, r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, log return on currency, currency volatility, log return on oil, volatility of oil, log return on US. Securities, securities volatility, log return on gold, gold volatility, volatility of regional stock market and log returns of regional stocks, respectively.

Source: Author's calculations

Table 5.2: Model 2, estimation results

$Coex_t = \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + u_t$			
Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
$Coex_{t-1}$	-0.45 (0.38)	-0.94** (0.44)	-0.47** (0.20)
r_fx_{t-1}	0.44* (0.26)	0.32 (0.22)	0.18 (0.17)
$Volatility\_fx_{t-1}$	5.30*** (1.79)	-0.05 (1.03)	1.87** (0.84)
r_oil_{t-1}	0.11 (0.10)	0.03 (0.7)	0.08 (0.06)
$Volatility\_oil_{t-1}$	-0.34*** (0.12)	0.02 (0.05)	-0.09** (0.04)
r_bond_{t-1}	-0.44*** (0.14)	0.38*** (0.10)	0.09 (0.07)
$Volatility\_bond_{t-1}$	-0.17 (0.13)	0.19** (0.09)	0.09 (0.07)
r_gold_{t-1}	0.18 (0.15)	0.05 (0.12)	0.07 (0.10)

Continue Table 5.2

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
$Volatility\_gold_{t-1}$	0.23 (0.27)	0.30 (0.21)	0.31* (0.16)
r_stx_{t-1}	-0.30* (0.17)	0.06 (0.15)	-0.13 (0.09)
$Volatility\_stx_{t-1}$	0.31*** (0.10)	0.03 (0.08)	0.20*** (0.06)
$Communication_{t-1}$	-0.22 (0.36)	0.43 (0.29)	0.18 (0.23)
Pseudo R-sq.	0.29	0.13	0.17
Number of observations	505	505	505

Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses. The first column represents estimation for coexceedance constructed by using returns below 5th percentile, the second column represents estimation for coexceedance constructed by using returns above 95th percentile and the last column represents estimation for coexceedance constructed by using returns below 5th percentile and above 95th percentile. *Coex, r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, log return on currency, log return on oil, volatility of oil, log return on US. Securities, securities volatility, log return on gold, gold volatility, volatility of regional stock market and log returns of regional stocks, respectively.

Source: Author’s calculations

Table 5.3: Model 3, estimation results

$Coex_t = \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + \beta_{13} President_{t-1} + u_t$			
Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
$Coex_{t-1}$	-0.43 (0.38)	-0.92** (0.43)	-0.47** (0.20)
r_fx_{t-1}	0.40 (0.27)	0.36 (0.22)	0.20 (0.17)
$Volatility\_fx_{t-1}$	5.31*** (1.77)	0.01 (1.04)	1.89** (0.84)
r_oil_{t-1}	0.10 (0.11)	0.01 (0.07)	0.08 (0.06)
$Volatility\_oil_{t-1}$	-0.34*** (0.12)	0.02 (0.05)	-0.10** (0.04)
r_bond_{t-1}	-0.47*** (0.14)	0.43*** (0.11)	0.10 (0.07)
$Volatility\_bond_{t-1}$	-0.18 (0.14)	0.20** (0.09)	0.10 (0.07)
r_gold_{t-1}	0.18 (0.15)	0.08 (0.12)	0.07 (0.10)

Continue Table 5.3

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
$Volatility\_gold_{t-1}$	0.21 (0.27)	0.37* (0.22)	0.33* (0.17)
r_stx_{t-1}	-0.28 (0.17)	0.02 (0.15)	-0.14 (0.09)
$Volatility\_stx_{t-1}$	0.32*** (0.10)	0.02 (0.09)	0.19*** (0.06)
$Communication_{t-1}$	-0.22 (0.37)	0.39 (0.29)	0.16 (0.23)
$President_{t-1}$	0.77 (0.59)	-1.58** (0.71)	-0.54 (0.45)
Pseudo R-sq.	0.30	0.16	0.17
Number of observations	505	505	505

Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses. The first column represents estimation for coexceedance constructed by using returns below 5th percentile, the second column represents estimation for coexceedance constructed by using returns above 95th percentile and the last column represents estimation for coexceedance constructed by using returns below 5th percentile and above 95th percentile. *Coex, r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, log return on currency, currency volatility, log return on oil, volatility of oil, log return on US. Securities, securities volatility, log return on gold, gold volatility, volatility of regional stock market and log returns of regional stocks, respectively.

Source: Author's calculations

Table 5.4: Model 2 – non-standard measure days, estimation results

$Coex_t = \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + u_t$			
Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
$Coex_{t-1}$	0.03 (0.90)	-0.94 (0.57)	-0.99*** (0.35)
r_fx_{t-1}	-0.02 (0.61)	0.77* (0.39)	0.28 (0.33)
$Volatility\_fx_{t-1}$	17.70*** (6.60)	3.08** (1.54)	4.18*** (1.46)
r_oil_{t-1}	0.09 (0.26)	0.06 (0.12)	0.12 (0.11)
$Volatility\_oil_{t-1}$	-1.15*** (0.40)	-0.07 (0.07)	-0.20*** (0.8)
r_bond_{t-1}	-1.03** (0.50)	0.34** (0.15)	0.13 (0.12)
$Volatility\_bond_{t-1}$	-0.92* (0.48)	0.19 (0.12)	0.03 (0.11)
r_gold_{t-1}	0.36 (0.36)	-0.17 (0.19)	-0.01 (0.16)

Continue Table 5.4

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
$Volatility\_gold_{t-1}$	1.23 (0.88)	-0.06 (0.37)	0.33 (0.33)
r_stx_{t-1}	0.07 (0.51)	0.04 (0.21)	-0.13 (0.14)
$Volatility\_stx_{t-1}$	0.43 (0.27)	0.15 (0.15)	0.33*** (0.12)
$Communication_{t-1}$	0.05 (0.62)	0.22 (0.38)	0.10 (0.33)
Pseudo R-sq.	0.47	0.20	0.27
Number of observations	215	215	215

Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses. The first column represents estimation for coexceedance constructed by using returns below 5th percentile, the second column represents estimation for coexceedance constructed by using returns above 95th percentile and the last column represents estimation for coexceedance constructed by using returns below 5th percentile and above 95th percentile. *Coex,r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, log return on currency, currency volatility, log return on oil, volatility of oil, log return on US. Securities, securities volatility, log return on gold, gold volatility, volatility of regional stock market and log returns of regional stocks, respectively.

Source: Author’s calculations

Quantile regression results for Germany and Greece on quantiles 1, 5, 10, 50, 90, 95 and 99 are presented in Table 6.1. Lagged coexceedance is not significant in any of the reported quantiles. However, currency volatility is significant only in the 99th quantile and suggests that fluctuations in exchange rate negatively influence coexceedance in the upper tail of the distribution. In all the quantiles, the volatility of bond carries positive sign and it has significant effect on German-Greek coexceedance in 50th quantile - higher volatility drives investors to stock markets and it increases the returns above their mean. Similar conclusion holds for the regional stock market volatility – for the lower tail of the distribution it holds that coexceedance is negatively affected by the volatility of the Eurostoxx 50 index indicating that the higher the volatility, the lower the returns of both countries and this also holds for the 99th quantile. This finding supports our previous conclusion. Constant is significant (at 1% and 5% level) only in the 1st , 5th, 90th, 95th and 99th quantile –in the lower tail cases the both markets have returns lower than their mean while in the upper tail both returns are above their mean. Estimate on communication is significant (5% level) only in the first quantile indicating negative relationship. Therefore, in the first quantile dovish statement would lead to increase in coexceedance, while hawkish one would cause the coexceedance to decline and both market returns would be lower than their mean minus 0.32 standard deviations. Currency volatility, oil volatility, return on gold and bond volatility are significant mainly in the higher quantiles. In the lower quantiles (1st, 5th and 10th) the pseudo R-squared attains the highest value (0.43, 0.26 and 0.17, respectively), but measure of goodness of fit is substantially lower for the rest of the presented quantiles. Hence, it indicates that the model fits lower quantiles much better.

Table 6.1: Germany – Greece, quantile regression results

$$Coex_t = \beta_0 + \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + u_t$$

Quantile	1	5	10	50	90	95	99
$Coex_{t-1}$	0.59 (0.46)	0.23 (0.28)	-0.09 (0.19)	-0.05 (0.08)	-0.01 (0.15)	0.09 (0.19)	0.13 (0.27)
r_fx_{t-1}	-0.14 (0.16)	0.14 (0.14)	0.10 (0.13)	0.06 (0.04)	0.03 (0.11)	-0.09 (0.18)	0.01 (0.21)
$Volatility\_fx_{t-1}$	-0.61 (0.77)	-0.79 (0.59)	-0.40 (0.53)	-0.19 (0.17)	0.25 0.38	-0.09 (0.08)	-1.40* (0.70)
r_oil_{t-1}	-0.09 (0.07)	-0.08 (0.05)	-0.05 (0.04)	-0.01 (0.01)	-0.03 (0.03)	-0.02 (0.05)	0.01 (0.06)

Continue Table 6.1

Quantile	1	5	10	50	90	95	99
r_oil_{t-1}	-0.09 (0.07)	-0.08 (0.05)	-0.05 (0.04)	-0.01 (0.01)	-0.03 (0.03)	-0.02 (0.05)	0.01 (0.06)
$Volatility\_oil_{t-1}$	0.02 (0.04)	0.03 (0.03)	0.01 (0.02)	0.01 (0.01)	-0.01 (0.03)	0.05 (0.04)	0.10** (0.05)
r_bond_{t-1}	0.02 (0.06)	0.02 (0.05)	0.04 (0.04)	0.04*** (0.01)	0.06 (0.04)	0.09* (0.05)	0.09 (0.06)
$Volatility\_bond_{t-1}$	0.07 (0.06)	0.01 (0.05)	0.01 (0.05)	0.02 (0.02)	0.03 (0.04)	0.09** (0.04)	0.07 (0.06)

Continue Table 6.1

Quantile	1	5	10	50	90	95	99
r_gold_{t-1}	-0.15** (0.07)	-0.03 (0.06)	-0.01 (0.05)	0.01 (0.02)	0.03 (0.05)	0.07 (0.08)	0.22** (0.11)
$Volatility\_gold_{t-1}$	-0.10 (0.11)	0.02 (0.11)	0.01 (0.09)	-0.01 (0.03)	0.05 (0.07)	0.02 (0.12)	0.24 (0.19)
r_stx_{t-1}	-0.06 (0.16)	0.04 (0.11)	0.09 (0.07)	0.01 (0.03)	0.05 (0.06)	0.01 (0.09)	0.05 (0.12)
$Volatility\_stx_{t-1}$	-0.09* (0.05)	-0.12** (0.05)	-0.12*** (0.04)	-0.04*** (0.01)	-0.04 (0.03)	-0.06 (0.05)	-0.13** (0.07)

Continue Table 6.1

Quantile	1	5	10	50	90	95	99
Communication$_{t-1}$	-0.32** (0.14)	-0.09 (0.12)	-0.02 (0.08)	0.02 (0.04)	0.10 (0.07)	0.08 (0.11)	-0.05 (0.13)
Constant	-1.12*** (0.32)	-0.46** (0.19)	-0.15 (0.12)	0.09 (0.07)	0.33** (0.13)	0.49** (0.24)	1.34*** (0.31)
Pseudo R-sq.	0.43	0.26	0.17	0.06	0.04	0.08	0.33
Number of observations	477						

Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses, computed by bootstrap using 100 replications. *Coex,r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, log return on currency and currency volatility, log return on oil, volatility of oil, log return on US. Securities, securities volatility, log return on gold, gold volatility, volatility of regional stock market and log returns of regional stocks, respectively.

Source: Author's calculations

Following estimation is performed for France and Germany (Table 6.2). Even in this case, coexceedance of the previous day is not significant for determining the current coexceedance. Results also suggest that in the lower quantiles lagged return on oil is significant with negative sign – in 5% of all the cases, higher oil returns would drive stock returns of both markets below their mean the next day. Interestingly, this conclusion was not observed in the estimation of model Germany-Greece. Additionally, in the last reported quantile return on gold and its volatility significantly affect coexceedance between France and Germany. Positive relationship is attained for their estimates and hence, in the upper tail of the distribution higher volatility and return would consequently cause higher stock returns on both markets. Unlike in the case of Germany and Greece, return on bond is significantly positive in quantiles 50, 90 and 95 indicating some comovement of returns on bonds and French and German stock returns in higher quantiles, but bond volatility is not significant only in 90th quantile. Regional stock market volatility is significant (and negative) in all the quantiles except 90th and 95th. Furthermore, communication is significant only in the first quantile and thus, we cannot reject our null hypothesis. Positive sign of the last estimate suggests different reaction to the nature of the central bank speech than in the previous case. Dovish statement would drive returns of both stock markets below their mean, while hawkish statement would cause an increase above their mean by 0.30 standard deviations. Regarding the constant, it is significant for all the quantiles except the 50th, it exerts negative sign for the lower quantiles and positive for upper quantiles. This result is logical since lower quantiles cover most of the negative returns, while the higher focus on the positive returns of both stock markets. In this case, currency volatility is significant in the 50th, 95th and 99th quantile with negative sign. Therefore, more volatile currency would lead to next day's returns lower than their mean in the upper quantiles, e.g. for the 99th quantile the return would be lower than the mean by approximately 1.5 standard deviations if currency volatility increased by 1 unit the day before. Return on oil is negative and significant in the lower quantiles, while its volatility with positive sign represents a significant determinant only in the upper quantiles. The rest of the independent variables is mostly insignificant and does not have any effect on the coexceedance between France and Germany. As in the previous estimation results the model fits the best the first and the last quantile (pseudo R-squared = 0.50 and 0.43, respectively).

Table 6.2: Germany – France, quantile regression results

$Coex_t = \beta_0 + \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + u_t$							
Quantile	1	5	10	50	90	95	99
$Coex_{t-1}$	0.32 (0.57)	0.52 (0.55)	-0.27 (0.47)	0.04 (0.16)	0.17 (0.28)	0.36 (0.49)	-0.60 (0.57)
r_fx_{t-1}	-0.19 (0.18)	-0.01 (0.13)	-0.01 (0.11)	0.02 (0.05)	0.05 (0.09)	0.15 (0.15)	0.03 (0.21)
$Volatility\_fx_{t-1}$	1.24 (1.04)	0.42 (0.60)	-0.28 (0.57)	-0.71*** (0.25)	-0.70 (0.50)	-1.75** (0.70)	-1.49* (0.80)

Continue Table 6.2

Quantile	1	5	10	50	90	95	99
r_oil_{t-1}	-0.18*** (0.06)	-0.11* (0.06)	-0.03 (0.05)	-0.01 (0.02)	-0.01 (0.03)	-0.04 (0.04)	-0.04 (0.05)
$Volatility\_oil_{t-1}$	-0.06 (0.05)	-0.04 (0.03)	0.01 (0.04)	0.03** (0.01)	0.03 (0.03)	0.07* (0.03)	0.12*** (0.04)
r_bond_{t-1}	0.13 (0.08)	0.04 (0.07)	0.08 (0.06)	0.08*** (0.02)	0.11*** (0.04)	0.14** (0.06)	0.06 (0.07)
$Volatility\_bond_{t-1}$	0.03 (0.11)	0.03 (0.09)	0.05 (0.06)	0.06*** (0.02)	0.08 (0.05)	0.21*** (0.06)	0.16** (0.07)

Continue Table 6.2

Quantile	1	5	10	50	90	95	99
r_gold_{t-1}	0.01 (0.07)	-0.06 (0.08)	-0.02 (0.07)	-0.02 (0.03)	-0.04 (0.07)	0.10 (0.09)	0.19** (0.08)
$Volatility\_gold_{t-1}$	-0.01 (0.12)	-0.19 (0.12)	-0.08 (0.10)	-0.01 (0.05)	0.01 (0.13)	0.17 (0.14)	0.33** (0.15)
r_stx_{t-1}	-0.15 (0.32)	-0.16 (0.27)	0.19 (0.22)	-0.06 (0.09)	-0.18 (0.15)	-0.24 (0.27)	0.41 (0.34)
$Volatility\_stx_{t-1}$	-0.24*** (0.08)	-0.15** (0.07)	-0.13** (0.06)	-0.04** (0.02)	0.03 (0.05)	-0.04 (0.05)	-0.11* (0.06)

Continue Table 6.2

Quantile	1	5	10	50	90	95	99
Communication$_{t-1}$	0.30* (0.16)	0.06 (0.15)	-0.01 (0.11)	0.07 (0.05)	0.10 (0.07)	0.09 (0.09)	0.14 (0.11)
Constant	-1.59*** (0.27)	-0.71*** (0.27)	-0.46** (0.21)	0.13 (0.10)	0.63*** (0.16)	0.88*** (0.21)	0.96*** (0.25)
Pseudo R-sq.	0.50	0.24	0.15	0.06	0.10	0.17	0.43
Observations	499						

Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses, computed by bootstrap using 100 replications. *Coex, r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, currency log return and volatility, oil log return and volatility, log return on US. Securities and its volatility, gold log return and volatility, regional stocks log returns and volatility, respectively.

Source: Author's calculations

Table 6.3 shows estimation results for the United Kingdom and Greece. Coexceedance of the previous day is significant only in the 50th quantile. Volatility of currency and return on oil are significant in the first and the very last quantile suggesting negative effect on coexceedance. Additionally, gold volatility and return significantly affect coexceedance in the lower quantiles indicating that one unit increase of these variables would cause decrease of both countries' return below their mean in the lower tail of the distribution. However, in the 99th quantile return on gold exerts positive sign. Moreover, volatility on the global stock market is a significant determinant of coexceedance in the lower half of the distribution and indicates negative relationship. Result regarding lagged communication is very similar to the one in Table 6.1. Nature of the statement is significant and exerts negative sign in the first quantile. Therefore, in the first quantile hawkish statement would drive returns of both markets below their mean, while reaction to the dovish statement would be opposite.The rest of the variables are not statistically different from zero in most of the reported quantiles. It can be repeatedly concluded that the model is best fitted in the first and the last quantile.

Table 6.3: The United Kingdom – Greece, quantile regression results

$$Coex_t = \beta_0 + \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + u_t$$

Quantile	1	5	10	50	90	95	99
$Coex_{t-1}$	0.13 (0.25)	-0.12 (0.17)	-0.12 (0.17)	-0.11* (0.05)	0.05 (0.13)	-0.15 (0.14)	-0.13 (0.23)
r_fx_{t-1}	0.09 (0.21)	0.11 (0.16)	0.21* (0.11)	0.06 (0.04)	0.03 (0.09)	0.24* (0.12)	0.28 (0.18)
$Volatility\_fx_{t-1}$	-1.67* (0.87)	-0.20 (0.51)	-0.52 (0.47)	-0.42*** (0.15)	-0.29 (0.33)	-0.73 (0.48)	-1.25* (0.69)

Continue Table 6.3

Quantile	1	5	10	50	90	95	99
r_oil_{t-1}	-0.14* (0.07)	-0.07 (0.05)	-0.03 (0.04)	-0.01 (0.01)	-0.03 (0.03)	0.01 (0.03)	-0.08* (0.04)
$Volatility\_oil_{t-1}$	0.09* (0.04)	0.01 (0.03)	0.03 (0.03)	0.03*** (0.01)	0.01 (0.02)	0.06* (0.03)	0.08* (0.04)
r_bond_{t-1}	0.05 (0.06)	0.04 (0.06)	0.07 (0.04)	0.04** (0.02)	0.02 (0.03)	0.13** (0.05)	0.06 (0.06)

Continue Table 6.3

Quantile	1	5	10	50	90	95	99
$Volatility\_bond_{t-1}$	0.11* (0.06)	0.02 (0.05)	0.05 (0.04)	0.01 (0.02)	0.05* (0.02)	0.05 (0.04)	-0.10 (0.07)
r_gold_{t-1}	-0.20*** (0.06)	-0.13* (0.07)	-0.02 (0.05)	0.01 (0.02)	0.03 (0.05)	0.09 (0.08)	0.28*** (0.09)
$Volatility\_gold_{t-1}$	-0.34*** (0.12)	-0.13 (0.11)	-0.03 (0.08)	-0.02 (0.03)	-0.08 (0.05)	-0.03 (0.11)	0.23 (0.18)
r_stx_{t-1}	0.01 (0.12)	0.18** (0.08)	0.10 (0.07)	0.10*** (0.03)	0.08 (0.06)	-0.01 (0.08)	0.18 (0.14)

Continue Table 6.3

Quantile	1	5	10	50	90	95	99
Volatility_stx$_{t-1}$	-0.13*	-0.15*	-0.22***	-0.08***	0.05	-0.01	-0.04
	(0.07)	(0.08)	(0.07)	(0.02)	(0.04)	(0.07)	(0.18)
Communication$_{t-1}$	-0.43**	-0.11	-0.06	0.01	0.08	0.07	0.06
	(0.18)	(0.12)	(0.09)	(0.04)	(0.06)	(0.09)	(0.12)
Constant	-1.04***	-0.58***	-0.40***	0.08	0.48***	0.71***	1.45***
	(0.23)	(0.16)	(0.13)	(0.06)	(0.11)	(0.15)	(0.27)
Pseudo R-sq.	0.43	0.28	0.18	0.09	0.06	0.11	0.36

Continue Table 6.3

Number of observations	474
Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses, computed by bootstrap using 100 replications. In this case, we consider exchange rate between pound and euro and its volatility. Instead of taking into account return and volatility on the regional market (Eurostoxx 50), we use global market return and its volatility (calculations based on STOXX Global 1800). *Coex, r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, currency log return and volatility, oil log return and volatility, log return on US. Securities and its volatility, gold log return and volatility, global stocks log returns and volatility, respectively.	

Source: Author’s calculations

Estimates resulting from quantile regression for the UK and Germany are shown in Table 6.4. Unlike the previous quantile regressions, the preceding coexceedance is significant in almost all of the reported quantiles (except quantile 5) and it is negative. Therefore, the higher the lagged coexceedance between these two countries is, the lower the coexceedance following day in particular quantiles. Another difference is the significance of the currency return in quantiles 10, 50, 90 and 95. Positive sign suggests that increase in the return leads to increase of both markets' return above their mean in the upper tail of the distribution. On the other hand, currency volatility would lead to decrease of stock return below its mean in Greece and the UK in almost all of the quantiles with the strongest effect in the 99th quantile, where the one unit increase in volatility would lead to decrease of both returns by 1.56 standard deviations below their mean. Volatility of oil is a significant variable with positive sign, but this holds only for the 50th, 95th and 99th quantile. In comparison to the previous estimation results, volatility on the global market is significant for the lower half of the distribution with negative sign indicating negative relationship with coexceedance but with stronger effect in the lower quantiles. Return on stock is mostly significant and positive. Additionally, return and volatility of the Treasury securities are significant and positive in the upper quantiles.Surprisingly, the nature of the statement affects coexceedance in the 95th quantile. Hence, communication stimulates the upper tail of the returns of both markets. Our hypothesis, that the nature of the communication can influence also relationship between the eurozone member and a country with official currency other than euro cannot be entirely rejected. Pseudo R-square exerts higher values than in the previously reported regressions, but the conclusion about the first and the last quantile being the best fits remains.

Table 6.4: The United Kingdom – Germany, quantile regression results

$Coex_t = \beta_0 + \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + u_t$							
Quantile	1	5	10	50	90	95	99
$Coex_{t-1}$	-0.46** (0.22)	-0.16 (0.22)	-0.44** (0.19)	-0.34*** (0.07)	-0.50*** (0.14)	-0.43*** (0.16)	-0.40* (0.24)
r_fx_{t-1}	-0.04 (0.23)	0.06 (0.15)	0.24** (0.11)	0.10* (0.06)	0.26* (0.15)	0.36* (0.19)	0.16 (0.17)
$Volatility\_fx_{t-1}$	-1.34* (0.78)	-0.96 (0.63)	-1.16* (0.67)	-0.77*** (0.22)	-0.32 (0.40)	-0.66* (0.39)	-1.56** (0.62)

Continue Table 6.4

Quantile	1	5	10	50	90	95	99
r_oil_{t-1}	-0.10 (0.07)	-0.08 (0.05)	0.02 (0.05)	0.01 (0.02)	0.02 (0.03)	0.01 (0.04)	0.01 (0.07)
$Volatility\_oil_{t-1}$	0.07 (0.05)	0.02 (0.04)	0.05 (0.04)	0.04*** (0.01)	0.02 (0.02)	0.05* (0.02)	0.11*** (0.04)
r_bond_{t-1}	0.13 (0.09)	0.06 (0.05)	0.10** (0.04)	0.07*** (0.02)	0.13*** (0.04)	0.12** (0.05)	0.05 (0.07)
$Volatility\_bond_{t-1}$	-0.04 (0.11)	0.03 (0.07)	0.01 (0.05)	0.02 (0.02)	0.09** (0.04)	0.07** (0.04)	-0.01 (0.06)

Continue Table 6.4

Quantile	1	5	10	50	90	95	99
r_gold$_{t-1}$	-0.04 (0.07)	-0.08 (0.07)	-0.01 (0.06)	-0.01 (0.03)	-0.01 (0.05)	0.02 (0.05)	-0.03 (0.08)
Volatility_gold$_{t-1}$	0.07 (0.14)	-0.03 (0.10)	-0.07 (0.07)	0.03 (0.04)	0.13 (0.08)	0.12 (0.10)	0.13 (0.15)
r_stx$_{t-1}$	0.24 (0.15)	0.24** (0.13)	0.33** (0.13)	0.25*** (0.05)	0.30*** (0.11)	0.33** (0.13)	0.51** (0.19)
Volatility_stx$_{t-1}$	-0.37*** (0.12)	-0.30*** (0.10)	-0.28*** (0.09)	-0.12*** (0.03)	0.01 (0.06)	-0.02 (0.08)	-0.05 (0.13)

Continue Table 6.4

Quantile	1	5	10	50	90	95	99
Communication$_{t-1}$	0.03 (0.15)	0.05 (0.12)	-0.07 (0.11)	0.06 (0.05)	0.07 (0.07)	0.15* (0.08)	0.12 (0.13)
Constant	-1.15*** (0.25)	-0.62** (0.26)	-0.28 (0.20)	0.07 (0.08)	0.33** (0.16)	0.61*** (0.20)	1.41*** (0.25)
Pseudo R-sq.	0.53	0.31	0.20	0.12	0.13	0.20	0.41

Continue Table 6.4

Number of observations	493
Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses, computed by bootstrap using 100 replications. In this case, we consider exchange rate between pound and euro and its volatility. Instead of taking into account return and volatility on the regional market (Eurostoxx 50), we use global market return and its volatility (calculations based on STOXX Global 1800). *Coex*, *r_fx*, *Volatility_fx*, *r_oil*, *Volatility_oil*, *r_bond*, *Volatility_bond*, *r_gold*, *Volatility_gold*, *r_stx*, *Volatility_stx* stand for coexceedance, currency log return and volatility, oil log return and volatility, log return on US. Securities and its volatility, gold log return and volatility, global stocks log returns and volatility, respectively.	

Source: Author's calculations

All in all, estimates from ordered logit suggest that volatilities of exchange rate, gold and regional stock markets are significant for prediction of the degree of coexceedance. Additionally, speeches of the ECB president, returns on bond and oil also play an important role as determinants. On the other hand, return on gold, regional market return and communication do not significantly affect probability of coexceedance. However, there is some evidence that markets react differently on days when non-standard measures are announced. It can also be concluded that coexceedance of two eurozone stock markets are affected by return on oil, volatility of gold, regional market and bond market return but the significance of the effect differs on individual quantiles. Communication can be considered as a significant determinant only in the case of coexceedance in the lower quantiles and in the 95th quantile of coexceedance between the UK and Germany. Furthermore, coexceedance between the UK and Greece is influenced by the nature of the statement in the first quantile. It should be further noted that while coexceedances with Greece exert always negative sign of communication variable, other cases show complete opposite. This might be caused by these factors: the economic situation of Greece or some unobservable differences in characteristics of Greek stock market and its participants. The former relates mainly to indebtedness and deflation. Interim forecast by the European Commision predicted deflation in Greece for 2012. Greek harmonized consumer price index (CPI) was below 1% at the end of 2012. Eventually, CPI dropped below zero in 2013 and did not return to nonnegative values until January 2016. All these arguments are in favor of hawkish signals being less preferred by Greece.

5.2 Robustness control

In this part, we examine whether the results are robust to change of the communication definition and to inclusion of additional independent variable.

5.2.1 First statement

This subsection presents results of estimation procedure using nature of the very first statement of a particular day. This method enables us to compare whether first statement is assigned more importance in spreading the extreme returns than all the statements made during the day. Similarly to the previous subsection, three different specifications of coexceedance are made.

Table 7.1 reports the estimation results of model 1 using the nature of the first statement of the day. Estimates are similar to those in the original model. Lagged coexceedance is negative and significant in the last two specifications, but this does not hold for extremely low returns, where it exerts no significance. Currency return does not significantly affect coexceedance in any of the specifications, while its volatility plays an important role in predicting joint occurrence of extremely high returns and extreme returns (without further diversification). Its positive estimate exerts the largest magnitude indicating the largest effect on coexceedance. Even when the first statement is used, higher return on oil and higher volatility of gold increase the probability of extremely low returns joint occurrence. However, this conclusion does not hold for extremely high returns as the estimates are not significant and hence, short term shocks do not affect upper tail returns. Return on securities and its volatility exert the similar values and significance levels as in Table 5.1.Volatility of regional market is important for prediction of share of the eurozone members experiencing extremely high returns (1% level of significance). As in the previous section presenting results of estimation with different definition of communication, even here the hypothesis of importance of statement's nature is rejected and we can conclude that it does not influence coexceedance. Estimation of model 2 (delayed reaction) with the first statement is also performed and reported in the appendix in Table 7.1a. However, coefficient on communication is again insignificant.

Table 7.1: Model 1 – first statement, estimation results

$$Coex_t = \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_t + u_t$$

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
$Coex_{t-1}$	-0.30 (0.34)	-0.68* (0.38)	-0.35** (0.16)
r_fx_{t-1}	0.05 (0.26)	0.27 (0.20)	0.02 (0.17)

Continue Table 7.1

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
Volatility_fx$_{t-1}$	1.27 (1.16)	1.52* (0.83)	1.44** (0.70)
r_oil$_{t-1}$	0.20** (0.09)	0.02 (0.07)	0.10* (0.05)
Volatility_oil$_{t-1}$	-0.09 (0.06)	-0.06 (0.04)	-0.08** (0.03)
r_bond$_{t-1}$	-0.33*** (0.12)	0.28*** (0.09)	0.09 (0.07)
Volatility_bond$_{t-1}$	-0.12 (0.12)	0.18** (0.08)	0.07 (0.06)
r_gold$_{t-1}$	0.16 (0.11)	0.03 (0.11)	0.09 (0.08)
Volatility_gold$_{t-1}$	0.52*** (0.20)	-0.16 (0.22)	0.29** (0.14)
r_stx$_{t-1}$	-0.28* (0.14)	0.06 (0.13)	-0.17** (0.08)
Volatility_stx$_{t-1}$	0.13 (0.08)	0.23*** (0.09)	0.22*** (0.06)
Communication$_{t}$	0.05 (0.29)	-0.40 (0.25)	-0.23 (0.19)

Continue Table 7.1

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
Pseudo R-sq.	0.22	0.17	0.19
Number of observations	506	506	506

Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses. The first column represents estimation for coexceedance constructed by using returns below 5th percentile, the second column represents estimation for coexceedance constructed by using returns above 95th percentile and the last column represents estimation for coexceedance constructed by using returns below 5th percentile and above 95th percentile. *Coex, r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, log return on currency, currency volatility, log return on oil, volatility of oil, log return on US. Securities, securities volatility, log return on gold, gold volatility, volatility of regional stock market and log returns of regional stocks, respectively.

Source: Author's calculations

Table 7.2 shows regression results for coexceedance of Germany and Greece using the nature of the first statement of the day. Signs and magnitudes of the significant estimates are similar to those obtained in Table 6.1. Conclusion regarding the ECB communication remains the same – nature of the speech is influential in the lowest quantile at 10% level of significance. Moreover, dovish communication would increase coexceedance while hawkish would decrease coexceedance in 1% of all the cases.

Table 7.2: Quantile regression using first statement, Germany –Greece

$$Coex_t = \beta_0 + \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + u_t$$

Quantile	1	5	10	50	90	95	99
$Coex_{t-1}$	0.64	0.13	-0.16	-0.05	0.04	0.09	0.12
	(0.44)	(0.30)	(0.20)	(0.08)	(0.15)	(0.20)	(0.26)
r_fx_{t-1}	-0.23	0.18	0.13	0.06	0.01	-0.10	-0.01
	(0.18)	(0.12)	(0.11)	(0.04)	(0.09)	(0.16)	(0.21)
$Volatility\_fx_{t-1}$	-0.68	-0.66	-0.48	-0.18	0.32	0.01	-1.25*
	(0.88)	(0.67)	(0.50)	(0.17)	(0.51)	(0.70)	(0.60)

Continue Table 7.2

Quantile	1	5	10	50	90	95	99
r_oil_{t-1}	-0.08 (0.06)	-0.10* (0.05)	-0.06 (0.04)	-0.01 (0.01)	-0.02 (0.03)	-0.01 (0.04)	0.01 (0.06)
$Volatility\_oil_{t-1}$	0.02 (0.05)	0.03 (0.03)	0.02 (0.03)	0.01 (0.01)	-0.01 (0.03)	0.04 (0.04)	0.10** (0.04)
r_bond_{t-1}	0.05 (0.06)	0.01 (0.06)	0.04 (0.04)	0.04*** (0.01)	0.07 (0.04)	0.07 (0.05)	0.10 (0.06)
$Volatility\_bond_{t-1}$	0.10 (0.07)	-0.02 (0.04)	0.01 (0.04)	0.02 (0.02)	0.03 (0.04)	0.08 (0.05)	0.05 (0.06)

Continue Table 7.2

Quantile	1	5	10	50	90	95	99
r_gold$_{t-1}$	-0.09 (0.07)	-0.02 (0.07)	-0.03 (0.05)	0.01 (0.02)	0.03 (0.05)	0.06 (0.08)	0.25 (0.10)
Volatility_gold$_{t-1}$	-0.13 (0.12)	0.01 (0.11)	-0.02 (0.08)	-0.01 (0.03)	0.05 (0.08)	-0.06 (0.15)	0.15 (0.19)
Volatility_stx$_{t-1}$	-0.07 (0.06)	-0.11** (0.05)	-0.11** (0.05)	-0.04*** (0.01)	-0.04 (0.03)	-0.03 (0.05)	-0.11* (0.06)
Communication$_{t-1}$	-0.22* (0.10)	-0.11 (0.09)	0.01 (0.07)	0.02 (0.04)	0.05 (0.06)	0.02 (0.10)	-0.02 (0.13)

Continue Table 7.2

Quantile	1	5	10	50	90	95	99
Constant	-1.15*** (0.28)	-0.41** (0.21)	-0.12 (0.13)	0.09 (0.07)	0.33* (0.16)	0.61** (0.25)	1.44*** (0.25)
Pseudo R-sq.	0.43	0.26	0.17	0.	0.04	0.08	0.33
Number of observations	477						

Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses, computed by bootstrap using 100 replications. *Coex, r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, log return on currency, currency volatility, log return on oil, volatility of oil, log return on US. Securities, securities volatility, log return on gold, gold volatility, volatility of regional stock market and log returns of regional stocks, respectively.

Source: Author’s calculations

5.2.1 Crisis

Another robustness check is made by including crisis dummy in the original model.Variable crisis is equal to one if crisis is present and zero otherwise. In particular, crisis is denoted as 1 in the period of 2008 until the first half of the second quarter 2009 (financial crisis) and from the beginning of 2011 until the end of 2012 (sovereign debt crisis). These periods were chosen based on the data from the Eurostat suggesting that GDP growth rates of the eurozone were negative during that time. Estimate of crisis is expected to be positive so that turmoil period would encourage the existence of extreme returns joint occurrence.

Table 7.3 presents estimation results of extended model. This model shows a small improvement in comparison to the original model due to higher pseudo R-squared. The last specification shows that the estimates regarding magnitudes, signs and significance are similar to those in the original model. In the second specification, volatility of bond is no longer significant as opposed to the original model. The first specification is robust to addition of dummy crisis and results are similar to the estimates of the original model. In all three cases dummy crisis is positive but insignificant leading to the conclusion that crisis period is not connected with structural break within the eurozone. This strong result should be taken into account with careful consideration since pseudo R-sq. is quiet low (0.14-0.29) and the model may need some improvement. Change of the definition of crisis period would probably result in slightly different estimate of crisis dummy.

Table 7.3: Model 2 - accounting for crisis period, estimation results

$$Coex_t = \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + \beta_{13} Crisis + u_t$$

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
$Coex_{t-1}$	-0.46 (0.39)	-0.98** (0.44)	-0.49** (0.20)

Continue Table 7.3

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
r_fx_{t-1}	0.43	0.31	0.16
	(0.27)	(0.22)	(0.17)
$Volatility\_fx_{t-1}$	5.22***	-0.31	1.71**
	(1.81)	(1.06)	(0.85)
r_oil_{t-1}	0.10	0.03	0.07
	(0.11)	(0.07)	(0.06)
$Volatility\_oil_{t-1}$	-0.34***	0.03	-0.09**
	(0.12)	(0.05)	(0.04)
r_bond_{t-1}	-0.45***	0.38***	0.09
	(0.14)	(0.10)	(0.07)
$Volatility\_bond_{t-1}$	-0.20	0.15	0.07
	(0.14)	(0.10)	(0.08)
r_gold_{t-1}	0.18	0.05	0.07
	(0.15)	(0.12)	(0.10)
$Volatility\_gold_{t-1}$	0.23	0.33	0.32*
	(0.28)	(0.21)	(0.17)
r_stx_{t-1}	-0.29*	0.08	-0.12
	(0.17)	(0.15)	(0.19)

Continue Table 7.3

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
Volatility_stx$_{t-1}$	0.31*** (0.11)	0.01 (0.09)	0.19*** (0.07)
Communication$_{t-1}$	-0.25 (0.37)	0.38 (0.30)	0.14 (0.24)
Crisis$_t$	0.43 (0.72)	0.67 (0.56)	0.49 (0.45)
Pseudo R-sq.	0.29	0.14	0.17
Number of observations	505	505	505

Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses. The first column represents estimation for coexceedance constructed by using returns below 5th percentile, the second column represents estimation for coexceedance constructed by using returns above 95th percentile and the last column represents estimation for coexceedance constructed by using returns below 5th percentile and above 95th percentile. *Coex, r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, log return on currency, currency volatility, log return on oil, volatility of oil, log return on US. Securities, securities volatility, log return on gold, gold volatility, volatility of regional stock market and log returns of regional stocks, respectively.

Source: Author's calculations

In conclusion, our main results are robust to the change of the communication definition and also to the inclusion of crisis dummy. Moreover, first statement's nature negatively affects coexceedance of German and Greek stock market in the first quantile, while significance of the speech nature does not hold for the whole eurozone. Crisis do not influence contagion spread in either of the reported cases.

6 Comparison with existing literature

This section is dedicated to comparison of our results with conclusions of the existing empirical literature. However, literature dealing with the effect of central bank communication on contagion is rather limited. We also compare the results and estimates of other independent variables.

Research paper by Baur et al. (2005) shows that lagged coexceedance is not significant in case of contagion in Asian countries, which is in line with our results for coexceedance between eurozone members. However, when coexceedance between the UK and Greece (or Germany) is estimated, coefficient on previous day's coexceedance gains significance in almost all the reported quantiles. Even though, its negative sign is in accordance with our results from ordered logit, it is opposite to what was observed in e.g. Christiansen et al. (2009). Additionally, our estimates of currency volatility from ordered logit are significant and positive but with larger magnitudes than in the case of the old EU member states in Christiansen et al. (2009). Furthermore, our study suggests that regional market volatility is significant and positive such as in Bae et al. (2003). In addition, significance of returns and volatility of oil for Greek stock market is also concluded in empirical study by Lake et al. (2013).

Beck et al. (2012) examining the correlation between the US and Canadian stock and bond markets reached similar conclusion when they claimed that monetary policy can affect comovement of two markets. We found that communication is an important determinant of coexceedance between two eurozone countries in the first quantile. Moreover, in the case of coexceedance between Germany and the UK, nature of the statements seems to play a significant role in the 95th quantile and hence, influences returns highly above their mean. Additionally, Garcia-Herrero et al. (2015) also find significant effect of dovish/hawkish words on Brazilian futures interest rates markets. Their findings suggest that hawkish communication tends to increase futures rates and dovish events have opposite effect. On the contrary, Rozkrut (2008) provides evidence that speeches of hawkish policy makers in Poland have negative impact on the national stock market. This is in line with our results of quantile regressions with stock market in Greece. Furthermore, Garcia-Herrero et al. (2013) show that hawkish tone causes interbank rates increase in Chinese market.

As it can be seen, results of this thesis confirm most of the conclusions of previous studies and there is compliance with their findings to large extent. However, it should be noted that none of the compared studies focused on the contagion within the eurozone and many of them used other measure than coexceedance and thus, the difference might be reasonable to substantial extent.

7 Conclusion

Central bank communication represents an important component in decision making of financial markets. While certain comovement of the markets might be present during tranquil periods, unusual or increased interdependence can appear in crisis times. In this thesis we try to examine effect of nature of the central banks' communication on joint occurrence of extreme returns as well as on extreme movements shared by two markets. Focusing on the eurozone area, we try to assess the former effect by following Bae et al. (2003) and using the similar definition of coexceedance (share of countries having extreme stock market returns). This variable is then stacked in 5 categories according to the severness of contagion. We apply method of order logit to analyze whether hawkish/dovish statements affect the probability of having higher share of countries with extreme returns. Our variable of interest is defined as the rounded average value of the statements for the day. Furthermore, we examine the effect of ECB president, crisis, first statement made on a particular day as well as days when non-standard measures are announced. Afterwards, we apply quantile regression as in Baur et al. (2005) to assess significance of communication on the lower level. The definition of coexceedance is slightly changed since here it measures extreme movements in two markets.

Being a central bank and conducting monetary policy in a currency union encompassing states with various cultural environments and different economic conditions is definitely not an easy task. This thesis also points out what many previous papers proved - ‘‘one size does not fit all’’. While dovish statements increase coexceedance between Greece and the UK, and between Germany and Greece in the first quantile, the effect on coexceedance between the rest of the examined countries is opposite. Additionally, if Germany and the UK are considered, nature of the message by a policymaker is significant for coexceedance only in the 95th quantile. However, ordered logit method applied on the whole eurozone brought different results – probability of coexceedance is not influenced by the hawkish/dovish tone of the central banker's speech. Even when crisis period is controlled for, estimates do not change substantially. On the contrary, when regression is performed only for the days when non-standard measures are announced, determinants of the eurozone coexceedance change their magnitude and in some cases also significance. Moreover, calming effect of president of the ECB is present but only when coexceedance reflects share of countries experiencing extremely high returns. Finally, we also examine the effect using only nature of the first statement made on a particular day. Results of ordered logit applied on the first and the second model support our conclusions when different definition of communication was used. Additionally, this is confirmed even by estimates from quantile regression for Germany and Greece.

Although, this empirical analysis provides deep examination of this topic, some space for further research still remains. Coexceedance between other eurozone countries and between 2 different markets such as bond and equity markets is recommended to be examined and compared to the existing results. Moreover, in some cases pseudo R-sq. is low suggesting modification of particular models. Nevertheless, the need of one unique definition of contagion seems to be crucial in order to be able to reliably detect and assess this phenomenom.

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Appendix

ADF Test for series: Gold spot price lagged differences: 2 no intercept, no time trend asymptotic critical values reference: Davidson, R. and MacKinnon, J. (1993), "Estimation and Inference in Econometrics" p 708, table 20.1, Oxford University Press, London 1% 5% 10% -2.56 -1.94 -1.62 value of test statistic: 0.3223
KPSS test for series: Gold spot price number of lags: 2 KPSS test based on y(t)=a+e(t) (level stationarity) asymptotic critical values: 10% 5% 1% 0.347 0.463 0.739 value of test statistic: 34.8170
ADF Test for series: Gold – transformed series lagged differences: 2 no intercept, no time trend

asymptotic critical values reference: Davidson, R. and MacKinnon, J. (1993), "Estimation and Inference in Econometrics" p 708, table 20.1, Oxford University Press, London 1%   5%   10% -2.56   -1.94   -1.62 value of test statistic: -22.7220
KPSS test for series: Gold-transformed series number of lags: 2 KPSS test based on y(t)=a+e(t) (level stationarity) asymptotic critical values: 10%   5%   1% 0.347   0.463   0.739 value of test statistic: 0.4308
Checking ARMA model for autocorrelation, heteroskedasticity and normality **PORTMANTEAU TEST with 16 lags** **Portmanteau:**   22.7393 p-Value (Chi^2):   0.0646 **Ljung & Box:**   22.9371 p-Value (Chi^2):   0.0613 **JARQUE-BERA TEST:** test statistic: 2123.3262 p-Value(Chi^2):   0.0000

skewness:	-0.3384
kurtosis:	8.8875
ARCH-LM TEST with 4 lags:	
test statistic:	38.2530
p-Value(Chi^2):	0.0000
F statistic:	9.8229
p-Value(F):	0.0000
Checking GARCH(1,1) for further dependencies	
ARCH-LM TEST with 4 lags for "GARCH Residuals"	
test statistic:	4.6218
p-Value(Chi^2):	0.3283
F statistic:	1.1608
p-Value(F):	0.3266
JARQUE-BERA TEST for "GARCH Residuals"	
test statistic:	60.8123
p-Value(Chi^2):	0.0000
skewness:	-0.4445
kurtosis:	3.8064
TEST OF NO REMAINING ARCH with 1 lags	
F-test stat.	2.0199
p-value	0.1556
degfree1	1.0000
degfree2	1012.0000

ADF Test for series: Oil spot price lagged differences: 2 no intercept, no time trend asymptotic critical values reference: Davidson, R. and MacKinnon, J. (1993), "Estimation and Inference in Econometrics" p 708, table 20.1, Oxford University Press, London 1% 5% 10% -2.56 -1.94 -1.62 value of test statistic: -1.0189
KPSS test for series: Oil spot price number of lags: 2 KPSS test based on y(t)=a+e(t) (level stationarity) asymptotic critical values: 10% 5% 1% 0.347 0.463 0.739 value of test statistic: 25.8515
ADF Test for series: Oil – transformed series lagged differences: 2 no intercept, no time trend asymptotic critical values reference: Davidson, R. and MacKinnon, J. (1993),

"Estimation and Inference in Econometrics" p 708, table 20.1, Oxford University Press, London 1% 5% 10% -2.56 -1.94 -1.62 value of test statistic: -21.3092
KPSS test for series: Oil – transformed series number of lags: 2 KPSS test based on y(t)=a+e(t) (level stationarity) asymptotic critical values: 10% 5% 1% 0.347 0.463 0.739 value of test statistic: 0.3048
Checking ARMA model for autocorrelation, heteroskedasticity and normality **PORTMANTEAU TEST with 16 lags** **Portmanteau:** 46.8827 p-Value (Chi^2): 0.0000 **Ljung & Box:** 47.2934 p-Value (Chi^2): 0.0000 **JARQUE-BERA TEST:** test statistic: 3734.3447 p-Value(Chi^2): 0.0000 skewness: 0.0157 kurtosis: 11.0153

ARCH-LM TEST with 4 lags: test statistic: 95.9922 p-Value(Chi^2): 0.0000 F statistic: 25.7769 p-Value(F): 0.0000
Checking GARCH(1,1) for further dependencies **ARCH-LM TEST with 4 lags for "GARCH Residuals"** test statistic: 2.1442 p-Value(Chi^2): 0.7093 F statistic: 0.5369 p-Value(F): 0.7087 **JARQUE-BERA TEST for "GARCH Residuals"** test statistic: 88.9335 p-Value(Chi^2): 0.0000 skewness: -0.2177 kurtosis: 4.1578 **TEST OF NO REMAINING ARCH with 1 lags** F-test stat. 0.1373 p-value 0.7110 degfree1 1.0000 degfree2 1395.0000

KPSS test for series: Treasury securities

number of lags: 2

KPSS test based on y(t)=a+e(t) (level stationarity)

asymptotic critical values:

10%	5%	1%
0.347	0.463	0.739

value of test statistic: 27.1582

ADF Test for series: Treasury securities

lagged differences: 2

no intercept, no time trend

asymptotic critical values

reference: Davidson, R. and MacKinnon, J. (1993),

"Estimation and Inference in Econometrics" p 708, table 20.1,

Oxford University Press, London

1%	5%	10%
-2.56	-1.94	-1.62

value of test statistic: -0.8270

ADF Test for series: Treasury securities-transformed series

lagged differences: 2

no intercept, no time trend

asymptotic critical values

reference: Davidson, R. and MacKinnon, J. (1993),

"Estimation and Inference in Econometrics" p 708, table 20.1,

Oxford University Press, London 1% 5% 10% -2.56 -1.94 -1.62 value of test statistic: -22.1388
KPSS test for series: Treasury securities-transformed series number of lags: 2 KPSS test based on y(t)=a+e(t) (level stationarity) asymptotic critical values: 10% 5% 1% 0.347 0.463 0.739 value of test statistic: 0.1036
Checking ARMA model for autocorrelation, heteroskedasticity and normality **PORTMANTEAU TEST with 16 lags** **Portmanteau:** 15.0129 p-Value (Chi^2): 0.3773 **Ljung & Box:** 15.1176 p-Value (Chi^2): 0.3702 **JARQUE-BERA TEST:** test statistic: 108.9235 p-Value(Chi^2): 0.0000 skewness: 0.0049 kurtosis: 4.3713 **ARCH-LM TEST with 4 lags:**

test statistic: 74.2015 p-Value(Chi^2): 0.0000 F statistic: 19.5997 p-Value(F): 0.0000
Checking GARCH(1,1) for further dependencies **ARCH-LM TEST with 4 lags for "GARCH Residuals"** test statistic: 2.4915 p-Value(Chi^2): 0.6462 F statistic: 0.6240 p-Value(F): 0.6454 **JARQUE-BERA TEST for "GARCH Residuals"** test statistic: 27.3800 p-Value(Chi^2): 0.0000 skewness: 0.0491 kurtosis: 3.6805 **TEST OF NO REMAINING ARCH with 1 lags** F-test stat. 0.8101 p-value 0.3683 degfree1 1.0000 degfree2 1389.0000
ADF Test for series: Exchange rate USD/EUR lagged differences: 2 no intercept, no time trend

asymptotic critical values reference: Davidson, R. and MacKinnon, J. (1993), "Estimation and Inference in Econometrics" p 708, table 20.1, Oxford University Press, London 1% 5% 10% -2.56 -1.94 -1.62 value of test statistic: -0.8016
KPSS test for series: Exchange rate USD/EUR number of lags: 2 KPSS test based on y(t)=a+e(t) (level stationarity) asymptotic critical values: 10% 5% 1% 0.347 0.463 0.739 value of test statistic: 8.1657
ADF Test for series: Exchange rate USD/EUR-transformed series lagged differences: 2 no intercept, no time trend asymptotic critical values reference: Davidson, R. and MacKinnon, J. (1993), "Estimation and Inference in Econometrics" p 708, table 20.1, Oxford University Press, London 1% 5% 10%

-2.56 -1.94 -1.62

value of test statistic: -21.0303

KPSS test for series: Exchange rate USD/EUR-transformed series

number of lags: 2

KPSS test based on y(t)=a+e(t) (level stationarity)

asymptotic critical values:

10% 5% 1%

0.347 0.463 0.739

value of test statistic: 0.1324

Checking ARMA model for autocorrelation, heteroskedasticity and normality

PORTMANTEAU TEST with 16 lags

Portmanteau: 21.8853

p-Value (Chi^2): 0.0810

Ljung & Box: 22.0583

p-Value (Chi^2): 0.0774

JARQUE-BERA TEST:

test statistic: 633.9270

p-Value(Chi^2): 0.0000

skewness: -0.1526

kurtosis: 6.2509

ARCH-LM TEST with 4 lags:

test statistic: 143.7478

p-Value(Chi^2): 0.0000

F statistic:	39.9751
p-Value(F):	0.0000
Checking GARCH(1,1) for further dependencies	
TEST OF NO REMAINING ARCH with 1 lags	
F-test stat.	2.4178
p-value	0.1202
degfree1	1.0000
degfree2	1426.0000
ARCH-LM TEST with 4 lags for "GARCH Residuals"	
test statistic:	1.9254
p-Value(Chi^2):	0.7495
F statistic:	0.4820
p-Value(F):	0.7490
JARQUE-BERA TEST for "GARCH Residuals"	
test statistic:	59.9650
p-Value(Chi^2):	0.0000
skewness:	-0.1839
kurtosis:	3.9345
ADF Test for series:	**Eurostoxx50**
lagged differences:	2
no intercept, no time trend	
asymptotic critical values	

reference: Davidson, R. and MacKinnon, J. (1993),

"Estimation and Inference in Econometrics" p 708, table 20.1,

Oxford University Press, London

1%	5%	10%
-2.56	-1.94	-1.62

value of test statistic: -0.2047

KPSS test for series: Eurostoxx50

number of lags: 2

KPSS test based on y(t)=a+e(t) (level stationarity)

asymptotic critical values:

10%	5%	1%
0.347	0.463	0.739

value of test statistic: 3.9908

ADF Test for series: Eurostoxx50 – transformed series

lagged differences: 2

no intercept, no time trend

asymptotic critical values

reference: Davidson, R. and MacKinnon, J. (1993),

"Estimation and Inference in Econometrics" p 708, table 20.1,

Oxford University Press, London

1%	5%	10%
-2.56	-1.94	-1.62

value of test statistic: -24.2056

KPSS test for series: Eurostoxx50 - transformed series

number of lags: 2

KPSS test based on y(t)=a+e(t) (level stationarity)

asymptotic critical values:

10%	5%	1%
0.347	0.463	0.739

value of test statistic: 0.1889

Checking ARMA model for autocorrelation, heteroskedasticity and normality

PORTMANTEAU TEST with 16 lags

Portmanteau: 36.0221

p-Value (Chi^2): 0.0010

Ljung & Box: 36.2427

p-Value (Chi^2): 0.0010

JARQUE-BERA TEST:

test statistic: 1403.0869

p-Value(Chi^2): 0.0000

skewness: 0.0225

kurtosis: 7.8593

ARCH-LM TEST with 4 lags:

test statistic: 183.5189

p-Value(Chi^2): 0.0000

F statistic: 52.6782

p-Value(F): 0.0000

Checking GARCH(1,1) for further dependencies

TEST OF NO REMAINING ARCH with 1 lags

F-test stat.	3.5306
p-value	0.0604
degfree1	1.0000
degfree2	1425.0000

ARCH-LM TEST with 4 lags for "GARCH Residuals"

test statistic:	8.3364
p-Value(Chi^2):	0.0800
F statistic:	2.0964
p-Value(F):	0.0790

JARQUE-BERA TEST for "GARCH Residuals"

test statistic:	56.2124
p-Value(Chi^2):	0.0000
skewness:	-0.1059
kurtosis:	3.9493

Table 4.a: Prevailing topics of statements

Topic						
name	rate change	growth	inflation	nonstandard measure	liquidity	rate appropriate
Weidmann	12%	10%	10%	22%	20%	7%
Wellink	29%	11%	20%	9%	14%	0%
Orphanides	22%	9%	31%	16%	3%	3%
Asmussen	6%	16%	19%	6%	6%	0%
Tumpel	17%	28%	17%	7%	3%	3%
Praet	29%	14%	14%	14%	7%	4%
Quaden	22%	26%	7%	4%	4%	7%
Provopoulos	22%	30%	4%	9%	13%	0%
Makuch	32%	26%	5%	0%	21%	5%
Ordonez	39%	6%	11%	11%	6%	6%
Bonello	28%	17%	17%	6%	6%	6%
Papademos	25%	13%	25%	6%	6%	0%
Coene	38%	13%	19%	13%	0%	13%
Kranjec	7%	21%	29%	14%	14%	0%
Sramko	0%	64%	0%	7%	7%	0%
Hurley	22%	33%	11%	0%	0%	11%
Knot	25%	0%	0%	38%	13%	0%
Honohan	0%	29%	14%	0%	14%	14%
Liebscher	0%	33%	67%	0%	0%	0%
Bonnici	50%	17%	0%	0%	17%	17%
Hansson	17%	0%	0%	0%	17%	17%
Visco	50%	25%	0%	25%	0%	0%

Source: Author’s calculations

Table 7.1a: Model 2 – first statement, estimation results

$Coex_t = \beta_1 Coex_{t-1} + \beta_2 r\_fx_{t-1} + \beta_3 Volatility\_fx_{t-1} + \beta_4 r\_oil_{t-1} + \beta_5 Volatility\_oil_{t-1} + \beta_6 r\_bond_{t-1} + \beta_7 Volatility\_bond_{t-1} + \beta_8 r\_gold_{t-1} + \beta_9 Volatility\_gold_{t-1} + \beta_{10} r\_stx_{t-1} + \beta_{11} Volatility\_stx_{t-1} + \beta_{12} Communication_{t-1} + u_t$			
Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
$Coex_{t-1}$	-0.45 (0.39)	-0.94** (0.44)	-0.47** (0.20)
r_fx_{t-1}	0.43* (0.26)	0.31 (0.22)	0.18 (0.17)
$Volatility\_fx_{t-1}$	5.32*** (1.78)	-0.11 (1.02)	1.84** (0.83)
r_oil_{t-1}	0.11 (0.10)	0.02 (0.07)	0.07 (0.06)
$Volatility\_oil_{t-1}$	-0.33*** (0.12)	0.02 (0.05)	-0.09** (0.04)
r_bond_{t-1}	-0.43*** (0.13)	0.37*** (0.10)	0.09 (0.07)
$Volatility\_bond_{t-1}$	-0.16 (0.13)	0.17* (0.09)	0.09 (0.07)
r_gold_{t-1}	0.18 (0.15)	0.04 (0.12)	0.07 (0.10)

Continue Table 7.1a

Extreme returns	Below 5th percentile	Above 95th percentile	Extreme return (below 5th or above 95th percentile)
Volatility_gold$_{t-1}$	0.26 (0.27)	0.27 (0.21)	0.28* (0.16)
r_stx$_{t-1}$	-0.30* (0.17)	0.07 (0.15)	-0.12 (0.09)
Volatility_stx$_{t-1}$	0.31*** (0.10)	0.04 (0.08)	0.20*** (0.06)
Communication$_{t}$	-0.10 (0.33)	0.24 (0.26)	0.04 (0.21)
Pseudo R-sq.	0.29	0.13	0.17
Number of observations	505	505	505

Notes: *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are reported in parentheses. The first column represents estimation for coexceedance constructed by using returns below 5th percentile, the second column represents estimation for coexceedance constructed by using returns above 95th percentile and the last column represents estimation for coexceedance constructed by using returns below 5th percentile and above 95th percentile. *Coex, r_fx, Volatility_fx, r_oil, Volatility_oil, r_bond, Volatility_bond, r_gold, Volatility_gold, r_stx, Volatility_stx* stand for coexceedance, log return on currency, currency volatility, log return on oil, volatility of oil, log return on US. Securities, securities volatility, log return on gold, gold volatility, volatility of regional stock market and log returns of regional stocks, respectively.

Source: Author's calculations