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MASTER'S THESIS

Central Bank Communication and Systemic Stress

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Declaration of Authorship

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

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Abstract

This thesis aims to examine the effect of European Central Bank's (ECB) oral communication on the financial systemic stress in the euro area. It considers ad-hoc speeches and interviews by the members of the ECB Governing Council as well as official press conferences between July 2008 and January 2014. The empirical analysis tests the effects of communication intensity and sentiment and whether they differ in different stress regimes. Regression results of ARIMA based models and Threshold auto-regressive model suggest that occurrence of official press conference increases the systemic stress, sentiment of communication matters only in the case of the ad-hoc speeches and interviews, but mainly that both the official and unofficial oral communication have a considerably stronger effect in periods of heightened systemic stress. Although the estimated effects are rather small, this thesis provides support for the hypothesis that ECB communication can affect the systemic stress.

JEL Classification	G20, E58, C23,
Keywords	central banks, communication, ECB, systemic stress

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Abstrakt

Tato práce zkoumá vliv verbální komunikace Evropské Centrální Banky (ECB) na systémový stres na finančních trzích v Eurozóně. Zajímá se jak o nahodilé projevy a rozhovory členů Rady guvernérů ECB, tak i oficiální tiskové konference, mezi červencem 2008 a lednem 2014. Empirická analýza testuje vliv intenzity i sentimentu komunikace a také jestli se tento vliv mění v různých režimech stresu. Výsledky evaluace ARIMA modelů a prahového autoregresního modelu ukazují, že konání oficiální tiskové konference krátkodobě zvýší systémový stres, že na sentimentu záleží jen v případě nahodilé komunikace a především, že oficiální i neoficiální komunikace má značně větší efekt v dobách zvýšeného stresu. Přestože jsou odhadnuté efekty spíše malé, tato práce dodává poporu hypotéze, že komunikace ECB může ovlivnit systémový stres.

Klasifikace JEL	G20, E58, C23,
Klíčová slova	centrální banky, komunikace, ECB, systémový stres

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Acronyms

AIC Akaike Information Criterion

AIWCS Asymmetric Importance Weighted Communication Sentiment

BoE Bank of England

CBCI Central Bank Communication Index

CISS Composite Indicator of Systemic Stress

CLI Composite Leading Indicator

ECB European Central Bank

EPUI Economic Policy Uncertainty index

Fed Federal Reserve

FOMC Federal Open Market Committee

GC Governing Council

IRF Impulse Response Function

IWCS Importance Weighted Communication Sentiment

KPSS Kwiatkowski–Phillips–Schmidt–Shin test

OECD Organisation for Economic Co-operation and Development

OLS Ordinary Least Squares

SETAR Self-Exciting Threshold Auto-Regressive model

TAR Threshold Auto-Regressive model

VAR Vector autoregression

Master's Thesis Proposal

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Proposed topic	Central Bank Communication and Systemic Stress

Motivation The recent financial crisis brought the issue of not only how to stabilize financial markets, but also how to communicate the needed policy measures. Communication of important policy makers is a strong tool, as the sole expression of certain intentions can guide the market agents to alter their behavior and have thus material impact on the real economy. Central banks are certainly among the most important policy makers and in the light of the crisis there has been a strengthened emphasis on their clear and reliable communication to maintain transparency and credibility. Even though the verbal communication has been a traditional tool of central banks, as Gertler and Horváth (2017) aptly remark, the manners and content of the communication have undergone a change. To satisfy the demand for information they communicate more often and ad-hoc beyond the official policy meetings, which also attracts higher attention given the universality of monetary policy in global economy. The need for non-standard measures has also broadened the mandate.

The existing literature focused on central bank communication and its impact on the financial market is rather abundant covering the links to interest rates, asset prices, exchange rates using various data frequencies. Numerous studies document that the central bank communication indeed affects various aspects of the financial markets. However, to the best of my knowledge, there exist no research aimed at the influence of central bank communication on the current level of stress in the financial system. This systemic stress can be defined as a state of financial system, in which the financial instability became widespread and impairs the functioning of financial system to the point where economic growth suffers materially (de Bandt and Hartman, 2000). Following similar intuition as Knütter et al. (2011) I believe that a transparent and consistent communication of central bank can help to adjust the expectations of economic agents and reduce uncertainties in the financial markets. On the other hand, if the statements are erratic or unexpected, it may

increase the uncertainties of the agents and increase the systemic stress. I want to test this proposed relationship empirically, conveniently the European Central Bank constructs a composite indicator of the systemic stress, which allows for real time measuring of the current financial system instability and offers a possibility to react more promptly and accurately.

As mentioned before, central banks are important players in the financial markets and one of their purposes is to maintain systemic stability, therefore I believe that it is useful to study the effectivity of the way they actually do so. I chose to inspect the effect of ad-hoc (non-official) communication of the members of the Governing Council of European Central Bank (ECB), which is arguably the most influential central bank in Europe and one of the most important in the whole world, on the level of systemic stress.

Hypotheses

Hypothesis #1: Statements of European Central Bank Governing Council affect the systemic stress.

Hypothesis #2: Statements expressing positive outlook have weaker impact on the systemic stress than the negative ones.

Hypothesis #3: Statements of GC member from country under financial stress or from a core member of the euro area have stronger impact on the systemic stress.

Methodology This thesis will be based on two crucial data sources. The data on the systemic stress will be covered by the aforementioned Composite Indicator of Systemic Stress (CISS), constructed and collected by the ECB on a weekly basis. The second important source is the data on central bank communication constructed and used by Gertler and Horváth (2017). They collect forward-looking public statements of the ECB Governing Council members (i.e. members of Executive Board and national central bank governors) on conventional and unconventional monetary policy and economic outlook. These statements are ad-hoc between policy decision meetings. The authors further coded the statements to specify, whether each of the indicated tightening or easing monetary policy or positive or negative economic outlook.

To test Hypothesis #1 I will conduct Ordinary Leas Square estimation to test the effect of ECB communication on the systemic stress, where the CISS will constitute the explained variable and the Gertler and Horvath (2017) data the main explanatory variable of interest. Additionally I will include other explanatory variables to account

for the development on various financial market segments. Furthermore, I will conduct also quantile regression to inspect whether the impact of ECB communication is more pronounced for certain levels of systemic stress.

For testing Hypothesis #2 I will observe the differences of how the systemic stress is affected by ECB indications of positive or negative outlook, or tightening or easing monetary policy. I expect the effect of negative news to be higher, however in this part I will most likely need to face also the issue of endogeneity. Intuitively, it is probable that the ECB will communicate more intensively in times of heightened financial stress and also that these statements will be more frequently with negative outlook.

In analyzing Hypothesis #3, I will focus on the authors of the statements and create dummy variables indicating who expressed it and what is his or her status in the ECB General Council. I expect the reaction of the financial system to be stronger for the president of the General Council or for the members from core Eurozone countries. Furthermore, the financial system may be more sensitive to statements of policy makers from countries under stress.

Expected Contribution This thesis contributes to the rich literature studying the communication of central banks and its effect to the real economy. It is innovative mainly in three aspects. First, the effect of central banks' communication on systemic stress was not studied before, while it sounds plausible that statements of central banks can eventually influence the overall sentiment on the global financial markets and this is the first attempt to evaluate this manner using the indicator of systemic stress issued by ECB. The second innovative approach is the usage of rich dataset of statements provided by ECB representatives because compared to the most of the previous studies this dataset collects informal statements that broaden the dataset substantially and allows for studying the topic in greater detail and from different aspects. Finally, it is expectable that central bank policy as well as its communication is of higher importance in periods of instability therefore this thesis can also contribute to existing literature by its coverage of post-crises period.

Outline

1. Introduction and Motivation: I will motivate the importance of central banks and mainly ECB as a policy maker on the global markets and its communication as traditional tool. I will also elaborate the issue of systemic stress.

2. Literature review: I will summarize the existing literature on the central banks' communication and its impact on financial markets. I will recapitulate the ways of measuring the systemic stress.

3. Data and Methodology: I will describe the data and their sources and the methodology of OLS and quantile regression. I will describe treatment of possible endogeneity.

4. Results: I will discuss my baseline regressions and robustness checks results.

5. Conclusion: I will summarize my findings, their contribution and implications for policy and future research.

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Author Supervisor

Chapter 1

Introduction

The latest financial crisis inspired an extensive debate about establishing and maintaining the stability of the financial system. A wide range of research emerged describing the crisis, causes of the financial markets turmoil and how to prevent it in the future. However, there is also evidence that instability of the financial system hinders economic growth and can cause considerable costs to the real economy, even if it does not escalate into an actual crisis (Levine 2005). Moreover, the financial markets are globalized and entail increasingly more complex financial instruments, which facilitates spreading of stress in the financial system.

There is thus an increased need for the policy makers to concern themselves about the stability of the financial system. One of the most important policy makers in every country is a central bank and even though its main objective is traditionally price stability, it can influence systemic stability as well. It sets interest rates and banking regulation and conducts foreign exchange operations, which can affect real economy variables such as inflation or output. Price stability itself can also aid financial stability because high inflation increases uncertainty. Furthermore, the central bank can provide liquidity and serve as a lender of last resort, which can also help to ensure financial system stability.

While central banks have direct tools to influence the real economy, they can also use a supplementary tool which is the communication of their decisions to the public. Not long ago central banks have been shrouded in mystery and the pervasive view was that the less they communicate and the more cryptic they are, the better (Blinder *et al.* 2008). However, this view has changed significantly and today it is believed that communication openness and transparency can contribute to greater credibility of the central bank and increase

the efficiency of the monetary policy (Woodford 2005). It has even been argued that managing public expectations is more important than managing the interest rates because financial market agents base their decisions on expectations about the long-term interest rates rather than on the overnight interest rates that the central bank sets (de Haan & Jansen 2009).

The importance of central banks has increased also with broadening of their mandate. In the times of increased uncertainty or crises, the central banks implemented various non-standard measures which needed to be carefully explained in more detail than standard monetary policy. Additionally, the means of central bank communication are also changing. As the banks open more to the public, they use more channels to present their decisions and opinions, such as periodical written reports, minutes or voting records from policy meetings, press conferences after policy meetings, and ad-hoc speeches and interviews. While all these channels are undoubtedly important and under great public scrutiny, the ad-hoc communication has one advantage. The policy makers can react with greater flexibility and in real time to any new developments on the financial markets and satisfy the increasing demand for information and guidance.

With greater need for stabilizing the financial markets and with increasing importance of central bank communication, this thesis considers the question whether the central banks can affect the stability of financial markets by their communication. Most likely they intend to do so and this thesis aims to empirically analyze whether they can be successful. Since central banks strive to manage expectations and reduce uncertainties, the hypothesis is plausible.

There is abundant literature researching how central bank communication influences various aspects of financial markets. It looks at its effect on various segments of the financial markets, mostly asset prices, foreign exchange rates and interest rates. Some studies focus on a certain form of communication, some try to compare them and others examine the effectiveness of specific communication strategies or timing. Overall, the previous literature provides considerable evidence that central bank communication affects financial markets, even though some of its form or strategies may be more important than others (Blinder *et al.* 2008; Ehrmann & Fratzscher 2007b; Rosa & Verga 2007; de Haan & Jansen 2009; Jansen & de Haan 2007).

Nevertheless, there seems to be no study examining specifically the relationship between central bank communication and the stress in the financial system. Knütter *et al.* (2011) ask the same question, however, they merely review

existing literature on the effects of central bank communication on financial markets in general. Researching the proposed relationship may be challenging partly because the stability of a financial system is an elusive concept, difficult to define and even more difficult to measure. Easier to grasp is the concept of the financial systemic stress that can be defined as a state of financial system in which the financial instability became widespread and impairs the functioning of the financial system to the point where economic growth suffers materially (de Bandt & Hartmann 2000). This can be proxied by measuring its symptoms in the real economy.

We test several research questions. We distinguish the effect of the communication intensity, meaning how many communication events occur, and the message of the communication - its sentiment. It is also hypothesised that some communication events may be more important than others, for instance, if they are delivered by the central bank president or if they concern non-standard policy measures. Finally, it is tested whether these effects differ in times of low stress and high stress.

The researched central bank is the European Central Bank, which is arguably one of the most influential central banks in the world and has a specific Governing Council structure comprising policy makers from 19 euro area sovereign states. We consider its official press conferences after policy meetings and ad-hoc speeches and interviews of the individual Governing Council members. This allows for comparison of official and unofficial communication. The financial systemic stress is measured by the Composite Indicator of Systemic Stress, a complex indicator of financial stress in the euro area developed by the ECB on a weekly basis.

The results of this thesis show that the occurrence of the policy meeting press conference slightly increases the financial stress, suggesting that the financial markets pay attention to these events and adjust their expectations. The sentiment of the communication seems to matter in case of the ad-hoc speeches, less so in case of the official press conferences. Perhaps the most compelling result of the empirical analysis is that the communication plays a considerably more important role in periods of heightened stress, concerning both the official and ad-hoc communication.

The empirical analysis thus provides tentative support for the hypothesis that central bank communication can affect the stress in the financial system. It also enriches the literature about the effects of central bank communication as it uses a rich dataset of unofficial speeches and interviews which are rarely

studied in the previous research, whereas their importance may be increasing. Finally, this thesis also contributes to the literature covering the last financial crisis and its specifics, since it suggests distinguished effect for low stress and high stress times.

The rest of this thesis is organized as follows. Chapter 2 introduces the development and specifics of central bank communication and the previous literature examining its influence. Further it explains the concept of financial systemic stress and its features, how is it measured and also the previous literature concerning this phenomenon. Chapter 3 systematizes the research questions of this thesis and formulates specific hypotheses to be tested in the empirical analysis. Chapter 4 describes the dataset and construction of variables. Chapter 5 presents the estimation models and the methodology used to evaluate them. Results of the empirical analysis are presented and discussed in Chapter 6 and the main findings are summarized in Chapter 7.

Chapter 2

Motivation and literature review

Central banks are certainly among the most important policy makers in every economy and usually play a key role, though not exclusive, in setting the monetary policy. Their importance is great without a doubt, but still, it seems to be even more considerable recently, namely during the European sovereign debt crisis or the times of deflation pressures and the issue of active zero lower bound. Lately, we have also witnessed the interventions of Swiss or Czech national banks, who capped the exchange rate of their national currencies with respect to the euro in order to counter overvaluation and deflation. Both of the currencies were artificially devalued by more than 8 %, leaving people apprehensive for several years about when will the cap be released and what will then happen with the exchange rate. It is not the objective of this thesis to analyze these episodes, however, they illustrate how pronounced can be the effects of central banks' decision making on our everyday lives and that it can also be quite instant.

While almost every country has its own central bank (with the exception of a few small states such as Andorra, Monaco or the Federal States of Micronesia), there are also several central banks whose influence extends far beyond the boundaries of one country. Among the most important central banks are Bank of England, Bank of Japan or Swiss National bank, but probably the most influential ones are the U.S. Federal Reserve (Fed) and European Central Bank (ECB). The ECB is even unique in a fact that it is designed to act as a central bank for multiple sovereign states. Its main objective is to maintain price stability in all states of the euro area, currently, there are 19 of them. Furthermore, the ECB is involved in creating banking regulation for all 28 member states of the European Union and all national central banks of these

states hold shares of the ECB's capital stock.

The main task of ECB is to set and implement the monetary policy in the euro area,[1] for which it typically uses the overnight interest rate. Nevertheless, it is rather indirect tool for maintaining prices stability of the assets that matter the most in an economy, such as long-term interest rates or equity prices (Ehrmann & Fratzscher 2007a). A supplementary tool can thus be the communication with the public to influence these prices. Blinder *et al.* (2008) define the central bank communication as "the provision of information by the central bank to the public regarding such matters as objectives of monetary policy, the monetary policy strategy, the economic outlook and the outlook for future policy decisions."

2.1 Development of central bank communication

The recent trend is extensive and very much open communication of the central banks and generally high transparency. The intuition behind this tendency is a belief that increased transparency and clear communication contribute to greater credibility and accountability which are required for successful achievement of the central bank's objectives. However, it was not always the case and this trend is a result of three decades' development and transformation. At the beginning of the 1980s, the central banks maintained an aura of mystery and a pervasive view was that they should communicate as little as possible and be cryptic when they do so (Blinder *et al.* 2008).

In the late 1990s, this opinion started to change with some economists expressing their idea that clearer communication could contribute to more efficient monetary policy and that by making itself more predictable, also the market reaction to monetary policy becomes more predictable for the central bank (Blinder 1999). Later, Woodford (2001) claimed that successful monetary policy is much more about affecting the market expectations than about effective control of overnight interest rates. Also according to de Haan & Jansen (2009) the intermediate and long-term interest rates depend on the expectations about the central bank's monetary policy rather than on the overnight interest rate, therefore the communication of future outlook is crucial.

We can also observe this development on the changes in communication policy, most apparently in the case of the Fed. Its former Chairman Alan

[1] The objectives and tasks of the ECB are clearly defined in the Statute of the European System of Central Banks and of the European Central Bank.

Greenspan was known for vague and intentionally confusing statements,[2] for which the term "Fedspeak" or "Greenspeak" became usual. Greenspan even took pride in being able to "mumble with great incoherence" as he used this strategy on purpose to not attract markets' attention to his statements (Blinder *et al.* 2001).

However, in 1994 the Fed started to communicate the policy decisions after every committee meeting and in 2003 the same Alan Greenspan announced that the Fed would keep the policy of low interest rates for a considerable period. Greenspan's successor Ben Bernanke was a proponent of central bank transparency and steered the Fed to further openness. Moreover, the financial crisis intensified the need for increased communication and stabilization of financial markets. The next Fed Chairman Janet Yellen continued to promote the vital role of communication in monetary policy and even stated that "what happens to the federal funds rate today or over next six weeks until next Committee meeting is relatively unimportant", and what actually matter are the market expectations of the Fed's monetary policy in the next few years.[3] These words mark the immense transformation of the Fed's attitude towards its communication with the public.

Also other central banks including the ECB have developed greater transparency in the last nearly 20 years and especially during the crisis. Nevertheless according to Blinder *et al.* (2008) the ECB has been more transparent then Fed ever since its establishment in 1998. One remarkable example of ECB communication and its power is the speech of its President Mario Draghi at the Global Investment Conference in London on July 26, 2012. In those times of the European Sovereign Debt crisis the bond yields of the troubled euro area states, such as Greece or Spain, were rising rapidly and the future of the common euro currency seemed grave. In his speech the ECB President strived to regain trust of the financial markets and then remarked with all seriousness: "Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough." The markets reacted promptly and even though the ECB introduced a program called Outright Monetary Transactions intended to buy bonds of the weak countries soon after Draghi's

[2]In a television interview (60 minutes with Leslie Stahl on September 16, 2007) he described his form of communication in the following way: "I would engage in some form of syntax destruction which sounded as though I were answering the question, but in fact, had not." When confronted with a fact that one of his statements resulted in two newspapers having opposite headlines, he responded "I succeeded".

[3]Part of Janet Yellen's speech at the Society of American Business Editors and Writers 50th Anniversary Conference in Washington D.C. on 13 July, 2003.

speech, it never needed to be used. The promise of such program and Draghi's compelling statement were enough to calm the markets and plunge the bond yields.

2.2 Why should central bank communication matter

The example of the President Draghi's speech shows that the central bank communication can indeed be a powerful instrument and the words of previous Fed Chairmen Yellen signal that it even may become a main tool of monetary policy.[4] However, it may not be as clear why and on what general circumstances the communication actually effectively work as a tool in implementing central bank's policy objectives. De Haan & Jansen (2009) present three conditions that matter for communication to be effective.

The first condition is that the public does not always understand the monetary policy and that an explanation of the central bank's stance and objectives helps for correcting expectations of the public, which are in themselves not perfectly rational. The second assumption is that the central bank changes its policy and does not stick to one rule for a long. If the central bank would commit to a certain never changing policy rule, it would not make any difference to repeat it to the public over and over again. Nevertheless, it is safe to say that this assumption is very realistic as the financial markets and even whole economies evolve rather dynamically these days.

The third condition assumes asymmetric information between the policy makers and the public. This can be understood in two ways. The first meaning is that the market agents may not know the reaction function of the central bank, in other ways they are not able to effectively forecast the policy decisions given certain market developments. The second meaning is that the public simply does not possess as much information about the future economic outlook as the central bank. The policy makers invest considerably more resources to accurately estimate the future development on financial markets. Obviously,

[4]The current Fed Chairman Jerome Powell took the office only in February 2018 hence it is too early to judge his approach to central bank communication. However, so far it seems that he is going to continue in the set path as he started to give the summary statements on press conferences in plain English, while his predecessors often read lengthy prepared statements written in monetary policy jargon. Jerome Powell also announced that he is going to hold a press conference after every Fed policy meeting, which was also not a common previous practice (Tankersley & Irwin 2018).

their forecasts are not correct all the time, but few studies document that for instance, the Fed was far more accurate in its forecasts of inflation or the direction of the economy during several past decades than the private sector (see Kohn & Sack 2003 or Romer & Romer 2000).

The assumptions for communication to matter seem reasonable and few arguments were presented suggesting that the communication with the public is a handy tool for the central bankers. Nevertheless, we need to also address the question, whether too much communication can be harmful. Several authors agree that the amount of communication is important and that from a certain point, more information can be confusing rather than clarifying, because there are limits on what amount of information can be processed effectively by market agents (Kahneman 2003; Winkler 2000). However, it is not quite possible to set an optimal level of communication and transparency, even though there are a few studies aimed at this topic.[5]

Another view is that the central bank should transparently inform the public about its monetary policy decisions and its policy reaction function, in other words, matters that it can actively set, but it should be more careful with communication about economic outlook or financial stability (King 2000). For instance, informing about unfavourable development in the economy or increased instability could alarm the market agents and cause further deterioration of the markets. One such case happened in 2000 when the President of the ECB Wim Duisenberg indicated that the ECB was not going to implement any further interventions in support of the euro, which resulted in an instant devaluation of the euro.

Beyond that, it also sends a poor signal when statements of different policy makers of the same central bank give different or even contradictory messages. Last but not least, there are obviously cases when a certain statement given by a central banker is confusing, which leads to misunderstanding by the public and can have a very much different impact than originally intended.

2.3 How central banks communicate

Clearly, there are certain downsides to central bank communication and the policy makers should think their words to the public through. The communication is however still a powerful instrument and rich literature documents its

[5]See for example Geraats (2002) or Van der Cruijsen *et al.* (2010).

influence on numerous aspects of financial markets. A short overview of those findings is presented further below in this chapter, but before that, we want to summarize the various means of central bank communication and also its typical objectives and content. Since this thesis is focused solely on the ECB in its empirical part, communication specifics of this particular bank are described.

For a better understanding of the way the ECB communicates and how it affects the financial markets, it is necessary to shortly introduce its structure and authority. The main decision-making body of the bank is the Governing Council. It formulates the monetary policy of the euro area, including for instance the decisions about setting the interest rates, and also establishes how are these decisions implemented. The Governing Council consists of six members of the Executive Board plus 19 governors of the national central banks of the euro area member states. The meetings usually take place every two weeks and monetary policy decisions are taken every six weeks.[6] Since Lithuania joining the euro area in 2015, the Governing Council triggered system of rotating voting rights to maintain the ability to take decisions even in a high number of member states. Four voting rates are shared by the five largest economies (Germany, France, Netherlands, Italy, and Spain), 11 voting rights are shared by the 14 remaining countries. The rights are rotated every month. Thus the largest countries have a slightly stronger voice in this voting system.

The Executive Board implements the monetary policy as specified by the Governing Council, it gives guidelines to the national central banks of euro area states and it also handles the everyday functioning of the ECB. The Executive Board consists of the President, currently Mario Draghi from Italy, the Vice President, currently Luis de Guindos from Spain, plus four other members. All Board members are appointed by the European Council for eight year non-renewable terms. The ECB guidelines specify that the Board members should not represent a particular country, instead they should focus on the euro area as a whole.

The Governing Council and the Executive Board are the most important decision-making bodies of the ECB and also this thesis will further focus on their public communication. However, there are two other decision-making bodies – the General Council and Supervisory Board. The General Council is responsible for the transitional issue concerning adoption of the euro and it should be dissolved once all EU countries adopt the common currency. It consists of the President and Vice President of the ECB plus the governors

[6] The policy meetings took place every month until January 2015.

of national central banks of all 28 EU member states. The Supervisory Board conducts the supervisory tasks of the ECB and it consists of Chair, Vice-Chair, chosen from Executive Board members, four ECB representatives, and national supervisors from euro area states.

Besides that the ECB has stressed the communication policy from its beginning, it also uses various means for expressing its stance to the public. These could be divided into scheduled and regular events, and ad-hoc statements and interviews. The ECB regularly publishes several bulletins and reports, such as the Economic Bulletin,[7] which presents a complex analysis of current economic and monetary situation, or a Financial Stability Review, which focuses on the risks for stability in the euro area. Furthermore, the ECB releases Annual Report, Convergence Report and Macroeconomic projections for the euro area.

The monetary policy is decided on Governing Council meetings and therefore regular press conferences take place after those meetings. The President and the Vice President of the ECB present introductory statement providing an overview and explanation of the Council's decision and then answer questions from the press. Since February 2015 the ECB also releases first account (or minutes) from the General Council meetings. These means of communication are regular events providing information on which the members of the General Council agree and give fairly clear and concise idea of the ECB's stance.

On the other hand, there are also ad-hoc interviews and speeches of the individual members of the Governing Council that occur irregularly and can be thus quite flexible in both content and timing. The policy makers may thus address new developments on the markets which the whole Council have not yet discussed at that point. Also, they can present their own personal opinions and interpretations of economic events. These views can differ for individual Governing Council members creating a source of confusions for the public.

This study uses the ad-hoc ECB communication in its empirical part because it can respond instantaneously to new information on financial markets and is thus the most flexible, as well as the introductory statements of policy meeting press conferences, which are medially scrutinized events and present the main official stances.

According to Blinder *et al.* (2008) we can further distinguish four different kinds of central bank communication. First, there are overall objectives and strategy, such as the long-term inflation targeting. The second aspect is in-

[7] The Economic Bulletin replaced the Monthly Bulletin which was released between years 1999 and 2014.

formation on specific policy decisions, which usually occurs after the Council meetings. Third, the ECB expresses its views on the economic outlook, these are often in a form of the bulletins and reports listed above. The last form of communication involves some sort of guidance about future policy decisions.

De Haan & Jansen (2009) argue that even though the ECB does not specify a quantitative guidance for its future policy development (like Bank of New Zealand or Sveriges Riksbank), we can observe certain "codewords" that signal the future monetary policy decisions. For example expression "interest rates are appropriate" indicates neutral comment on interest rates. Alternatively, the term "vigilance" was seen as a signal of upcoming change in policy for a period of 2003–2007.

In addition to this classification of content, we could also distinguish the communication on monetary policy more generally to information regarding conventional as opposed to unconventional monetary policy. In the times of crises when ECB used unconventional measures more often and also communicated about them more often, it can be interesting to focus also on the impact of this kind of information.

2.4 What are the effects of central bank communication

The previous sections of this chapter fairly cover the various aspects and specifics of central bank communication and also present arguments why it should matter for the development of financial markets. This section examines the previous research on the influence of central bank communication. The first part of the literature examines whether there even is any effect of the central bank communication on the financial markets.

Neuenkirch (2012) studies the influence of both central bank formal transparency and informal communication using a sample of nine major central banks in years 1999 – 2007. The paper suggests that both of these forms of communication affect market expectations and reduce the variation of expectations. Nevertheless, according to his findings, the informal communication has lower impact and does not reduce the variation in expectations. Finally, the author argues that all of the studied central banks are relatively homogenous, meaning that they are in large developed economies, use short-term interest rates as their main instrument, do not face severe inflation and are all rela-

tively transparent. The conclusion of the paper may therefore not apply for central bank communication in emerging markets that have generally more variation in their monetary regimes.

Rosa & Verga (2007) analyze the consistency and effectiveness of the ECB communication represented by the introductory statement of the ECB President in his monthly press conference held after the Governing Council policy meeting. For the tested period of 1999 – 2004 the authors argue that ECB's statements provide new and important information and are on average followed by corresponding deeds. Moreover, their results suggest that the ECB's words can speak as loud as actions and that it is able to influence money market interest rates just by its communication.

Neuenkirch (2012) and Rosa & Verga (2007) thus provides empirical evidence that communication of central bank can have indeed material influence on the financial markets, even though there are some limitations. A rich stream of research is then focused on the effect of central bank communication on a particular aspect of financial markets. Most of these studies are concerned with the effect on market interest rates, exchange rates or stock prices.

One of such studies is Kohn & Sack (2003) that addresses the influence of public statements by the Federal Open Market Committee (FOMC) and Chairman of the Fed to market interest rates. The authors use data on FOMC policy statements, Chairman's congressional testimonies, and Chairman's speeches, to assess their effect on volatility of market interest rates[8] in the period of 1989 – 2003. Their results indicate that both the FOMC statements and the Chairman's testimonies have considerable influence on short- and intermediate-term interest rates.

Kohn & Sack (2003) also aim to provide an explanation for this effect and argue that it is likely so that the investors take the statements as hints about the Fed's policy inclinations, and also that they update their views on economic outlook based on the FOMC's statements. On the other hand, the Chairman's speeches do not seem to have any significant effect on the market rates and also statements on asset price valuations do not have any consistent influence on the market participants. However, we need to note that the data used for this study are from before 15 years already and that the regime of central bank communication has been changing considerably in the past decades, also due

[8]Namely, the following variables are used with various maturities: federal funds futures rates, euro-dollar futures rates, Treasury yields, Treasury forward rates, the S&P 500 index, and the foreign exchange value of the dollar.

to the change of Fed's Chairman which occurred in 2006, therefore the market response to the communication may also be different in current time.

Given that one of the basic tasks of central banks is to manage the country's currency, it is natural that the central banks want to use communication to influence the exchange rate. Most studies studying whether the central banks are capable of that use data on verbal interventions aimed to affect the exchange rates. One such paper by Jansen & de Haan (2005) focuses specifically on statements by the ECB that were supposed to support the euro. The authors use the period of 1999 – 2002, the early days of the European Economic and Monetary Union (EMU), when the euro depreciated against the dollar and the central bankers actively verbally supported the euro in the intent to "talk it up". Using daily exchange rate data, the authors argue that such efforts were generally not successful and that the ECB statements had only little effect on the level of the exchange rate. Furthermore, for some types of communication events they find an asymmetric effect, meaning that markets react differently to positive and negative news. In contrast, they find a considerable effect on the volatility of exchange rate, which may indicate that the markets actually listen to the central bank's talks, but also that the central banks should be careful with their verbal interventions because increased volatility may increase uncertainty.

Later the same authors further build on their research and in Jansen & de Haan (2007) use high-frequency data to answer the same question. Similarly, they claim that the effects of ECB statements were only small and short-lived. They further add that these effects were larger when the verbal intervention was mentioned in the Bloomberg news headline. Contrarily, they find little evidence that the statements have any effect on the exchange rate volatility. There also seems to be no difference in the effectiveness of verbal interventions by ECB Executive Board members and national central bank presidents.

In contrast to these two studies, Fratzscher (2008) makes an argument that central bank communication was effective in influencing exchange rate in his studied period of 1990 – 2003. The author assesses the effectiveness of communication by central banks of the United States, euro area, and Japan and finds that verbal interventions moved exchange rates on average by 0.15 – 0.20 %, regardless whether they were supported by actual intervention. Furthermore, the communication seems to be even more effective when it deviates from the prevalent policy mantra. However, we need to notice that the author uses data for Bundesbank communication for the period 1990 – 1998 and ECB

communication after 1999 and the results show that the communication was less effective in the ECB period. Also the US communication seems to be less effective over time. These results are therefore somewhat in line with Jansen & de Haan (2005) and Jansen & de Haan (2007) who researched later period.

The research provides abundant evidence that the central bank communication indeed forms the expectations of the public and thus affects the financial markets in various ways. However, it is by no means clear, what is the best communication strategy. Other studies thus research the optimal level of transparency, effectiveness of collegial versus individualistic communication or timing of the news.

Woodford (2005) comments on the communication strategy for the central banks, using mainly the example of Fed. He argues that greater openness of its communication has undoubtedly increased the ability of the public to anticipate the monetary policy and hence also increased its effectiveness. He also adds that the communication strategy needs to be further developed to be adaptable to the ever-developing financial markets. Also, he believes that the central banks need to base their projections of future policy decision on an explicit model. Furthermore, they should explain their assumptions on future policy and also explicate that these projections are not necessarily commitments.

Ehrmann & Fratzscher (2007a) compare the effectiveness of communication strategies of the Fed, the ECB and the Bank of England (BoE) as each of these central banks uses a different one. The authors argue that the Fed pursues individualistic communication but collegial decision making, the opposite holds for the BoE, and the ECB uses a collegial approach in both communication and decision making. The results confirm the importance of the central bank communication as a financial market driver and show that its effectiveness is similar for the ECB and the Fed, despite their different communication strategies. Furthermore, the authors also claim that the asset prices' reaction is stronger in the case of statements by the Fed's Chairman than in the case of the other members of the Federal Open Market Committee. Whereas in the case of the ECB the markets react similarly to communication by the President and also by other members of the General Council.

Ehrmann & Fratzscher (2007b) then further study the communication of these three banks in particular focus on its timing. They find that for all the three banks the communication intensifies prior to committee meetings, particularly when interest rates are going to be changed. Other conclusions go in line with their previous work in the way that they differ for the central

banks. The markets react notably stronger to communication prior interest rate change for the Fed and the ECB. In the case of the Fed, the markets tend to further adjust after the actual change in rate. Communication expressing different stance than the current monetary policy is in turn more influential for the ECB. The rationale here is that ECB's communication is perceived as collegial same as the decision making and therefore that such statements reflect a consensus view of the Council.

Other studies focus on specific channels of the central bank communication. Born *et al.* (2013) ask how communication about financial stability affects the financial markets. They build an extensive dataset on Financial Stability Reports (FSRs), speeches and interviews on the financial stability by 37 central banks over 14 years, from 1996 till 2009. The authors argue that the communication does, in fact, affect the financial markets, however, there is a significant difference between the FSRs and the speeches and interviews. While the FSRs seem to be clearly creating news which notably moves the stock markets in the expected direction and also reduces noise and market volatility, especially when the statement is optimistic, the speeches and interviews have only little effect on the stock markets and none on the market volatility. On the other hand, these effects change with the market conditions and other factors. The authors document that in the time of the financial crisis, the FSRs had a lesser effect than before the crisis, whereas the speeches and interviews did move the financial markets. They conclude that financial stability communication by central banks can indeed influence financial markets and is perceived as relevant news.

Horváth & Vaško (2016) also explore the relationship between central bank communication and financial stability. Unlike Born *et al.* (2013), they look more generally on central bank transparency regarding their policy framework to safeguard financial stability, however, the FSRs are still considered to be the essential channel of financial stability communication. The authors construct an index of financial stability transparency based on various criteria. They construct this index for 110 countries in years 2000 – 2011 and use it in regression analysis to examine what determines the central bank financial stability transparency. Finally, they also use it to examine whether the financial stability transparency affects financial stability, which is similar to the aim of this study.

The authors arrive to several conclusions. Firstly, communication on financial stability is a relatively new phenomenon that has developed mostly in the past decade and has been continuously increasing. Unsurprisingly, the financial

stability transparency is greater in OECD countries and in countries that are also more transparent about their monetary policy. More interesting is their finding that financial stability transparency is beneficial for the financial stability, but only to some degree, too much transparency can be harmful. The intuition behind this finding may be that too high transparency in the time of worsened stability can actually escalate the distress or panic on financial markets. Nevertheless, it needs to be noted that Horváth & Vaško (2016) use IMF financial stress index as a measure of financial instability, which is simpler and less complex than the CISS used in this study. Similarly, their financial stability transparency index with its annual frequency has quite different nature than detailed weekly data on separate speeches of central bankers used in this thesis.

Gertler & Horváth (2018) do not examine a particular topic of communication such as the two previous studies, but the ad-hoc public communication of members of ECB's Governing Council. This is rather distinctive as there are only a few studies using unofficial speeches and interviews by central bank policy makers. They study the impact of this communication on high-frequency financial markets data. Using least squares and quantile regression they conclude that the ad-hoc communication affects financial markets, especially interest rates and also stock markets. On the other hand, they find little or no effect on the exchange rates. Furthermore, they find a stronger effect of communication in case of key members of the Governing Council, whereas there seems to be generally no evidence that the timing, sequencing or even content plays a role in the market response. Nevertheless, it is one of the few studies using informal central bank communication and arguing that this communication matters.

This section illustrates how broad is the literature studying various impacts of central bank communication. It provides evidence that the public expectations can be affected by the communication which can translate into changes in asset prices, exchange rates, interest rates or volatilities of these variables. Nevertheless, to the best of our knowledge, there exists no empirical study of the effect of central bank communication on the financial stability or financial systemic stress. Knütter *et al.* (2011) ask this question, however, they do not conduct an original empirical analysis. Instead, they only summarize previous empirical evidence of central bank communication effects and argue that its effects are pronounced which provides an incentive to explicitly focus on financial stability effects of central bank communication. This thesis further continues

in this exact path.

2.5 Financial systemic stress and its features

There seems to be no universal definition of systemic stress in the financial system and so one can find multiple definitions in the previous literature and also numerous proxies to measure it. This is caused also by the fact that no two episodes of financial stress are the same, therefore it is not easy to agree on more specific definition (Hakkio & Keeton 2009). Blix Grimaldi (2010) uses a very general proposition that financial stress is the product of vulnerable markets and of either exogenous or endogenous shocks. The more vulnerable the markets are, the more likely a shock is to result in stress. Other researchers see the stress as some disruption to normal functioning of the markets, such as Balakrishnan *et al.* (2011) who define financial stress as a period when the financial system is under strain and its ability to intermediate is impaired. Similarly, the ECB broadly defines financial stress as an interruption of the normal functioning of the financial system ECB (2009).

Holló *et al.* (2012) interprets systemic stress as a period in which the financial instability becomes so widespread that it impairs the functioning of a financial system to the point where economic growth and welfare suffer materially. Illing & Liu (2006) formalize financial stress as the force exerted on economic agents by uncertainty and changing expectations of loss in financial markets and institutions.

The previous literature also often attributes some characteristic phenomena to the financial stress. Hakkio & Keeton (2009) summarize and describe five key symptoms in which they concur with other papers (Holló *et al.* (2012), Louzis & Vouldis (2013) or Fostel & Geanakoplos (2008)). The five symptoms as characterized by Hakkio & Keeton (2009) are the following:

- *Increased uncertainty about the fundamental value of assets* can be a result of heightened uncertainty about the overall economic outlook. The fundamental value of financial assets is, in fact, the present discounted value of future cash flows from this asset and these cash flows depend on the future state of the economy. Nevertheless, it can also arise due to financial innovations that make it difficult for market agents to assign probabilities to certain outcomes. The uncertainty also often increases when losses are incurred for the first time on a new financial instrument.

This increased uncertainty about fundamentals then manifests itself in increased asset price volatility, because market agents tend to have a stronger reaction on new information.

- *Increased uncertainty about the behaviour of other investors* occurs in similar situations as the previous feature – when a new financial instrument or practice makes it difficult to assume probabilities for different outcomes or when previous assumptions about this new element prove to be incorrect. In these situations, the market agents are uncertain not only about the fundamental value of assets but also about what other agents believe the value is and how will they behave. The consequence is again increased asset price volatility.

- *Increased asymmetry of information* might occur because the variation in the quality of financial instruments or borrowers increases in times of economic downturns. It is then more difficult for lenders to determine the borrowers' actual risk, whereas the borrowers have better knowledge about their own risk. Furthermore, the borrowers may also start doubting their information about the borrowers' quality (such as credit ratings). The information asymmetry can cause an increase in the cost of borrowing as the lenders require a higher rate of return.

- *Decreased willingness to hold risky assets (flight to quality)* can be explained by two theories. The first one is that in periods of worsened or uncertain economic outlook people become simply more cautious, lose their risk appetite and tend to invest in safer assets. The second theory claims that market agents tend to underestimate the risks in time of economic expansion (due to heuristics or short memory) and then overestimate the risks when the losses start to pile up and the economy is stressed (Jack M. Guttentag 1986). As a result, the lenders and investors prefer safe assets and demand higher return on risky assets, which widens the rate of return spread of the safe and risky assets.

- *Decreased willingness to hold illiquid assets (flight to liquidity)* can be caused by caution of market agents who fear that they may need to liquidate some assets to meet their obligations. Also, the information asymmetry may cause certain assets to be perceived as illiquid because the market values them below their fundamental value and thus they cannot be sold without a considerable loss. Investors therefore increase

their demand for liquid assets, which widens the rate of return spread of the liquid and illiquid assets.

Different episodes of stress may involve all or only some of these symptoms, they can also have different intensity and relative significance. These features can also inflict or intensify each other and that is why they often occur all at once, especially in periods of high and long-term stress.

The financial stress is in most of the literature seen as a continuum which is low in "normal" times. Heightened financial stress manifests itself with one or more of the previously described symptoms and extremely high financial stress escalates into a crisis (Illing & Liu 2006).

2.6 How to measure the financial systemic stress

Just as there is no simple definition of financial stress, there is also no easy way to measure it. There is no single natural indicator of the overall level of financial stress. Therefore, scientists aim to construct a financial stress index that would serve as a measure of financial stress. Such index measures rather latent conditions and is constructed from various economic and financial data using sophisticated statistical techniques (Kliesen *et al.* 2012).

A large part of the previous literature focuses on the development of such indices and the validation of their accuracy compared to historical data. These indices are usually constructed for individual countries to capture their level of financial stress more accurately than in case of more general design. Even though each index is unique, the construction can be predominantly described in three steps.

The first one is the choice of raw indicators that should capture the symptoms of financial stress. They should also cover all the important segments of the financial system[9] These variables are mostly swap spreads, bond yield spreads (for bonds of different maturities and qualities), volatilities of yield on bonds or money markets rates, volatility of exchange rates or certain stock market indices. The choice of variables is limited mostly by two requirements - sufficient time span allowing for historical validation and frequency (usually daily, weekly, or at least monthly) allowing for real-time measurement.

[9]The division of the segments can somewhat differ, for example, Holló *et al.* (2012) use equity market, bond market, money market, foreign exchange market and financial intermediaries, while Illing & Liu (2006) use banking sector, foreign exchange market, debt markets and equity markets.

The second step is standardisation or other transformation of the various raw indicators to put them on a common scale. This is most commonly done by subtracting the sample mean from the raw score and then dividing this difference by the sample standard deviation (Holló *et al.* 2012). However, it is implicitly assumed that all the variables are normally distributed, which is very unrealistic and it is the drawback of this approach. To avoid this mistake, some papers use transformation based on variables' sample cumulative distribution functions. Rarely, more complicated methods are used, such as passing data through various filters or eliminating variability that can be explained by the historical real activity of inflation (Kliesen *et al.* 2012).

The third step is to group the transformed variables into subindices based on the market segments or, as in Nelson & Perli (2007), by the traits they are measuring (in this case level, liquidity and co-movement), mostly using equal weighting scheme. Fourth and probably the most difficult step is the aggregation of the individual indicators or subindices into one final index. The simplest method is equal weighting, which is simple arithmetic average of the subindices. The more complicated ones are for example principle component analysis, regression-based weighting, credit weighting (based on subindices' share on total credit), portfolio theory (taking into account cross-correlation between the subindices and their relative importance for real economic activity).

The final indicator is a single number measuring the current level of stress in the financial system. Historical comparison and real-time monitoring then allow for assessment of the fitness of the financial system. Studies aimed at developing financial stress indices further evaluate the accuracy of the index by assessing its level in the cases of historical crises. Again, it is not straightforward how to establish what is a crisis and when it started or ended. Some authors arbitrarily choose "well known" episodes. Some create a survey among prominent economists and policy makers to find substantiated consensus on cases of crises (Illing & Liu 2006) or conduct a word search in periodical publications by a central bank (Blix Grimaldi 2010). Nevertheless, a good financial stress indicator should balance Type I errors (failure to report a crisis) and Type II error (falsely reporting a crisis).

2.7 Previous literature on financial systemic stress

The stream of literature focusing on developing financial stress indicators is rich, expanded also due to the analytical needs of the most recent financial crisis, and it is not the aim of this study to describe it in detail. Nonetheless, merely simplified summary of the important or unique stress indicators follows, grouped by the country of its focus.[10]

One of the key studies in this area is Illing & Liu (2006) developing a financial stress index for Canada. The authors present several different approaches on weighting and aggregation of the raw variables into the index and then compare them with Canadian history of crises.

Naturally, a large part of this literature focuses on financial stress indices for the United States, such as Nelson & Perli (2007) and their financial fragility indicator. Their approach is somewhat unique as it reduces the original variables into three summary statistics that represent their level, rate of change, and comovement. These are then used in a logit model to predict the probability of crises. Hakkio & Keeton (2009) create the Kansas City Financial Stress Index (KCFSI) using principal component analysis. Their study is however seminal because of the organized description of the features of financial systemic stress and its effects on the real economic activity.

Building on Hakkio & Keeton (2009), Kliesen & Smith (2010) use very similar principal component analysis methodology, only with higher data frequency, in the construction of St. Louis Financial Stress Index (STLFSI). A more complex and sophisticated version of factor analysis is applied in the creation of the National Financial Conditions Index by Brave & Butters (2012). Finally, the Cleveland Financial Stress Index constructed by Oet *et al.* (2011) is interesting because of its aggregation method that consists of applying time-varying credit weights to four market segment subindices. These weights represent the proportion of financial flows in the segment.

Another important and heavily studied financial system is Europe and the euro area. We can find financial stress indices both for certain individual states and also for the euro area as a whole. Maybe one of the first ones is developed for Switzerland by Hanschel & Monnin (2005), however, it only focuses on the banking sector and it comprises from not only market price data, but also balance sheet and non-public data. The authors also admit that this index

[10]Detailed description and comparison of various financial stress indicators can be found in Kliesen *et al.* (2012).

failed to capture some smaller crises. Louzis & Vouldis (2013) create financial systemic stress index for Greece which takes into account the cross-correlation between its five subindices. Their validation based on crises survey shows that the index can timely identify crisis periods.

First attempt to develop a comprehensive financial stress indicator for the euro area is done by Blix Grimaldi (2010). Her method for constructing this indicator is very similar to the one in Nelson & Perli (2007), but she further proposes a modification so that the indicator can be used as a leading indicator.

Second financial stress indicator for the euro area is the Composite Indicator of Systemic Stress (CISS) developed by Holló *et al.* (2012). It comprises five market sector subindices aggregated into one index taking into account their time-varying cross-correlations. This feature causes that the value of CISS is relatively higher when stress occurs in more financial market sectors at the same time. Additionally, the authors present TVAR model and Markov switching model to identify regimes of low and high stress and show that while the CISS has an insignificant effect on the economic activity in the low-stress periods, it is considerable in the high-stress periods. Their findings provide an incentive for further research of financial systemic stress and what affects it because the stress then can have a material impact on the real economy.

van Roye (2011) follows the methodology of Brave & Butters (2012) in the construction of financial market stress indicator for the euro area and Germany. His dynamic factor model allows him to use an unbalanced panel of more than 20 variables with various frequencies, which distinguishes him from Blix Grimaldi (2010) and Holló *et al.* (2012). Using his indicator, he finds that increase in financial stress results in a significant inhibition of GDP growth and that as much as 30 % of GDP growth variation in the euro area can be attributed to changes in financial stress. Islami & Kurz-Kim (2013) also develop a financial stress index for the euro area and it is one of the few that have a daily frequency. This is however redeemed by using only six variables which are available at this frequency and a fairly simpler aggregation method then in Holló *et al.* (2012).

There are also studies that create more general financial stress index for several countries, often for the important advanced economies. One such is the Global Index of Financial Turbulence (GIFT) by ECB (2009) which covers six indicators for each of 29 main economies and uses fairly simple weighting and aggregation methods. Lo Duca & Peltonen (2013) develop similarly simple financial stress indicator for 28 countries (10 advanced and 18 emerging

economies).

Cardarelli *et al.* (2011) then also develops a financial stress index for 17 advanced economies but apply a different view on what is the financial stress. The authors define episodes of financial stress as those periods when their index is more than one standard deviation above its trend. They then investigate which episodes of stress were followed by an economic slowdown or even a crisis and try to find differences between episodes of stress that led to a slowdown and those that did not. They argue that periods of stress originating in the banking sector tend to lead to deeper and longer downturns. Also, downturns preceded by banking distress tend to last longer than those that are not preceded by stress. Finally, they find that more arms'-length financial system are likely to be more vulnerable to banking distress.

The existence of financial stress indicators also for Hong Kong (Yiu *et al.* 2010), India (Khundrakpam *et al.* 2017), Malaysia (Abdullah *et al.* 2017) or Colombia (Morales & Estrada 2010) proves the abundance of the literature on developing financial stress indicators.

There is also literature that focuses not only on the construction of a financial stress index, but mostly on using this index to identify the real impacts of the stress on the economy. Mallick & Sousa (2013) research this question for the euro area. They use a stress index largely inspired by Cardarelli *et al.* (2011) and estimate several specific VAR models along with the policy rate, growth in the monetary aggregate and set of macroeconomic variables. They find that monetary policy contraction causes deterioration of systemic stress and that the negative shock in stress causes output contraction, fall in the interest rate and negative effect on commodity price and inflation rate. The authors argue that their finding provides support for close monitoring of financial stress conditions and for the importance of macro-prudential risk management.

Davig & Hakkio (2010) asses the effect of financial stress on the US economic activity. The authors make use of their previously developed KCFSI and identify two regimes, one normal in which the stress is low and economic activity high, and a distressed regime in which the stress is high and economic activity low. Such finding would not be very surprising but they further find that the effect of financial stress on the economic activity can be quite higher in the distressed regime than in the normal regime.

The existing literature on the financial systemic stress is mainly oriented to developing accurate stress indicators. Nevertheless, further analysis using such indicators suggests that the effects of shocks in the financial stress on

the real economy can be quite considerable, especially in periods of heightened uncertainty. Such evidence is provided by Cardarelli *et al.* (2011), Davig & Hakkio (2010), Mallick & Sousa (2013) or Holló *et al.* (2012). This, therefore, provides a strong incentive to further study the financial systemic stress, what are its causes and how it can be influenced to prevent material injury of the economy.

Chapter 3

Development of hypotheses

In Section 2.1 we describe that it is now a common belief that communication with the public is an important tool for central banks because it is a way how they can affect public expectations. It is also reasonable to believe that the central banks can be successful because the conditions for communication to actually matter in eyes of the public are likely to occur in reality. That is that the public does not always understand the central bank's policy and its expectations not always rational. Second, the central bank does not follow a never changing policy rule. And third, the central bank has better information about the future outlook than the public (de Haan & Jansen 2009).

In Section 2.4 there are documented numerous empirical studies which document that the central bank is indeed able to influence the public so that there is a measurable reaction on the financial markets. This gives us a reason to believe that the central bank communication may also affect the level of financial systemic stress. The significant features of financial stress are increased asymmetry of information, uncertainties about the fundamental value of assets and behaviour of other market agents (Hakkio & Keeton 2009). These uncertainties emerge when the market agents have different expectations about future outlook or lack of information about it. Therefore there may be an opportunity for the central bank to provide the public with new information and to affect its expectations so that they vary less.

Nevertheless, there are various dimensions of the central bank communication and thus it is necessary to ask more specific questions concerning the effect of central bank communication on financial systemic stress.

As described above, central banks nowadays tend to increase their transparency and openness by communicating more often and through various chan-

nels. The first research question thus suggests itself - is this openness beneficial for financial stability? The intensity of communication is also the easiest to measure, communication events can be simply counted. The first hypothesis' specification thus follows:

Hypothesis 1. Increased central bank communication intensity decreases the financial systemic stress.

It can be argued that the central bank provides valuable information to the public and in this way it can reduce uncertainties and unify public expectations. The financial systemic stress then also decreases with decreased uncertainties. Previously, Born *et al.* (2013) document a decrease of stock market volatility in reaction to Financial Stability Report publication, which supports this hypothesis. On the other hand, our dataset contains only oral communication for which Born *et al.* (2013) find only weaker evidence. Besides that, Winkler (2000) suggests that too intensive communication may become more confusing than clarifying. It should thus be considered also the possibility of a non-linear relationship between communication intensity and financial systemic stress.

While the amount of communication may have some effect on the financial systemic stress, the content of the communication is what should essentially matter. The financial market agents do not adjust their expectations based on the mere fact that the central bankers communicated but based on the actual message of the communication. Even if we found no significant effect of communication amount, it is still possible that the communication content is relevant for financial systemic stress. Therefore, we introduce a second hypothesis that the sentiment of communication affects financial systemic stress.

Hypothesis 2. Communication expressing positive outlook or tightening policies decreases the financial systemic stress. Communication expressing negative outlook or further easing policies increases the financial systemic stress.

The intuition for this hypothesis is that positive news should calm the markets and reduce the uncertainties about the future economic outlook. The perspective of favourable future outlook could also slightly alleviate the fear of holding risky or illiquid assets, which are other characteristics of financial stress. On the other hand, negative news could alarm the markets and cause their further deterioration. Negative outlook may also deepen the uncertainties about future market development and thus increase the stress.

Following Gertler & Horváth (2018), it is further presumed that there are

various characteristics of the statement that matter for its significance and real impact on the financial systemic stress. Gertler & Horváth (2018) find for instance stronger effect of communication by ECB President Draghi then by other GC members.

Hypothesis 2.1. Central bank communication has a stronger effect on the financial systemic stress in the following cases:

(a) the statement is given by the president of the central bank.

(b) the statement is given by policy maker from a core member state of the euro area.

(c) the statement is given by policy maker from a member state that is in distress.

(d) the statement is given in an important financial center.

(e) the communication concerns non-standard policy measure.

(f) the communication concerns monetary policy rather than economic outlook.

(g) the statement is given shortly before the upcoming scheduled policy meeting.

The first three sub-parts of the hypothesis are related to the particular policy maker who made the statement. It seems quite clear that the more important position the person has, the more attention is paid to him/her. In the ECB the president should attract the most attention. However, also the national central bank governors from core member states of the euro area may be listened more carefully, as they likely have a more respected position among the other national central bank governors. Alternatively, if certain country faces financial distress the public may expect its national governor to provide information on the outlook.

We further hypothesize that the location and timing of the communication event also matter. It is likely that the communication will attract more attention if it occurs shortly before regularly scheduled policy meeting because it may indicate the future course of the central bank's monetary policy. Ehrmann & Fratzscher (2007b) even finds empirical evidence supporting this claim. Communication in main financial centers (such as London, Frankfurt, New York or Tokyo) may also be monitored more closely.

Finally, the topic of communication should not be ignored. If the topic is monetary policy, a matter that the central bank can actively set or directly influence, it should be seen as a credible statement and may be more valuable for the public than an assessment of future economic outlook, which the central bank actually can not influence. This effect can be even more pronounced if the communication concerns a non-standard policy measure, which is by its nature an extraordinary provision.

The actual sentiment of the communication may also be seen as its another important characteristic which can affect its importance. Accordingly, it is expected that there may be asymmetry in the effects of communication expressing positive outlook and the communication expressing negative outlook.

Hypothesis 2.2. Communication expressing negative outlook or further easing policies has a stronger effect on the financial systemic stress than communication expressing positive outlook or tightening policies.

The phenomenon of a stronger reaction to negative news or negative shock is well documented on the financial markets (Koutmos & Booth 1995; Campbell & Hentschel 1992; Chen *et al.* 2003), therefore it is likely that also the effect of negative communication on financial systemic stress may be stronger. Jansen & de Haan (2005) even document such asymmetric effect of central bank communication on exchange rates, therefore, there may be a reason to believe that this could apply also for the effect on financial systemic stress. Because of risk-aversion, the public may be more alerted by a negative future outlook and thus have a stronger reaction.

Finally, we also consider that the effect of central bank communication may be affected by the contemporaneous situation on financial markets. Market agents may be more alerted and perceptive in times of heightened financial stress or even crises and thus react differently than in calmer times. A third hypothesis is therefore specified.

Hypothesis 3. Central bank communication has a stronger effect in periods of heightened financial systemic stress.

It is likely that the public does not pay as much attention to the central bank communication in times of low systemic stress and favourable economic conditions because there is not much reason to be cautious or expect extraordinary policy measures. However, in periods of heightened stress the public may listen more carefully to what the central bankers have to say. It is more

likely that the policy rate will be changed or that non-standard measures will be introduced. In the presence of uncertainties, information about the future economic outlook may also be more valuable than in calmer times. The public may simply expect the central bank policy makers to present a solution for a crisis or inform about their estimations about future development. Born *et al.* (2013) provide some support for this hypothesis and claim that speeches and interviews by central bankers affect the financial markets in times of crisis while they have no effect in normal times. Financial stability reports, on the other hand, move the markets less during crises. Nevertheless, their findings support the hypothesis that the market conditions matter for the communication importance.

Specifying the hypotheses is necessary for the development of empirical models, determining appropriate estimation methods and source of data. The dataset and methodology used in the empirical analysis are described in 4 and 5, respectively.

Chapter 4

Data

The two most important data sets for the empirical analysis are the systemic stress variable and ECB communication data. The views on what exactly is systemic stress and how to measure it differ and therefore there does not exist one single correct data. We choose to use the Composite Indicator of Systemic Stress (CISS) (Holló *et al.* 2012) that is described in Section 4.1. For the ECB communication we use two datasets to capture both ad-hoc and official communication. The ad-hoc statements and speeches by the members of the ECB Governing Council (ECB GC) between policy meetings are collected by Gertler & Horváth (2018), the data about ECB GC policy meeting press conference official introductory statements are created by Baker *et al.* (2016). Both of these datasets are described in Section 4.2.

4.1 Systemic stress data

There are many different approaches how to measure systemic stress as described above in Section 2.7. Nevertheless, Composite Indicator of Systemic Stress (CISS) introduced by Holló *et al.* (2012) is selected as the most appropriate measure for the purpose of presented empirical analysis. This measure is constructed from a wide variety of stress indicators in different market segments in order to measure systemic stress and the past evidence of financial distress periods seems to be well indicated by the CISS. There are also two practical advantages of CISS for application in presented empirical analysis. The CISS is constructed from data available with high frequency (daily or weekly), which enables to follow the immediate effect of ECB communication on systemic stress. Also the CISS was developed by the ECB and consequently uses data

from euro area, which should be at most relevance for ECB communication, and is publicly available on the ECB's website.

More specifically, the CISS aggregates in total 15 raw stress indicators from 5 different segments – money market, bond market, equity market, financial intermediaries and foreign exchange market (3 indicators for each). These indicators are mainly measures of volatilities on these markets (e.g. volatility of the Euribor rate, volatility of German government bond index, volatility of stock market indices of non-financial or financial sector, volatility in exchange rates) or measures of spreads (e.g. interest rate spread between Euribor and French T-bills, yield spread between non-financial corporations and government bonds, interest rate swap rate, yield spread between financial and non-financial corporations), but also the CMAX indicator that measures maximum cumulated non-financial market index losses in certain moving window (Patel and Sarkar, 1998), or measure of correlation coefficient between stock and government bond returns as there can be tendency to shift funds from risky stocks to more safe bonds in the periods of higher risk, which should lead to negative correlation.

Higher values of all these measures, except the last one, indicate higher systemic stress and all of these are also an ex-post measures realized by market. Moreover, all these raw indicators are quite standard measures with long data series, so the CISS can be calculated back to 1999.[1]

These individual raw stress indicators are synthesized into the CISS in several steps in order to create indicator of systemic stress that is robust to outliers and stable in time. Moreover, the CISS puts larger weights to individual indicators when the stress occurs in more segments simultaneously. In the first step, all individual raw stress indicator are ordered ascendantly and transformed by its empirical cumulative distribution function, so this transformation into order statistic $z_t = F_n(x_t)$ is more robust compared to normal standardization by mean and standard deviation. Consequently, all resulting transformed individual stress indicators are in the interval $(0, 1]$.

In the second step, simple arithmetic averages of three indicators in every segment create five sub-indices $\mathbf{s_t}$. Finally, the CISS is defined as $CISS_t = (\mathbf{w} \circ \mathbf{s_t})\, \mathbf{C_t}\, (\mathbf{w} \circ \mathbf{s_t})'$, where $\mathbf{w}$ is the weighting matrix corresponding to the importance of individual segments and $\mathbf{C_t}$ is the matrix of correlation coefficients[2], which is an innovative transformation in line with portfolio theory, that

[1] Holló *et al.* (2012) further developed proxy measure of the CISS using other raw stress indicators that can be tracked even back to 1987.

[2] Correlation coefficients are estimated using EWMA with $\lambda = 0.93$.

identifies higher stress (risk) in situation, when individual market segments are correlated. In the same time, the CISS remains theoretically in interval $(0, 1]$. However, for the purpose of our analysis, the CISS values are multiplied by 100 so that the estimated coefficients are easier to read. The CISS in the empirical analysis of this thesis thus takes values between 0 and 100.

4.2 European Central Bank communication data

In the previous research concerning central bank communication, mostly the official forms of communication have been used. However, the means and content scope of central bank communication have undergone a change towards greater transparency in the last decades, as we describe in Section 2.1. The central banks nowadays communicate more often and ad-hoc beyond the policy meetings to satisfy the demand for information. Nevertheless, the official ECB communication needs to be taken into account as well, because it is still closely monitored by the public and provides first-hand information when the ECB changes their policy rates. For these reasons, we use both a unique dataset of ECB ad-hoc communication and a dataset about ECB policy meeting press conferences.

4.2.1 ECB ad-hoc communication dataset

The dataset on ECB ad-hoc communication was created by Gertler & Horváth (2018) by filtering out forward looking statements by the ECB GC members between policy decision meetings from the Reuters News in the period of July 2008 – January 2014. These are public statements from speeches, conference discussions and media interviews. The authors then identified the content of each communication event, whether it concerned economic outlook, conventional monetary policy or unconventional policy. The authors further assigned values of -1,0 and 1 based on the outlook they indicate. Value -1 was assigned to communication events that indicate negative outlook, easing policies or warn about downward risks to price stability. Value 0 was assigned to communication events with neutral outlook with no signal of policy change. Value 1 was assigned to communication events that indicate positive outlook, tightening policy or mention upward risks to price stability.

The dataset also contains various other information about each of the communication events. Naturally, there is the date and time of the statement and

number of days until the next policy meeting of ECB GC. The author of each statement is also known. We further have information on speakers' position in the ECB (President, Vicepresident, Executive Board member or national central bank governor), their home country and how long are they in the function. Finally, the place where the communication events was given is also recorded. The authors of the dataset thus identified communication in important financial centers (London, Frankfurt, New York, Tokyo, Hong Kong, Singapore, Shanghai, Zurich), or if it occurred in the home country of its author.

However, the ECB ad-hoc communication data comprise separate communication events taking place throughout the week, often there occurred more of them in a single day. On the other hand, the dependent variable in the empirical analysis is the CISS with a weekly frequency. All other data series thus need to be transformed to the same frequency.

The ad-hoc communication data need to be aggregated to weekly data with weeks ending on Friday 18:00, to correspond to CISS time frame. However, this aggregation differs based on the particular hypothesis we want test and to what should the communication variable represent. The plainest aggregation is used for testing Hypothesis 1, we count the number of all communication events in a given week. For Hypothesis 2 we need a variable measuring the communication climate, whether it is predominantly positive and signaling hawkish monetary policy, or negative and signaling dovish monetary policy. We construct this variable by calculating the sum of policy inclination of all communication events in a given week.

To test Hypothesis 2.1 we filter only communication matching the specification of each subpart and then create the transformations described above. The filters for the subparts a) – f) are fairly straightforward as all these characteristics are readily available for each statement in the dataset. For testing the last subpart we assign higher weights to communication events given shortly before policy meeting. Analogically, for Hypothesis 2.2 we filter and compare communication indicating positive outlook and hawkish monetary policy to communication indicating negative outlook and dovish monetary policy. For testing Hypothesis 3 we can use all of the variables described above, what changes is the modelling approach.

Moreover we define Importance Weighted Communication Sentiment index (IWCS) and Asymmetric IWCS (AIWCS) in order to capture Hypotheses 2.1 and 2.2 in a single measure. These measures aim to capture more relevant information while mitigating the problem of high correlation of individual aggregate

measures and reducing the number of coefficients that need to be estimated in further analysis.

The measures are defined by putting arbitrarily larger weight to presumably more important communication event, while keeping the weight of each individual communication event in interval $(0, 1)$:[3]

$$
\begin{aligned}
Comm_t &= \sum_{i \in week} Sentiment.Code_i \\
IW_i &= \left(\frac{1}{POST_i} + \frac{1}{\sqrt{DtoGC_i}} + \frac{I_{south,i} + 1}{2} + \frac{I_{nsm,i} + 1}{2} + \frac{I_{mp,i} + 1}{2} \right) /5 \\
IWCS_t &= \sum_{i \in week} IW_i * Sentiment.Code_i
\end{aligned}
$$

$$
\begin{aligned}
AIW_i &= IW_i * \frac{I_{neg,i} + 1}{2} \\
AIWCS_t &= \sum_{i \in week} AIW_i * Sentiment.Code_i
\end{aligned}
$$

Where I denotes dummy variables indicating whether the communication was done by southern country[4] representative ($south$), whether it concerns non-standard measures (nsm), monetary policy issues (mp) and whether it has negative sentiment (neg). $POST$ order members of ECB GC by its position from national central bank governors, through Executive Board members to ECB president from 3 to 1. $DtoGC$ counts number of days until the next ECB GC meeting.

Inherently, it holds that $All_t \geq IWCS_t \geq AIWCS_t$ for $\forall t$, which requires careful interpretation of estimated coefficients in further analysis.[5] The coefficients would be directly comparable only in case of hypothetical communication event of president in the day of GC meeting from southern country concerning non-standard monetary easing policy measure.

All the variables described above are summarized in Table 4.1 in connection to the hypotheses they are testing.

[3]We use this simple way of setting weights as it is much easier to interpret and compare the estimated coefficients as opposed to more sophisticated techniques such as principle component or other factor analysis.

[4]It is presumed that the public could pay more attention to policy makers from distressed countries, in the tested sample period these are the southern countries, namely Cyprus, Greece, Italy, Portugal, Spain and Malta.

[5]In our sample the $IWCS$ and $AIWCS$ are on average 58% and 45% of flat aggregate, respectively.

Table 4.1: Hypotheses and corresponding communication variables

	Hypothesis	Communication measure	Variable
H1	Increased central bank communication intensity decreases the financial systemic stress	number of statements	*comm.count*
H2	Communication expressing positive outlook or tightening policies decreases the financial systemic stress. Communication expressing negative outlook or further easing policies increases the financial systemic stress.	total policy sentiment of statements	*comm.sum*
H2.1	Central bank communication has a stronger effect on the financial systemic stress in the following cases:	- importance weighted	*IWCS*
a	the statement is given by the president of the central bank	- by ECB president	*president*
b	the statement is given by policy maker from a core member state of the euro area	- by core state representatives	*core*
c	the statement is given by policy maker from a member state that is in distress	- by southern countries representatives	*south*
d	the statement is given in an important financial center	- in financial centers	*fin.center*
e	the communication concerns non standard policy measure	- about non-standard policy measures	*non-standard*
f	the communication concerns monetary policy rather than economic outlook	- about monetary policy	*M. policy*
g	the statement is given shortly before upcoming scheduled policy meeting	- divided by number of days to next GC	*DtoGC*
H2.2	Communication expressing negative outlook or further easing policies has a stronger effect on the financial systemic stress than communication expressing positive outlook or tightening policies	number/total of statements with negative sentiment	*comm.negative*, *IWCS_neg*, *AIWCS*
H3	Central bank communication has stronger effect in the periods of heightened financial systemic stress.	- with cross-product of stress regime dummy	*low/high stress*

4.2.2 ECB official communication dataset

The dataset on ECB official communication is constructed by Picault & Renault (2017). Their Central Bank Communication Index (CBCI) measures the inclination of ECB press conference introductory statement using textual analysis. The data actually comprise two indicators - monetary policy indicator (MP index) and economic outlook indicator (EC index) - as the authors differentiate the content on this two topics.

While Gertler & Horváth (2018) classify the entire communication events with one value of either 1, 0 or -1, Picault & Renault (2017) consider individual groups and assign them inclinations. The final aggregated indicator thus can take any value between 1 and -1, with 1 indicating the strongest hawkish monetary policy or the strongest positive economic outlook, and -1 indicating the strongest dovish monetary policy or the strongest negative economic outlook. Various characteristics of each introductory statement are thus expressed in a single number.

The ECB press conference is held after the Governing Council policy meeting, which took place every month during our sample period. There are other forms of ECB official communication, mainly written, but the press conference is probably the main channel and the CBCI can therefore serve as a representation of ECB's official communication.

4.3 Other explanatory variables

To account for other factors that could affect the financial systemic stress we include the Composite Leading Indicator (CLI) and the Economic Policy Uncertainty index (EPUI).

The Composite Leading Indicator (CLI) is developed by the OECD and provides leading indication of the business cycle and economic activity. A turning point in the CLI should forecast a turning point between economic activity expansion and slowdown with $6 - 9$ months lead. The CLI is constructed on a monthly frequency by aggregating several time series to cover a wide range of short term economic activity indicators. These component series provide an indication of future economic activity and differ for each country, but often include consumer or business confidence indicator, changes in orders and inventory, housing permits, inflation or unemployment. Individual country CLIs are

weighted based on each country's GDP into one Composite Leading Indicator for the euro area.

The Economic Policy Uncertainty index is based on media coverage of economic policy uncertainty developed by Baker *et al.* (2016). The index is constructed by first filtering and counting the number of articles containing terms associated with economic policy uncertainty in 10 major European newspapers. This number is then normalized into an index with monthly frequency.

Baker *et al.* (2016) find a significant dynamic relationship between the EPUI and real macroeconomic variables and that it foreshadows declines in output. This index can thus represent other policy communication, besides the central banks', because the financial systemic stress may be affected also by other policy than the monetary policy.

Both the series of CLI and EPUI have only monthly frequency and values for each week simply do not exist. To be able to use these series in a model with weekly CISS, we need to artificially impute weekly values to them. We do this using cubic spline interpolation which should produce a smooth interpolating polynomial.

4.4 Sample summary statistics

Combining the data into one dataset, 291 weekly observations are obtained. Policy meeting press conferences take place only monthly, thus there are 67 of them in the sample period. All other variables are either aggregated or interpolated to obtain value for each week and the sample statistics are summarized in Table 4.2. It can be inferred that the CISS varied quite a lot in the observed period with standard deviation of more than 20 and values between 2 and almost 84, which is the all time highest values of CISS. All the communication variables have negative means indicating that the ECB communication had more negative sentiment. There were on average almost 5 unofficial communication events every week. Also the mean of CLI below 100 indicates that the economy was below its long-term potential.

Table 4.3 presents summary statistics on the unofficial communication with certain chosen characteristics. The table shows that the ECB president communicated in more than one third of all weeks in the sample period and gave almost 140 statements mostly with negative sentiment. Half of all statements concerned monetary policy and almost 30 % discussed non-standard measures. 30 % of all communication events had neutral sentiment but negatively inclined

statements prevailed over positive ones, especially for policy makers from southern countries and if they concerned non-standard policy measures. Finally, we can also notice that there are 29 weeks during which no unofficial communication occurred.

Table 4.2: Summary statistics of data

Variable	N	Mean	SD	Min	Pctl(25)	Pctl(75)	Max
Systemic stress data (Holló et al. *2012)*							
CISS	291	33.57	20.88	2.10	17.05	44.51	83.98
Δ CISS	291	−0.11	5.73	−34.68	−2.75	2.88	20.15
Ad-hoc communication data (Gertler & Horváth 2018)							
comm_count	291	4.76	4.18	0	2	7	21
comm_sum	291	−0.38	3.64	−18	−2	1	11
IWCS	291	−0.23	1.99	−9.72	−1.01	0.54	6.45
AIWCS	291	−0.62	1.65	−9.72	−1.10	0.18	3.22
Official communication data (Picault & Renault 2017)							
press conf.	291	0.23	0.42	0	0	0	1
EC_index	67	−0.11	0.16	−0.48	−0.22	0.02	0.23
MP_index	67	−0.16	0.33	−0.72	−0.36	0.01	0.72
Control variables (Baker et al. *2016; OECD 2017)*							
EPUI	291	171.62	46.74	82.68	137.02	206.43	304.17
CLI	291	99.50	1.50	96.03	98.73	100.59	101.84

Table 4.3: Details of ad-hoc communication data

Variable	Occurance in weeks	Total events	Portion of: negative	positive	neutral
president	103	139	0.41	0.27	0.32
core	256	1,035	0.37	0.33	0.30
south	93	166	0.55	0.15	0.30
fin_center	189	388	0.35	0.38	0.27
nsm	174	404	0.44	0.33	0.24
monetary policy	209	725	0.38	0.29	0.33
economic outlook	158	322	0.40	0.31	0.29
all communication	262	1,384	0.39	0.31	0.30

Chapter 5

Methodology

This chapter describes the modelling approach of the empirical analysis. Models for testing the research questions established in Chapter 3 are presented. ARIMA based models and VAR models are introduced for testing Hypotheses 1 and 2, Threshold AR model is used for testing Hypothesis 3. Besides, several econometric issues are identified in certain variables from the dataset introduced in previous chapter and their treatment is described.

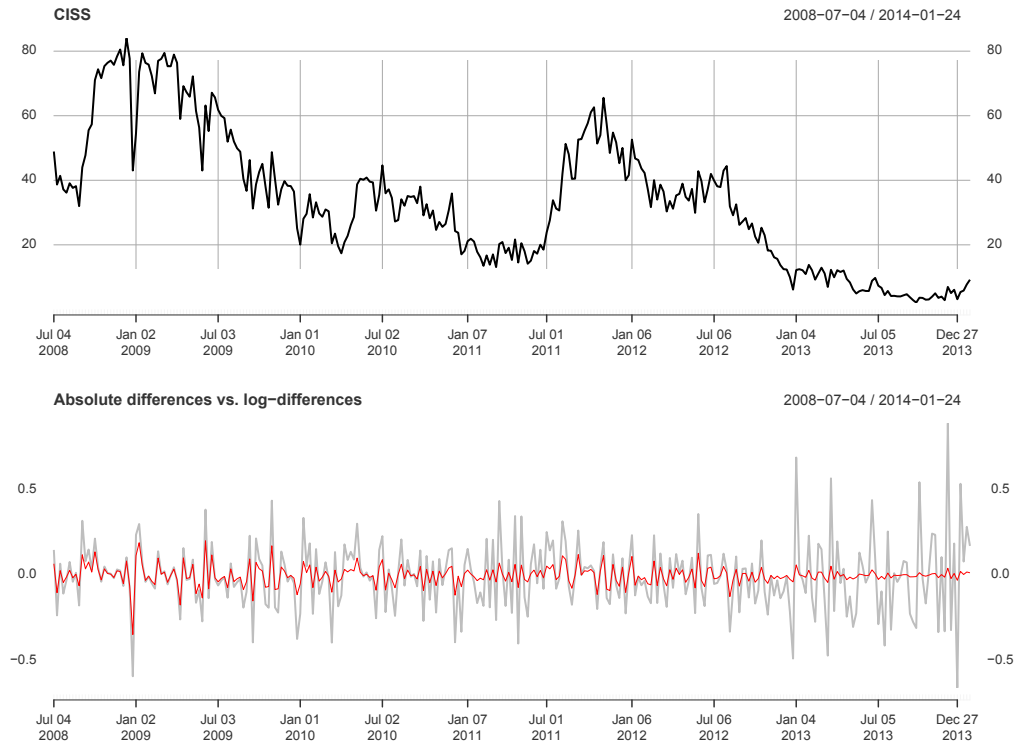
5.1 Basic analysis of CISS

One of the requirements for using OLS estimator in time series data is stationarity of the time series. If this assumption does not hold, the OLS estimator would be inconsistent. We can hypothesize that the dependent variable CISS should be stationary in the long run, otherwise the economy would become distorted. However, the analyzed sample period for the empirical analysis is limited to July 2008 – January 2014 because this is the time span of the ad-hoc communication dataset and this period contains both major crises in euro area during the past decade - the financial crises starting in 2008 and the following sovereign debt crises starting in 2010. These events cause large variation in CISS within the sample.

Looking at the graph of the CISS over this sample period in Figure 5.1, it indicates the presence of a trend and non-stationarity. We test for it using the Augmented Dickey-Fuller Test, which tests for the presence of unit root under the null hypothesis. The test shows that we cannot reject the null hypothesis of non-stationarity. Alternatively, the Kwiatkowski *et al.* (1992) KPSS test was applied having the trend-stationarity as a null hypothesis. In our sample,

the KPSS test rejects the null hypothesis on 95 %, supporting the alternative hypothesis of a unit root. Therefore, the CISS is first-differenced[1] ($\Delta CISS_t = CISS_t - CISS_{t-1}$) for the purpose of next regression analysis. According to the Augmented Dickey-Fuller test, we can reject the presence of unit root in the $\Delta CISS_t$ at 1% significance level.

Figure 5.1: CISS over analysed sample period



Note: The upper graph shows the level of CISS over the tested sample period. Note that the original CISS data were multiplied by 100. The bottom graph compares the absolute differences of CISS (the dark red line) and the logarithmic differences of CISS (the light grey line). *Source*: Author's own calculations.

Using Auto-Correlation function and Partial Auto-Correlation function of $\Delta CISS_t$, serial correlation of first order with negative sign is further identified. Therefore, three simple univariate models specification of $\Delta CISS_t$ are compared. While ARMA(1,1) shows evidence of over-fitting, the AR(1) and MA(1) models shows qualitatively very similar results with slightly lower Akaike Information Criterion (AIC) for the MA(1) model, which becomes the stepping stone for further analysis.

[1]Alternatively, the log-differences (by grey color in Figure 5.1) expressing the percentage change was studied. Nevertheless, such a transformation magnifies the variation in low stress periods compared to periods of higher stress, which is undesirable, and the following analysis uses absolute differences.

We can also notice the heteroscedasticity in $\Delta CISS_t$ as the variance of $CISS$ increases with the higher level of stress. Even authors of the CISS (Holló *et al.* 2012) identify that there are up to 3 regimes of CISS using Markov Switching Model. On substantially longer time series, they develop 3 regimes model with regime dependent intercepts and variance of residuals, while having regime independent AR(1) term. We try to address this issue in Hypothesis 3.

5.2 Modeling approach for testable hypotheses

In order to test the hypotheses 1 and 2, the base Moving Average model of the first order, MA(1), is enriched by adding explanatory variables of interest. Those are either official or ad-hoc communication variables. On top of that we also include two control variables $EPUI$ and CLI that are supposed to be exogenous and should control for policy uncertainty and real economy cycle. The presented models could be formalized as:

$$\Delta CISS_t = \alpha\epsilon_{t-1} + \boldsymbol{\beta X_t} + \boldsymbol{\gamma Z_t} + \epsilon_t \tag{5.1}$$

Where $\boldsymbol{X_t}$ is the matrix of communication variables, which varies according to the tested hypothesis. $\boldsymbol{Z_t}$ is matrix of control variables $(\Delta EPUI_t; \Delta CLI_t)'$ that remains the same for almost all model specifications. The ϵ_t is the error term assumed to be IID and ϵ_{t-1} represents the MA(1) term. The α, $\boldsymbol{\beta}$, $\boldsymbol{\gamma}$ are respective parameters to be estimated. This model can be estimated by standard Maximum Likelihood estimator.

Alternatively to model specification 5.1, the moving average term (ϵ_{t-1}) is in some cases replaced by auto-regressive term ($\Delta CISS_{t-1}$).

$$\Delta CISS_t = \alpha\Delta CISS_{t-1} + \boldsymbol{\beta X_t} + \boldsymbol{\gamma Z_t} + \epsilon_t \tag{5.2}$$

Similarly to CISS, also the ad-hoc communication variables are tested for stationarity. While the intensity of communication (*comm.count*) seems to be stationary,[2] the sentiment of ad-hoc communication is highly positively autocorrelated from week to week and even the Dickey-Fuller test cannot reject the presence of unit root. Therefore the communication sentiment variables are

[2]There is a negative autocorrelation of the ad-hoc communication intensity, where the current week increased communication intensity is likely to be followed with decreased communication intensity in the next week.

differenced for the purpose of regression analysis, which removes any doubt on the presence of unit-root.

The Hypothesis 3 is tested using the so called Threshold Auto-Regressive model (TAR), which basically only adds the cross-products with regime specific dummy variables to 5.2.[3] This enables us to compare the estimated coefficient for different regimes and test whether the CISS is in high stress regime more sensitive to ECB communication. The final model specification is formalized:

$$\begin{aligned}\Delta CISS_t =& (\alpha_L \Delta CISS_{t-1} + \boldsymbol{\beta_L X_t} + \boldsymbol{\gamma_L Z_t}) * I\left[CISS_{t-1} < \tau\right] \\ &+ (\alpha_H \Delta CISS_{t-1} + \boldsymbol{\beta_H X_t} + \boldsymbol{\gamma_H Z_t}) * I\left[CISS_{t-1} \geq \tau\right] + \epsilon_t \end{aligned} \tag{5.3}$$

Where τ is the threshold value which is unknown parameter and $I[\cdot]$ is binary indicator of the condition in brackets. Consequently, the model 5.3 is not linear in parameter. Estimation procedure is described by Tong (1990) and commonly referenced as Self-Exciting TAR (SETAR). Once the threshold is set, the model becomes linear in parameters and can be estimated using OLS. Therefore, the $\hat{t}au$ could be selected by repetitive grid search along the possible threshold values. In this case, the chosen optimized statistic is AIC as shown in Figure 6.3.

We limit the set of possible threshold values to keep at least 20 % of observation in each regime which is equivalent to 59 observations. This further reduces the degrees of freedom for estimation of regime specific coefficient. Therefore, the model is further simplified by forcing certain coefficients to be regime independent based on AIC comparison and similarity of coefficients for both regimes. Finally, the preferred model specification is the following with $\alpha_L = \alpha_H$ and $\boldsymbol{\gamma_L} = \boldsymbol{\gamma_H}$:

$$\begin{aligned}\Delta CISS_t =& \alpha \Delta CISS_{t-1} + (\boldsymbol{\beta_L X_t}) * I\left[CISS_{t-1} < \tau\right] \\ &+ (\boldsymbol{\beta_H X_t}) * I\left[CISS_{t-1} \geq \tau\right] + \boldsymbol{\gamma Z_t} + \epsilon_t \end{aligned} \tag{5.4}$$

The Hansen (1997) test of threshold adequacy is customized for the final specification of TAR model (5.4). The test is an F-test based where the Sums of Squares Residuals (SSR) are compared for the unrestricted TAR model and

[3] Alternatively, Holló *et al.* (2012) use the Markov Switching model, which is indeed more sophisticated, but on the other hand it requires to estimate additional coefficient, which leads us to use of more straight forward TAR model.

the restricted linear model without regimes (5.2). Under the null hypothesis, those models are similar suggesting no regimes in data.

It is easy to calculate standard F-statistics, but the critical values need to be simulated using bootstrap method, because the threshold is not identified under null hypothesis. Simulation is done based on Hansen (1997) procedure in 3 repetitive steps. First, random numbers are drawn from standard normal distribution. Second, both models restricted and unrestricted are fitted with generated numbers as an explained variable. Third, F statistics is calculated for each repetitive run. The critical values of Hansen test is then obtained as a percentiles of simulated distribution of our F statistic. We use 5000 iteration in simulation for this analysis.

5.3 Simultaneity of CISS and ECB communication

Common econometric issue is the endogeneity of an explanatory variable. In the case of financial systemic stress and central bank communication, there could be suspicion of simultaneous effects resulting in endogeneity of both variables and corrsponding bias in estimated coefficients. It is quite possible that the members of ECB GC respond to the overall level of stress in the system in their speeches or that it influences the frequency with which they communicate with the public. For example, it might be likely that the ECB GC members try to reduce the uncertainty on financial markets in periods of higher stress by communicating more often than in low stress periods. Also, the content of their statements may be affected by a high stress environment so that their statements have more negative character.

On the other hand, the nature of our data may overcome the simultaneity issue. In fact, Gertler & Horváth (2018) construct the communication dataset only from forward-looking statements. If these statements are actually fully forward-looking and based on expected macroeconomic developments, it is unlikely that the communication events would be endogenous. The financial systemic stress should then have no or very limited effect on this ECB communication Gertler & Horváth (2018). However, if the uncertainty in the economy is too high, the current state of the economy may be a more accurate signal of future development than forward-looking expectations. In this case, simultaneity may become an issue.

Therefore besides the ARIMA model described in the above section, which assume the exogeneity of the ECB communication variables, we also construct

and estimate a Vector Autoregressive models (VAR) that allow to control for simultaneous effect. These are constructed in structural form as a system of two equations:

$$\Delta CISS_t = \alpha_1 + \delta_{1,2}\Delta CISS_{t-1} + \beta_{1,1}X_t + \beta_{2,1}X_{t-1} + \boldsymbol{\gamma_1 Z_t} + \epsilon_t \tag{5.5}$$

$$X_t = \alpha_2 + \delta_{2,1}\Delta CISS_t + \delta_{2,2}\Delta CISS_{t-1} + \beta_{2,2}X_{t-1} + \boldsymbol{\gamma_2 Z_t} + \nu_t \tag{5.6}$$

Where X is the communication variable that is suspected of being endogenous and $\boldsymbol{Z}$ is matrix of exogenous variables. Such structural VAR model is not identified and cannot be directly estimated without additional assumptions. Therefore the reduced form model is estimated equation by equation using OLS :

$$\Delta CISS_t = a_1 + c_1\Delta CISS_{t-1} + b_1X_{t-1} + \boldsymbol{\gamma_1 Z_t} + e_t \tag{5.7}$$

$$X_t = a_2 + c_2\Delta CISS_{t-1} + b_2X_{t-1} + \boldsymbol{\gamma_2 Z_t} + v_t \tag{5.8}$$

The estimates of coefficients $\hat{a}$, $\hat{b}$ and $\hat{c}$ are decomposed to the structural coefficients $\hat{\alpha}$, $\hat{\beta}$ and $\hat{\gamma}$ using the Cholesky decomposition, which directly assumes that $\delta_{2,1} = 0$. This means that we assume that systemic stress ($\Delta CISS_t$) has no contemporaneous effect to ECB communication and it can have only lagged effect. Even though, this is a strong assumption, it seems plausible, because the ECB representatives do not necessarily need to be well informed about the contemporaneous development of the systemic stress in current week and therefore they react only with some lag based on developments in the past weeks.

Resulting effects of structural model identified by Cholesky decomposition are visualized by orthogonal Impulse Response Functions (IRF). Those are constructed to show the dynamic response of variables to structural shocks in error terms ϵ_t and ν_t of equations 5.5 and 5.8. In order to show statistical relevance of estimated IRFs, confidence intervals are simulated using the bootstrap method that repetitively sample the structural errors and re-estimate the IRFs. The detailed methodology of VAR models including IRF is described by Lütkepohl (2005).

Chapter 6

Results

6.1 Communication intensity effect

According to Hypothesis 1 the ECB provides valuable information and thus helps to reduce uncertainties in the financial markets and the more communication, the larger the decrease of CISS. The model described under Equation 5.1 in Section 5.2 is estimated by MLE and the results are presented in Table 6.1 in columns (1) and (2). The variables of interest are the number of ad-hoc communication events in a given week *comm.count* and a dummy indicating whether a official press conference was held $press\ conf$. In model (2) a squared communication amount is also included to test whether there is some level since which the communication starts to be harmful. The model was also estimated with lagged values of *comm.count* and $press\ conf$, however this model specification shows signs of overfitting.

The estimated coefficients are negative and very low in magnitude, but also insignificant for the amount of unofficial communication in both model specifications. There also seems to be no effect of squared ad-hoc communication amount. On the other hand, the coefficient on $press\ conf.$ is significant and positive, which is the opposite of what is expected under Hypothesis 1, and suggests that if a policy meeting with press conference occurs, the CISS increases by about 1.5 in the same week. This is a small but non-negligible effect.

The control variables are also significant and their coefficients have the expected sign. When the CLI indicates unfavourable real economy outlook, the CISS increases. The coefficient on EPUI suggests that the more newspaper articles mention policy uncertainty, the higher the increase in CISS.

As described in Section 5.3, the amount of unofficial communication could

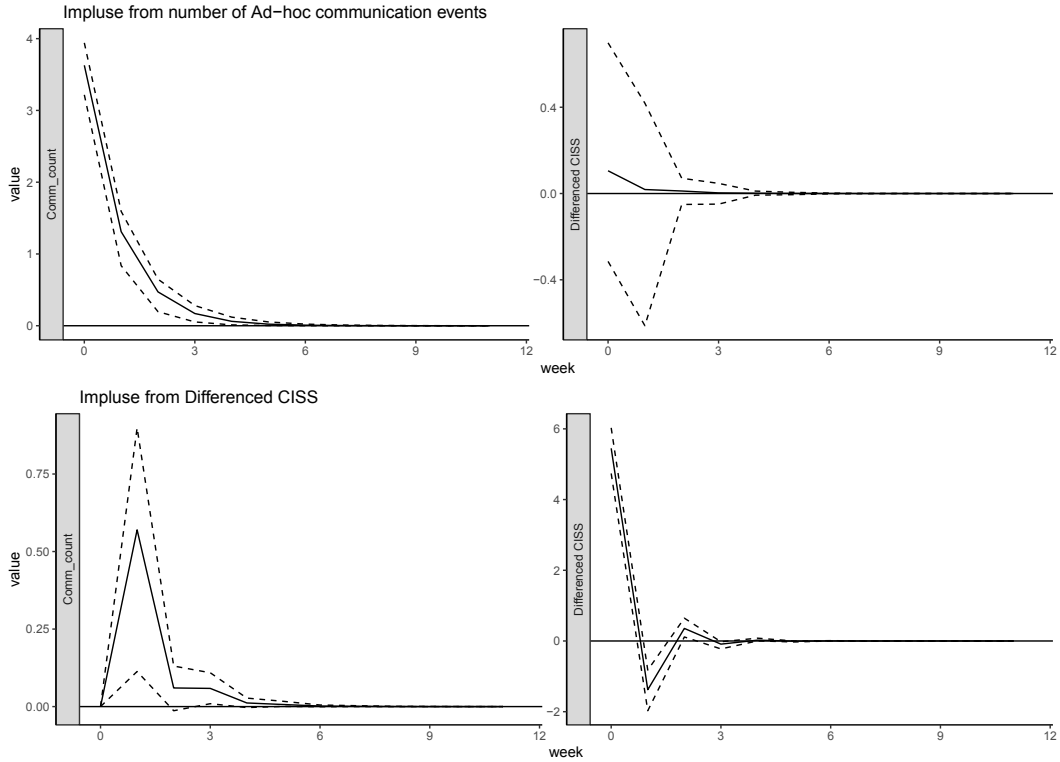
Table 6.1: ARIMA and VAR models estimates to test Hypothesis 1

	ARIMA		*VAR*	
	Δ CISS	Δ CISS	Δ CISS	# Comm
	(1)	(2)	(3)	(4)
Δ comm.count	−0.054	−0.174		
	(0.038)	(0.107)		
Δ comm.count [sqr]		0.011		
		(0.009)		
press conf. [dummy]	1.226*	1.547**	1.977**	−4.149***
	(0.690)	(0.737)	(0.777)	(0.517)
Δ comm.count [lag]			0.012	0.358***
			(0.078)	(0.052)
Δ CISS [lag]			−0.253***	0.105***
			(0.057)	(0.038)
MA[1]	−0.419***	−0.423***		
	(0.068)	(0.068)		
Δ EPUI	0.088***	0.092***	0.099**	−0.002
	(0.025)	(0.025)	(0.040)	(0.026)
ΔCLI	−8.420***	−7.454**	−10.809**	−2.086
	(2.841)	(2.925)	(5.020)	(3.342)
const			−0.654	4.011***
			(0.502)	(0.334)
Observations	290	290	289	289
R^2			0.104	0.264
Adjusted R^2			0.088	0.250

Note: Columns (1) and (2) present results of two different ARIMA models, columns (3) and (4) present results of a VAR model. Variables marked with Δ are differenced, [sqr] denotes that the variable is squared, [dummy] denotes dummy variable, [lag] denotes lagged variables. MA[1] is the moving average term of order 1. The standard errors are reported in the parentheses, stars denote significance on 10% (*), 5% (**) and 1% (***) significance level.

also be endogenous on the CISS, because it is possible that the policy makers adjust their communication intensity to the current financial systemic stress. Therefore VAR model is estimated according to the specification in Section 5.3.

Figure 6.1: Impulse response functions of VAR model testing Hypothesis 1



Note: Orthogonal impulse response functions corresponding to VAR model results in columns (3) and (4) of Table 6.1. The impulse response functions are depicted by the solid line, dashed lines represent 90% confidence intervals derived using bootstrap. *Source*: Author's own calculations.

The results of the VAR model are presented in Table 6.1 in columns (3) and (4) with dependent variables $\Delta CISS$ and *comm.count*, respectively. The amount of ad-hoc communication has no significant effect on the change of CISS and indeed it seems that there is mild reverse causality – that ECB representatives tend to communicate more when the systemic stress grows. Furthermore, the results of model (4) show that the amount of unofficial communication is strongly affected by the official press conference. The ad-hoc communication on average decreases by more than 4 communication events in those weeks when the press conference is held. The official communication enters the VAR model as an independent variable because the policy meetings and subsequent press conferences are scheduled every four weeks, regardless of the level of stress. Its

occurrence is thus exogenous. The effect of a press conference on change in CISS is again significant and positive with coefficient 1.98.

The structural VAR model is illustrated by the impulse response functions depicted in Figure 6.1. The upper right part of the figure shows the response of CISS to a shock in amount of communication. We can see that the response in CISS is very low and highly insignificant. The bottom left part of the figure depicts the response of communication amount to a shock in CISS. In this case, the response in the amount of communication is significant, but dies after two weeks.

The amount of ad-hoc communication thus seems to have no significant effect, while the official press conferences seem to slightly increase the CISS. This could be explained such that the markets need to adjust to the new information and therefore the stress rises. This finding, contrary to Hypothesis 1, suggests that information provided during these press conferences are processed by financial market agents heterogenously which increases the uncertainties and consequently the CISS. Other explanation may be that already the expectations prior to the press conference about its outcome are diverse among the financial market agents and that could lead to an increase in CISS as well.

6.2 Communication content effect

Estimation results presented in the previous section indicate that the amount of ad-hoc ECB communication does not affect the CISS. Nevertheless, the content of the communication might be more important than its intensity and so this section examines whether it matters to the CISS. The variables of interest are the overall sentiment of ad-hoc communication events in a given week *comm.sum* and inclination indicators of monetary policy related content $MP\ index$ and economic outlook related content $EC\ index$ of the ECB press conference. The dummy variable indicating press conference occurrence $press\ conf.$ is also kept in the model because the previous section found its effect to be significant for the change in CISS.

The results of the MA(1) model are presented in column (1) of Table 6.2. The coefficient on our variables of interest are all negative, indicating that positive news causes a slight decrease in the CISS, whereas negative news causes the opposite.

The effect of ad-hoc communication is weakly significant, but fairly small - one more positively inclined statement decreases the CISS by 0.2. The press

conference sentiment seems to have no effect on the CISS, neither the monetary policy related content, nor the economic outlook related content. A possible explanation of this may be that the public adjusts their expectations to the news from press conference heterogenously, which raises the CISS, regardless of the sentiment of this communication.

Given that the estimation shows some weak evidence in support of the Hypothesis 2, we further focus on whether ad-hoc statements with certain characteristics cause a larger change in CISS as presumed under Hypothesis 2.1. The official communication has always the same characteristics therefore there is nothing to be tested in this way.

The results are summarized in columns (2) – (10) of Table 6.2 and indicate that some of the characteristics may actually increase the importance of the statement, yet most of them are only little significant. The CISS seems to react stronger if the speaker is the president of ECB or national governor from a southern state. On the contrary, it does not matter if the communication event occurs in a financial center or if the speaker comes from a core member state of the euro area. The topic of the communication seems to matter as well because we find the coefficients for non-standard measure news to be significant. Also, monetary policy related ad-hoc communication seems to matter more than the one regarding economic outlook. Finally, the statements also matter more the closer they are before the policy meeting because they may indicate the outcome of the policy meeting which is found to matter for the CISS.

Even though these results are in line with what we hypothesise in Hypothesis 2.1, they are not a proper test of whether the specific communication events truly matter more than others. This is because the models' estimates do not include the variable of total communication sentiment. Such results are presented in Table A.1 in Appendix A and show that we can not formally reject that the effect is the same for the selected specific communication compared to the other communication. This statistically unsupportive tests can be partly caused by the high correlation of selected communication sentiment variable with the overall communication sentiment variable. In combination with relatively low number of observations it results in high standard errors of the estimates and indecisive test.

The Hypothesis 2.1 thus can not be properly corroborated, however it can be noticed that the estimates in Table 6.2 indicate a stronger effect of certain unofficial communication compared to the effect of overall communication. This brings us to an idea to construct a variable which weights the importance of

each communication event based on the characteristics that are likely to affect the CISS stronger according to the results in Table 6.2. This variable should capture that some communication events may be more important than others while reducing dimensionality of the data. It is labeled *IWCS* (importance weighted communication sentiment) and the exact definition of this variable is described in Section 4.2.

We run the model estimation with the new variable and find its coefficient to be negative as expected and significant on 5% significance level. It suggests that importance weights are relevant and provide better fit of the data. The $IWCS$ is thus used in further analysis. The magnitude of the coefficient indicates that the CISS changes by $-0.427 \cdot 0.9 = -0.384$, if there is one more communication event with the highest weight, which is by the ECB president, one day before policy meeting, concerning non-standard monetary policy measure.[1] For somehow average communication event given by national central bank governor, two weeks before policy meeting and concerning standard monetary policy issue, the effect is $-0.427 \cdot 0.51 = -0.218$, which is fairly similar as for the flat sum *comm.sum* in model (1). Therefore, the average effect is comparable for both measures, nevertheless the better fit of IWCS, represented by higher significance level, is also indirect support for Hypothesis 2.1.

Under Hypothesis 2.2 it is suggested that the communication sentiment may have asymmetric effect on the systemic stress, meaning that negative news may cause greater change in the CISS than positive news. This hypothesis is tested similarly as Hypothesis 2.1 and the results are presented in Table 6.3. The total sentiment of the negatively inclined ad-hoc communication is filtered in the data *comm.negative* and its estimated coefficient is almost twice as high than for the total sentiment, which indicates larger effect of negative news on CISS. Nevertheless, if both variables *comm.sum* and *comm.negative* are estimated in one model, their coefficients are not significant and the possibility that there is no difference between the effects of negative news and positive news can not be rejected. Same as before, it may be attributed to low number of observation and high correlation between these two variables.

Analogously, $IWCS$ *negative* is created to account for importance weighted negative news and also the conclusions are quite the same - the negative news seems to matter more, even though the test in model specification Appendix A can not reject that there is no significant difference. Still, the magnitude of

[1] The highest weight is in fact 0.9 as it is not possible for the speaker to be the ECB president and also southern country national governor.

coefficient is weakly supportive for Hypothesis 2.2. We therefore broaden the *IWCS* to assign higher weight also to negatively inclined communication and call this new variable *AIWCS* - asymmetric importance weighted communication sentiment. The estimated coefficient on *AIWCS* is again significant and more negative than for the *IWCS*.[2]

The dummy for press conference occurrence is kept in the model as it is significant and its coefficient stays virtually the same in all estimated specifications. The variables *MP index* and *EC index* for press conference sentiment did not test significant in the previous analysis, therefore they are not included. Also, distinguishing the effects of positive and negative news is not possible for the official communication due to the nature of the available data.

Results form the previous Section 6.1 indicate that the amount of ECB communication is somehow influenced by the change in CISS and so it is considered that the CISS may also affect the sentiment of communication. VAR model is estimated for the variables that tested significant in the simple MA(1) model analysis - for the total communication sentiment *comm.sum*, importance weighted communication sentiment *IWCS* and also for the asymmetric importance weighted communication sentiment *AIWCS*. All the three models show no significant effect of the ad-hoc communication sentiment on the change in CISS, but also no reverse effect from CISS to communication sentiment. The results are presented in Table B.1 in Appendix B since they show no significant coefficients and do not indicate endogeneity of the unofficial communication by Granger causality test. Therefore the VAR model is abandoned in further analysis.

The results estimated in this section thus provide some evidence for Hypothesis 2, 2.1 and 2.2 that there is a effect of central bank communication sentiment on the change in CISS. Nevertheless, this effect is fairly low and only for the ad-hoc communication sentiment, the sentiment of policy meeting press conference seems to have no effect. The VAR model estimation does not provide an evidence of reversed causality of the communication sentiment, therefore the further analysis builds on the ARMA models.

[2]Note that magnitudes of coefficients on *IWCS* and *AIWCS* need to be compared with caution as the weighting scheme slightly distorts the base units.

Table 6.2: ARIMA models estimates to test Hypotheses 2 and 2.1

Δ CISS [ARIMA]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
MA[1]	−0.439***	−0.441***	−0.436***	−0.435***	−0.429***	−0.433***	−0.439***	−0.428***	−0.433***	−0.440***
	(0.068)	(0.068)	(0.069)	(0.067)	(0.068)	(0.069)	(0.068)	(0.068)	(0.068)	(0.068)
Δ EPUI	0.083***	0.087***	0.084***	0.086***	0.088***	0.087***	0.082***	0.089***	0.082***	0.083***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)	(0.024)	(0.024)	(0.025)	(0.024)	(0.024)
Δ CLI	−7.830***	−8.035***	−7.945***	−7.958***	−8.184***	−8.037***	−7.593***	−8.200***	−7.795***	−7.755***
	(2.706)	(2.689)	(2.722)	(2.724)	(2.765)	(2.729)	(2.702)	(2.767)	(2.728)	(2.699)
press conf. [dummy]	1.540**	1.653**	1.565**	1.804***	1.702**	1.618**	1.502**	1.721**	1.527**	1.521**
	(0.692)	(0.686)	(0.691)	(0.686)	(0.696)	(0.684)	(0.687)	(0.687)	(0.687)	(0.690)
Δ EC index	−3.619	−2.812	−3.118	−3.139	−2.020	−2.425	−4.420	−1.850	−3.173	−3.864
	(3.780)	(3.691)	(3.740)	(3.712)	(3.690)	(3.656)	(3.787)	(3.710)	(3.691)	(3.769)
Δ MP index	0.946	1.059	0.988	1.143	1.050	0.934	0.686	1.021	1.041	0.913
	(1.831)	(1.830)	(1.830)	(1.827)	(1.842)	(1.824)	(1.827)	(1.838)	(1.821)	(1.828)
Δ comm.sum	−0.199*									
	(0.113)									
Δ president		−0.846*								
		(0.463)								
Δ core			−0.207							
			(0.137)							
Δ south				−0.671*						
				(0.380)						
Δ fin.center					−0.014					
					(0.240)					
Δ non-standard						−0.459*				
						(0.238)				
Δ Monetary Policy							−0.413**			
							(0.173)			
Δ Economic Outlook								0.070		
								(0.278)		
Δ DtoGC									−0.777**	
									(0.376)	
Δ IWCS										−0.427**
										(0.207)
Observations	290	290	290	290	290	290	290	290	290	290
Akaike Inf. Crit.	1,798	1,798	1,799	1,798	1,802	1,798	1,796	1,801	1,797	1,797

Note: Δ CISS is the dependent variable in all 10 ARIMA models. Variables marked with Δ are differenced, [dummy] denotes dummy variable, MA[1] is the moving average term of order 1. The standard errors are reported in the parentheses, stars denote significance on 10% (*), 5% (**) and 1% (***) significance level.

Table 6.3: ARIMA models estimates to test Hypothesis 2.2

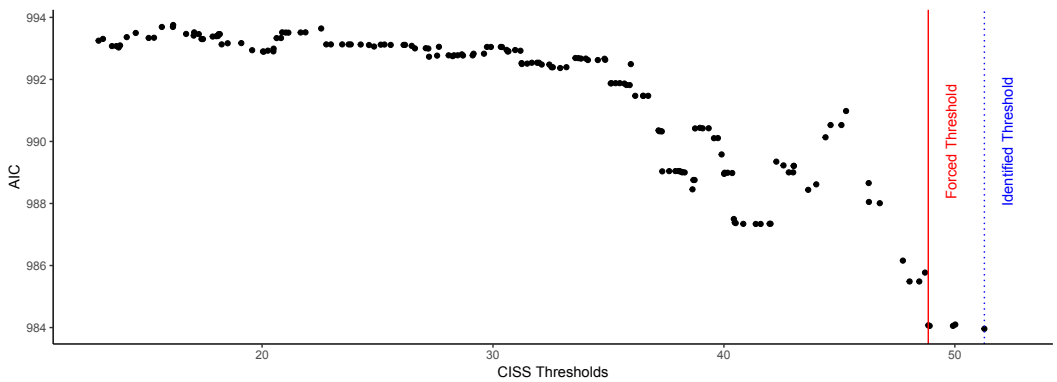
	Δ CISS [ARIMA]						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
MA[1]	−0.436***	−0.454***	−0.455***	−0.437***	−0.456***	−0.456***	−0.446***
	(0.068)	(0.066)	(0.066)	(0.068)	(0.066)	(0.066)	(0.068)
Δ EPUI	0.084***	0.081***	0.082***	0.083***	0.081***	0.081***	0.081***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Δ CLI	−7.927***	−7.906***	−7.926***	−7.867***	−7.869***	−7.874***	−7.818***
	(2.719)	(2.620)	(2.618)	(2.713)	(2.608)	(2.609)	(2.662)
press conf. [dummy]	1.766***	2.189***	2.228***	1.777***	2.223***	2.234***	1.964***
	(0.557)	(0.590)	(0.623)	(0.556)	(0.588)	(0.619)	(0.564)
Δ comm.sum	−0.175		0.032				
	(0.109)		(0.165)				
Δ comm.negative		−0.348**	−0.382*				
		(0.151)	(0.229)				
Δ IWCS				−0.380*		0.018	
				(0.199)		(0.308)	
Δ IWCS negative					−0.696**	−0.715*	
					(0.273)	(0.421)	
Δ AIWCS							−0.568**
							(0.245)
Observations	290	290	290	290	290	290	290
Akaike Inf. Crit.	1,795.930	1,793.169	1,795.131	1,794.887	1,791.999	1,793.996	1,793.143

Note: Δ CISS is the dependent variable in all 7 ARIMA models. Variables marked with Δ are differenced, [dummy] denotes dummy variable, MA[1] is the moving average term of order 1. The standard errors are reported in the parentheses, stars denote significance on 10% (*), 5% (**) and 1% (***) significance level.

6.3 Regime-dependent communication effect

According to the Hypothesis 3 the regime of stress may matter for the communication importance. This hypothesis is tested by a SETAR model as described in 5.2, which identifies a threshold value of CISS determining two different regimes - low stress regime and high stress regime. Three model specifications are estimated with three different unofficial communication sentiment variables that tested to be significant in the previous analysis of Hypothesis 2 - the simple sum of weekly sentiment *comm.sum* and the two importance weighted measures *IWCS* and *AIWCS*. The dummy variable indicating policy meeting press conference is also included in the model as it seems to affect the change in CISS. The sentiment of official press conference was also tested for different regimes, but without any significant results, therefore it is not included in final model specification.

Figure 6.2: Threshold estimation for the SETAR model



Note: The figure plots AIC against different potential thresholds for the CISS. The threshold with the lowest AIC is marked by the blue dashed line, the chosen threshold is marked by the full red line. *Source*: Author's own calculations.

The identified threshold varies depending on the variables used in the model specification but since all the three communication variables are very similar, also the thresholds are close to each other for all the estimated models. The plot of possible thresholds in CISS against the AIC for the model with *comm.sum* is presented in Figure 6.2, analogous plots for models with *IWCS* and *AIWCS* look similar. The identified threshold with the lowest AIC is marked by the blue dashed line, which is on the bound given by the condition of at least 20 % observation for each regime.[3] Eventually we choose the one threshold value

[3]There are only 291 observations in the sample, therefore this step ensures that there are enough observations to estimate each of the regime-specific models.

of CISS (48.85, marked by the red full line) for all three models to make the subsamples directly comparable. This threshold has very similar AIC as the identified thresholds and also marks the clear decline in the AIC. Figure 6.3 then plots the chosen threshold in CISS over the level of CISS in the analysed sample period.

Figure 6.3: Identified threshold of CISS regimes

Note: The figure plots the level of CISS over analyzed sample period, red horizontal line marks the threshold between low and high stress regimes used in analysis. *Source*: Author's own calculations.

For all three models specification and selected threshold value, the Hansen test, comparing the models with and without thresholds, strongly rejects that there is no threshold, which supports the adequacy of selected SETAR model. In fact, the F-statistics is 1.90 for the specification with *comm.sum* as an explanatory variable, model (1) in Table 6.4, while the simulated critical values for 90%, 95% and 99% are 0.94, 1.22 and 1.88, respectively. Therefore, the null hypothesis is rejected even on 99% confidence level.

The results of the SETAR models estimation are presented in Table 6.4 and show a compelling support for the Hypothesis 3. The estimated coefficients on all the three communication sentiment variables in the high stress regime are significant and have larger magnitudes than in the model with only one stress regime. Contrarily, there seems to be no effect of the unofficial communication sentiment in the low stress regime. However, even in the high stress regime the effect of unofficial communication on CISS is still relatively low. According to the coefficient on *comm.sum*, if the change in communication sentiment is 1, the CISS changes by -0.404. That is a fairly small change in CISS with values between 0 and 100.

The weighted variables need to be interpreted more carefully. The coefficient on *IWCS* indicates that the CISS changes by $-0.791 \cdot 0.9 = -0.712$, if there is

one more communication event with the highest weight, which is by the ECB president, one day before policy meeting, concerning non-standard monetary policy measure. However, if the communication event is given by national central bank governor, two weeks before policy meeting and concerns standard monetary policy, its effect on CISS is only $-0.791 \cdot 0.51 = -0.403$ which is very similar to the unweighted measure. The model with $AIWCS$ indicates that the communication events with the highest weight and negative sentiment increase the CISS by $0.802 \cdot 0.9 = 0.722$, while the positively inclined communication events would decrease the CISS by only a half of that, by 0.361.

Presence of the official press conference increases the CISS by roughly 5.5 in the high stress regime under all the model specifications, which is a considerable change. This effect is also more than three times what was estimated in the general model, while there seems to be no effect in the low stress periods. The control variables EPUI and CLI are included as regime independent to simplify the model. When estimated in as regime-dependent, their coefficients were largely similar in both regimes.

According to the SETAR model estimation, the effect of unofficial communication sentiment on the CISS thus seems to be minimal even in the high stress periods, however significant. In the low stress periods there seems to be no effect at all. Occurrence of the official press conference increases the CISS notably also only in the high stress regime. This evidence support the hypothesis that the public pays more attention to the central bank communication in periods of increased financial stress. This may be explained such that information are more valuable in times of uncertainty or that the public expects the central bank to inform about future outlook or crisis measures.

Table 6.4: SETAR models estimates to test Hypothesis 3

	Δ CISS		
	(1)	(2)	(3)
low stress: comm.sum [Δ]	−0.002		
	(0.128)		
high stress: comm.sum [Δ]	−0.404**		
	(0.160)		
low stress: IWCS [Δ]		−0.047	
		(0.236)	
high stress: IWCS [Δ]		−0.791***	
		(0.289)	
low stress: AIWCS [Δ]			0.036
			(0.323)
high stress: AIWCS [Δ]			−0.802***
			(0.300)
low stress: Conference [dummy]	0.640	0.617	0.647
	(0.759)	(0.757)	(0.748)
high stress: Conference [dummy]	5.456***	5.590***	5.786***
	(1.532)	(1.533)	(1.565)
Δ CISS [AR1]	−0.248***	−0.246***	−0.251***
	(0.056)	(0.056)	(0.056)
EPUI [Δ]	0.088**	0.087**	0.089**
	(0.039)	(0.039)	(0.039)
CLI [Δ]	−9.128*	−9.039*	−9.049*
	(4.980)	(4.970)	(4.972)
Observations	289	289	289
R^2	0.130	0.133	0.132
Adjusted R^2	0.108	0.112	0.110

Note: Δ CISS is the dependent variable in all 3 SETAR models. Variables marked with Δ are differenced, [dummy] denotes dummy variable. low stress/high stress indicates whether the coefficient is estimated in low or high stress regime. The standard errors are reported in the parentheses, stars denote significance on 10% (*), 5% (**) and 1% (***) significance level.

Chapter 7

Conclusion

Over the last three decades, the central bank transparency and communication evolved dramatically. The communication strategy has come a long way from Fed's Alan Greenspan taking pride in "mumbling with great incoherence" and general aura of mystery in the 1980s to publishing minutes and voting records from policy meetings and press conference statements spoken in plain English today. The ECB has been more transparent then the Fed since its establishment, still its communication has developed notably to a greater openness and contributed to the effectiveness of its monetary policy (De Haan & Jansen 2009). The means and channels of central bank communication have also expanded and the central bank representatives nowadays communicate more often even between policy meetings and beyond official forms of communication to satisfy the ever-increasing public demand for information. Communication developed into a powerful instrument in central banks' toolkit (Blinder *et al.* 2008).

A rich stream of literature studies how the central bank communication affects public opinions and financial market development. It brings a considerable evidence of central bank communication being able to influence various aspects of financial markets. Numerous studies document the effects of central bank communication in various forms and argue that it can affect both level and volatility of stock prices (Blinder *et al.* 2008), interest rates (Rosa & Verga 2007), and exchange rates (Fratzscher 2008). Nevertheless, there seems to be only little research devoted to the effect of central bank communication on the financial stability or financial systemic stress. This thesis aims to fill in this space.

The stress in financial system can hinder economic growth and if it spreads

to more segments of financial markets, it can eventually escalate into a crisis. Existing research also shows that even small shocks in the systemic stress can have quite considerable and long-lasting impacts on economic activity, output or inflation (Mallick & Sousa 2013; Davig & Hakkio 2010). This evidence provides an incentive for the researchers to further study the systemic stress and also for the policy makers to closely monitor the stress conditions.

This thesis focuses on the ECB and both its official and unofficial oral communication. We formulate several specific hypotheses about the relationship between communication and financial systemic stress measured by a complex indicator of systemic stress, the CISS. We aim to assess the effect of amount of communication, its sentiment, whether certain communication can have stronger effect than other and also whether the communication has different impact in normal times compared to times of distress.

Our empirical analysis finds no evidence that the amount of ECB ad-hoc communication can influence the CISS. Contrarily, it seems that there is a mild reverse causality - the ECB representatives communicate more when the stress increases. On the other hand, the CISS rises in weeks when policy meeting press conferences are held. This can indicate that the public has diverse expectations about the the outcome of the policy meeting or that it adjusts to the news introduced in the press conference heterogenously. Nevertheless, the effect is short-term and not very high.

The sentiment of the ad-hoc communication seems to affect the CISS, however this effect is even smaller. We also show a weak support for the hypothesis that certain ad-hoc communication with specific characteristics can have a stronger effect than other communication. Therefore we construct a measure of importance-weighted communication sentiment which is found to better fit the data. Interestingly, the sentiment of official press conferences shows no effect on the CISS.

Finally, we find a compelling evidence that the occurrence of a press conference and sentiment of the ad-hoc communication plays a notably greater role in the periods of heightened systemic stress. Even thought the estimated effects are again fairly small, they should not be neglected because other research finds considerable material impacts of even a small shock in the financial systemic stress, especially in periods of distress.

Few drawbacks of the analysis however need to be mentioned. Most importantly, the financial systemic stress data are constructed only with weekly frequency which forces us to aggregate the communication data to the same

frequency. This way considerable information is lost and also the results are not so straightforward to interpret. Daily data on the systemic stress could certainly improve the analysis.

The analysis could also benefit from a longer sample period and thus more observations which could also help to more precise and more significant results. The studied sample period is actually a period with the highest historical values of financial systemic stress since 1999 which provides for not a particularly representative sample. Including a longer pre-crisis and post-crisis period could cause arriving to a different patterns in the results. Furthermore, even though we try to test and account for endogeneity of the communication on the systemic stress, it may still be an issue in the analysis.

Nevertheless, although there are some limitations, we still believe that our empirical analysis provides some evidence that the ECB communication can affect the financial systemic stress. The effects seem to be small, but considering the frequency with which the ECB communicates, they can add up to a non-negligible influence. Provided that it is corrected for the drawbacks of our analysis, future research on the proposed relationship may bring valuable findings.

This thesis also contributes to the empirical literature concerning effects of unofficial communication because it utilizes a rich and quite unique dataset of ad-hoc ECB GC members' speeches and interviews developed by Gertler & Horváth (2018). This type of central bank communication is not covered very often in the existing literature because it is rather demanding to compile a sufficiently large dataset. Nevertheless, the importance of the ad-hoc communication may be increasing because it can address new developments on financial market with greater flexibility. Considering that the sample period of our analysis covers the last financial crisis, it can also contribute to the literature studying its specifics.

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Appendix A

Test results of Hypothesis 2.1

This Appendix presents the results of testing the Hypothesis 2.1. According to this hypothesis, communication with certain characterisitcs should have a greater effect on the CISS than other communication. This is empirically tested by including both the overall communication sentiment (*comm.sum*) and also a measure of only the specific communication sentiment, for instance by the ECB president (*president*) in model (1). The effect of president's communication is thus the sum of estimated coefficient on the *comm.sum* and on the *president*. Under the null hypothesis of a simple t-test, the coefficient on *president* equals zero. Seeing that the standard deviation of this coefficient has nearly the same magnitude as the coefficient itself, making it highly insignificant, we fail to reject the null that the president's communication has the same effect as other communication.

Analogously, columns (2) – (8) of Table A.1 show the same results for communication by core member states representatives, southern states representatives, communication in financial centres, communication concerning non-standard policy measure, monetary policy or economic outlook or communication closer to date of policy meeting, respectively.

Table A.1: Test results of Hypothesis 2.1 using full model specification

	Δ CISS [ARIMA]							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MA[1]	−0.442***	−0.436***	−0.437***	−0.448***	−0.434***	−0.434***	−0.434***	−0.429***
	(0.068)	(0.068)	(0.067)	(0.067)	(0.069)	(0.068)	(0.069)	(0.069)
Δ EPUI	0.084***	0.084***	0.084***	0.085***	0.086***	0.083***	0.084***	0.083***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)	(0.024)	(0.024)	(0.025)
Δ CLI	−7.937***	−7.925***	−7.878***	−7.890***	−7.989***	−7.766***	−7.801***	−7.867***
	(2.687)	(2.719)	(2.710)	(2.657)	(2.726)	(2.723)	(2.720)	(2.749)
press conf. [dummy]	1.781***	1.769***	1.893***	1.839***	1.735***	1.852***	1.800***	1.661***
	(0.557)	(0.559)	(0.569)	(0.562)	(0.556)	(0.557)	(0.555)	(0.560)
Δ comm.sum	−0.109	−0.190	−0.119	−0.272**	−0.066	0.035	−0.294**	0.105
	(0.123)	(0.243)	(0.121)	(0.138)	(0.145)	(0.177)	(0.132)	(0.253)
Δ president	−0.595							
	(0.520)							
Δ core		0.020						
		(0.298)						
Δ south			−0.442					
			(0.416)					
Δ fin.center				0.345				
				(0.298)				
Δ non-standard					−0.358			
					(0.318)			
Δ Monetary Policy						−0.401		
						(0.267)		
Δ Economic Outlook							0.523	
							(0.334)	
Δ DtoGC								−1.058
								(0.866)
Observations	290	290	290	290	290	290	290	290
Akaike Inf. Crit.	1,796.620	1,797.926	1,796.803	1,796.585	1,796.664	1,795.695	1,795.483	1,796.449

Note: Δ CISS is the dependent variable in all 8 ARIMA models. Variables marked with Δ are differenced, [dummy] denotes dummy variable, MA[1] is the moving average term of order 1. The standard errors are reported in the parentheses, stars denote significance on 10% (*), 5% (**) and 1% (***) significance level.

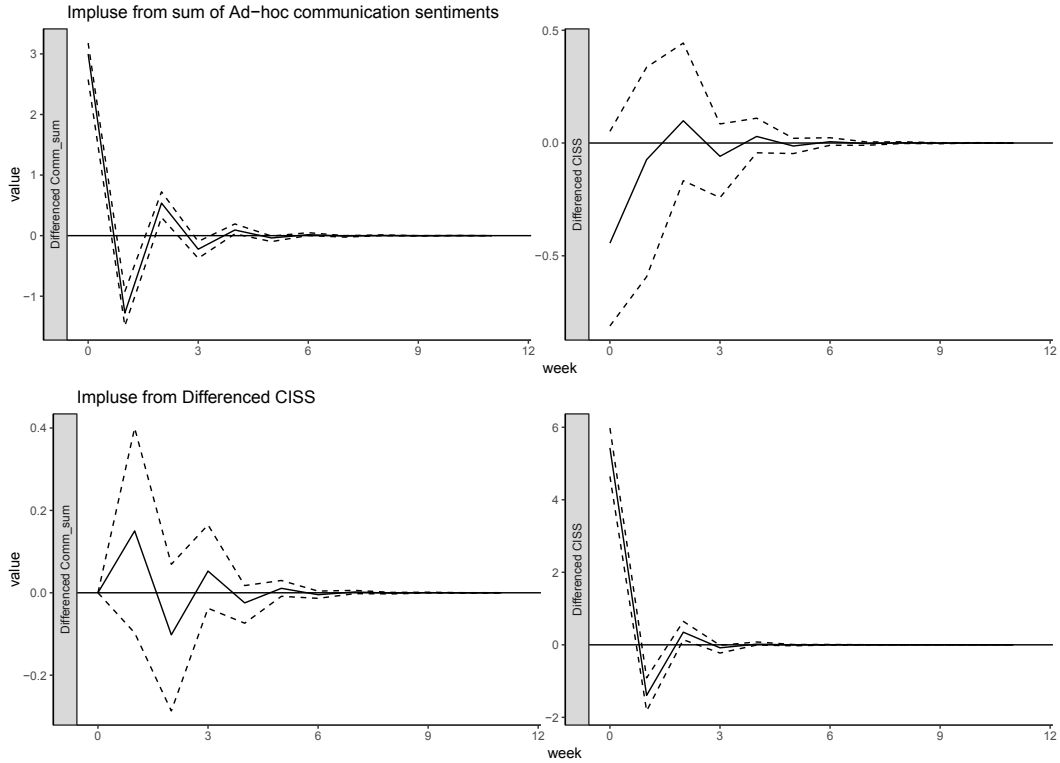
Appendix B

VAR model of Hypothesis 2

This appendix shows the regression results of the VAR models in reduced form (Table B.1) as well as corresponding IRFs that are estimated to test Hypothesis 2. The results are quite comparable to the main results in section 6.2 showing significant effect of change in ad-hoc communication sentiment to CISS. However, it shows that there is no reverse causality from CISS to ad-hoc communication sentiment, which is also tested by Granger causality in a reduced model estimates. Similarly, the IRF in bottom left segment of Figure B.1 shows no significant response of Communication sentiment to shock in CISS.

These results confirm that the main results presented in 6.2 should not be subject to bias caused by simultaneity of CISS and sentiment of ad-hoc communication.

Figure B.1: IRF of VAR model testing Hypothesis 2



Note: Orthogonal impulse response functions corresponding to VAR model results VAR(1) of Table B.1. The impulse response functions are depicted by the solid line, dashed lines represent 90% confidence intervals derived using bootstrap. *Source*: Author's own calculations.

Table B.1: VAR models estimates to test results of Hypothesis 2

	VAR (1)		VAR (2)		VAR (3)	
	Δ CISS	Δ comm.sum	Δ CISS	Δ IWCS	Δ CISS	Δ AIWCS
Δ comm.sum [lag]	−0.063	−0.422***				
	(0.098)	(0.054)				
Δ IWCS [lag]			−0.137	−0.424***		
			(0.179)	(0.054)		
Δ AIWCS [lag]					−0.281	−0.465***
					(0.213)	(0.052)
Δ CISS [lag]	−0.257***	0.028	−0.258***	0.017	−0.259***	0.002
	(0.057)	(0.031)	(0.057)	(0.017)	(0.057)	(0.014)
press conf. [dummy]	2.006***	−0.113	2.001***	−0.033	1.958**	0.355*
	(0.766)	(0.422)	(0.766)	(0.229)	(0.765)	(0.188)
Δ EPUI	0.099**	−0.030	0.099**	−0.017	0.098**	−0.015
	(0.040)	(0.022)	(0.040)	(0.012)	(0.040)	(0.010)
ΔCLI	−10.783**	2.694	−10.768**	1.518	−10.694**	1.114
	(5.007)	(2.757)	(5.006)	(1.500)	(4.995)	(1.227)
Intercept	−0.602	0.015	−0.601	0.001	−0.592	−0.085
	(0.366)	(0.201)	(0.365)	(0.110)	(0.365)	(0.090)
Observations	289	289	289	289	289	289
R^2	0.105	0.189	0.106	0.192	0.109	0.236
Adjusted R^2	0.089	0.175	0.090	0.177	0.094	0.222

Note: Results of 3 different VAR models. Variables marked with Δ are differenced, [dummy] denotes dummy variable, [lag] denotes lagged variables. The standard errors are reported in the parentheses, stars denote significance on 10% (*), 5% (**) and 1% (***) significance level.