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Faculty of Social Sciences
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MASTER THESIS

ECB's Oral Communication and Future Monetary Policy

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Declaration of Authorship

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

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Abstract

The thesis aims to shed light on the European Central Bank's communication in order to identify its main components bearing information about future changes in the policy rate. For the analysis, the study introduces a modification of a widely used approach based on the dissent expressed in previous monetary policy vote. Since the European Central Bank does not publish the vote's details the communication of the central bank is used as a proxy. Results not only confirm the predictive power of the communication but furthermore indicate that the financial markets do not fully incorporate the information contained. A detailed analysis shows the relevance of the timing, delivery and content of the communication. The study therefore provides a summary of the important factors of the European Central Bank board members' statements for predicting future monetary policy.

JEL Classification	C25, D53, E43, E58
Keywords	ECB, communication, monetary policy, MRO

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Abstrakt

Cíl této práce spočívá v identifikaci a vyjasnění vlivu prvků v komunikaci Evropské centrální banky představující hlavní nositele informací o budoucích změnách v depozitní sazbě. V rámci analýzy je prezentována úprava široce uplatňovaného postupu založeném na nesouhlasu vyjádřeném při schůzích bankovní rady během volbě nové sazby. Výsledky nejen potvrzují vhodnost užití komunikace centrální banky pro předpovědi, ale navíc poukazují na fakt, že finanční trhy tyto informace plně nezachycují. Detailní analýza dále odhaluje význam načasování, předávání a obsahu komunikace. Práce tedy shrnuje relevantní faktory vycházející z komunikace členů bankovní rady Evropské centrální banky pro predikce budoucí monetární politiky.

Klasifikace JEL	C25, D53, E43, E58
Klíčová slova	ECB, komunikace, monetární politika, MRO

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Acronyms

CDF Cummulative distribution function

ECB European Central Bank

FED Federal Reserve

FOMC Federal Open Market Committee

GC Governing Council

MPC Monetary Policy Committee

MRO Main Refinancing Operation rate

OLS Ordinary least squares

Master Thesis Proposal

Author	Bc. Nicolas Fanta
Supervisor	doc. Roman Horváth Ph.D.
Proposed topic	ECB's Oral Communication and Future Monetary Policy

Topic characteristics Since monetary policy has become more transparent, its changes are more predictable. The thesis is going to uncover how the future monetary policy of the European Central Bank (ECB) can be predicted by the oral communication of the ECB representatives. The influence of several properties of the communication that are likely to influence the magnitude of the change in the monetary policy are also going to be analyzed.

The main factor consists the quantified measure of the dissent expressed during the vote about the future monetary policy rate. In the paper of Horváth et al. (2012) the metric is defined as the difference between the average policy rate voted for by the individual board members and the policy rate that is the outcome of the majority vote. The rationale of that indicator is that some board members may realise the necessity of a change in the rate sooner which makes a lag when implementing changes and causes dissent in the during the monetary policy votes in the early phase. The content of the oral communication, whether it is conventional or unconventional monetary policy, is likely to be influential. Another important aspect relies in the timing of the communication: the closer the communication is to the monetary policy meeting the more likely it is to inform about the change. The thesis will also investigate if the impact of various speakers trying to identify if there are individuals and groups within the board that have a stronger influence than others. The study will therefore assess several likely factors and summarize their relevance when predicting the future policy rate.

Hypotheses The thesis' objective will consist in the clarification of the following hypotheses:

Hypothesis no.1: Oral communication of the ECB signals monetary policy.
Hypothesis no.2: The importance of the communication depends on the one who speaks.
Hypothesis no.3: The content of the communication matters.
Hypothesis no.4: The timing of the communication has a significant effect.

Methodology The methodology will follow the one which has been presented in the papers of Horváth et al. (2012) and Gerlach-Kristen (2004). Several variables will be added in order to control for other likely effects, however the decision-making process of the ECB's board is going to be of key interest. The newly added variables reflect the aspects of the communication such as its timing, content or speaker. A non-linear estimation will be used to estimate the model: an ordered probit estimation which is as well presented in the paper of Horváth et al. (2012).

Outline

1. Introduction
2. Theoretical Background
3. Related Work
4. Methodology
5. Empirical Analysis
6. Conclusion

The thesis is expected contribute to the current academic literature by investigating the process of the ECB's communication and by summarising the signifficance of effects in communication when predicting changes in monetary policy.

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Author Supervisor

Chapter 1

Introduction

Until the 1990s central banks had been shrouded in mystery and everyone agreed they should do so. Nowadays the approach evolved and central banks 's communication forms an important part of the strategy in order to contribute to the effectiveness of monetary policy and to reduce the level of uncertainty on the market. How open the central bank should be, however, still remains questionable. One of the arguments supporting secrecy measures is that poorly designed communication can have a harmful effect: a good example of a negative effect of communication was in October 2000 when the ECB president Wim Duisenberg hinted that there would be no further interventions which led to a sudden depreciation of the Euro. Such example justifies why central bankers prefer to keep the provided information limited and hold future ambitions in secret. The potential sources for predicting changes in monetary policy rate therefore remain limited. Exceptions however can be found, such as the central banks of New Zealand or Norway, who publish the numerical path of future policy rates.

Central banks have several communication tools at their disposal: some as the Bank of England, regularly publish reports monitoring the economic environment and unveiling its assessment, others (like the ECB) hold press conferences after each monetary policy meeting. What is common for all is that each monetary policy meeting of the board of the central bank involves a vote on the preferred policy rate. If published, the voting record from the meeting (i.e. the number of concurring and dissenting votes) may help the financial markets to follow the central banks' ambitions. In the last decade, several studies (Gerlach-Kristen (2004), Horváth *et al.* (2011), El-Shagi & Jung (2015), etc.) have been showing that the dissent that can be observed from the voting record

is predictive about future changes in the policy rate. The reasoning is that some board member may capture important information about the necessity of a change sooner than others. The rate is implemented few meetings after that, after the rest of the board is successfully convinced. When quantified, such initial disagreement visible in the bank's summary of the vote on monetary policy meeting (voting record) can serve as an early bird indicator of future change in the policy rate in the next votes.

Empirical research analysing the predictability of future monetary policy was performed mostly on central banks publishing their voting record from the monetary policy meeting. Gerlach-Kristen (2004) and El-Shagi & Jung (2015) study the Bank of England, Horváth *et al.* (2011) add the Czech Republic, Hungary, Poland and Sweden to their sample. Other central banks, such as the ECB, remain mostly unstudied because an analysis based on the dissent in the monetary policy vote could not have been elaborated, since its voting record is not published. Fortunately, the central bank frequently communicates and its statements in the media may serve as a suitable proxy for the voting record of the monetary policy meeting since these captures the opinion of the cited board members'. Pesci (2016) presents one of the exceptions devoted to such way of analysis. His study however incorporates only a small proportion of the central bank's communication and as it will be further demonstrated, the model presented does not show satisfactory results for the data of observed period of the present study. The present study not only monitors the information contained in the skew (i.e. the metric quantifying the level of dissent within the monetary policy committee), but also assesses other factors (such as timing, speaker characteristics, impact of the ECB president's opinion, etc.) closely related to the communication in order to predict changes in future ECB's policy rate. By including these additional factors, the model not only attains better results but also reveals patterns in the central bank's communication.

According to the empirical analysis of this thesis, dissent expressed during the monetary policy vote, similarly as for other central banks, is found to be informative about the future monetary policy. The hypothesis of the dissent being informative remained valid even after the inclusion of market expectations, thus showing that the markets does not fully incorporate the information available in the ECB's communication. In terms of timing of the communication, empirical evidence not only validates the predictive power of dissent two periods ahead, furthermore it shows that the most informative statements are given a week before the monetary policy meeting. Such division of the data

indicates that the financial markets only incorporate statements of the ECB representatives provided until the last week before the monetary policy meeting. During the week before the meeting the delivered messages appear to be the most informative. The investigation of the statement's content showed that those related to conventional policy measures (such as the quantitative easing programme) fail to be predictive. The most likely explanation for that can be explained by a vast part of the data which follows a period of economic turmoil linked to the zero-lower bound policy rate. The present study also sheds light on the relevance of the speaker and presents evidence that dissent expressed by eurozone governors is more predictive than the Executive Board members'. Moreover, a summary of the most and least dissenting countries is provided. The opinion expressed by the president however could not have been confirmed as a valid predictor of the future policy rate.

In the first part of the study, a review of the literature devoted to central bank communication is provided. This part among other things justifies the factors used in the empirical analysis. The aim of the second part of the literature review is to discuss papers focussing on the predictive power of dissent on future changes in monetary policy. The methodological part starts by providing a description of the data and summarises the variables used later in the models' estimations. A brief recapitulation of the modelling technique is followed by a summary of the methodology used in the literature. Since this study models dissent based on communication and not by the voting records some of the commonly used approaches had to be modified. These modifications are described in the methodology. At the beginning of the empirical analysis a baseline model is presented. This model is then further updated for various factors for each of which a chapter is dedicated. For a clearer analysis, each of the factors is analysed separately (since the aim is to unveil the relevance of each of these). The main findings of the thesis are summarised in the Conclusion (Chapter 6).

Chapter 2

Theoretical Background

Monetary policy transparency has dramatically increased over the last period, leaving space for eventual estimation and modelling of the process of its creation. But first of all, how can central bank transparency be defined? The paper of Faust & Svensson (2001) present a definition of the Central bank transparency as the one *"that is, how easily the public can deduce central bank goals and intentions from observable"*. Another term closely related to this study is central bank communication, which according to Blinder *et al.* (2008) can be defined as *"the provision of information by the central bank to the public regarding such matters as the objectives of monetary policy, the monetary policy strategy, the economic outlook, and the outlook for future policy decisions."* Therefore, any statement regarding the mentioned topics made by any of the central bank representatives can be viewed as communication.

This study has the objective to clarify whether the ECB's communication can predict the future monetary policy. Before further developing the topic, an important question arises: Does the central bank communication really increase the predictability of monetary policy? Sturm & De Haan (2011) centred their research around the ECB's presidential introductory statement held during the conference following the monetary policy meeting and found that the observed communication events (i.e. the presidential introductory statements) contains valuable information for predicting further moves of the policy rate. The study in its empirical research regroups indexes from previous research[1]. It is worthwhile mentioning that the results are robust even when the interbank

[1]Namely the studies of Rosa & Verga (2005), Berger *et al.* (2011), Heinemann & Ullrich (2005), Conrad & Lamla (2007), and Ullrich (2008) and thus provides a summary of the literature devoted to the conference after the ECB's monetary policy meeting.

rate is included (which models market expectations) in the model, meaning that the market rates do not fully incorporate the information revealed.

Even if relevant for predicting changes in the policy rate, the communication can affect the markets in various ways. There have been studies such as David Archer (2005) providing evidence that the market reacts only to some extent. The mentioned paper suggests that this might be caused by the fact that the market adjust its rates only if it shares the same underlying assumptions as the central bank. Also, Hayo & Neuenkirch (2013) inform that the signal from central bank communication may be noisy if the speaker defends his personal opinion rather than argue in favour of the monetary policy committee. Such noise can then have a harmful effect due to the herding behaviour of market participants (describe by Bikhchandani *et al.* (1998)) who supposedly follow the ones who they assume to be better informed. The central bank's signal can therefore trigger an opposite movement in the market's expectations than was the original ambition. Predictability of the central bank may also fall when diversity of views of central bankers increases as shows evidence in Fratzscher (2006). In such cases, as said Wim Duisenberg on one of his press conferences, the markets should listen to the ECB's president[2].

Some authors such as Bernanke *et al.* (2004) or Eggertsson & Woodford (2003) go even further and underline the communication about expected future rates as the essential tool of monetary policy. Communication patterns however vary across central banks and the optimal level of transparency as well as the optimal communication strategy thus still remains questionable. Blinder *et al.* (2008) in his study identifies four main features to make the communication of the central bank matter:

- non-stationarity (either of the economy or of the policy development)
- learning environment (by and about central banks)
- non-rational expectations or asymmetric information between the bank and the public

Information asymmetry between the central bank and the public can be simply justified by the fact that the central banks devote much more effort to forecasting the economy. According to Blinder *et al.* (2008) several studies even go further and according to them the financial markets update their expectations

[2]Available in the European Central Banks 's Introductory statement from November 2001.

based on the information provided by central banks. The content of the central bank's communication can be divided into at least four areas of monetary policy:

- the overall intentions and strategy
- the reasons for specific decisions
- the economic outloo
- future monetary policy decisions

Strategies and the objectives in quantitative terms of the central banks are either set up by the banks themselves or by their governments (or in the case of the Federal Reserve even by the legislation – price stability and full employment but these however are not quantitative). Central banks have several tools for (at least partially) communicating these at their disposal and use them in different mixtures. Some banks, such as the Bank of England, provide a press release only when making unexpected decisions. Others make announcements on a regular basis, such as the ECB.

Regular publication in general represents one of the most important tool of the central banks' communication. The ECB publishes its Monthly Bulletin, which contains a review of the economic development and also information about the analytical framework, a week after each monetary policy meeting. The Bank of England publishes quarterly reports: The Inflation Report and the Quarterly Bulletin. Through these the bank informs about the current economic analyses, forecasts of inflation for the upcoming two years, current development of the market and monetary policy operations. Committee members play an important part in the communication since these also express their personal opinions in the media.

Despite the debate in publishing strategic objectives and related information, the central banks nowadays publish on a regular basis some of their forecasts of future economic outlook. Yet opinions differ for the communication of future policy rates. Some central banks, such as the Federal Open Market Committee, release statements about the course of their future monetary policy. Other banks (such as New Zealand, Norway or Iceland) go even further and publish quantitative forecasts of their policy rates. The common objectives for all released materials are to provide some sort of guidance for the public to identify likely trends for the future policy decisions and to prevent eventual

pitfalls. The forecasts however also warn that they may not always predict precisely future trends since the provided rates are conditional on the actual available information. The delivered information from central banks also varies in terms of precision and delivery time. Since the Bank of England publishes its minutes, it provides more detailed information to the public than the ECB at the press conference following each Governing Council (GC). The minutes, however, are published with a 1-day delay and in contrast to the question-and-answer sessions of the ECB (held at the press conference after every GCmeeting), it does not allow to clarify eventual ambiguities.

Communication strategies of committee members vary across the world. Blinder (2004) distinguishes three different types of committees depending on the number of dissenting votes in the decision-making meetings committees across central banks, each having a different type of strategy for taking decisions:

- Individualistic (Positions are offered, discussions are held and are followed by a vote.) – RBNZ, the Bank of Canada and the Bank of England.
- Genuinely collegial (The governor seeks or sets up a consensus which he further defends.) – ECB
- Autocratically collegial ("The chairman's going-in position is the likely consensus.") – the Federal Reserve (FED) Federal Open Market Committee (FOMC).

Since the ECB does not publish its voting records, the specifics of the decision-making process cannot be inferred. The bank however, according to Ehrmann & Fratzscher (2007), has signalled that it is done in a collegial manner. For the purpose of making predictions, the collegial approach to decision-making and communication seems to be naturally more informative: after spotting the most influential committee member, the markets have a strong basis for predicting at their disposal. The argumentation why the ECB is efficient thanks to its communication is however much more complex.

Before assessing various communication strategies, let's mention the definition of monetary policy efficiency that can be found in Ehrmann & Fratzscher (2007) as *"the ability of financial markets to predict future monetary policy decisions; and second, the ability of policymakers to influence financial markets by moving asset prices"*. In other words, changes in policy measures must be predictable and must have an impact on the market. Several criteria for its

assessment depending on several points of view can be identified, for instance Ehrmann & Fratzscher (2007) mention communication dispersion, communication consistency with policy decisions and voting dispersion. The communication strategy of the individualistic committee should be based on the diversity of views so that the market could understand the degree of uncertainty involved in the monetary policy making (i.e. in a cacophony of contradictory opinions the market might be confused even more). On the other hand, if presented to the public, the diversity in the opinions of a collegial committee would damage the clarity of the communication.

Based on the empirical results of Ehrmann & Fratzscher (2007), the ECB shows low levels of dispersion and high levels of consistency in terms of communication between monetary policy meetings (compared to the FED or the Bank of England). The votes are mentioned to be mostly unanimous, thus making the future move anticipatory. On the other hand, the FED reaching higher levels of dissent in communication and voting (also confirmed empirically by the study compared to the ECB and Bank of England) may still be well anticipated if the markets can identify a committee member whose opinion reflects the majority. The empirical analysis also revealed that the FED and ECB are roughly equally predictable. Overall the conclusion of the paper is that communication via committee members can influence markets, but with a various effect across countries. For instance, in case of the ECB, the reaction of the market was statistically the same regardless who was communicating the news (president or another committee member).

Despite the variety of possible strategies and goals, most central banks in the world share one common practise: purdah. The term refers to a voluntary abstaining from communication in the period around monetary policy meetings. The length of the purdah period varies and central banks mostly do not define it precisely. The Bank of England mentions in its Communications Guidance for Monetary Policy Committee (MPC) Members[3] that *"Particular care needs to be taken in the period between the Monday discussion and the announcement of the MPC decision on Thursday"* (which represents 4 days). According to its website the ECB follows a one week pre-meeting communication restriction. Such practise may be seen as a violation of the transparency objective of the central banks, however cases of excessive sensitivity of financial markets in the pre-meeting purdah indicate that eventual communication may induce even higher levels of volatility on the market.

[3]Based on the the Bank of 's Communication Guidance for MPC Members.

The purdah has been further analysed in Ehrmann & Fratzscher (2009) who provides an assessment of the effect of the purdah communication on financial market rates in the case of the Federal Reserve. For the empirical analysis, the authors regrouped all information financial markets received about the statements of the FOMC members from 1994 to 2007. The results of the study confirm that the pre-FOMC purdah statements are linked to increased levels of volatility of the market: the model estimated that their effect is *"about three to four times larger than those in the inter-meeting period outside the purdah"*. On the other hand, the post-FOMC purdah and non-purdah communication appear to reduce uncertainty. An analysis of whether the pre-FOMC purdah content is different is also provided with the aim to clarify the causality: either the communication tends to bring highly important news and induces increased volatility or the markets are much more sensitive in the pre-FOMC purdah phase. Seniority does not show to play any role as opposed to the Bank of England, where El-Shagi & Jung (2015) recommend to treat senior members separately. Finally, the effects of the statements do not depend on whether policy rates will change in the upcoming meeting or not. The paper therefore confirms the importance of the communication as a tool to guide financial markets via an estimation of its effect on the volatility of market rates.

The importance of today's communication mechanisms of central banks appears to have a solid support throughout the literature. When processing the communication items the decision making-type of the monetary policy committee should be regarded. As mentioned in the literature the ECB's board decision-making process is viewed as collegial. This means in terms of communication that a diversity in opinions of the board members should therefore damage the predictability of future changes. Despite that common multitude of expressed opinions, studies on the contrary show that the ECB maintains a high level of consistency which is a positive indicator for using these to estimate changes in future monetary policy.

Chapter 3

Related Work

The econometric analysis of the present study is based on several papers which are going to be summarised in the following part. For clarity reasons, each paper is going to be described separately in order to highlight its main contributions. The first two papers, Gerlach-Kristen (2004) and Horváth *et al.* (2011), present a basis for studies estimating changes in the policy rates of central banks based on the dissent expressed during monetary policy assessment meetings. The methodology used in these studies is broadly applied throughout the literature. The next papers present elaborations of the baseline approach. These updates of the methodology will be further updated and developed in this study.

3.1 Gerlach-Kristen

Gerlach-Kristen (2004) introduced the idea that the voting records of the Bank's of England Monetary Policy Committee could be informative about future policy interest rate. The question of the informative power of the voting record was addressed by testing whether it has an impact on expectation formation in the financial markets. To be able to test for significance of the additional information brought by the voting record, there must be at least some dissenting votes. In case of the Bank of England, the MPC members' views do not diverge much, but when they do, the minority's opinion usually tend to predict future monetary policy changes. Thus, for the purpose of the analysis Gerlach-Kristen introduced an indicator measuring the proportion of dissent in the vote for the optimal policy rate. The variable was named as skew and denotes the difference between the mean and the median of a selected policy

rate. If everybody in the MPC votes for the same rate, the mean and the median are the same, the skew is zero and therefore according to the above presented hypothesis, there is no likely change in the rate. On the other hand, the larger the minority voting for a lower/higher rate, the larger the difference between the median and the mean (thus a negative/positive skew) which informs about a possible decrease/increase of the policy rate. During the period between 1999 and 2001 the mean of the vote usually changed earlier than the median which might indicate that the voting record could indeed be informative.

In practise the voting record is usually published with a delay: the interest rate decision is at time t-1, the voting record is published (usually two weeks later) at t and the next policy rate decision is announced at t+1. Thus, the model estimates the following equation:

$$\Delta i_{t+1} = a_1 skew_t + u_{t+1},$$

where Δi_{t+1} stands for change in policy rate at time t, $skew_t$ represents the skew variable and u_t represents the White noise. The model is then estimated via Ordinary least squares (OLS) and ordered PROBIT techniques and shows significant results for the skew variable. This mere model however does not confirm if the voting records themselves are informative since the information they bring can only reflect the market's rates expectations. For that purpose, Gerlach-Kristen added the interest rates term structure as a proxy for these expectations:

$$\Delta i_{t+1} = a_0 + a_1 \Delta i_t + a_2 skew_t + a_3 (i_{\chi(t),L} - i_{\chi(t),S}) + u_{t+1},$$

where $(i_{\chi(t),L} - i_{\chi(t),S})$ represents the spread between market interest rates with different maturities ($L > S$). Based on the market rates's expectation hypothesis, the long term-market rates are formed by the path of short-term rates plus a premium. Thus, if a monetary tightening is expected, the market rates are likely to increase, which would justify a positive slope of the term structure. If the market's expectations provide most of the information about the upcoming policy rate, the skew variable should no longer be significant. However, it is not the case in most of Gerlach-Kristen results where both skew and term structure variables remained significant at least at a five percent level[1]. The paper therefore confirms the predictive power of the voting records

[1]The paper presents models for different maturities in the term structure ranging from overnight to 12-month rates. Also, the models are estimated by both OLS and ordered PROBIT techniques.

on future policy rates in the case of the Bank of England. In the next presented papers, it can be observed that this model, which includes market expectations, provides a model difficult to outperform.

The study, in addition to the above mentioned, suggests that the voting records may be informative more than one period ahead by estimating the term-structure-improved model at the day of the publication of the voting record. Similarly, as in the one-period-ahead modelling, if fully incorporating the information from the previous period's vote, the financial market expectation (represented by the term structure) should remain significant in contrast to the skew which should not. Despite the expectations, the results of Gerlach-Kristen show that both discussed variables have a predictive value and are significant.

3.2 Horvath, Smidkova and Zapal

Horváth *et al.* (2011) in the first part the paper presents a theoretical decision-making model and simulates voting outcomes to see under which conditions the voting records are informative. The second part investigates the effect on data from five inflation-targeting countries: the Czech Republic, Hungary, Poland, Sweden and the UK. Monetary policy in those countries is driven by an independent committee or board members who decide on the level of the repo rate. The paper not only confirms the significance of the information in the voting records in all the observed countries it also shows that these results are robust to the timing and way of the voting record announcement. One of the most important feature of the model is the heterogeneity of opinions of the board members (on the optimal rate) which is modelled as the sum of the optimal interest rate and a White noise. The chairman's opinion is modelled the same way as the chair members only with a smaller variance in the White noise term. An important assumption is that before the vote, the previous period's optimal rate is known to every board member. The new policy rate is set up according to a (standard majority) vote between the previous rate and the alternative rate suggested by the chairman. To avoid technical complexities brought by the full rationality assumption, Horváth *et al.* (2011) presents four different models of committee behaviour:

- Democratic (The chairman of the central bank is a democratic leader whose has the right to suggest proposals.)

- Consensual (The chairman of the central bank *"has a dominant position in his proposal-making power."*)
- Opportunistic (The chairman of the central consults the views before the meeting and offers the most preferred opinion.)
- Intertemporal democratic (Similar to the democratic with the exception that all committee members *"take into account the effect of their current behaviour on their future decision."*)

Each of the models has been simmulated with the aim to investigate the inforative power of the skew indicator. Among the presented committee behaviour models in the paper, the democratic is considered the most important since it delivered signifficant skew estimates and it allowed to elaborate important hypotheses about future monetary policy prediction:

- If the monetary policy rate fails to be at its optimum, the publication of voting records may play an important informative role for other economic agents.
- The skew variable is informative if and only if the committee members act differently (either have different sources of information, react differently based on the same information or there is no committee member able to persuade the rest about his opinion).
- If the economy is too volatile, the information brought to the committee is very unclear or there is only a few members, the skew may still be uninformative.

An interesting finding of the estimation is that the democratic and consensual models showed increased levels of volatility in their paths in comparison to the opportunistic model. The third hypothesis will be challenged in the following empirical part since its dataset covers the last financial crisis. Interestingly, despite increased volatility, the skew based on the ECB communication remained informative. In the empirical part of the paper, the information carried in the skew variable is tested on real data from inflation-targeters such as the Czech Republic, Hungary, Poland, Sweden and the UK. As a first step the following Baseline model (as presented in Gerlach-Kristen (2004)) is estimated:

$$\Delta i_{t+1} = a_0 + a_1 \Delta i_t + a_2 skew_t + u_{t+1},$$

where Δi_t stands for change in policy rate at time t and u_t represents the White noise. The upper equation was estimated by an ordered PROBIT technique. The changes in policy rate are coded in five categories: none, small and large (positive and negative), where large changes were considered as changes larger or equal to 50 basis points. Similarly, as Gerlach-Kristen (2004), the study tests the relevance of the skew by including the term structure in the equation. The results remained stable even in the cases of robustness checks which involved a different selection long and short money market rates. Therefore, the paper confirms the finding of Gerlach-Kristen (2004) for the tested banks: the dissent within the central banks'boards is not fully reflected by the market expectations.

The extension of the baseline model incorporates the effect of dispersion in the voting records, which is measured by the standard deviation of the individual votes. The aim of the variable is to measure the level of dissent in order to monitor the level of uncertainty within the board. The model then has the following form:

$$\Delta i_{t+1} = a_0 + a_1 \Delta i_t + a_2 skew_t + a_3 (i_{\chi(t),L} - i_{\chi(t),S}) + a_4 dispersion_t + u_{t+1},$$

where $(i_{\chi(t),L} - i_{\chi(t),S})$. The second expansion's result did not differ very much from the previous one's: dispersion appeared to be significant a 10% level in the case of Hungary and the UK, where the negative coefficient suggests that an increased diversity of opinions is present with rates associated with a loosening of policy. Finally, even after estimating the model on pre-crisis data, the results remain mostly unchanged.

3.3 Jonasova and Horvath

The study of Horvath & Jonášová (2015) presents an update of the paper of Horváth *et al.* (2011). On an enlarged dataset of the latter[2], the study investigates whether the voting records are predictive about monetary policy at t+2 and t+3, The rationale for that is that the voting records may also include some "early bird" indicator. These signals may arise too early to be easily identified so policy optimisation does not follow immediately. A definition of the indicator is provided: *"The dissent as of the early bird type if the policy rate is indeed changed within the next three monetary policy meetings in the*

[2]The end of the observed period in the paper of Horváth *et al.* (2011) is February 2009, Horvath & Jonášová (2015) update it till the mid-2014.

direction of the dissenting vote relative to what the majority voted for." It is evident that there are some dissenting votes without any following appropriate change in policy rates, but many dissenting votes actually do predict the course of future monetary policy well. The modelling technique used in the paper of Horvath & Jonášová (2015) is an ordered PROBIT which is based on the one presented in Gerlach-Kristen (2004) and Horváth *et al.* (2011):

$$\Delta i_{t+2} = a_0 + a_1 \Delta i_t + a_2 skew_t + a_3 (i_{\chi(t),L} - i_{\chi(t),S}) + u_{t+2}$$

$$\Delta i_{t+3} = a_0 + a_1 \Delta i_t + a_2 skew_t + a_3 (i_{\chi(t),L} - i_{\chi(t),S}) + u_{t+3},$$

where the only change relies in the lags of the explained variable. According to the results, the "early bird" indicator is found to be significant for all countries (i.e.: the Czech Republic, Poland, the UK and Sweden) except Hungary. There are several hypotheses to explain it: either the central bank's independence has decreased and financial markets do not view the voting records as informative or this insignificance can be explained by a turbulent economic environment causing increased levels of volatility.

Thanks to the enlarged dataset (covering the whole period of the recent global financial crisis), the authors could also investigate whether the voting records are predictive during the financial crisis. The skew variable showed significant results one period ahead (except Hungary), however other following periods did not (except only 1 case, the UK). This result provides evidence that financial markets seem to recognise that the policy making process differs in calm and crisis times. The paper thus confirms the results of Horváth *et al.* (2011) that the voting records are informative about the policy rates selected on the next monetary policy meeting. If the macroeconomic environment is not too volatile, the voting records are informative even about the next two or three monetary policy meetings.

3.4 El-Shagi and Jung

El-Shagi & Jung (2015) give an important contribution to the debate about the appropriate level of central bank transparency. The paper investigates whether publication of the minutes and voting records of the Bank of England's MPC has increased the predictability of the future development of monetary policy to the markets. For the analysis, the authors use a sample beginning in October 1998 to end-2014 (i.e. a dataset from the first publication of minutes

and voting records until recently). In the introductory review of the data the authors observe a strong increase of dissent among policy-makers during the crisis period. Thanks to the relatively large period, the dataset also covers the years when the policy rate was held very close to the zero-lower bound (since March 2009). Therefore, it can be analysed whether the presented model is valid even in such a lasting period without any changes in the policy rate.

During the period of turmoil the role of the Bank of England's communication consisted in convincing the markets that the interest rates would stay at their levels as long as the bank followed its quantitative easing policies. There are two points of view on such approach: either it can be believed that great levels of agreement in communication can cause an improved level of predictability of monetary policy decisions by the financial markets in the short-term or it may mean that the markets do not trust such a high level of agreement in the communication and expect a sudden change in the policy rates. If there are some members of the MPC concerned with the second option, dissent in opinions on the policy rate can be present (i.e. the skew is likely to be non-zero) which may cause the invalidity of the estimated model over time[3].

Such longer periods, when the policy rate reaches its zero-lower bound, present an issue concerning the use of skew as a predictor according to El-Shagi & Jung (2015). Contrarily to crisis times, where uncertainty reached high levels and the skew was changing and thus was still informative, the long period of very low policy rates may make the estimated model invalid. This can be caused by the fact that the markets may be concerned that the central bank surprises them by suddenly changing its monetary policy course. Hopefully in periods of very low interest rates the Bank of England incorporated only conventional interest rate changes which then made the relationship robust even during low interest rate periods. Such higher disagreement in the MPC (thus higher skew values) was present in the discussions about when to exit from the extraordinary accommodative stance between July 2010 and July 2012 and at the end of 2014. During these periods, the skew lacked its ability to provide useful information. In the empirical part, the baseline methodology used for the estimation does not differ from the studies of Horváth *et al.* (2011) or Horvath & Jonášová (2015). Thus, in the first part the baseline ordered PROBIT and the market-expectations models, which models the forecast interest rates on

[3]Since the model predicts changes based on dissent, any longer period showing a diversity of opinions in the central bank's board without any actual change reduces the predictive power of the model.

the days before and after the publication of MPC minutes, are provided:

$$\Delta i_{t+1} = a_1 skew_t + e_{t+1}, \text{ and}$$

$$\Delta i_{t+1} = a_0 + a_1 \Delta i_t + a_2 skew_t + a_3 market_{\chi(t)\pm\tau} + u_{t+1},$$

where Δi_trepresents the change in policy rate at t (a discrete variable where -1 represents a decrease, 0 no change, 1 an increase), the skew variable is the same as defined in Gerlach-Kristen (2004), $market_{\chi(t)\pm\tau}$ denotes the financial market expectations indicator (one day after or one day before the release of the minutes for the meeting depending on the model)[4] and u_t is a Gaussian error term.

The estimation of both pre-monetary-policy meeting and post-monetary-policy meeting market expectations plays a crucial role for the assessment information in the MPC's minutes. If the minutes bring relevant information and the markets "learn" from it, the model using post-monetary-policy meeting expectations should show an increased fit in comparison to the pre-monetary-policy meeting expectations or the baseline models. The results of the analysis in the first part show that the skew's significance is robust to the inclusion of market expectations. In terms of models the Vuong test suggests that the market-expectations have a better fit only when the post-monetary-policy meeting expectations are considered and thus confirms the relevance of minutes' publication.

El-Shagi & Jung (2015) also present further refinements in the skew variable where they suggest that it can consider the seniority of the members or their membership status (the MPC is composed of five internal and four external members). The author justifies the membership status update of skew variable by presenting the empirical analysis of Gerlach-Kristen (2009) which concludes that a *"skew based only on the dissenting votes of outsiders is more informative in predicting future policy changes than those based on insiders"*. Analogically this approach could be used to treat separately the ECB's Executive board and the Eurozone National governors (i.e. divide the Governing Council into two categories).

[4]Several financial market indicators are used with the aim to capture the market's expectation. These are represented by the term structure estimated via the difference of market rates on long and short maturities similarly as in Gerlach-Kristen (2004).

3.5 Pesci

In Pesci (2016) a similar approach as the one presented in this thesis can be found. Instead of investigating the effect of current dissent on future monetary policy, the paper monitors only a short period centred around monetary policy decision announcements and evaluates whether there are some changes in the ECB's own perception of its future policy. The study decomposes the information brought by each of the monetary policy announcements into two different components: the first one is brought by the decision itself and the other is represented by the communication used (i.e. the vocabulary used by the ECB's president).

The sources of the present and Pesci's analyses are similar – both use written media: Pesci uses Reuters and Factiva; the present study uses only articles published on Reuters. In terms of observed periods there is a great difference: the paper on one hand uses a larger time period but on the other hand uses only data collected in three-days intervals centred around monetary policy decision announcements. On the other hand the author of this study uses articles published during the whole-time period. Pesci (2016) justifies the usage of articles published a day after and before the announcement by stating that *"the only news which might convey information on the ECB'stance and which systemically reach the public during dt, d(t-1) and d(t+1) (...) are those related to the announcement of the decision taken at the GC meeting on the key ECB rates and 2) the words of the ECB President at the press conference"*. In other words, the study incorporates only in communication related directly to the policy announcement whereas the present study tries to investigate more the possible patterns in the ECB's communication.

The model presented by Pesci (2016) covers a large period between January 1999 and December 2013 and contains 175 announcements of decisions taken at regular monetary policy meetings (also referred as events). Changes in the ECB's perception of its own attitude towards possible changes in its policy rates are measured by the difference between the post-event and pre-event indexes (also mentioned as the stance variable). The empirical model is based on the one presented in Lucca & Trebbi (2009) where this difference represents the unexpected component of the information brought by the FOMC (in Pesci's case GC) announcement. The dataset used for the research is based on a script which searches the articles for pre-defined combinations and counts the sums of their occurrences. Each occurrence of any sequence is weighted with

the weights of 1, -1 and 0 for hawkish, dovish and neutral. Hawkishness is characterised there as *"the willingness by a central bank to raise its policy rates in the near future"* whereas dovishness represents the willingness to decrease these. Neutral stance represents an attitude of the central bank without any willingness to change the rates. For each event, the weighted occurrences of the pre-defined combinations are summed and divided by the total number of occurrences. These steps lead to values of the stance variable in the interval [-1;1], where a negative (positive) results indicate a hawkish (dovish) attitude and zero indicates a perfectly neutral attitude. Thus, for each event there is a measure of the ECB's attitude towards further changes in monetary policy. The precision of the automated sentiment analysis of each article however remains questionable since it is most likely unable to "read between the lines" and capture minor evidence. Even the smallest details in the expressions used might be of key importance when understanding the statements of the GC. Therefore, a personally run sentiment analysis of the articles is preferable. In addition to the stance variable, Pesci (2016) also includes market expectations where this factor is approximated by the difference in the one-month Euribor spot rate between the day of the announcement of monetary policy decisions and the following day[5]. The author does not forget to investigate potential correlation of the market expectations with the ECB stance variables to avoid multicollinearity. No evidence of high correlation is found therefore the two variables can be added to the model. One would expect this correlation to be high since the announcement may bring new information about the current stance of the ECB which would then lead to a revision of the current market rates. Since there is not a high level of correlation Pesci (2016) deduces that the announcement of the ECB does not bring almost any new pieces of information about the ECB'stance and that the main information about the perception of ECB's stance is conveyed by the press conference (and not by the policy change itself).

The paper also investigates how the perception of the central bank 's stance affects market expectations about future policy rates. For the purpose of the analysis Pesci (2016) adds the difference of one-month Euribor n-month forward rate between (where n=1, ... , 6). The explanatory variables are the stance variable and the variable accounting for market expectations. The results con-

[5]Such choice is justified by mentioning Rosa & Verga (2005) who used this approach as a proxy for market expectations when analysing the impact of the ECB's president introductory statement to the monthly press conference.

firm a significant relationship between the perception of the ECB'stance and future policy rates expectations, e.g. a stance more hawkish than expected leads to higher expectations of future policy rates than anticipated.

One of the benefits of Pesci's model is that it can be easily further replicated and used since it has pre-defined an automatic searching and data analysing methodology. On the other hand, it does not allow for a deeper investigation of patterns in the ECB's communication and the text-mining algorithm may not always capture linguistic subtleties in the communication which could result in an incorrect scoring of the announcement. Since the ECB also follows a 7-days purdah guidance, the choice of the days to collect statements from seems a bit unfortunate since the amount of statements by definition of purdah will be very limited. The suitability of Pesci's metric is tested in the empirical part and the effect appears to be insignificant on the data used for this study. Such finding leads to the question whether the methodology could not be more elaborated by scoring the ECB's announcements personally and collecting more of these (by for instance increasing the timespan cantered around the GC for news collection).

Chapter 4

Methodology

The following chapter is divided into three parts. In the first one the dataset used for the empirical analysis will be presented. The following part will present the main metric used for quantifying the level of dissent within the monetary policy committee. Since the data for its regular computation are not available an analogical approach based on the media communication of the ECB will be presented. The final part will provide a brief recapitulation of the estimation technique used in the models.

4.1 Data description

Since the ECB does not publish its voting records the model used in the studies of Horváth *et al.* (2011) and Horvath & Jonášová (2015) cannot be applied directly. The present study, similarly as Pesci (2016), estimates the skew based on the communication of the ECB. Such approach has support in the literature, for instance Hayo & Neuenkirch (2013) in their conclusion tackle the topic of substituting the voting record by the speeches by national central bank presidents and the Executive Board members. For the purpose of this analysis, the present study uses the dataset used by Gertler & Horvath (2017). The data consist of a review of verbal unscheduled communication, involving more than 2150 news articles published on the Reuters website between the 1st of July 2008 and the end of January 2014. The analysis focused on public statements related to future guidance in conventional and unconventional monetary policy and in economic outlook contained in speeches and media interviews of all ECB GC members available on Reuters News. Following the methodology of Ehrmann & Fratzscher (2007), only forward-looking statements were selected.

Each communication item was then classified based on its sentiment towards tightening or easing policies or based on the positive or negative future outlook[1]. The sentiment of each article can be viewed as hawkish (with a code value of 1 as willing to increase the policy rate), dovish (with a code value of -1 as willing to decrease) or neutral (with a code value of 0 as unwilling to change). Therefore, articles coded by 1 present a positive economic outlook, warn about the upward risks to price stability or upcoming policy tightening. Neutral articles signal no change in the future economic outlook or no future changes in monetary policy and finally dovish communication express a negative positive outlook, express worries about downside risks to price stability or support additional easing policies. On one hand, it can be argued that this approach is too brief and should involve a finer grid by coding the statements on a scale from -3 to +3, based on Berger *et al.* (2011). On the other hand, such approach is more prone to subjectivity which can make the data-preparation process less comprehensible.

For the purpose of the investigation of monetary policy decisions the rate on the Main Refinancing Operation rate (MRO) was used. There have been 15 changes in the rate during the observed period, which means that the GC maintained the rate unchanged in almost 78% of the meetings. Market expectations, as discussed further on, have been modelled by the term structure via Euribor and the Eonia rates. Since these should capture the market expectations, a part of which is the expectation about changes in the MRO rate, the dataset contains their values one day before the monetary policy meeting.

In addition to the above-mentioned data, additional variables were added to the dataset to further explore possible patterns and characteristics in the ECB 's communication. The following table provides a brief summary of these. More detailed descriptions of the variables are provided in the next chapters.

4.2 Background of the skew variable

The skew variable represents the most common tool to capture levels of dissent within the governing council of a central bank and recent studies show evidence about its predictive power on future monetary policy. The variable, as presented in Gerlach-Kristen (2004), is defined as the difference between the average voted rate and the resulting rate:

[1]To reduce potential pitfalls arising from the subjective matter of the task, the data was carefully cross-checked and consolidated.

Table 4.1: Summary of the variables used

Variables	Description
Speaker-weighted skew	Skew variable computed from average sentiments of GC members
Purdah-omitting skew	Skew variable omitting statements published a week before the GC meeting
Purdah skew variables	Skew calculated based only on statements published a week before the GC meeting
Presidential opinion	Skew variable based solely on the communication of the ECB president
Executive board and national governors skew	Skew variables computed separately for the ECB 's Executive Board and the eurozone governors
Conventional/unconventional policy communication skew	Skew variable calculated only based on statements made about conventional/ unconventional monetary policy measures

$skew_t = average(i_{j,t}) - i_t$, which can also be written as:
$skew_t = average(i_{j,t}) - i_t,$
$skew_t = mean(i_{j,t}) - median(i_{j,t}),$

where i_t is the monetary policy rate and $i_{j,t}$ is the rate voted by the board member j. Generally speaking, the skew variable can be described as the difference between the mean and the median of a selected policy rate or in other words the mean of the suggested rates and the selected policy rate. A positive (negative) skew variable indicates that there is at least one board members prone to a higher (lower) policy rate than the one that has been selected by the majority. The rationale of the skew being informative lies in the fact that a non-zero skew is likely to be caused by the fact that some board members have acquired information about the "optimal rate" sooner than others. The adjustment process however takes time which means that the optimal rate is adopted only after a few meetings.

In terms of constructing the time series for the model it should be noted that central banks publish their voting record usually with a delay (of e.g. 1 day in case of the Bank of England or 2 weeks for the Czech National Bank). For an illustration let's consider an interest rate decision taken at time t. The voting record of that meeting is released later and let's denote it as time $t + \tau$. Next assume that it is available before the following interest rate decision (which is held at time t+1). The main point of the empirical analysis lies in the

relationship between the skew computed based on the voting record of the interest rate decision taken at t and the upcoming interest rate decision at time t+1. Obviously, if available later than in t+1 the voting record of the policy decision from time t loses much of its potential for eventual forecasts.

Due to the unavailability of the voting record, the skew in case of the ECB will be estimated based on the opinion towards monetary policy expressed in the central bank's statements in the intermeeting period preceding the vote. In other words, if grouped by publication dates into intervals for intermeeting periods, the coded sentiments for each published article can be regarded as proxies for individual votes[2]. The meetings of the GC of the ECB are held on a Thursday in the first and third week of each month. Monetary policy itself is assessed only at the first meeting of the month therefore the interval used in the time series is one month[3]. By doing so the data has been grouped into 67 intermeeting intervals beginning in June 2008 and ending in January 2014. The skew variable used for the purpose of this study looks as follows:

$$skew_t = average(i_{j,t}) - i_t,$$

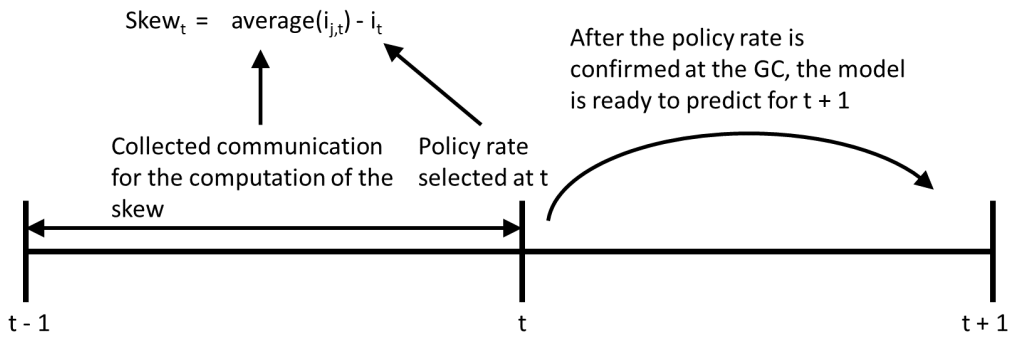
where t represents the t^{th} monetary policy meeting, i indicates the opinion (towards future monetary policy) in the j^{th} published article between monetary policy meeting t-1 and t and $i_t$is the change in the policy rate. For a better understanding of the skew computation a schema is provided below:

In order to have same scales, the voted policy rate could not be used directly (for the skew calculation) since the committee members'statements provide only information about suggested changes and their direction but mostly do not specify whether how large the change should be. For this reason, the voted policy rate variable is either 1 (if the rate was increased), -1 (if decreased) and 0 (if unchanged). Therefore, the skew takes positive (negative) values whenever the policy rate is surpassed by (or surpasses) the mean sentiment. Since the opinion expressed in communication is used, it may happen, that the skew goes beyond the [-1,1] interval. The obtained skew values for the observed period however take on values between -0,88 and 0,82 (with one exception reaching 1,1).

[2]A new version of the voting rights came into force in 2015, where a rotating system of voting rights was introduced. Note that in the observed period from the 1st of July 2008 till the end of December 2013 the one member one vote principle was actual, which does not require additional assumptions for modelling the votes.

[3]The second meeting in every month (if held) serves to deal with various tasks and responsibilities of the ECB and the Eurosystem.

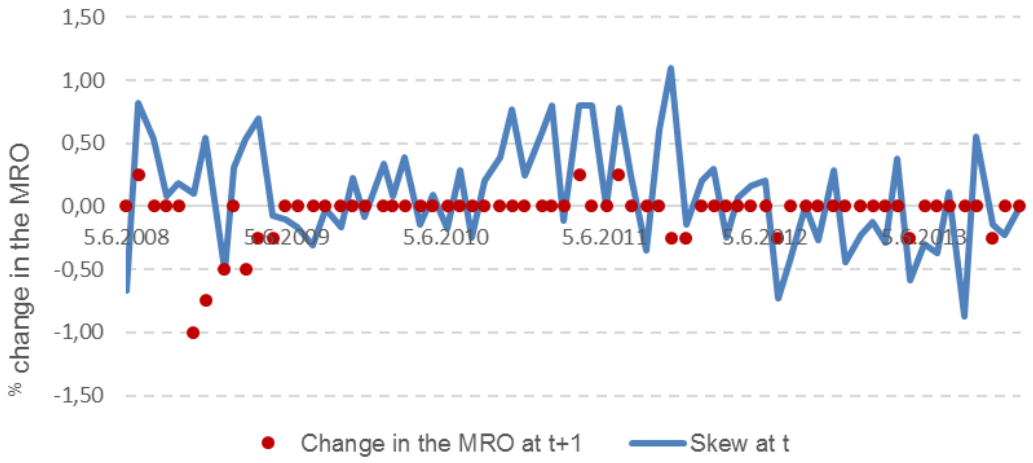
Figure 4.1: Skew predictive mechanism



Source: Author's schema.

Due to the fact that the data follow a turbulent period the skew in some cases fails to predict future movements of the MRO. This can be caused by surprise effects that came after the collapse of Lehman Brothers in September 2008 or after the inauguration of Mario Draghi in November 2011. These surprise events are visible on the plot below, where the skew is plotted with the changes in monetary policy.

Figure 4.2: The informative power of the skew



Source: Author's calculations.

4.3 Ordered PROBIT summary

Before proceeding to the estimation of the model a brief summary of the ordered PROBIT technique is provided. Since the outcomes of the here presented model have an ordinal ranking, the usage of an ordinary least square method is inappropriate.

Let's have a continuous variable y*, that is formed by a linear combination of some predictors $\mathbf{x_i}$ and a standard-normally distributed disturbance term:

$y_i^* = \mathbf{x_i}\beta + \mathbf{e_i}$, $\mathbf{e_i} \sim N(0,1)$, $\forall i = 1,...,N$ and $n \in N$, y_i^* represents the observed variable taking values from 1 through m for which:

$y_i < j \Leftrightarrow \mu_{j-1} < y_i^* \leq \mu_j$, where $j = 0...., m$, μ_j represent the thresholds (also mentioned as threshold points) and $\mu_1 = -\infty$ and $\mu_m = +\infty$.

Hence probability of the outcome j is as:
$P[y_i = j] = P[\mu_{j-1} - \mathbf{x_i}\beta < e_i < \mu_j - \mathbf{x_i}\beta] = \Phi(\mu_j - \mathbf{x_i}\beta) - \Phi(\mu_{j-1} - \mathbf{x_i}\beta)$

The model is then estimated with MLE, where the log-likelihood function has the following form:

$$ln\mathcal{L} = \sum_{i=1}^{N}\sum_{j=0}^{m} Z_{ij} ln[\Phi_{ij} - \Phi_{ij-1}],$$

where $\Phi_{ij} = \Phi[\mu_j - \mathbf{x_i}\beta]$ and $\Phi_{ij-1} = \Phi[\mu_{j-1} - \mathbf{x_i}\beta]$ and $Z_{i,j}$ equals to 1 if y_i and 0 otherwise. It is important to know that the parameters of the model do not necessarily represent the marginal effects as we are accustomed to in the OLS regressions. The parameters of the model are represented as follows:

$$\frac{\delta E[y|\mathbf{x}]}{\delta \mathbf{x}} = \frac{dF(\mathbf{x}'\beta)}{d(\mathbf{x}'\beta)}\beta = \boldsymbol{f}(\mathbf{x}'\beta)\beta,$$

where $\boldsymbol{f}(.)$ is the density function that corresponds to the cumulative distribution, $\boldsymbol{F}(.)$. For the normal distribution, this result is

$$\frac{\boldsymbol{\delta E[y|\mathbf{x}]}}{\boldsymbol{\delta \mathbf{x}}} = \frac{\boldsymbol{dF(\mathbf{x}'\beta)}}{\boldsymbol{d(\mathbf{x}'\beta)}}\beta = \boldsymbol{f}(\mathbf{x}'\beta)\beta,$$

where ϕ denotes the standard normal density. Obviously, the effects will vary with the values of x. In the interpretation Greene (2003) suggests to calculate the value at the means of the regressors, and where necessary, other pertinent values.

The magnitude of the effect of a dummy variable is simple to obtain. We only need to take the difference of two cumulative distribution functions, where

the variable is equal to one and the other where it is equal to zero while other while holding other variables fixed:

$$G(\beta_0 + \beta_1 + \beta_2 x_2 + ... + \beta_k x_k) - G(\beta_0 + \beta_2 x_2 + ... + \beta_k x_k)$$

The effects of discrete variables can be examined in a similar way: for instance, to see what an increase from c to c+1 is the difference of the appropriate Cummulative distribution function (CDF)s should be taken.

$$G[\beta_0+\beta_1 x_1+\beta_2 x_2+...+\beta_k(c_k+1)]-G(\beta_0+\beta_1 x_1+\beta_2 x_2+...+\beta_k x_k)$$

Multiple restrictions testing for the models in the present study uses the likelihood ratio statistic:

$$LR = 2(L_{UR} - L_R),$$

where L_{UR} denotes the log-likelihood value of the unrestricted model and L_R denotes the log-likelihood value of the restricted model. The likelihood ratio statistic follows (under the null hypothesis) an approximate a chi-square distribution with q degrees of freedom, where q is the number of restrictions being tested. In other words, under the null hypothesis the unrestricted model's fit is indifferent from the fit of the restricted model. The likelihood ratio statistic will be further used to assess the joint significance of the coefficients estimated in the model and to analyse significance of improvements of the baseline model.

In addition to the likelihood ratio statistic a pseudo R^2 measure will be used. Since the usual R^2 indicator cannot be obtained for such non-linear estimation, the MC Fadden's pseudo R^2 and pseudo adjusted R^2 used instead:

$$R^2 = 1 - \frac{L_{UR}}{L_0}, \text{ and}$$

$$adj.R^2 = 1 - \frac{L_{UR}-q}{L_0},$$

where L_{UR} is the log-likelihood function for the estimated model, L_0 is the log-likelihood for a model only with an intercept and q is the number of parameters. Such metric behaves in a similar way as the R^2 from OLS: when the model has no explanatory value, the pseudo R^2 is zero and vice versa with an increasing fit (i.e. decreasing log-likelihood of the estimated model) the metric approaches 1, Wooldridge (2015) also mentions the percent correctly predicted as another measure of goodness-of-fit. In case of the ordered PROBIT model, the technique consists in classifying the fitted values based on

the estimated thresholds and then computing the correctly predicted guesses. The usage of this statistic without any other measure of goodness-of-fit can be misleading. Imagine for instance a model predicting an outcome with a very low frequency in the data (such as complications in pregnancy), where the explained variable is binary (either there were problems or not, thus 1 and 0). The model may predict only zeros and still have a 90% correctly predicted (if 10% of the explained variable are ones). Therefore, a high percentage of correctly predicted is not sufficient to validate the fit of the model which makes the adjusted R^2 is preffered.

Chapter 5

Empirical analysis

5.1 The Baseline model

Similarly, as in paper of Horváth *et al.* (2011) (Central banks' voting records and future policy) the here presented models use the above explained PROBIT estimation technique. The dependent variable (accounting for changes in the MRO was coded into categories depending on the magnitude of the change: small (+-25 bpts), large (+-50 bpts) and no change (0 bpts)[1]. Increases by more than 50 basis points did not happen in the observed period which leaves the number of categories to 4 in total. In the first part of the estimation the relationship of the skew and the change in policy rate is analysed based on the approach used in the papers of Gerlach-Kristen (2004) and Horváth *et al.* (2011). The baseline model is therefore defined as follows:

$$\Delta i_{t+1} = a_0 + a_1 skew_t + a_2 \Delta i_t + u_{t+1},$$

where Δi_t represents the change in the MRO at time t, u_t is the error term and $skew_t$ represents the skew variable obtained from the statements published between monetary policy meetings at t-1 and t. According to Horváth *et al.* (2011), the coefficients a_1 and a_2 are expected to be positive. The rationale for the coefficient a_1 to be positive is that if some of the board members voted for a higher interest rate, it is likely that he might have captured information about the necessity of the change a later he will manage to persuade the rest of board and aan increase in the policy rate will be accepted[2]. A negative

[1] 0 refers to large (50 bpts) decrease, 1 represents a small (0.25 bpts) decrease, 2 means no change and 3 small (0.25 bpts) increase.

[2] It is likely the case when the voting record is informative for future policy since they capture the expressed dissent.

estimate of $\boldsymbol{a_1}$ (on the skew variable) would mean that the future policy rate change is going to be of the opposite direction than the skew itself, which does not give much sense. If $\boldsymbol{a_1}$ is significant, the hypothesis that the voting record contains valuable information is confirmed. From that it can be inferred that the conditions of the theoretical model presented in Horvath (2011) are fulfilled and the voting mechanism is likely to be represented by the democratic model (from the already mentioned study). Some of the causes of an insignificant coefficient $\boldsymbol{a_1}$ can be attributed to situations of high volatility or special voting mechanisms, where there is either too many or almost no dissenting votes.

The estimate of $\boldsymbol{a_2}$ can be understood as a rate smoothing parameter which results from the intention of the central bank to avoid sudden changes. In other words, if the central bank prefers to make gradual changes, a change in the policy rate, which follows a period with a stable rate is likely to be followed by another change (of the same direction, i.e. increase or decrease of the target rate). This should therefore result with a positive estimate of $\boldsymbol{a_2}$, Following the methodology presented in Horváth *et al.* (2011) and Gerlach-Kristen (2004), the simple model was estimated and gave the results listed below.

Table 5.1: The weighted skew model

$\boldsymbol{\Delta i_t}$	1,3*** (0,3)
$\boldsymbol{Skew_t}$	1,73*** (0,46)
threshold 1	0,57 (0,47)
threshold 2	1,28** (0,51)
threshold 3	4,94*** (0,74)
Log-likelihood	-37,22
Correct predictions	53 (80,3%)
Mc Fadden pseudo R^2	22,46%
Adjusted Mc Fadden pseudo R^2	18,29%
Chi-squared statistic	0,04

Notes: Robust standard errors are reported into parentheses. *, **, *** denote significance at 10%, 5%, 1% respectively. The Chi-squared statistic denotes the Chi square statistic where the baseline model was used as the restricted model.

As it can be observed, the regression brings highly significant estimates. The coefficients $\boldsymbol{a_1}$ (skew variable parameter) and $\boldsymbol{a_2}$ (change in the policy rate at t) take on the values of 1,3 and 1,73 and show p-values smaller than 1%. The parameters are as expected both positive which confirm the hypotheses that

eventual policy rate changes are of the same sign that the preceding skew and that changes in policy rates are more likely to be gradual. Three thresholds were obtained from the regression, where threshold 1 represents the borderline between large and small expected decrease of the policy rate, threshold 2 is the switching point between small and no change and threshold 3 indicates the cut point between no expected change and possible increase. Both thresholds separating the "no change" area (threshold 2 and 3) are significant, which provides a stronger basis for eventual predictions when estimating possible future changes after a stable period.

Threshold 2 indicates that when the $a_1 skew_t + a_2 \Delta_t$ are smaller than 1,3, the policy rate is likely to be reduced by 25 bpts in the following monetary policy assessment. Analogously values of $a_1 skew_t + a_2 \Delta_t$ surpassing 4,94 signal a potential increase of the MRO rate by 25 bpts. Thus, if $a_1 skew_t + a_2 \Delta_t$ lies between 1,3 and 4,94 the policy rate is very likely to remain unchanged. Since threshold 1 is not significant values $a_1 skew_t + a_2 \Delta_t$ lower than 0,61 do not always lead to a decrease of the MRO rate of 50 and more bpts. Let's assume that no change in the policy rate was the conclusion of the previous monetary policy meeting, but the news analysis reported a skew of 0,4. According to the above presented results a small change in the policy rate is likely to be expected[3].

5.2 Term structure inclution

If central banks and the rest of the financial sector have the same information set at their disposal, the expectations of both should not differ by much. Assuming that markets are efficient and fully incorporate the available information in the rates, the skew should not bring any additional information about the upcoming policy rate since the variable was calculated based on the content of published news (already fully contained in the market expectations). In terms of modelling this would mean that if a variable accounting for the financial market's expectations is added to the equation, the skew variable should no longer be significant.

Following the model presented in Gerlach-Kristen (2004), the market expectations are modelled by the term structure which is represented by the difference between money market rates with long and short maturities. For

[3] Since $\mathbf{1,3 \times 1 + 0,4 \times 1,73 > 1,3}$, where 1,3 represents the no change/small change threshold.

the purpose of the estimation Eonia, Euribor 3 and 12 months' market rates were used[4]. Since the skew incorporates news released until the GC meeting, so should the term structure. Therefore, the term structure for time t was computed for the trading day preceding the monetary policy meeting held at t+1. The model then has the following form:

$$\Delta i_{t+1} = a_0 + a_1 skew_t + a_2 \Delta i_t + a_3 (i_{t,L} - i_{t,S}) + u_{t+1},$$

where $i_{t,L}$ represents a money market rate with a long maturity and $i_{t,S}$ represents a money market rate with a short maturity one day before the monetary policy vote.

The results show, despite the expectations, the skew variable to be significant at least at a 5% level in all six models, which provides evidence that the skew based on published ECB announcements enlarges the information set used in financial market expectations. This may not necessarily mean that the ECB has a wider information set than the markets, the central bank can simply devote more funds and effort to the search of relevant information. Another explanation could be, that the market does not fully incorporate all available news into its rates meaning that there some inefficiencies may be present.

In terms of goodness-of-fit, the Chi square statistics indicate that most of the models do not significantly improve the baseline model. The best fits, having significant chi square statistics at 5% and 1% levels, were obtained for the 1-month overnight and 3-months overnight term structure models. The same conclusion about the models can be inferred based on the Mc Fadden pseudo R^2: by including the term structure the models' Mc Fadden pseudo R^2 increased[5], but except 3 models it did not surpass 0,05. The above listed results therefore show evidence supporting the hypothesis that the skew is not fully reflected in the money market rates.

What is however unusual are the negative estimates obtained for the term structure variables where the Eonia rate was used. The negative coefficient on the term structure can be interpreted as if the MRO is more likely to decrease the more the market expects the rates to rise (i.e. the more the term structure increases), which can be considered as very unlikely in a normal economic environmnet. As depicted in the Figures 5.1 and 5.2 below, the overnight rate, as opposed to the Euribor rates, is much more sensitive to unusual events, thus

[4]The data for the estimation were obtained from the database www.quandl.com.

[5]The baseline model's adjusted pseudo R2 of 18,33% is surpassed by 5 out of the 6 term structure models.

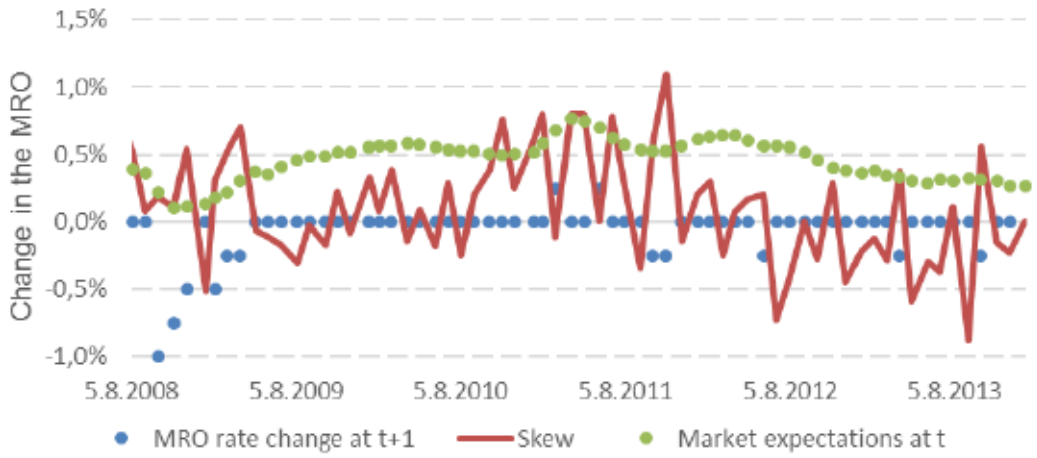
Table 5.2: Term structure added

	Eur. 12M 3M	*Eur. 12M 1M*	*Eur. 12M Eon.*	*Eur. 3M 1M*	*Eur. 3M Eon.*	*Eur. 1M Eon.*
$\boldsymbol{\Delta i_t}$	0,58 (0,42)	1,09*** (0,35)	1,52*** (0,3)	1,28*** (0,3)	1,37*** (0,29)	1,48*** (0,33)
$\boldsymbol{Skew_t}$	1,13** (0,48)	1,46*** (0,52)	2,31*** (0,52)	1,86*** (0,5)	2,46*** (0,51)	2,44*** (0,54)
$\boldsymbol{Term\_structure_t}$	4,68** (2,01)	1,73 (1,06)	-1,3* (0,67)	-0,81 (1,61)	-2,45*** (0,8)	-3,26*** (1)
threshold 1	1,17** (0,59)	1,32* (0,69)	-0,18 (0,6)	0,43 (0,61)	-0,55 (0,56)	-0,04 (0,5)
threshold 2	2,01*** (0,62)	2,07*** (0,66)	0,58 (0,62)	1,13* (0,62)	0,34 (0,57)	0,95* (0,52)
threshold 3	6,04*** (0,94)	5,89*** (0,89)	4,36*** (0,7)	4,84*** (0,78)	4,31*** (0,63)	4,94*** (0,71)
Log-likelihood	-33,35	-35,94	-35,11	-37,1	-31,44	-30,07
Correct predictions	54 (81,8%)	53 (80,3%)	54 (81,8%)	53 (80,3%)	56 (84,8%)	57 (86,4%)
Mc Fadden pseudo R^2	30,52%	25,12%	26,85%	22,71%	34,51%	37,36%
Adj. Mc Fadden pseudo R^2	24,27%	18,87%	20,60%	16,46%	28,26%	31,11%
Chi-squared statistic	7,7	2,51	4,17	0,21	11,53***	14,26***

Notes: Robust standard errors are reported into parentheses. *, **, *** denote significance at 10%, 5%, 1% respectively. The Chi-squared statistic denotes the Chi square statistic where the baseline model was used as the restricted model.

making the computed term structures vary much more. Such spikes in the term structure obtained from rates with longer maturities are missing since the unusual events affect the most the short-term rates. When plotted, the term structure variable based on rates with longer maturities present a smoother line. The cause of the first series of shocks after September 2008 can be explained by the collapse of the Lehmann Brothers resulting in an unexpected expansionary monetary policy. After that, the next shock came when Mario Draghi became the ECB's new president in November 2011. Until then the market responsiveness to central bank's president communication was low but Draghi changed the course. Gertler & Horvath (2017) in their study underline the influence of several ECB members on 2-year OIS rate and Draghi not only shows to have a significant impact on the rate, but also has the highest influence from the whole sample of the observed ECB board members. The shock can be explained by the fact that it took time to the markets to "learn" how to react on his communication. Another potential issue related to the negative term structure based on the overnight rate consists in the period when the monetary policy rate reached its zero-lower bound (since 2012). During that period, the market overnight rate reached its technical minimum and thus made the communication fail to predict future decreases in the policy rate. Longer maturity rates were less affected and further decrease remained possible in their case.

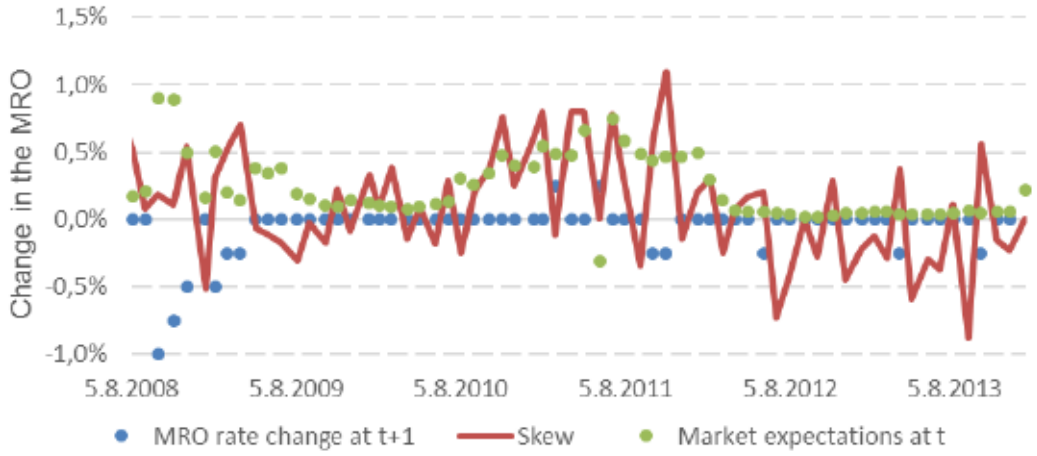
Figure 5.1: Informative power of the term structure obtained from the Euribor 12 months and Eonia rates Euribor 3 months rates



Source: Author's calculations.

Due to these extraordinary events in the observed period which is projected mostly in the overnight rate, the 12-months Euribor and 3-months Euribor term

Figure 5.2: Informative power of the term structure obtained from the Euribor 12 months and Eonia rates



Source: Author's calculations.

structure will be used for further modelling purposes. The model incorporating this term-structure presents the third best result in term of goodness-of-fit measures (after the models incorporating overnight rates in the term structure variable) therefore this term structure will be used for further modelling purposes.

5.3 Predictive value of the skew for more periods ahead

Dissent in approaches towards monetary policy does not necessarily signal change in the upcoming vote, it can also be predictive more meetings ahead as Horvath & Jonášová (2015) present in one of their conclusions. The hypothesis is based on the idea that it may take more monetary policy meetings to the early bird to convince the rest of the board. Following the investigation of such effect an analysis of the relation of the skew and changes in the ECB'policy rate more than one period in the future is provided. The research covers two and three periods ahead by a model which was estimated based on the following equations:

$$\Delta i_{t+n} = a_0 + a_1 skew_t + a_2 \Delta i_t + u_{t+1}$$

$$\Delta i_{t+n} = a_0 + a_1 skew_t + a_2 \Delta i_t + a_3 (i_{t,L} - i_{t,S}) + u_{t+1},$$

where n stands for the n-th period after t, $(i_{t,L} - i_{t,S})$ reresents the term structure computed based on the difference of the Euribor 3-months and Eonia rates[6].

Table 5.3: Two periods ahead predictive model

	Baseline model	*Term structure included*
Δi_{t-1}	0,72** (0,29)	0,69** (0,29)
$Skew_{t-1}$	0,77* (0,42)	0,88** (0,41)
$Term\_structure_{t-1}$	-	-0,56 (0,69)
threshold 1	-0,17 (0,52)	-0,48 (0,62)
threshold 2	0,4 (0,53)	0,11 (0,62)
threshold 3	3,43*** (0,64)	3,13*** (0,68)
Log-likelihood	-44,05	-43,62
Correct predictions	50 (78,1%)	51 (78,5%)
Mc Fadden pseudo R^2	8,23%	9,04%
Adjusted Mc Fadden pseudo R^2	1,98%	2,79%
Chi-squared statistic	13,70***	12,92***

Notes: Robust standard errors are reported into parentheses. *, **, *** denote significance at 10%, 5%, 1% respectively. The Chi-squared statistic denotes the Chi square statistic where the baseline model was used as the restricted model.

As visible from the results, the skew appears to be significant at least at a 10% level in both equations signalling that it is informative about changes in the rate two monetary policy meetings ahead. In terms of correct predictions, the models appear to be almost the same as the baseline model (that reached 53 corresponding to 80,3%). However, the chi-square test, the pseudo and adjusted pseudo R^2 indicate a significant decrease in goodness-of-fit. Compared to the one period ahead predictive models, the above presented give slightly worse predictions, and lack a statistically significant threshold between the no-expected change and expected decrease levels. Therefore, in spite of giving quite satisfactory results in terms of correct predictions and significant skew variables, the results of the two periods ahead models show a significant decrease in their goodness-of-fit.

[6]The selection of the Eonia rate and the Euribor 3-month rate to calculate the term structure is not random. In the term structure analysis, this combination was the second best in terms of correct predictions and goodness-of-fit. The usage of the 1 month Euribor and Eonia rates (despite of its the best fit as a term structure) would not give sense since it does not capture the market's expectations more than one period ahead.

Since the two periods ahead estimation showed a lower in fit compared to the baseline model, the three periods ahead analysis is also expected to do so. The purpose of making the estimation however still gives sense since it can shed light on the relationship of the skew and the change in policy rate two periods later.

Table 5.4: Three periods ahead predictive model

	Baseline model	*Term structure included*
Δi_{t-2}	0,5* (0,29)	0,5* (0,29)
$Skew_{t-2}$	-0,16 (0,4)	-0,1 (0,43)
$Term\_structure_{t-2}$	-	-0,3 (0,71)
threshold 1	-0,61 (0,54)	-0,76 (0,64)
threshold 2	-0,05 (0,54)	-0,19 (0,64)
threshold 3	2,83*** (0,59)	2,7*** (0,66)
Log-likelihood	-45,37	-45,25
Correct predictions	50 (78,1%)	50 (78,1%)
Mc Fadden pseudo R^2	5,48%	5,73%
Adjusted Mc Fadden pseudo R^2	-0,77%	-0,52%
Chi-squared statistic	16,34***	16,10***

Notes: Robust standard errors are reported into parentheses. *, **, *** denote significance at 10%, 5%, 1% respectively. The Chi-squared statistic denotes the Chi square statistic where the baseline model was used as the restricted model.

As expected, the above listed results reject significance of the lagged skew variable. It should be noted that the number of correct predictions remained almost the same as in the two-periods ahead analysis. Very low metrics of goodness-of-fit are obtained (the adjusted pseudo R^2 is even negative, which is possible by definition of the metric) indicating that it cannot be confirmed that the skew is informative on the voting record three periods ahead.

5.4 Analysis of statements relevance

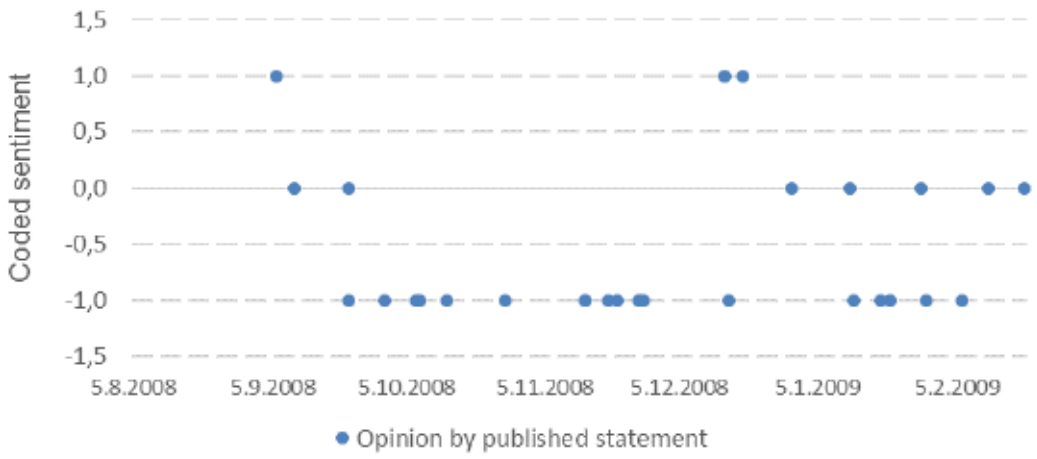
Should all of the ECB members' statements be regarded equally? Does timing play a role in the statements' importance? Which are the statements that are the most informative? The following chapter is in its first part going to unveil patterns in the timing of the communication and in its second part the

importance of communication items will be investigated in order to see if they should be regarded as equally important.

5.4.1 Weighted skew approach

Since the presented baseline skew calculation is based on news articles, it may occur that some of the GC members give their opinion to the media more often than others. In other words, it may be that more commonly discussed opinions would overweight other but less commented important views which could make the skew an imprecise and inappropriate proxy for the voting record. The data also show that the opinion of the GC members' communication varied during the inter-meetings period. Such property of the data presents another argument for grouping the news items sentiments by speakers since the baseline skew does not differentiate between frequent indecisive and less frequent but confident GC members. For instance, the stance of Jean-Claude Trichet from September 2009 to March 2009 (depicted below in Figure 5.3) shows how the opinion in his statements varied, especially in January 2009: three statements opting for an increase in the policy rate and one preferring no change. Should these four statements have the same weight as statements from four other GC members who commented the situation in that inter-meeting period only once?

Figure 5.3: Trichet's opinion towards future monetary policy in released news



Source: Author's calculations.
Notes: 1 represents willingness to increase the policy rate, -1 to decrease and 0 to keep it unchanged.

A counterargument for such procedure would be that the increased fre-

quency of the speaker giving statements in the media could be caused by the importance the ECB gives to the opinion. In such case the bias in the skew would be rejected and there would not be any difference between the modified and baseline skew. Another argument could be that the change in opinion of the speaker was not always a change in opinion. The reviewed news articles did not always directly tackle monetary policy but also other relevant topics from which the attitude towards future policy rates could have been inferred (such as the overall economic outlook for a longer time horizon). In other words, varying reported sentiment towards future monetary policy during one period between two monetary policy meetings might be seen as an opinion inconsistency.

For the purpose of analysing the potential bias, the opinions of each GC member expressed in the news articles has been averaged in each period. Such measure will give equal weights to medially active GC members:

$$\boldsymbol{skew_t = average(i_{j,t}) - i_t}$$

$$\boldsymbol{\Delta i_{t+1} = a_0 + a_1 skew_t + a_2 \Delta i_t + u_{t+1}}$$

The $\boldsymbol{i_{jt}}$ variable no longer represents the opinion in the jth published article between monetary policy meeting t-1 and t. Instead it represents the average opinion of the published articles of the jth speaker [7].

Table 5.5: The weighted skew model

$\boldsymbol{\Delta i_t}$	1,3*** (0,3)
$\boldsymbol{Skew_t}$	1,73*** (0,46)
threshold 1	0,57 (0,47)
threshold 2	1,28** (0,51)
threshold 3	4,94*** (0,74)
Log-likelihood	-37,22
Correct predictions	53 (80,3%)
Mc Fadden pseudo R^2	22,46%
Adjusted Mc Fadden pseudo R^2	18,29%
Chi-squared statistic	0,04

Notes: Robust standard errors are reported into parentheses. *, **, *** denote significance at 10%, 5%, 1% respectively. The Chi-squared statistic denotes the Chi square statistic where the baseline model was used as the restricted model.

[7] Considering that there are n speakers in the period bounded by t-1 and t and $\boldsymbol{j \in [1, n]}$.

As shown by the results the modified skew is informative about future changes in the policy rate, however the hypothesis of giving too much weight to majority opinions cannot be confirmed since the updated skew model does not perform significantly better than the baseline model. The Mc Fadden pseudo R^2 metric is even slightly lower than in the baseline skew model and rejects the hypothesis of a significant improvement in the model's fit. Also, the chi-square test fails to confirm significant difference between the baseline and the updated skew models. Therefore, it can be concluded that there is evidence that the ECB does not appear to over-emphasise some of the prevalent opinions in the GC. Such finding is in line with the conclusion of Ehrmann & Fratzscher (2007) informing that despite the variety of provided statements, the ECB manages to remain highly consistent. The baseline skew indicator will thus be used for further modelling purposes.

5.4.2 Conventional and unconventional policy measures' related communication

Since the global financial turmoil in 2007, central banks across the world started not only cut their policy rates, they also implemented unusual policy measures to face it. Borio & Zabai (2016) for that purpose further distinguished between balance sheet policies, forward guidance and negative policy rates. The following analysis will focus on explaining to what extent is the communication linked to unconventional monetary policy explanatory about future changes in the (conventional) monetary policy rate. In other words, this chapter will try to assess whether communication about unconventional policy helps to predict future changes in monetary policy. Since this type of communication is not directly linked to the policy rate, the common sense would suggest that it should be less informative or even could be omitted. The data has been treated following the methodology of Borio & Zabai (2016) in order to classify each communication item as either conventional or unconventional monetary policy topic leaving 291 conventional and 1094 unconventional communication items[8]. To measure the relevance of the communication types, skew variables have been computed for both unconventional and conventional communication items and regrouped into one model as follows:

[8]I.e. each communication statement regarding negative policy rates, forward guidance or balance sheet operations (such as quantitative easing) were regarded as unconventional policy topics. Conventional monetary policy on the other hand regroups topics centered around the policy rates.

$$\Delta i_{t+1} = a_0 + a_1 skew_{t,unconv} + a_2 skew_{t,conv} + a_3 \Delta i_t + u_{t+1}$$

where $skew_{t,unconv}$ represents the skew from unconventional policy items at time t and $skew_{t,conv}$ represents the skew from conventional ones.

Table 5.6: Conventional/unconventional monetary policy model

	Simple model	Unconventional communicaiton removed	Term-structure augmented
Δi_t	1,46*** (0,29)	1,31*** (0,27)	0,7** (0,34)
$Unconv\_pol\_skew_t$	1,36*** (0,39)	1,55*** (0,38)	1,22*** (0,35)
$Conv\_pol\_skew_t$	0,71 (0,46)	-	-
$Term\_structure_t$	-	-	4,44** (1,81)
threshold 1	0,79 (0,5)	0,54 (0,5)	1,17** (0,56)
threshold 2	1,61*** (0,5)	1,35*** (0,49)	2,15*** (0,56)
threshold 3	5,72*** (0,73)	5,27*** (0,71)	6,42*** (0,99)
Log-likelihood	-33,83	-34,76	-31,13
Correct predictions	54 (81,8%)	54 (81,8%)	55 (83,3%)
Mc Fadden pseudo R^2	29,52%	27,57%	35,14%
Adjusted Mc Fadden pseudo R^2	23,27%	23,41%	28,89%
Chi-squared statistic	6,74	4,87	12,13 **

Notes: Robust standard errors are reported into parentheses. *, **, *** denote significance at 10%, 5%, 1% respectively. The Chi-squared statistic denotes the Chi square statistic where the baseline model was used as the restricted model.

The initial expectation of the insignificance of the skew from unconventional communication does not appear to be confirmed by the results despite the large proportion of the conventional communication items in the data. One of the explanations of the insignificance could be, that this type of measures is linked to the zero-lower bound policy rate period during which further lowering of the rate met its technical constraints. Support for that fact could be found in El-Shagi & Jung (2015) who mentions that the skew may lose its predictive power during in such case. What is however unexpected is the significance of the unconventional policy measures' skew which can apparently substitute for the conventional one. Its significance can be justified as well by the period of turmoil where conventional measures failed and the unconventional ones (represented by the Quantitative easing programme) appeared to be handier. Such

result is in line with Borio & Zabai (2016) who confirms the success of unconventional policies. Goodness-of-fit measures indicate a better fit in comparison to the baseline model, which is however insignificant based on the chi square statistic. The insignificance of the conventional communication skew parameter justifies the exclusion of conventional communication and for completeness, the new skew variable (based solely on unconventional communication items) was tested against the term structure.

The removal of the conventional communication slightly reduced the fit of the model, therefore no significant improvement can be observed, but the measures are still higher than the ones of the baseline model. Based on the chi-square statistic, which fails to confirm a significantly different fit than the one of the baseline model, it can be inferred that a more precise model can be obtained by omitting the conventional communication from the skew calculation. When including the term structure[9] in the model, the goodness-of-fit significantly improves and furthermore both term structure and unconventional monetary policy communication skew are significant, meaning that the restricted skew is not fully reflected in the market expectations. The analysis therefore shows evidence for omitting the inclusion of conventional communication statements during crisis for the ECB as they appear to lack predictive power.

5.4.3 Measuring the effect of purdah

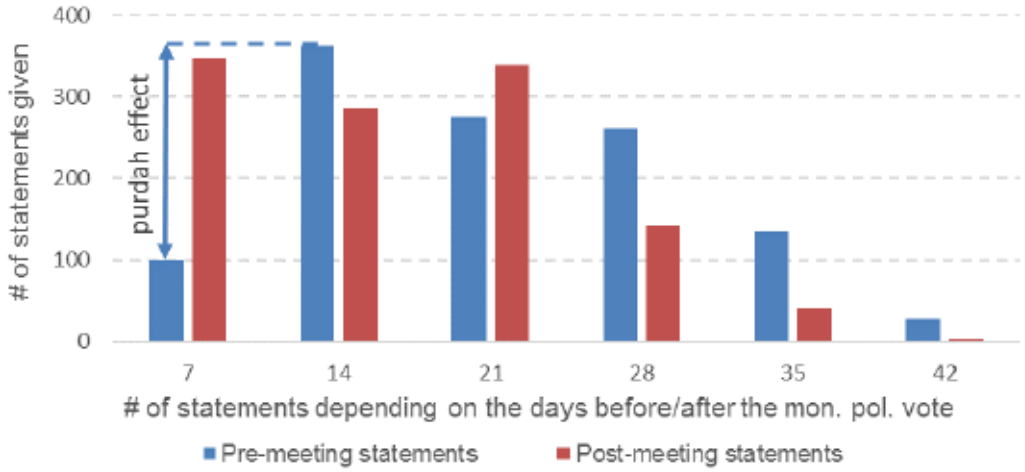
Given the evidence shown on US interest rates' volatility and purdah communication in Ehrmann & Fratzscher (2009) an analysis of purdah communication of the ECB for the observed period is at hand. The aim of this investigation is to find out whether more attention should be given to announcement released only a few days before the monetary policy meeting since these (in the case of the USA), according to in Ehrmann & Fratzscher (2009), *"have a large effect on US interest rates, about three to four times larger than those in the inter-meeting period outside the purdah."* Based on the mentioned study, central banks tend to limit their communication in the days (usually a week) surrounding the monetary policy announcement. The few statements released in that period serve to stabilise the market and reduce volatility and the following analysis will test how relevant are these when predicting upcoming changes in the policy rates. The purdah period can also be viewed as a period when no

[9]Where the term structure is represented by the difference of EURIBOR rates with 12 and 3 months maturities'.

breakthrough announcements should be given, i.e. no more important information about upcoming changes should be provided and the central bank's board is only supposed to try to reduce uncertainty via its communication channels.

If the purdah statements bring valuable information, by omitting them in the skew calculation the variable would lose much of its predictive power and the model's metrics would indicate a lower goodness-of-fit. On the other hand, even with lower predictive power the purdah communication may still be informative: when replacing the skew in the baseline model by purdah and non-purdah skew variables, the skew calculated from purdah communication would be significant but with a lower effect compared to the non-purdah skew. Therefore, both the relevance of the purdah communication and its effect will be tested.

Figure 5.4: Histogram monitoring the amount of statements given before/after the monetary policy meeting



Source: Author's calculations.

The ECB, as mentioned in the literature review, follows a seven days purdah. In the histogram above the decrease in the number of statements given a week before the monetary policy meeting (denoted as the purdah effect) is clearly visible. The bank despite the turmoil in the observed period therefore managed to follow its one-week pre-meeting communication restriction.

To test the importance of the purdah communication skew variables for purdah-only communication and non-purdah communication will be computed. Two approaches were used for the analysis: the first has the objective to measure the impact of the exclusion of the purdah communication while the second focuses on the effect of the purdah communication. For that purpose, the following two equations were estimated:

$$\Delta i_{t+1} = a_0 + a_1 skew_{t,purdah-omitted} + a_2 \Delta i_t + u_{t+1}$$
$$\Delta i_{t+1} = a_0 + a_1 skew_{t,purdah-omitted} + a_2 skew_{t,purdah} + a_3 \Delta i_t + u_{t+1}$$

According to the results, the purdah period statements should not be disregarded despite the significance of the skew estimate obtained by omitting these from the dataset. The pseudo R^2 measures decreased for the purdah omitting model in comparison to the baseline model but the chi-square statistics do not indicate that the decrease is significant. From the combined model results it can be observed that both skew variables are significant at a 1% level, which based on the magnitudes, indicate that purdah communication is relevant but less informative (due to the lower coefficient). In terms of goodness-of-fit the adjusted pseudo R^2 is almost the same therefore it is no surprise that the chi-square statistic is insignificant.

After including the term structure to the model in order to check for the robustness of the results, the non-purdah skew becomes no longer significant. In combination with the significance of the term structure and the purdah skew it can be inferred that the market expectation fully integrates the information from the non-purdah communication. To additionally test that hypothesis, the model excluding the non-purdah communication was estimated. Results show only a minor change in the magnitude of the estimated parameters and in addition to the minor drop in goodness-of-fit the superiority of purdah communication can be confirmed.

The relevance of the Purdah communication presents one of the key assumptions in Pesci (2016) who investigated the period of three days centred around the Governing Council meeting. For the analysis, a metric similar to the skew was used. Despite the proven significance in the study, the mere purdah-based communication metric of Pesci (2016) fails to be informative about future changes in the policy rate for the observed period of the present study (from the 1st of July 2008 to the 28th of December 2013). The estimation results can be found in the Appendix B.

Table 5.7: Purdah analysis model

	Purdah omitted	Combined model	Term structure included	Non-purdah communication omitted
Δi_t	1,17*** (0,31)	1,41*** (0,31)	0,66 (0,46)	0,41 (0,41)
$Purdah\_omitted\_skew_t$	1,45*** (0,47)	1,33*** (0,47)	0,56 (0,53)	-
$Purdah\_skew_t$	-	0,76*** (0,28)	0,93** (0,37)	1*** (0,36)
$Termstructure_t$	-	-	5,65*** (2,18)	6,66*** (2,01)
threshold 1	0,48 (0,49)	0,78* (0,47)	1,5** (0,62)	1,43** (0,65)
threshold 2	1,16** (0,52)	1,5*** (0,53)	2,4*** (0,68)	2,33*** (0,71)
threshold 3	4,67*** (0,75)	5,41*** (0,82)	6,99*** (1,08)	6,9*** (1,17)
Log-likelihood	-38,64	-36,06	-31,5	-31,94
Correct predictions	53 (80,3%)	53 (80,3%)	53 (80,3%)	55 (83,3%)
Mc Fadden pseudo R^2	19,50%	24,87%	34,37%	33,46%
Adjusted Mc Fadden pseudo R^2	15,33%	18,62%	28,12%	27,20%
Chi-squared statistic	2,88	2,28	11,40***	10,52***

Notes: Robust standard errors are reported into parentheses. *, **, *** denote significance at 10%, 5%, 1% respectively. The Chi-squared statistic denotes the Chi square statistic where the baseline model was used as the restricted model.

5.5 Speaker importance

When estimating upcoming changes in policy rate based on media communication, the speaker may matter. Riboni & Ruge-Murcia (2010) for instance weight the votes of committee members by seniority and by dissent of each member in the past. The rationale for such procedure is, that more experienced members tend to be more influential and that "serial" dissenters appear to be more willing to share their disagreeing view, which gives them more influence on the final decision. The following chapter is going to test seniority and groups significance by focussing on the ECB president, the ECB executive board members and eurozone governors.

5.5.1 The ECB presidential sentiment informative power

One of the most likely members of the Governing Council to have a higher influence is the president of the ECB. The observed period incorporates the presidencies of Jean-Claude Trichet and Mario Draghi, both having completely different communication patterns. According to Gertler & Horvath (2017) markets' responsiveness to Draghi's communication is high whereas Trichet did not show any significant results. This may be caused by the approach towards communication where Draghi preferred to inform himself about the bank's decisions, while Trichet chose a more collegial approach by letting other members of the GC comment on these. Based on these different approaches, an analysis of the joint data is not likely to bring significant results for the whole sample. For that purpose, the data was split to divide the presidencies. The rationale of treating the presidential opinion separately is that it may have a greater weight and furthermore, since the president is more likely to communicate strategic intentions of the bank, his opinion may be predictive more periods ahead. Two lags of the presidential opinion monitoring variable have been added to the model since these may reflect the long-term ambitions of the central bank. For the analysis, a skew variable computed solely from the ECB's president's statements have been selected to model the presidential opinion:

$$presidential\_skew_t = average(i_{p,t}) - i_t$$

where $i_{p,t}$ denotes opinion in the published articles of the ECB's president. The divergence of the presidential opinion stated in the bank's communication may signal changes in the monetary policy rate further in the future. The updated version of the model thus has the following form:

$$\Delta i_{t+1} = a_0 + a_1 skew_t + a_2 \Delta i_t + a_3 (i_{t,L} - i_{t,S}) + a_4 presidential\_skew_t + u_{t+1}$$

According to the finding of Ehrmann & Fratzscher (2007) which mentions that *"euro area markets respond to communication by the ECB President and other Governing Council members to a very similar extent"*, the newly estimated variable representing the presidential opinion should not significantly improve the model. Results appear to be confirm this finding, but before rejecting the initial hypotheses, several facts need to be pointed out. As shown above, Trichet's opinion indicator shows to be significant while Draghi's does not. The second presidency in the observed period is linked to turbulent changes in the economy accompanied with a policy rate attaining its zero-lower bound and difficulties of the financial markets to interpret Draghi's communication (Gertler & Horvath (2017)) in the beginnings. Next it should be noted, that the analysis should be taken only as illustrative since the number of observations is very (39 observations for Trichet and 28 in case of Draghi). The lack of observations could explain the insignificant results obtained in case of Draghi's presidency having low chi-squared statistics and thus rejecting the joint significance of all of the included variables. Trichet's models on the other hand appear to be significant which can be partly explained by the larger dataset and partly because his opinion might have really mattered. Furthermore, the hypothesis of the importance of the presidential opinion cannot be completely rejected since the full-sample model shows both presidential and second lag presidential skews significant. Therefore, any direct conclusions cannot be drawn since the approach towards communication in case of the two mentioned presidents was different. The analysis shows evidence supporting the importance of the presidential opinion during the presidency of Trichet and fails in case of Draghi. The relevance of past expressed presidential opinions thus still remains questionable.

Table 5.8: Add caption

	Full sample		Trichet		Draghi	
	Simple	Lags included	Simple	Lags included	Simple	Lags included
Δi_t	1,36*** (0,29)	1,47*** (0,32)	1,97*** (0,44)	1,96*** (0,43)	0,49 (0,88)	3,42*** (0,66)
$Skew_t$	1,39*** (0,49)	0,7* (0,36)	2,13** (0,95)	1,82* (0,98)	0,82 (0,89)	1,36 (1,18)
$President\_skew_t$	0,5 (0,31)	1,38*** (0,52)	1,6*** (0,55)	1,64*** (0,58)	0,35 (0,51)	0,44 (0,58)
$President\_skew_{t-1}$	-	0,11 (0,29)	-	0,07 (0,45)	-	0,12 (0,4)
$President\_skew_{t-2}$	-	0,65** (0,28)	-	0,44 (0,44)	-	0,53 (0,37)
threshold 1	0,69 (0,44)	0 (0)	1,8*** (0,51)	0 (0)	0,91 (1,54)	8,71*** (1,03)
threshold 2	1,4*** (0,48)	0,78 (0,54)	2,52*** (0,65)	1,6*** (0,61)	0 (1,58)	7,87*** (0,93)
threshold 3	5,22*** (0,73)	1,54*** (0,56)	7,73*** (1,61)	2,35*** (0,74)		
Log-likelihood	-36,55076	-33,99453	-17,18022	-16,21762	-15,1353	-11,75801
Correct predictions	54 (81,8%)	52 (81,2%)	33 (84,6%)	32 (86,5%)	22 (81,5%)	21 (84,0%)
Mc Fadden pseudo R^2	23,85%	29,17%	43,88%	47,03%	1,97%	23,84%
Adjusted Mc Fadden pseudo R^2	17,60%	18,76%	34,09%	30,70%	-17,46%	-8,54%
Chi-squared statistic	1,3	0,54	2,00	1,72	2,00	0,48

Notes: Robust standard errors are reported into parentheses. *, **, *** denote significance at 10%, 5%, 1% respectively. The Chi-squared statistic for the whole sample models denotes the Chi square statistic where the baseline model was used as the restricted model. In case of Draghi's and Trichet's model the constan-only respective models were used (for the data following the given presidency).

5.5.2 Eurozone governors' and Executive Board' statements relevance

The predictive power of dissent can also be assessed for groups within the board of the central bank since it is likely that the disagreement expressed in some groups could be more informative than from others. The research was already tackled by Gerlach-Kristen (2009) who found that a skew based on the dissent of external members of the Bank of England's MPC is more predictive than the same metric based on the internal ones[10]. Following this approach, the main source of predictive dissent in the ECB's can be spotted. The Governing Council can be divided into two groups: the Executive Board (consisting of 6 members) and Eurozone central bank governors[11]. Similarly as the outside members in Gerlach-Kristen (2009), the Eurozone governors are more likely to present new approaches since they represent a variety of economies and opposed to the Executive Board members they do not closely collaborate together on a daily basis (which in case of the Executive Board may in the long-term align their opinions). Despite the number of national governors being approximately three times higher than the Executive Board members, both categories on average provided the same number of statements during the observed period (48% Executive Board and Eurozone governors 52%). There is also no clear dominance in terms of dissenting opinions presented in the communication: 51% of the total dissenting communication is presented by the Executive Board members while the National governors have 49% of the total number. Based on the communication data it can be inferred that the average Executive Board member communicates much more often than a central bank governor and presents dissenting views in a similar proportion as the national governors do. Therefore, the aim of the following analysis is to obtain a more detailed view on the source of the early bird indicating future changes in the monetary policy. The analysis has been performed by computing separate skew measures for each category and estimating a model for each:

$$\Delta i_{t+1} = a_0 + a_1 skew_{t,ExecutiveBoard} + a_2 skew_{t,Nationalgovernors} + a_3 \Delta i_t + a_4(i_{t,L} - i_{t,S}) + u_{t+1}$$

[10]The MPC in this matter present an unusual example. Outside members of the committee are distinguished economists from academia and public sectors and the aim of such inclusion of these is to provide "fresh air", i.e. present new opinion and constantly assess the inside board members' suggestions.

[11]The number of these increased in the observed period due to the enlargement of the Eurozone from 15 to 19.

As apparent from the results, the chi-square statistic confirms a significantly lower fit in the model neglecting the eurozone governors' communication, meaning that the Executive Board's skew is not only less informative than the national governors', but its omission (i.e. the Eurozone-governors-skew-only model) brings same results as the baseline model. This finding is also supported when estimating both skew variables together in one model where only the national governors' skew remains significant. The inclusion of the term structure further underlines the sufficiency of the eurozone governors skew and validates that the information it holds is not fully incorporated within the market expectations.

The relevance of the national governors' communication is in line with the finding of Gerlach-Kristen (2009), whose justifications for the Bank of England's outside members can be summarised in the following points:

- The groups have access to analytical resources.
- Different strategic behaviour – dissent can be viewed negatively when considering a long career for insiders, however, it can attract more media attention to the insider, whose term in the MPC is limited anyway.
- Insiders' and outsiders' preferences may be represented by different loss functions.

In case of the ECB, there are two most likely arguments to explain the results. The first is that the Eurozone governors do not collaborate as closely together as the Executive board does. Such cooperation may partly hinder the generation of new ideas. This argument can be related to the difference in analytical resources mentioned by Gerlach-Kristen (2009): national governors are more likely to analyse the problem from a more national perspective which may generate more diverse opinions. Next, the objectives of the national governors may differ more since they act in the name of different economies. Dissent from this point of view is backed up by the necessity of whole countries and does not simply represent a personal disagreement on the suggested policy rate. From the chart below it can be observed that the German-speaking countries appear to be part of the minority the most often, since their central bank governors' dissenting statements represent more than 50% of dissenting statements in the dataset. On the other hand, the Southern eurozone members seldom disagree with the planned monetary policy which illustrates well the sides during the negotiation. The significance of the German economy within

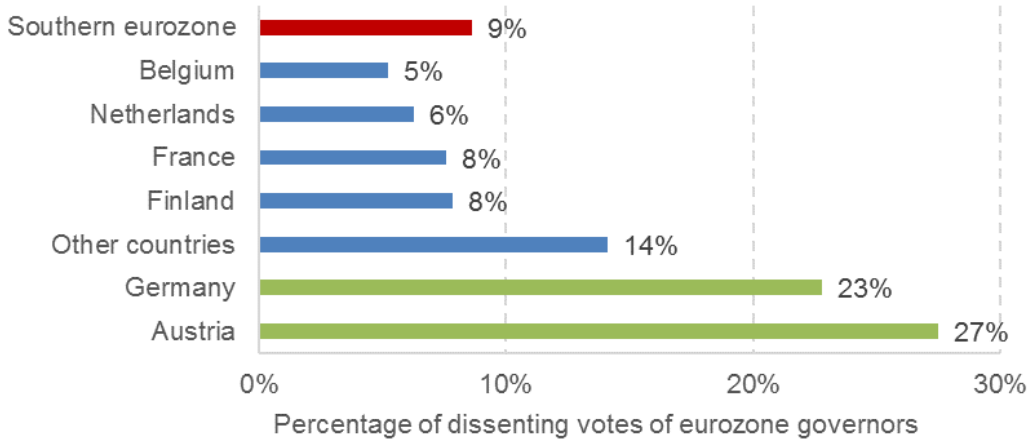
Table 5.9: ECB Executive Board and Eurozone governors model

	Eurozone governors skew	Executive board skew	Both combined	Both combined with term structure
Δi_t	1,25*** (0,29)	1*** (0,28)	1,28*** (0,3)	0,5 (0,42)
$Euro\_governors\_Skew_t$	1,63*** (0,41)	-	1,42*** (0,36)	1,14*** (0,39)
$Exec\_board\_Skew_t$	-	0,89*** (0,34)	0,33 (0,33)	-0,08 (0,39)
$Termstructure_t$	-	-	-	5,13** (2,12)
threshold 1	0,46 (0,47)	0,24 (0,46)	0,55 (0,49)	1,12* (0,62)
threshold 2	1,16** (0,51)	0,88* (0,48)	1,25** (0,52)	1,99*** (0,66)
threshold 3	4,87*** (0,72)	4,17*** (0,64)	4,98*** (0,75)	6,11*** (1,03)
Log-likelihood	37,61	-40,93	-37,32	-33,83
Correct predictions	53 (80,3%)	53 (80,3%)	53 (80,3%)	54 (81.8%)
Mc Fadden pseudo R^2	21,65%	14,73%	22,25%	31,31%
Adjusted Mc Fadden pseudo R^2	17,48%	10,56%	16%	22,98%
Chi-squared statistic	0,82	7,46**	0,24	8,46

Notes: Robust standard errors are reported into parentheses. *, **, *** denote significance at 10%, 5%, 1% respectively. The Chi-squared statistic denotes the Chi square statistic where the baseline model was used as the restricted model.

the eurozone than may explain the weight given to the German opinion and thus the informative power of the skew computed for the eurozone governors (which is formed by more than 50% by communication items from German-speaking GC members).

Figure 5.5: Dissenting votes per eurozone countries



Source: Author's calculations.
Notes: The Southern eurozone represent Greece, Spain, Italy, Portugal and Cyprus. The plot depicts only the dissent expressed by the national governors since these are officialy represent their countries.

Chapter 6

Conclusion

The aim of this study was to clarify whether the communication of the ECB can be used as a relevant predictor of future monetary policy. For that purpose, a new approach focussing on the ECB representatives' statements is presented. The new methodology relies on the assumption that any dissent expressed during a central bank's board monetary policy meeting can be predictive about changes in the policy rate. The reasoning of that is that some board member can acquire important information about the necessity of a change in policy sooner than others and other members may become convinced only after some time. The topic has been developed in the studies of Gerlach-Kristen (2004) and Horváth *et al.* (2011) who quantified that level of disagreement and used it as a predictor for future changes in the rate. Since the ECB does not publish its voting record, the skew metric (i.e. the quantified dissent within the GC) was obtained from the scored communication items of the ECB based on the presented opinion about future monetary policy. The data therefore contain every relevant statement made by the ECB representatives within the observed period which makes it an unprecedented technique that has not been applied yet.

Since the observed period (starting at July 2008 and ending in January 2014) includes important events such as the collapse of the Lehman Brothers or the zero-lower bound policy rate period of the ECB, the data contain very unusual finacial market situations that could be identified as outliers. During these times policy rates to reached their technical minima and made further decreases much more complicated. Such irregularities have been taken into consideration since they might have affected the results; therefore, a careful interpretation is preferred.

Mere disagreement with the selected policy rate visible in the ECB members' statements was empirically confirmed to be a valid predictor of future changes in the policy rate. The result is robust to the inclusion the term structure serving as a proxy for market expectations in the model. It should be noted that the indicator represents a strict test of robustness since it measures the market expectations only a day before the monetary policy meeting (therefore it should incorporate all the news available before the meeting). The robustness of the model to such important factor shows that the metric based on the banks's communication increases the predictability of the central bank and thus presents an argument for the publication of the voting record. The empirical evidence shows that even the voting ratio (i.e. only the numeric proportion of agreeing and disagreeing members) would suffice.

Similarly, as in Horvath & Jonášová (2015), the skew in case of the ECB is confirmed to be predictive two periods ahead, thus too meetings after the meeting the communication is related to. The hypothesis of being predictive three meetings in advance is on the other hand rejected. The timing of the communication delivery shows to affect differently the markets, since these based on the empirical evidence tend to fully incorporate the ECB board members' statements published until the week before the monetary policy meeting. This week preceding the policy rate assessment is denoted as purdah and according to the ECB's guideline, its members are supposed to keep the released information at a minimum level in order to prevent excess volatility on the market. According to the results, the statements released during this period, despite their very low number, are the most imformative and the market do not fully consider them. The analysis observed two skew variables: one omitting the purdah period and one solely based on it. Altogether the two factors remained significant, but after the inclusion of the market expectations, the purdah-omitting skew was no longer relevant. The model then indicated that the market expectations, modelled by the term structure, can without a great loss of predictive power fully substitute for the information contained within the non-purdah ECB communication.

When analysing the relevance of the statements it has been tested whether the communicated opinions should be averaged by speakers in order to balance more communicative GC members and the less quiet ones. Due to the lower, but yet good-enough, performance in comparison to the baseline model, the method was rejected. In the second part the ECB's communication was divided into two parts focussing on whether it concerned conventional or un-

conventional policy measures. Despite the majority of the conventional policy communication items within the data (forming approximately 72%), the skew based on it was found insignificant. This is likely to be due to the large proportion of the zero-lower bound policy rate period in the observed time-span. The significance of the unconventional policy communication metric on the other hand indicates that during economic-crisis times the unconventional policy news from the ECB are more informative. When the content of the news is disregarded, the skew however remains robust and is still predictive.

In terms of speaker importance two factors were considered: the strength of the presidential opinion and categorical differences within the ECB board where the Executive Board was compared to eurozone governors. When investigating the effect for the whole dataset, the presidential skew appeared to serve not only as a valid indicator for the upcoming meeting but furthermore it was found to be informative three meetings in advance. Such result presents evidence that the ECB president tends to communicate strategic goals much more often than the other GC members. The division of the GC into two categories indicated that despite the very balanced representation of both in terms of the given statements the national governors' communication contains most of the predictive value – in fact so much that the exclusion of the Executive Board's communication from the data does not significantly reduce the fit of the estimated model. The presidential opinion expressed by the skew variable considering only statements of the ECB's president failed bring any additional improvements to the baseline model. It is however unclear whether the hypotheses of relevance of the presidential opinion should be completely rejected due to the large period of uncertainty contained within the data. When estimated separately for the presidencies of Jean-Claude Trichet and Mario Draghi, the model showed significant results for Trichet, thus presenting evidence that the insignificance of the effect for the whole data could indeed be caused by the period of economic turmoil.

The thesis therefore provides a summary of the factors in the ECB's communication that should be regarded when predicting changes in the MRO. Several possibilities of continuing the research are at hand. The first could be the elaboration of a predictive model combining the most relevant factors identified. Another would be to study more the dissent expressed by national governors and try to identify the most powerful. If used on a larger dataset the impact of the crisis could be further developped.

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Appendix A

Pesci (2016) approach results

Table A.1: Model suggested by Pesci(2016)

$\boldsymbol{\Delta i_t}$	0,68 (0,28)
$\boldsymbol{Skew_t}$	0,29 (0,28)
threshold 1	-0,37 (0,51)
threshold 2	0,22 (0,53)
threshold 3	3,27*** (0,63)
Log-likelihood	-43,44
Correct predictions	52 (78,8%)
Mc Fadden pseudo R^2	9,5%
Adjusted Mc Fadden pseudo R^2	5,33%
Chi-squared statistic	11,78

Notes: Robust standard errors are reported into parentheses. *, **, *** denote significance at 10%, 5%, 1% respectively. The Chi-squared statistic denotes the Chi square statistic where the constant-only model was used as the restricted model and the above listed as the unrestricted.

Appendix B

Content of the enclosed CSV

There is a CSV file enclosed to this thesis which contains the data used for the analysis.