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Interest rate setting and communication at the ECB

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Abstract

Based on ordered Probit models and twenty years of euro area data, we estimate empirical reaction functions for the ECB´s monetary policy and augment them with communication indicators. First, we find that the ECB responded to risks to price stability in line with its primary objective, and that the account of post-meeting communications about risks to price stability and to growth significantly enhances the modelling of its reaction function. Second, we detect that the ECB also responded to the evolution of the federal funds rate, thereby confirming the importance of international interest rate linkages or the global cycle that it reflects. Third, while confirming Gerlach's (2007) finding on the relevance of M3 growth for explaining future interest rate changes, we show that this result only holds for the period before the global financial crisis.

JEL Codes: E43, E52, C22, C25

Keywords: Probit model, monetary policy reaction function, communication indicators, staff projections, Survey of Professional Forecasters.

NON-TECHNICAL SUMMARY

This paper analyses the ECB's interest rate setting over two decades by estimating empirical reaction functions. We consider that tracking monetary policy decisions with key macroeconomic variables, as in Taylor-type rules is not optimal, because this would neglect valuable information from the judgemental risk assessment of the Governing Council in charge of the decisions. We estimate ordered Probit models, thereby capturing the discrete nature of the changes in policy interest rates, asymmetries and non-linearities in the ECB's reaction post-crisis. We examine whether ECB communications matter for its monetary policy reaction function and whether the ECB's response to the risks to price stability changed over time. Our empirical analysis, which covers the period from January 1999 to December 2018, includes the episode when its main policy rate reached the zero lower bound and the ECB introduced non-standard monetary policy measures to support the effective transmission of its policy rates. Therefore, we construct a synthetic policy rate that is equal to the main refinancing rate up to June 2014 and thereafter evolves along with changes in the deposit facility rate and in the ECB's net monthly asset purchases under its asset purchase programmes (APP). As benchmark, we specify empirical reaction functions for the ECB based on inflation and growth projections, M3 growth and the federal funds rate.

In a first step, we augment the reaction functions with variables capturing the granular assessment underlying the central economic scenario. We test whether the inclusion of granular indicators underlying the Governing Council's "quantitative risk assessment" (variables that the ECB often mentions in the context of its risk assessment) help to improve the benchmark reaction function. In a second step, we augment the reaction functions with communication indicators and disentangle the impact of policy-makers' judgement as conveyed in ECB communications on policy rate decisions from that of underlying economic fundamentals. To extract indications on the Governing Council's judgemental risk assessment, we code textual information from the Introductory Statements at ECB press conferences - which reflect the collective judgement of the Governing Council - and extract from these official communications ordinal indicators on the risks to price stability and to growth. Alternatively, we include the KOF Monetary Policy Communicator, which is available for each meeting, in our reaction functions. It is based on media analysts' reading of the balance of risks to price stability contained in Introductory Statements at press conferences and translates them into an index that captures also other dimensions of the communications such as the tense and ambiguity of the statements.

Overall, we find that our ordered Probit reaction functions match closely the policy-makers' response

over the last twenty years including the financial crisis episode. Results from (benchmark) reaction functions based on staff projections, broad money M3 growth and the federal funds rate show that the ECB responded to the evolution of the inflation outlook and support the view that the ECB adjusted its policy rates in line with its primary objective of price stability. We find that ECB policy rates responded to broad money growth in the pre-crisis period, but not thereafter. This analysis shows that the ECB also responded to the federal funds rate, thereby confirming the importance of international interest rate linkages or the global cycle that it captures. We also show that inflation and growth projections from ECB staff provide satisfactory summaries of the information regularly analysed by the Governing Council, because - relative to Staff projections - the inclusion of external forecasts deteriorates the overall fit of the reaction function. Furthermore, - relative to the benchmark reaction function - the results show a slight improvement of the overall fit of the reaction function with the inclusion of some granular indicators underlying the ECB's quantitative risk assessment, namely oil prices and the PMI manufacturing. This confirms that monetary policy decisions also respond to actual risks surrounding the central economic scenario.

Previous papers provide mixed evidence on the empirical relevance of communication indicators in ECB reaction functions. Based on the augmented reaction functions, we contribute to the literature by showing that the post-meeting communications of the Governing Council about the risks to price stability and to growth at press conferences added relevant information to the ECB policy reaction function. First, we show that the inclusion of communication indicators in policy reaction functions enhances the explanatory power of ECB reaction functions. Second, we find that the indications of the Governing Council about the balance of risks at press conferences provided helpful orientation to markets and the general public on where the ECB was heading to at future policy meetings. Reflecting its mandate, ECB communications about the risks to price stability appear to be more helpful for anticipating its interest rate setting than its communications about the risks to growth. Finally, we show that the ECB's judgmental risk assessment is based on information from its central economic scenario. We estimate separate reaction functions for the ECB communications on the balance of risks (that is, where a communication indicator itself is the dependent variable in the estimation), and find that they are essentially, but not fully, driven by the latest inflation and growth projections by Staff as well as information from broad money growth and the Fed's policy rate.

1. Introduction

In order to decide on the course of monetary policy, the ECB's Governing Council monitors a large amount of data on the euro area economy and assesses risks to price stability over the medium term. The decision meetings take place at discrete time intervals (initially at monthly frequency, since 2015 every six weeks) and are accompanied immediately thereafter by detailed post-meeting communications including press releases and press conferences; "accounts" of the meetings are subsequently published with a lag of four weeks.[1] The ECB has developed its own approach to organising, evaluating and cross-checking the information relevant for assessing risks to price stability in the euro area, which also underlies its communications: a two-pillar monetary policy strategy (for details see Issing, 2003; Jung, Mongelli and Moutot, 2010). This framework makes a clear distinction between alternative explanations of the inflation process as propagated by traditional schools of economic thought. It calls for separately analysing the indications from the economic analysis, mainly based on macroeconomic projections, and from the monetary analysis, mainly based on monetary and credit aggregates. Within the ECB's two-pillar strategy, the monetary analysis has the role of cross-checking, from a medium to long-term perspective, the short to medium-term indications on the risks to price stability, as suggested by its economic analysis. The Governing Council communicates the outcome of the cross-check of the two forms of analyses regularly on press conference days together with an indication of the overall risks to price stability and to economic growth.

Communications by policy-makers are important, because they convey information about the central bank's current assessment of macroeconomic developments, its risk assessment and policy reactions at forthcoming meetings (Bernanke, 2015; Issing, 2005; Yellen, 2012; Weidmann, 2018; Blinder, Ehrmann, Fratzscher, de Haan and Jansen, 2008). In this respect, central banks have adopted different communication strategies, which can be similarly effective (Ehrmann and Fratzscher, 2007a). In times of elevated uncertainty, like in the aftermath of the global financial crisis, signalling becomes an increasingly important channel of monetary policy (Melosi, 2017). Through forward guidance, central banks have an influence on both interest rate and inflation expectations. The impact of policy signals from communications on market expectations, which can be captured by (high-frequency) movements in overnight indexed swap (OIS) rates and interest rate futures, may lead to substantial revisions in expectations of monetary policy and influence both asset prices and interest rates at different maturities (Brand, Buncic and Turunen, 2010; Gürkaynak, Sack and Swanson, 2005). In the aftermath of the 2008 financial crisis, the use of systematic forward guidance as a policy tool attracted

[1] Since January 2015, the ECB has published a summary of the Governing Council deliberations on monetary policy ("accounts"). These accounts aim at offering a fair and balanced reflection of policy deliberations and are therefore close to what other central banks call "minutes".

considerable attention both in policy circles and in academia. The ECB and the Fed provided markets with extensive forward guidance at the zero lower bound (ZLB) of nominal interest rates (Moessner and Rungcharoenkitkul, 2019). Central banks used different types of forward guidance, which have different effects on uncertainty about future rates (Ehrmann, Gaballo, Hoffmann and Strasser, 2019).

For as long as the central bank's reaction function is sufficiently well understood by markets, central bank communication would not be required for predictability. In periods of heightened uncertainty, however, central bank communication may become more important than their actions, because by influencing expectations and by conveying the central bank's risk assessment they help to stabilise the economy. Nevertheless, most papers for the euro area abstract from the role of communications when analysing the ECB's interest rate setting using estimated reaction functions (Carstensen, 2006; Gerlach, 2007; Boeckx, 2010; Gerlach and Lewis, 2014) and Taylor-type rules with or without money (e.g., Taylor, 1999; Eleftheriou, Gerdesmeier and Roffia, 2006; Beck and Wieland, 2008).[2] Moreover, previous papers provide mixed evidence on the relevance of communication indicators in empirical reaction functions. Some papers show that official communications of major central banks have helped to improve the near-term predictability of interest rate decisions (e.g., Berger and Sturm, 2011; Hayo and Neuenkirch, 2010; Rosa and Verga, 2007; Rosa, 2009; Sturm and de Haan, 2011; Jung, 2016). Recent papers have applied linguistic algorithms to measure the sentiment of policy deliberations in the form of quantitative communication indicators of ECB communications (e.g., Ehrmann and Fratzscher, 2007b; Bulíř, Čihák, Šmídková, 2009; Fischer, Lenza, Pill and Reichlin, 2009; Rosa and Verga, 2007; Heinemann and Ulrich, 2007; Coenen, Ehrmann, Gaballo, Hoffmann, Nakov, Nardelli, Persson, and Strasser, 2017; Picault and Renault, 2017; Hansen, MacMahon, Prat, 2018).

The aim of the present paper is twofold. First, we analyse the extent to which the ECB's reaction in real-time is explained by economic fundamentals and by the Governing Council's own judgement. For this purpose, we construct communication indicators, which reflect the collective judgement of the Governing Council, and augment the ECB's reaction function with them. The risk communicated by policy-makers in their regular risk assessment may differ from the actual risk, which is surrounding the projections (Kilian and Manganelli, 2008). In this study, we capture the actual risk through the lenses of the ECB's "quantitative risk assessment" (variables that the ECB often mentions in the context of its risk assessment), which surrounds the central economic scenario. Based on the Governing Council's judgemental risk assessment contained in ECB Introductory Statements at press conferences, we code ordinal communication indicators measuring how the committee collectively

[2] A reaction function describes how, given economic conditions and other relevant indicators, interest rates would have been set in real-time.

assesses the risks to price stability and the risks to growth for the euro area at each policy meeting. We also use the KOF Monetary Policy Communicator, which is similarly based on the ECB Introductory Statements at press conferences (Lamla and Rupprecht, 2006). Second, we reassess the drivers of the ECB's reaction function in the light of twenty years of data. This issue is topical, because ECB President Christine Lagarde recently announced an in-depth review of the monetary policy strategy after twenty years of ECB´s existence.[3] Previous studies have argued that indications from the ECB's economic analysis are important, while those from the monetary analysis would be less important for understanding its policy response. While market perceptions about how monetary policy responds to inflation became more accurate after the ECB's clarification of its monetary policy strategy in 2003, there was an increasing misperception regarding the ECB's reaction to output after the outbreak of the global financial crisis (Schmidt and Nautz, 2012). We include conventional drivers in the reaction function and disentangle the contributions of the economic and monetary analyses.

We contribute to the literature by showing that the post-meeting communications of the Governing Council about the risks to price stability and to growth at press conferences provided helpful orientation to observers. We find that the ECB responded to the federal funds rate, thereby demonstrating the importance of international interest rate linkages or the global cycle that it captures. We confirm Gerlach's (2007) result on the relevance of M3 growth for explaining future interest rate changes, but show that this result only holds in the period before the global financial crisis. Relative to conventional reaction functions and Taylor-type rules, our approach is based on ordered Probit techniques and thus allows capturing non-linearities in the interest rate setting behaviour - which notably was present in the post-crisis sample period, and discreteness.

The paper is structured as follows. Section 2 introduces our communication indicators. Section 3 presents data and methods, Section 4 discusses the empirical results and Section 5 concludes.

2. ECB policy rates and communication indicators[4]

2.1 Choice of the policy rate

Over the past twenty years the ECB's interest rate cycle has evolved profoundly (see Chart 1). Initially, it displayed large upward and downward swings reflecting the business cycle. In the aftermath of the financial crisis, however, the interest rate cycle shifted towards lower rate levels and longer phases than before and the term structure became flatter (Brand, Bielecki and Penalver, 2018).

[3] See the Introductory Statement at the ECB press conference on 12 December 2019.
[4] Appendix A provides details on the synthetic MRO rate and the communication indicators.

We construct a synthetic policy rate to capture the monetary policy actions of the ECB. It reflects that the ECB signalled its monetary policy stance mainly through its policy interest rates during the past two decades, including in the aftermath of the 2008 financial crisis when its non-standard measures were seen as a complementary instrument that supported the effective transmission of the standard policy rate signals (Cour-Thimann and Winkler, 2012; Cour-Thimann, Heider and Praet, 2014). This was no longer the case when the policy interest rates eventually reached the ZLB. In that more recent period, the ECB´s monetary policy actions will be better captured by a synthetic policy rate. In general, the rate on the main refinancing operations (MRO) is the ECB's policy rate. After the ECB's main policy rate hit the ZLB in June 2014, the ECB only lowered its deposit facility rate, thereby introducing negative interest rates and creating an effective lower bound (ELB) at negative rates,[5] and the deposit facility rate more closely signalled the monetary policy stance. Alternatively, to obtain a continuous rate, some studies have used the one-day interbank interest rate (EONIA rate) as policy rate, when estimating policy reaction functions.[6] Chart 1 shows that the EONIA rate closely followed the policy rate until about the beginning of 2015, when the ECB introduced its asset purchase programme (APP). Although it became negative, it did not fully summarise the ECB's monetary policy stance.

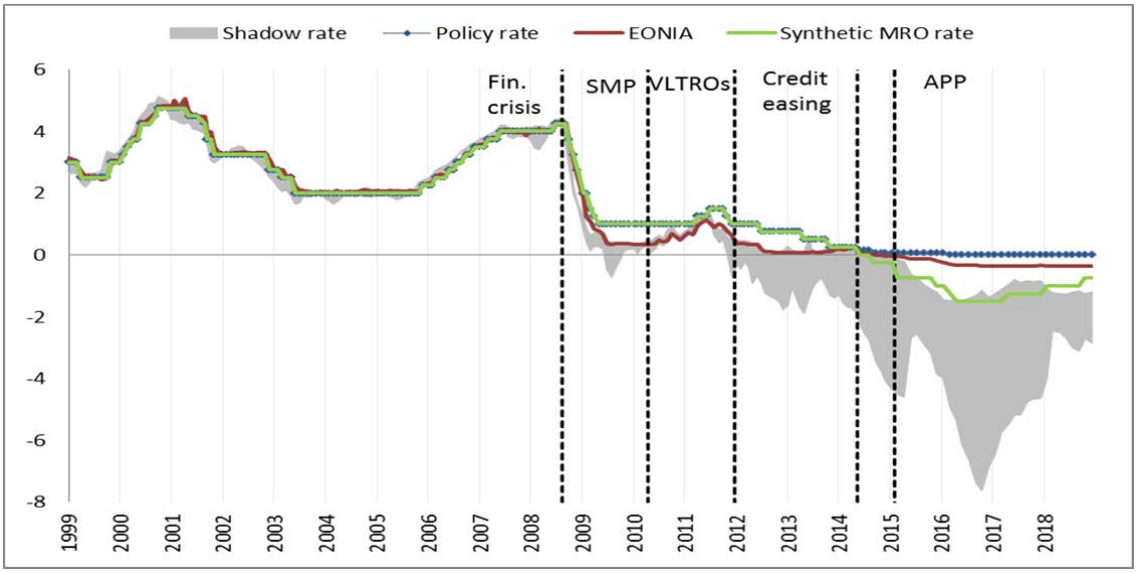
The ECB, like other central banks, tends to change its policy rates in small steps. Chart 2 shows that the majority of its monetary policy meetings led to unchanged MRO rates, while changes by ± 25 basis points were frequent and larger changes of 50 basis points and more were infrequent.[7] For the sample 1999-2018, the Jarque-Bera test for normality rejects that interest rate changes are normally distributed and this was related to a shift post-crisis in the distribution from symmetric to skewed towards easing.[8]

To gain a better description of the monetary policy stance throughout the full sample, we compute a synthetic MRO rate in levels (see Chart 1). We exploit the fact that the MRO rate and the deposit facility rate move in tandem and code changes in the deposit facility rate as changes in the policy rate even after the MRO rate hit the ZLB. For example, on 9 December 2015, the ECB lowered the deposit facility rate without changing the MRO rate and we code this as a cut of the policy rate by increase of monthly purchases to EUR 60 billion in March 2015 corresponding to -50bp, the further 25bp. We code the ECB's large-scale asset purchases as changes in the synthetic MRO rate: with the increase to

[5] The ELB implied that the main refinancing rate remained thereafter unchanged, though the ECB made adjustments to its deposit facility rate after March 2016 and took new non-standard monetary policy measures aimed at easing the monetary policy stance.
[6] EONIA is the abbreviation for Euro Overnight Index Average.
[7] A similar pattern was observed for the US Federal Reserve (Poole, 2005).
[8] On 13 April and 13 July 2011, the ECB hiked interest rates by 25bp, respectively, thereby responding to second-round effects related to oil price increases.

Chart 1: ECB policy rates and shadow rates

(in percentages per annum)

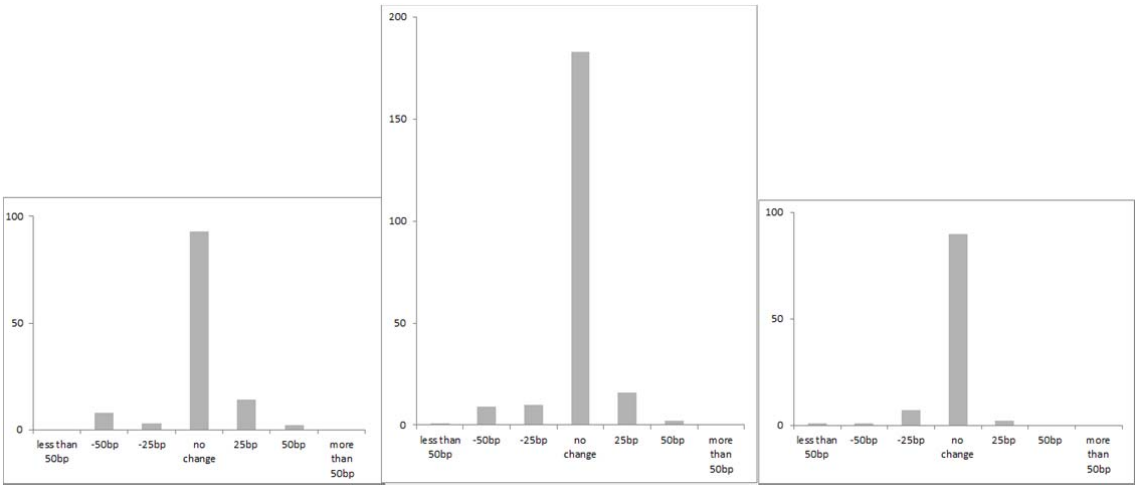


Notes: The shadow rate is shown as a corridor, which includes measures by Krippner (2019), Lemke and Vladu (2017), and Wu and Xia (2016) for the euro area. The synthetic MRO rate is based on the MRO rate, the DFR and the APP.
Source: ECB and own calculations.

Chart 2: Changes in the ECB main refinancing rate

(number of MRO rate changes)

(1999-2008) **(1999-2018)** **(2009-2018)**



Source: ECB.

EUR 80 billion monthly in April 2016 to -25bp, and the stepwise reduction in the level of net monthly asset purchases in April 2017, January 2018 and October 2018 each to +25bp.

To make robustness checks of the synthetic rate, we also consult genuine shadow rates for the euro area. Chart 1 shows a corridor including different estimates of the shadow rate for the euro area. A shadow rate is a metric for the stance of monetary policy in a zero lower bound environment, which captures the stance of monetary policy in the same way the policy rate does in normal times (Krippner, 2012). The synthetic MRO rate moves broadly in line with the upper corridor of ECB shadow rates (see Chart 1). The decline in the shadow rate confirms that the ECB's asset purchase programmes (APP) contributed to a more accommodative monetary policy stance compared to what interest rate cuts would have achieved alone. While different measures of the shadow rate agree on the direction, the estimated levels differ considerably. This is not surprising, since the literature has shown that estimates of shadow rates can be quite sensitive to differences in term structure models and the assumptions made about where the effective lower bound on interest rates lies.

2.2 Selection of communication indicators

The ECB communicates with the markets and the public continuously to explain its interest rate decisions, to provide near-term policy guidance, and to anchor inflation expectations (ECB, 2009). In this respect, the press conference with Q&As from journalists after the Governing Council meeting is a key event (Ehrmann and Fratzscher, 2009).[9] The Introductory Statement at the press conference signals collective judgements of the Governing Council on the risks to price stability and economic growth for the euro area as a whole. For example, at its meeting on May 2005 the Introductory Statement says: "*To sum up, the economic analysis confirms that underlying domestic inflationary pressures remain contained, while there continue to be medium-term upside risks to price stability which need to be monitored closely. Cross-checking with the monetary analysis supports the case for continued vigilance with regard to the materialisation of such risks.*" Based on this judgemental risk assessment, for which further details can be obtained from the Editorial of the ECB Monthly Bulletin, we construct two ordinal communication indicators on the risks to price stability and the risks to economic growth, respectively (see Chart 3). While these statements contain no information on

[9] Under President Trichet, the ECB started to make use of forward guidance, when it communicated with the market in a tightening cycle that began in December 2005 with "code words" resembling a traffic light system and giving collective guidance for monetary policy decisions at the next meetings. Since 2014, the ECB made use of forward guidance as a separate policy tool providing information about the Governing Council's collective views regarding policy interest rates and non-standard measures at future meetings, expanding the horizon for which forward guidance applied (Cœuré, 2018).

whether individual members dissented from the assessment,[10] the ECB communications are explicit on the overall balance of risks, thus reducing the degree of subjectivity in constructing related indicators (i.e., coding is based on our reading and no word count algorithm is applied). If the information is ambiguous we consulted the further messages given in the subsequent Q&A session and the editorials of the Monthly Bulletin or subsequent Economic Bulletins.[11] We collect the indications on the balance of risks to price stability (over the medium term) and the balance of risks to economic growth for 224 meetings (January 1999 to December 2018), and map them into an ordinal scale with five values.[12] A value of -2 would indicate large downside risks, -1 downside risks, 0 absence of risks, +1 upside risks and +2 large upside risks to price stability economic growth, respectively. Since the primary objective of the ECB is price stability, the value 0 for the risks to price stability means that the Governing Council believes a change in the monetary policy stance is not warranted.

Chart 3 shows that risks to price stability were fairly symmetric, while risks to growth were skewed to the downside. The ECB responded to upside (downside) risks to price stability with hiking (lowering) interest rates in line with its primary objective of price stability. Risks to price stability and to growth often pointed in the same direction, but we also identify episodes when both risks gave contradicting indications (i.e., during 2005-2009 and 2010-2012). Because interest rate changes and the direction of risks to price stability are broadly aligned, there is a close match between "words" and "deeds".

Linguistic algorithms, which map the sentiment of policy deliberations in the form of quantitative communication indicators, may provide additional information on the complexity and ambiguity of ECB communications. We therefore include the KOF Monetary Policy Communicator (KOF MPC) in our analysis, which translates forward-looking statements from the Introductory Statements at press conferences concerning risks to price stability into an index that captures also other dimensions of the communications such as the tense and ambiguity of the statements.[13]

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[10] In this respect, no systematic information about disagreement on the risk assessment in the committee has been published. The "accounts" of Governing Council meetings contain some information on diversity of views in the risk assessment, though individual views or votes are not disclosed.

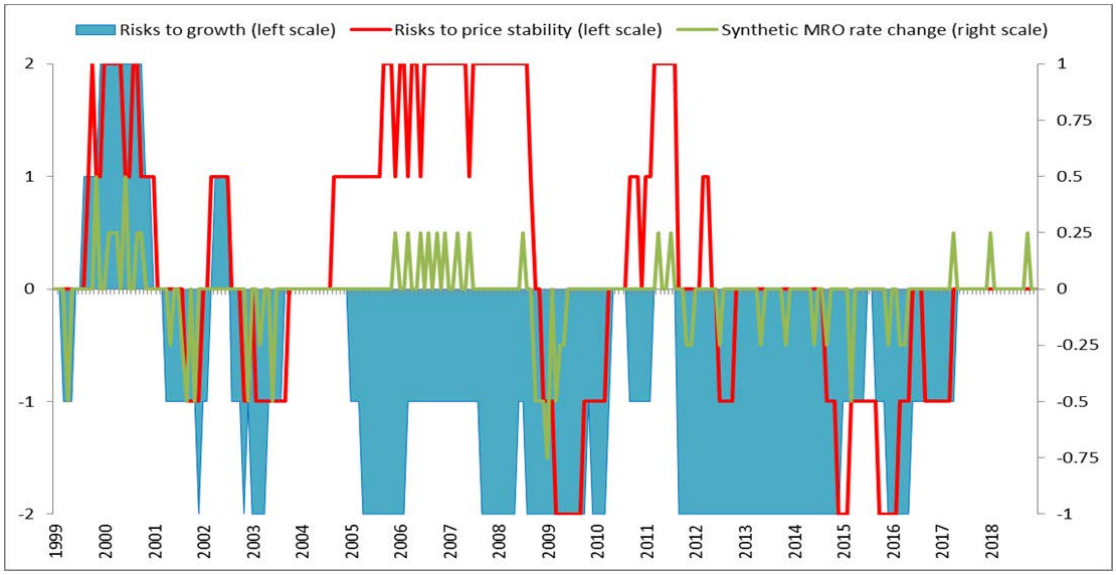
[11] For instance, this applies to the risk of price stability for which over recent years no explicit indications were given, although it was implicit.

[12] Note that recent ECB communications at press conferences no longer give explicit summary indications on the risks to price stability over the medium term, while they are still clear about the risks to growth.

[13] As explained by Sturm and de Haan (2011): *"The KOF MPC is based on the interpretation of the introductory statements by the ECB President by Media Tenor, a media research institute. Media analysts read the text of the introductory statement of the monthly press conference sentence by sentence and code them. The coding is aggregated by the KOF Swiss Economic Institute into an index by taking balances of the statements that reveal that the ECB sees upside risks to future price stability and statements that reveal that the ECB sees downside risks to future price stability, relative to all statements about future price stability (including neutral ones). (…) By construction, the values of the KOF MPC are restricted to be in the range of minus one to plus one. The larger a positive (negative) value of the KOF MPC, the stronger the ECB communicated that there are upside (downside) risks for future price stability."*

Chart 3: Communication indicators and policy rate changes

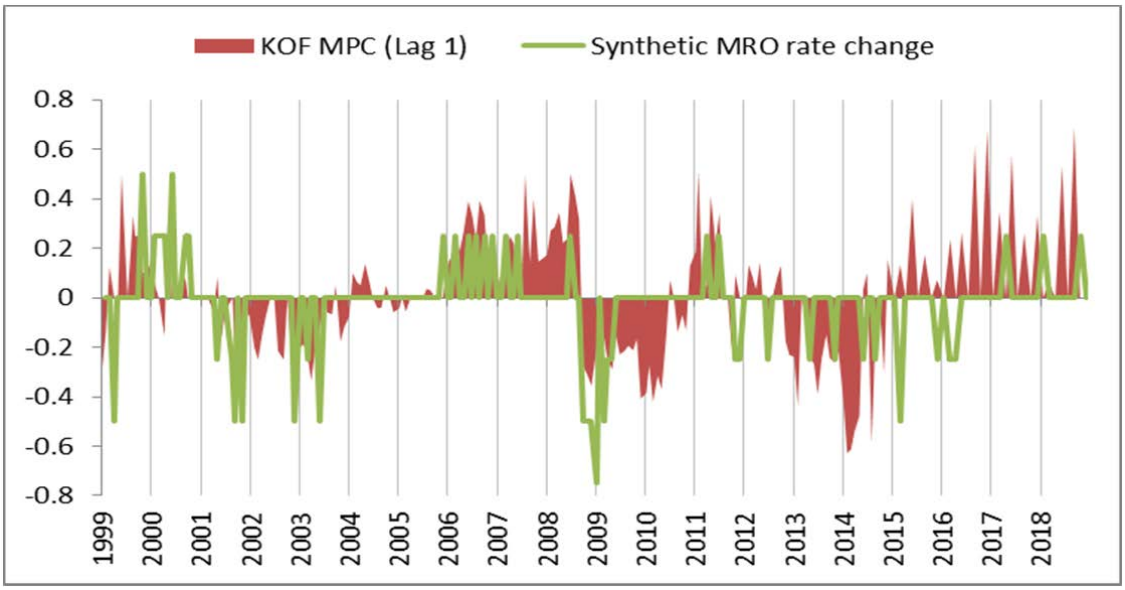
(ordinal scale (lhs); percentage points (rhs))



Notes: Changes in the synthetic MRO rate are relative to the previous month.
Source: ECB.

Chart 4: The KOF Monetary Policy Communicator and ECB policy rates

(in percentage points)



Notes: The KOF MPC is lagged by one month and changes in the synthetic MRO rate are relative to the previous month.
Source: KOF.

According to Sturm and de Haan (2011) and as is visible from Chart 4, this indicator contains information that helps to predict the next policy decision of the ECB.

3. Ordered Probit models for the ECB's reaction function

3.1 Choice of the modelling approach

A Probit model is well suited for the analysis of a discrete choice problem such as the monetary policy response to the changing economic environment. At a meeting, the Governing Council of the ECB faces a discrete choice between tightening the monetary policy stance, loosening it or keeping it unchanged. The discrete nature of the monetary policy response to the changing economic environment and the possible presence of asymmetries and non-linearities is best analysed with ordered Probit techniques. Asymmetry and non-linearity in the use of interest rate adjustments may arise from several sources: from the policy response itself (asymmetries in the strategy or the expected impacts of monetary policy on the economy), from macroeconomic developments and uncertainties, from a combination of these two factors and from the presence of a ZLB. Non-linearity can be exogenous to monetary policy if embedded in the economic behaviour, or endogenous if it is related to asymmetric policy preferences or constraints. In this respect, Aguiar and Martins (2008) detect a tendency for euro area inflation outcomes to be below the upper threshold of the ECB's price stability definition, which relates to policy-makers' preferences and aims at credibility-building in the early years of the monetary union. Dolado and Maria-Dolores (2005) provide evidence for a convex Phillips curve implying that the central bank loss function could be asymmetric. Under these constraints, it would be inappropriate to fit the model using a linear OLS model.[14]

We estimate reaction functions, whereby the information set is based on the data available to policy-makers at the time decisions were taken, and these real-time data reflect their genuine constraints (data and model uncertainty). Using Taylor's rule as an example, Orphanides (2001) demonstrates that real-time policy recommendations differ considerably from those obtained with ex post revised data. In this respect, the literature has widely acknowledged that simple policy rules cannot give the full picture behind interest rate decisions, even if real-time data and forecasts are used. The Governing Council's

[14] Instead of specifying an ordered Probit model, as is done in this paper, interest rate changes for the period 2009-2018 could be modelled by means of a zero-inflated ordered Probit model (see Brooks, Harris and Spencer, 2012). The use of such a model is indicated if the large majority of decisions taken by the ECB fell into one particular choice category of the decision tree (e.g., a majority of decisions would imply interest rate hikes of a specific amount or keeping rates unchanged). However, this methodological advancement is not necessary for the samples considered since the observed distribution of interest rate changes appears to be fairly symmetric around the choice of no change in interest rates (see Chart 2).

assessment is based on a broad set of information and analysis and is evidently more comprehensive than a policy rule. Nevertheless, a large literature confirmed that Taylor-type policy rules would work well for the euro area.[15] In this respect, we do not need to identify the precise numerical target underpinning the ECB's reaction function, which has been assessed elsewhere (Hartmann and Smets, 2018; Hannoun, Issing, Liebscher, Schlesinger, Stark, and Wellink, 2019; Rostagno, Altavilla, Carboni, Lemke, Motto, Saint-Guilhem and Yiangou, 2019).

In its regular communication at press conferences, the ECB President reports on the Governing Council's "central economic scenario" and its judgemental "risk assessment". The central economic scenario encompasses a wide range of indicators regularly monitored within the ECB's economic analysis. As part of the economic analysis, macroeconomic projections by Eurosystem/ECB staff help to structure and synthesise a large amount of economic and financial data and ensure consistency across different sources of economic evidence (see ECB, 2016). While they are updated every quarter,[16] in intermeeting periods staff provides policy-makers with forecast updates on the basis of long-run elasticities to take into account revisions in the underlying technical assumptions. As an alternative source for inflation and growth forecasts, we include data from the ECB's Survey of Professional Forecasters (SPF), which has been publicly available since the start of monetary union in 1999 and can be considered as a measure of market expectations.[17] Inflation and output projections are typically used in forward-looking Taylor-type rules (Orphanides, 2001). In addition, the economic analysis provides an in-depth analysis of the driving forces of inflation and economic growth and their implications in terms of risks, where the indications from granular indicators form a "quantitative risk assessment".

As regards the monetary analysis, indications from money and credit growth are used to cross-check the outcome of the economic analysis over longer horizons. Inflationary pressures not only emerge from the interaction of supply and demand shocks, but may also be linked to asset price developments which have a longer transmission lag to prices than the other shocks. Issing (2009) suggests that an important advantage of the two-pillar monetary policy strategy is that its monetary analysis provides timely indications about the build-up of asset price imbalances. Traces of a "leaning against the wind" approach (Trichet, 2005) in the reaction function may therefore be captured through a positive reaction

[15] E.g., Eleftheriou, Gerdesmeier and Roffia, 2006; Blattner, Catenaro, Ehrmann, Strauch and Turunen, 2008; Orphanides and Wieland, 2013; Smets and Hartmann, 2018.

[16] Since September 2004, the ECB has published macroeconomic projections for the euro area four times a year. Initially this was not the case. Eurosystem staff macroeconomic projections started being published as of December 2000 - initially twice a year - in the Monthly Bulletin and later on the ECB website on press conference days.

[17] The SPF asks a panel of forecasters located in the European Union (EU) for their short- to longer-term expectations for macroeconomic variables such as euro area inflation, growth and unemployment.

of policy rates to money growth (or credit growth). Indeed, these aggregates reflect movements in excess liquidity, the accumulation of which can lead to unsustainable asset price developments and financial imbalances.

The US Federal Reserve can be considered a "Stackelberg" leader in the international monetary system, thus causing other central banks to follow, as shown by Belke and Cui (2010). Within the analysis of the international environment, the ECB pays attention to changes in the monetary policy stance of other large central banks with a view to the implications this has for trade developments and exchange rates, and eventually for price stability. In line with the trend in financial globalisation, the literature on monetary policy rules for open economies and international cooperation argues that interdependencies have increased over time (Clarida, Gali and Gertler, 2000; Taylor, 2013). This could explain why in our empirical analysis the federal funds rate better captures international spillovers than the nominal effective exchange rate of the euro, which can be at times very volatile. Overall, international interest rate linkages could be important for understanding the ECB's interest rate setting beyond the assessment of trade effects in the staff projections (Beckmann, Belke and Dreger, 2017).

We focus in our benchmark empirical reaction function on the "central economic scenario" of the ECB. To this end, we include (real-time) measures describing the state of the euro area economy, in particular output (real GDP growth) and inflation (HICP inflation), based on ECB/Eurosystem staff macroeconomic projections or the SPF. Furthermore, we add money growth (or credit growth), and the federal funds rate. We test whether these variables are significant and check which specification fits the data best. Then we augment the reaction functions with indicators from the quantitative risk assessment and communication indicators, and test whether these variables help to improve the empirical reaction function. The inclusion of communication indicators (lagged by one meeting period) as explanatory variables allows examining whether communications at press conferences gave clues on forthcoming monetary policy decisions. This analysis addresses in particular the issue whether "words" from the previous meeting and "deeds" of the ECB match.

3.2 The ordered Probit model

Let monetary policy be described by a simple linear static interest-rate rule (Judd and Rudebusch, 1998; Orphanides and Wieland, 2008):

$$i_t^T = \alpha_0 + \alpha_\pi \pi_t + \alpha_y y_t + \alpha_z Z_t \qquad (1)$$

where i_t^T is the desired nominal target interest rate implied by the interest rate rule, α_0 is a constant, α_π, α_y, α_z are coefficients, π_t is the annual inflation rate, y_t is the annual GDP growth rate in real terms (or forecasts of these variables, respectively) and Z_t is a vector containing other driving factors.[18]

Because stabilising market expectations is crucial for a successful monetary policy, it may imply a role for interest rate smoothing (Woodford, 2003). Empirically, the short-term market interest rate (i_t^m as a proxy for the policy rate) is estimated to be mostly determined by its lagged level and to adjust only gradually to a desired level (i_t^T): [19]

$$i_t^m = \rho i_{t-1}^m + (1-\rho) i_t^T \quad (2)$$

where ρ captures the degree of interest rate smoothing. The fact that the interest rate smoothing parameter ρ is sizeable has been interpreted as an indication of the presence of policy inertia or as gradualism in interest rate setting, but it may also emerge from misspecifications in the interest rate rule (Rudebusch, 2002), a problem which can be remedied in part by augmenting the rule with additional variables.

Allowing for interest rate smoothing, the interest rate rule can be written as a function of the change in interest rate Δi_t^m in the form of an error-correction model (Judd and Rudebusch, 1998):

$$\Delta i_t^m = \gamma(i_t^T - i_{t-1}^m) + \rho \Delta i_{t-1}^m + \varepsilon_t \quad (3)$$

where γ refers to the speed of adjustment of actual interest rates to the interest rate rule and ε_t is an error term. The policy rate can be thought of as adjusting to its level i_t^T in continuous terms, reflecting incoming changes in the economic environment, where i_t^T is the nominal target interest rate derived from the interest rate rule.

Because the ECB sets interest rates at discrete time intervals and in steps, only discrete changes are observed. Inserting (1) in (3) and rearranging the terms yields a Probit model that has been used by Gerlach (2007) in order to describe interest rate setting at the ECB:

$$i_t^* - i_{t-1}^m = \tilde{\alpha} + \tilde{\alpha}_\pi \pi_t + \tilde{\alpha}_y y_t + \tilde{\alpha}_z Z_t - \gamma i_{t-1}^m + \rho \Delta i_{t-1}^m + \varepsilon_t \quad (4)$$

where $\tilde{\alpha}_i \equiv \alpha_i \gamma$ and an asterisk indicates that the dependent variable is unobserved (or latent). The actual change in the interest rate, whose predicted value depends on the position of the latent variable

[18] Taylor (1993) specifies the second term as an output gap instead of an output growth gap. This assumption has been criticised in that the level of the output gap is surrounded by larger uncertainty than its change, the output gap not being observable in real time.

[19] As noted by Goodhart (1998), "virtually all attempts to estimate the Taylor rule empirically require the addition of the lagged dependent variable, in order to fit well. […] This means that Central Banks have historically changed rates by only a small fraction of their ultimate cumulative reaction in response to an inflationary shock or to a deviation of output from potential."

i^*_t relative to a set of jointly estimated thresholds (a_i), is observable. The shock ε_t should be normally distributed.[20] Subsequently, the predicted probability of a given ordinal policy outcome at each point in time (Δi_t) is computed using the cumulative standard normal distribution function.

What is observed is the actual change in the interest rate, which depends on where the latent variable is relative to a set of threshold values. In the sample that includes the financial crisis we notice six different policy choices. Since the policy indicator is ordinal, we code six possible outcomes for the MRO rate, as in Gerlach (2011). Equation (5) shows how the six discrete interest rate changes (i.e., -75bp, -50bp, -25bp, 0bp, +25bp and +50bp), where the latent variable takes the values [-3, -2, -1, 0, 1, 2], can be linked to the estimated thresholds:

$$\Delta i_t = \begin{cases} 0.50 & if\ i_t^* - i_{t-1}^m \leq a_0 \\ 0.25 & if\ a_0 < i_t^* - i_{t-1}^m \leq a_1 \\ 0 & if\ a_1 < i_t^* - i_{t-1}^m \leq a_2 \\ -0.25 & if\ a_2 < i_t^* - i_{t-1}^m \leq a_3 \\ -0.50 & if\ a_3 < i_t^* - i_{t-1}^m \leq a_4 \\ -0.75 & if\ \ i_t^* - i_{t-1}^m < a_5 \end{cases} \quad (5)$$

First, in the benchmark version of the Probit model (4) and (5), which captures non-linearity through the thresholds, we include real-time measures for (one-year ahead) inflation (π_t) and growth projections (y_t), and further variables and controls (Z_t): the M3 annual money growth rate ($\Delta M3_{t-2}$), the federal funds rate (ff_{t-1}) and the Aruoba-Diebold-Scotti (ADS_{t-1}) business conditions index for the United States (see Aruoba, Diebold and Scotti, 2009). The inclusion of the ADS index in the reaction functions allows controlling for spillover effects from changes in real business conditions for the United States to the European economy. It is significant in all regressions and it ensures that the response to the fed funds rate is disentangled from changes in the health of the US economy. The reaction function thus constitutes an ordered-response model that describes how the latent change in the policy rate responds to macroeconomic information, money growth and the federal funds rate, as observed in real time. The time notation is such that we refer to the month for which data are available. Given lags in the statistical reporting of monetary data for the euro area, the real-time data at t typically refer to the month t-2. Likewise, at a Governing Council meeting the federal funds (target) rate from the Fed's last meeting of the month t-1 is known.

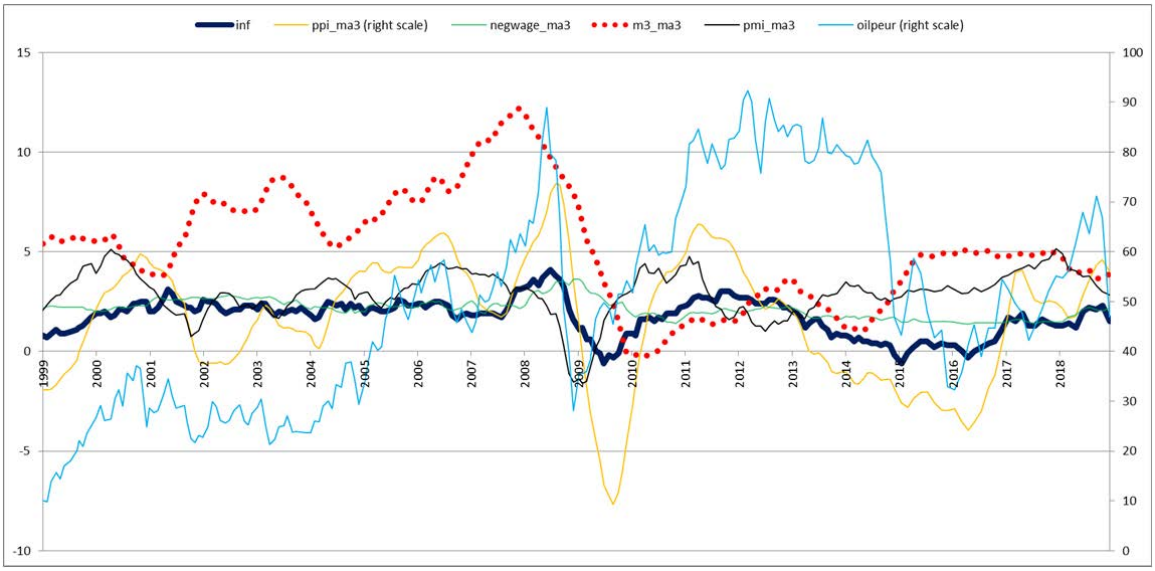
Second, we augment the benchmark specification with real-time observations of the variables that the ECB sometimes mentions in its risk assessment: such "quantitative risk assessment" variables are the

[20] According to the Jarque-Bera test, normality is typically rejected in this specification. However, when controlling for heteroscedasticity (with the White/Huber method) instead of assuming constant variance, we find that this has only a marginal impact on the estimated coefficients.

term spread, shorter-term determinants of inflation such as the level of oil prices, negotiated wage growth and changes in producer prices (whose rise may generate potential second-round effects on inflation), as well as changes in the PMI for the manufacturing sector (which captures business sentiment and is a leading indicator for real GDP growth). Chart 5, which illustrates the leading indicator relationship between broad money M3 and euro area inflation, shows that these granular variables exhibit different lead-lag cycles to headline inflation, thus providing further information on the transmission. The Probit model modified in such way states that the Governing Council will adopt one of its policy options depending on the central economic scenario, as assessed based on the one hand on the economic analysis, observed money growth, the previous response by the Fed, and the lagged level (and the lagged change) of the repo rate, and on the other hand on the risks surrounding the central economic scenario from the quantitative risk assessment.

Chart 5: Euro area inflation and quantitative measures of risks to price stability

(in percent per annum (lhs); in levels and in EUR (rhs))



Notes: inf is the annual rate of headline inflation, m3_ma3 is the 3-month centred moving average of broad money growth M3, pmi_ma3 is the 3-month moving average of the PMI manufacturing, negwage_ma3 is the 3-month moving average of negotiated wage growth, taken as an indicator of labour cost growth, ppi_ma3 is the 3-month moving average of producer price inflation, and oilpeur is the level of oil prices measured in euro.
Source: ECB, Eurostat.

Third, we include the communication indicators for risks to price stability and risks to growth with a one-month lag, thereby analysing the forward-looking signals from the Governing Council's assessment. That Probit model describes that the Governing Council will adopt one of its policy

options depending on the one hand on macro variables such as the expected level of inflation, expected economic growth, observed money growth, the observed federal funds rate, the lagged level (and the lagged change) of the policy rate, and on the other hand on its previous communications on the balance of risks.

Finally, we modify the approach further and estimate an ordered Probit model for the communication instrument itself, explaining it based on conventional macroeconomic indicators:

$$c_t^* = \omega + \omega_\pi \pi_t + \omega_y y_t + \omega_Z Z_t - \gamma i_{t-1}^m + \rho \Delta i_{t-1}^m + \varepsilon_t \quad (6)$$

where c_t is our ordinal measure of the ECB's communication about the risks to price stability or to growth (RP, RG), the latent variable (c_t^*) can take five values each [-2,-1,0,+1,+2], and ω_i, γ and ρ are coefficients and ε_t is an error term. When estimating (6) we include further variables and controls (Zt): the M3 annual money growth rate ($\Delta M3_{t-2}$), the federal funds rate (ff_{t-1}) and the Aruoba-Diebold-Scotti (ADS_{t-1}).

4. Results

In this Section we present the results of the empirical ECB reaction function for different samples and indicator sets (Z_t). We use indicators that were available to members of the Governing Council in real-time at their policy meetings.[21] We emphasise that our analysis uses real-time observations at meeting frequency for the ECB interest rate, key macroeconomic and financial variables, in particular the ECB/Eurosystem staff macroeconomic projections or the SPF for inflation and output, as well as indicators of the ECB's communication. When explaining policy rates by projected variables endogeneity concerns may arise, but the use of forward-looking variables that are subject to real-time uncertainty about the future interest rate path attenuates greatly such concerns (Orphanides, 2001).

In the aftermath of the financial crisis the transmission mechanism underwent massive changes and interest rates gradually approached the ZLB. The Probit model captures regime changes by changes in the size and significance of the coefficients, when varying the length of the sample.[22] In order to identify possible changes in the driving factors for the ECB's interest rate setting, we report estimation

[21] For instance, the two-month lag for monthly monetary data reflects the availability of monetary statistics. For high frequency (financial and foreign exchange) variables used in alternative specifications, averages in the month preceding the interest rate decision are considered, in recognition of the facts that Governing Council meetings are scheduled at the beginning of each month and that trends in volatile market data are more relevant than daily developments for policy-makers.

[22] By employing the smooth transition model, Gerlach and Lewis (2014) detect a shift in the reaction function after the outbreak of the financial crisis in 2008 and a shift back in the second half of 2010 following the introduction of the Securities Markets Programme (SMP) of the ECB.

results for the full sample (1999-2018) and two sub-samples with different length: the pre-crisis period (1999-2008) and the pre-ZLB period (1999-2014). We report estimations in which the regressors are normalised to allow for a direct comparison of their relative contributions.[23] The normalisation uses information available over the estimation sample. Such rescaling facilitates the interpretation of the results, while preserving the real-time nature of the variables.

Section 4.1 reports the results for the benchmark specification, Section 4.2 the results for the reaction function augmented with granular indicators underlying the ECB's quantitative risk assessment, Section 4.3 the results for reaction functions with communication indicators.

4.1 Benchmark reaction function

We start by estimating the ordered Probit model (4) and (5) with macroeconomic indicators and financial variables, which are regularly monitored in the economic and monetary analysis of the ECB. In our benchmark specification, we include as explanatory variables Staff projections of inflation and of real GDP growth,[24] annual M3 growth, the fed funds rate and controls. This implies that: $Z_t = [\Delta M3_{t-2}, ff_{t-1}, \phi_{t-1}]$, where ϕ_t is the ADS index. We use a three-month centred moving average for M3 so as to filter out noise. Following Gerlach (2007), we include the (backward-looking) level of the policy rate (i_{t-1}) and its change at the previous meeting (Δi_{t-1}).[25] In sum, the "conventional" Probit model describes that the Governing Council will adopt one of its policy options depending on the expected level of inflation, expected economic growth, observed broad money growth, the level of the fed funds rate and the lagged level (and the lagged change) of the ECB's policy rate.

The results from these Probit models (Table 1) support the view that the ECB adjusted its policy rates in view of the inflation outlook. The fact that this result is less robust with an OLS estimation involving the same variables confirms the necessity of properly capturing the non-linearities, which the Probit model does.[26] In this respect, the thresholds in the Probit model also allow for modelling that policy-makers may wait for sufficient evidence to give them a clear picture before taking a monetary policy decision. Table 1 (upper panel) shows that the coefficients for inflation and growth

[23] A variable x_t is normalised as follows: $x_t = (X_{kt}-X_k)/\sigma_k$, where X_k is the mean and σ_k is the standard deviation.
[24] These are based on mid-ranges of the published quarterly Eurosystem/ECB staff projections for the one-year ahead horizon.
[25] Studies by Gerlach (2007 and 2011) and Gerlach and Lewis (2014) for samples before the ZLB episode use the lagged MRO rate instead of the lagged policy rate. We checked that doing so does not change the results and the results are available from the authors.
[26] Compared with OLS estimates of ECB reaction functions using the same variables, the ordered Probit specification appears to better capture the specific (non-linear and discrete) pattern of interest rate adjustments (see the results in Table 1a, Appendix B). This is suggested by the relatively large percentage of predicted outcomes (around 80%), and in particular by the higher significance of the estimated coefficients.

projections are significant and display the expected (positive) sign during the pre-crisis and pre-ZLB period, albeit inflation projections are only marginally significant for the full sample. Mirroring massive impairments of the transmission mechanism post-crisis, the results show some time-variation in the weights, in particular during the ZLB episode. The still overall similarity of the results for the pre-ZLB period and the full sample tend to support the choice made in this paper to model monetary policy decisions on the basis of a synthetic MRO rate that spans over the ZLB period as described in Section 2.1.

Table 1: Ordered Probit Estimates of ECB Reaction Function

	Macro variables		Financial variables						
	Projected inflation (1)	**Projected real GDP growth** (2)	**Annual M3 growth (-2)** (3)	**Fed funds rate (-1)** (4)	**Policy rate (-1)** (5)	**Change in policy rate (-1)** (6)	**Pseudo-R^2**	**LR-statistic**	**Correct predictions (in %)**
with ECB staff macroeconomic projections									
pre-crisis period 1999- 2008	**0.50** *(3.19)*	**0.75** *(2.34)*	**0.61** *(2.62)*	**0.88** *(2.33)*	-0.70 *(-1.75)*	**-0.35** *(-2.43)*	0.29	47.18	78.76
pre-ZLB period 1999-2014	**0.25** *(2.13)*	**0.40** *(2.10)*	0.19 *(1.41)*	**0.99** *(3.79)*	**-1.07** *(-3.63)*	-0.02 *(-0.18)*	0.24	69.34	79.67
full sample 1999-2018	0.20 *(1.83)*	-0.04 *(-0.32)*	-0.04 *(-0.31)*	**0.87** *(4.09)*	**-0.51** *(-3.07)*	0.02 *(0.19)*	0.20	68.77	80.51
with forecast from the SPF									
pre-crisis period 1999- 2008	**0.59** *(2.65)*	-0.17 *(-0.77)*	0.42 *(1.86)*	**1.07** *(2.31)*	-0.57 *(-1.34)*	-0.52 *(-1.80)*	0.32	37.16	84.62
pre-ZLB period 1999-2014	0.07 *(0.51)*	0.16 *(0.86)*	0.24 *(1.41)*	**0.96** *(3.18)*	**-0.89** *(-2.68)*	0.06 *(0.50)*	0.20	46.70	81.88
full sample 1999-2018	0.15 *(1.06)*	-0.12 *(-0.95)*	0.02 *(0.11)*	**0.84** *(3.53)*	**-0.47** *(-2.85)*	0.07 *-0.68*	0.17	48.93	82.24

Notes: The dependent variable is the policy rate change. Policy rate is the synthetic MRO rate (which is based on the MRO rate, the DFR and the APP) whose change is transformed into an ordinal rate; the lagged rate (and change) is based on its continuous rate. The regressions include the ADS index for the United States. Data have been normalised, the regressions contain a constant which is not different from zero. Coefficients that are significant at the 5% level or lower are bold faced; z-statistics are in parentheses; Probit estimates use the Huber-White correction. The pseudo R^2 squared is an analog to the R^2 reported in linear regression models. The LR statistic on the overall significance of the model tests the joint null hypothesis that all slope coefficients are zero; it is never significant at the 5% level.

Our results provide a rebuttal to an earlier finding by Gerlach (2007) that the ECB would only respond to economic growth but not to inflation. We show that this assessment changes if inflation and growth projections instead of past values of these variables are used in the reaction functions, thus confirming that the ECB has acted in line with its primary objective of price stability. For the pre-crisis and pre-ZLB period, we find that policy rates responded to both expected inflation and economic growth in the

euro area. The projections for inflation and growth appear to be highly significant at the selected horizons of one-year ahead, but results are similar when the forecast horizon is lengthened by one year. Our findings corroborate the view that in pursuing price stability, the ECB has displayed forward-looking behaviour. This can be seen from the fact that forward-looking staff projections work better in the reaction function than contemporaneous or backward-looking variables (which are in particular affected by short-lived cost-push effects, and tend to neglect the longer-lasting impact on consumption and inflation coming through the transmission of asset price movements).

Regarding the monetary pillar, our results confirm Gerlach's (2007) finding on the relevance of M3 growth for explaining interest rate changes, albeit not when the post-crisis period is considered.[27] We find that the ECB reacted to the indications of M3 growth during the pre-crisis years.[28] This confirms that the ECB used information from broad money as a cross-check of the indications from the economic analysis on the risks to price stability, as stipulated by its two-pillar monetary policy strategy. In the aftermath of the financial crisis, the Introductory Statement continued to provide information on the cross-check from monetary analysis, and the ECB clarified that its monetary analysis would be far broader than just focusing on M3 (Papademos and Stark, 2010). While markets continued to use the signals from the ECB's monetary analysis for their prediction of interest rate changes (Jung, 2018), broad money growth does not enter the ECB policy reaction function during the post-crisis period. Anecdotal evidence suggests that when explaining its monetary policy response to the shocks caused by the financial crisis, developments in credit featured more prominently within the ECB's monetary analysis, since these data provide useful information about the workings of several transmission channels that were important in the post-crisis period (e.g., the credit channel, the risk-taking channel and the portfolio rebalancing channel). As a robustness check, replacing the three-month moving average of M3 growth by the three-month moving average of credit growth (to euro area residents) did not improve the results (not reported here for the sake of brevity), suggesting that the ECB did not display a significant response to the credit indicator either.

The results from the Probit models also support the view that the ECB adjusted its policy rates in response to international spillovers. We detect a significant and sizeable reaction of ECB's interest rates to the federal funds rate for all samples. Our results therefore support the view that when setting interest rates, the Governing Council of the ECB took into account interest rate changes by the Fed or more broadly changes in the global economic and financial environment.

[27] Note that by contrast to Gerlach (2007), an early study by Berger, de Haan, and Sturm (2006) found that the ECB's monetary analysis would not well explain the interest rate setting of the ECB.
[28] Note that this result would not hold if monthly observations of M3 were used instead of the three-month moving average.

The results on the lagged change of the policy rate provide some insight on the debate whether central banks follow a gradual approach in interest rate setting or not.[29] It has been argued that the presence of interest rate cycles implies that interest rate moves in a persistent manner for some time (so that an interest rate hike for instance is likely followed by another interest rate hike). We find that the coefficient on the lagged change of the policy rate is negative and significant (Table 1, column 6) and confirm the finding by Gerlach (2007) that central bankers tend to make interest rate changes to "*clear the air*" (implying that it is less likely that a central bank changes interest rates at two consecutive meetings).

In order to address potential endogeneity concerns, which may still be present despite the use of real-time data, we provide further checks for robustness and replace the Staff projections for inflation and output with the corresponding forecasts from the SPF (see also Gerlach and Lewis, 2014). ECB projections are forecasts that are conditional on a set of assumptions about the international environment, financial conditions and fiscal variables. Staff projections are not conditioned on a reaction function and do not include the judgement of the Governing Council. The SPF is a comprehensive survey of indicators such as inflation and output for the euro area economy and can be used as a cross-check of the Staff projections. Forecast comparisons suggest that the SPF outperforms Staff projections for economic growth, while the opposite holds for inflation forecasts (Kontogeorgos and Lambrias, 2019).

Our additional results suggest that some key findings are not confirmed when external forecasts from the SPF are used (see Table 1, bottom). The coefficient for inflation forecasts in the reaction function is now only significant for the pre-crisis period. Moreover, we obtain the result that the coefficient on economic growth forecasts is clearly insignificant for all samples when forecasts from the SPF are used, which supports the view that the ECB policy-makers rely indeed on the internal analysis, and thus on the Staff projections rather than external forecasts. These findings may also be related to the "missing inflation" episode after 2012, which describes the phenomenon that inflation was disappointingly low, despite a sustained economic recovery, and made it more difficult to forecast inflation and output in the post-crisis period (Ciccarelli and Osbat, 2017). The finding that ECB's monetary policy actions respond to the federal funds rate remains robust for all samples, with a similar magnitude as above.

[29] "Gradualism" means that a central bank implements its desired monetary policy stance through a series of small policy steps, in order not to surprise markets, but instead steer their expectations by timely communications. However, interest-rate gradualism is at odds with the view that a central bank should respond decisively to incoming shocks so as to stabilise the economy.

4.2 Reaction function including the ECB's "quantitative risk assessment"

In this Section, we augment the ECB reaction function with more granular indicators underlying the outlook for inflation and growth, which are potential drivers of the risks to price stability and are often mentioned by the ECB in the context of its risk assessment. We test whether they help to improve the benchmark Probit models (4) and (5) and augment the indicator set (Z_t), where $Z_t = [\Delta M3_{t-2}, ff_{t-1}, \zeta_t, \phi_{t-1}]$, where ϕ_t is the ADS index, and ζ_t is chosen from $\{ts_t, oil_t, \Delta w_{t-1}, \Delta pp_{t-1}, \Delta PMI_{t-1}\}$: the set of risk assessment variables are thus the term spread, the level of oil prices, negotiated wage growth, (annual) changes in producer prices, as well as changes in the PMI for the manufacturing sector.[30] The Probit model augmented in this way describes the central bank response to both the central economic scenario and the risks surrounding it. In terms of the ECB's strategy, the augmented Probit model describes the central bank response to the central economic scenario, including the short-run drivers of inflation, and, as far as the inclusion of M3 growth is concerned, its long-run drivers. Given that the ECB conducts a broad-based risk assessment as part of its monetary policy strategy, the inclusion of variables that the ECB more specifically invokes when assessing actual risks surrounding its central economic scenario should help to increase the probability of correctly predicting a change in the policy rate. That is, the higher the perceived risks to price stability implied by the evolution of these variables, the higher the likelihood of a hike in the policy rate, and conversely.

On the one hand, this exercise (Table 2, column financial variables) demonstrates the robustness of the findings concerning the relevance of broad money growth in the pre-crisis period and that of the federal funds rate in all sample periods for understanding the ECB's policy response. On the other hand, it shows that some benchmark results are sensitive to the inclusion of an additional driver (Table 2, column quantitative risk assessment). This holds in particular for the response of policy rates to the Staff projections for growth, with which the term spread as a forward-looking indicator of recessions tends to compete (post-crisis). It also holds for the response to the Staff projections for inflation, which are crowded out if we include oil prices or changes in producer prices (the coefficients for projected inflation are no longer significant in their presence): such measures of shorter-term price pressures may indeed generate second-round effects on inflation and therefore contribute to upside risks to price stability. At the same time, if we include the negotiated wage growth or changes of the PMI manufacturing, the response of ECB policy rates to inflation and output projections is similar to that in the benchmark case (albeit for the full sample the inclusion of the PMI improves the relevance of projected inflation and the overall fit).

[30] Although the term spread could be endogenous, it is included, because it is a predictor of future economic growth and regularly monitored and discussed by the Governing Council of the ECB.

Table 2: Ordered Probit Estimates of ECB Reaction Function with "Quantitative Risk" Measures

	Macro variables		Financial variables				Quantitative risk assessment							
	Projected inflation	Projected real GDP growth	Annual M3 growth (-2)	US Fed fund rate (-1)	Policy rate (-1)	Change in policy rate (-1)	Term spread	Oil price	Negotiated wage growth(-1)	Producer price inflation(-1)	PMI manu-facturing	Pseudo-R^2	LR-statistic	Correct predictions (in %)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)			
pre-crisis period	**0.73**	**1.36**	**0.99**	0.30	**-7.25**	-	-6.45					0.55	91.00	86.73
1999- 2008	*(4.04)*	*(3.03)*	*(3.26)*	*(0.98)*	*(-5.94)*		*(-1.17)*							
pre-ZLB period	0.21	-0.06	-0.08	**0.81**	**-3.50**	0.27	**-3.06**					0.31	87.13	82.42
1999-2014	*(1.92)*	*(-0.29)*	*(-0.47)*	*(3.11)*	*(-4.11)*	*(1.92)*	*(-3.35)*							
full sample	0.19	**-0.40**	-0.26	**0.73**	**-2.18**	0.19	**-2.08**					0.22	78.52	80.09
1999-2018	*(1.72)*	*(-2.29)*	*(-1.76)*	*(3.48)*	*(-4.14)*	*(1.72)*	*(-3.07)*							
pre-crisis period	0.23	**0.88**	0.28	**0.90**	**-0.79**	**-0.46**		**0.81**				0.32	53.17	77.00
1999- 2008	*(1.21)*	*(2.53)*	*(0.93)*	*(2.42)*	*(-2.07)*	*(-2.73)*		*(2.18)*						
pre-ZLB period	0.11	**0.53**	0.26	**1.05**	**-1.00**	-0.09		0.31				0.26	72.98	79.67
1999-2014	*(0.82)*	*(2.34)*	*(1.88)*	*(4.09)*	*(-3.33)*	*(-0.77)*		*(1.73)*						
full sample	0.07	0.10	0.06	**0.92**	**-0.47**	-0.04		**0.30**				0.21	73.75	80.51
1999-2018	*(0.54)*	*(0.65)*	*(0.56)*	*(4.53)*	*(-2.79)*	*(-0.41)*		*(2.22)*						
pre-crisis period	**0.52**	**0.93**	**0.68**	**1.04**	**-1.00**	**-0.37**			0.40			0.30	49.36	78.76
1999- 2008	*(3.26)*	*(2.71)*	*(2.79)*	*(2.97)*	*(-2.31)*	*(-2.47)*			*(1.95)*					
pre-ZLB period	**0.24**	0.35	0.24	**0.96**	**-0.98**	-0.03			-0.13			0.24	69.73	79.67
1999-2014	*(2.03)*	*(1.85)*	*(1.57)*	*(3.66)*	*(-3.18)*	*(-0.29)*			*(-0.72)*					
full sample	0.20	-0.06	-0.02	**0.86**	**-0.47**	0.02			-0.05			0.20	68.84	80.51
1999-2018	*(1.84)*	*(-0.44)*	*(-0.19)*	*(4.04)*	*(-2.46)*	*(0.16)*			*(-0.31)*					
pre-crisis period	0.24	**0.81**	**0.65**	0.77	-0.61	**-0.49**				**0.56**		0.32	51.70	78.76
1999- 2008	*(1.20)*	*(2.45)*	*(2.85)*	*(1.94)*	*(-1.48)*	*(-2.87)*				*(2.07)*				
pre-ZLB period	0.26	**0.40**	0.19	**0.99**	**-1.07**	-0.02				-0.02		0.24	69.40	79.67
1999-2014	*(1.63)*	*(2.13)*	*(1.40)*	*(3.86)*	*(-3.65)*	*(-0.18)*				*(-0.14)*				
full sample	0.11	-0.04	-0.02	**0.87**	**-0.52**	0.02				0.12		0.20	69.57	80.51
1999-2018	*(0.70)*	*(-0.29)*	*(-0.18)*	*(4.07)*	*(-3.18)*	*(0.19)*				*(0.90)*				
pre-crisis period	**0.51**	**0.77**	**0.62**	**0.86**	-0.68	**-0.36**					0.24	0.29	47.36	79.65
1999- 2008	*(3.19)*	*(2.29)*	*(2.56)*	*(2.36)*	*(-1.74)*	*(-2.40)*					*(0.40)*			
pre-ZLB period	**0.29**	**0.42**	0.14	**0.91**	**-0.96**	-0.05					0.68	0.25	71.75	79.67
1999-2014	*(2.54)*	*(2.39)*	*(1.05)*	*(3.73)*	*(-3.26)*	*(-0.48)*					*(1.50)*			
full sample	**0.27**	0.03	-0.06	**0.80**	**-0.47**	-0.02					**0.93**	0.21	75.03	81.36
1999-2018	*(2.52)*	*(0.27)*	*(-0.55)*	*(3.88)*	*(-2.93)*	*(-0.24)*					*(2.44)*			

Notes: The dependent variable is the policy rate change. Policy rate is the synthetic MRO rate (which is based on the MRO rate, the DFR and the APP) whose change is transformed into an ordinal rate; the lagged rate (and change) is based on its continuous rate. The regressions include the ADS index for the United States. The term spread is computed as the difference between long-term (approximately ten years) government bond yield for the euro area average minus 3-week EONIA swap rate. The spread includes inflation risk premia, among other elements. Data have been normalised, the regressions contain a constant which is not different from zero. Coefficients that are significant at the 5% level or lower are bold faced; z-statistics are in parentheses; Probit estimates use the Huber-White correction. The pseudo R^2 squared is an analog to the R^2 reported in linear regression models. The LR statistic on the overall significance of the model tests the joint null hypothesis that all slope coefficients are zero; it is never significant at the 5% level.

This suggests that certain factors from the quantitative risk assessment are absorbed by Staff projections for inflation and growth, while the term spread as an early indicator of recessions, and oil and changes in producer prices, which capture more directly risks to price stability, had a separate influence. At the same time, the results show that the inclusion of an additional variable from the quantitative risk assessment only marginally improves the overall fit of the Probit model.

4.3 Reaction functions with communication indicators

We turn to the role of communication indicators in ECB reaction functions. By nature, our communication indicators include information about policy-makers' collective judgement, and ignore deviating views of individual Governing Council members. In the Probit model (4) and (5), we add two communication indicators measuring respectively risks to price stability (RP) and risks to growth (RG), as communicated at the previous meeting, where $Z_t = [M3_{t-2}, ff_{t-1}, RP_{t-1}, RG_{t-1}, \phi_{t-1}]$ and ϕ_t is the ADS index. Table 3 shows that both communication indicators had a significant impact on ECB policy rates, where coefficients have the expected sign.[31] By comparison to the benchmark reaction function (Table 1), the pseudo R^2 for the Probit models is substantially higher, which suggests that this specification performs better. We observe that in this specification (and for all samples) coefficients for the Staff projections are insignificant (and are insignificant or of the wrong sign in the case of forecasts from the SPF), while the corresponding coefficients of the two communication indicators are sizeable and significant (at the 1%-level) with the expected sign. The size of the coefficients shows that, consistent with the ECB mandate, the Governing Council of the ECB placed more weight on risks to price stability than on risks to growth (see Table 3, column 7 and 8).

As a robustness check, we replace both communication indicators by the KOF Monetary Policy Communicator for the euro area (the results are reported in Table 3b, Appendix B). The KOF Communicator, which translates the Introductory Statements concerning risks to price stability from the ECB press conferences into an index, provides a quantitative measure of ECB communications. Despite its conceptual similarity, we find that this indicator was only significant at the 10%-level in the above regressions for the pre-ZLB period. The inferior performance may be related to the fact that the KOF Communicator also captures other dimensions of the communication and not only the forward-looking information on the direction of risks to price stability.

[31] The results using ECB shadow rates are reported in Appendix B, Table 3c.

Table 3: Ordered Probit Estimates of ECB Reaction Function augmented with Communication Indicators

	Macro variables		Financial variables				Communication				
	Projected inflation	Projected real GDP growth	Annual M3 growth (-2)	Fed funds rate (-1)	Policy rate (-1)	Change in policy rate (-1)	Risks to price stability (-1)	Risks to growth (-1)	Pseudo-R^2	LR-statistic	Correct predictions (in %)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)			
with ECB staff macroeconomic projections											
pre-crisis period 1999- 2008	0.05 *(0.21)*	0.07 *(0.12)*	0.55 *(1.61)*	0.30 *(0.86)*	**-1.14** *(-2.63)*	**-0.56** *(-2.05)*	**2.51** *(3.62)*	**0.94** *(3.43)*	0.52	85.61	83.19
pre-ZLB period 1999-2014	0.08 *(0.50)*	0.05 *(0.17)*	**0.35** *(2.26)*	**0.90** *(3.22)*	**-1.29** *(-3.59)*	-0.12 *(-0.97)*	**0.72** *(4.18)*	**0.54** *(4.30)*	0.36	101.66	80.22
full sample 1999-2018	-0.03 *(-0.18)*	-0.27 *(-1.37)*	0.10 *(0.77)*	**0.75** *(3.36)*	**-0.87** *(-4.71)*	-0.07 *(-0.64)*	**0.77** *(4.83)*	**0.44** *(3.66)*	0.31	107.96	81.34
with forecasts from the SPF											
pre-crisis period 1999- 2008	0.18 *(0.62)*	-0.34 *(-1.18)*	0.50 *(1.77)*	0.55 *(1.42)*	**-0.96** *(-2.50)*	-0.57 *(-1.70)*	**2.04** *(3.29)*	**0.79** *(2.09)*	0.48	55.79	86.81
pre-ZLB period 1999-2014	**-0.46** *(-2.45)*	-0.13 *(-0.54)*	**0.43** *(2.34)*	**0.94** *(2.67)*	**-1.02** *(-2.39)*	-0.17 *(-1.24)*	**0.92** *(4.07)*	**0.68** *(3.82)*	0.34	78.63	83.75
full sample 1999-2018	**-0.40** *(-2.14)*	**-0.35** *(-2.16)*	0.15 *(1.04)*	**0.75** *(3.06)*	**-0.54** *(-2.94)*	-0.11 *(-0.88)*	**0.81** *(4.36)*	**0.53** *(3.61)*	0.28	82.85	81.78

Notes: The dependent variable is the policy rate change. Policy rate is the synthetic MRO rate (which is based on the MRO, the DFR and the APP) whose change is transformed into an ordinal rate; the lagged rate (and change) is based on its continuous rate. The regressions include the ADS index for the United States. Data have been normalised, the regressions contain a constant which is not different from zero. Coefficients that are significant at the 5% level or lower are bold faced; z-statistics are in parentheses; Probit estimates use the Huber-White correction. The pseudo R^2 squared is an analog to the R^2 reported in linear regression models. The LR statistic on the overall significance of the model tests the joint null hypothesis that all slope coefficients are zero; it is never significant at the 5% level.

In sum, we confirm that ECB statements at press conferences contain useful information for predicting interest rate changes at the next meeting. We show that the signals from both communication indicators (RP, RG) are complementary. The enhanced performance of the reaction function shows that these communications provide more comprehensive information to markets and the general public, which includes the information of the central economic scenario (as summarised by the Staff projections that are crowded out by the inclusion of communication indicators), but also goes beyond it. While communication indicators may capture the risks surrounding the central economic scenario, they add in particular information about policy-makers' judgements regarding the underlying risks and perceived uncertainties on the state of the economy as well as about the ECB's readiness to change policy rates.

Table 4: Ordered Probit Estimates of ECB Communication Reaction Function

		Macro variables		Financial variables						
	Dependent variable (risks to …)	**Projected inflation** (1)	**Projected real GDP growth** (2)	**Annual M3 growth (-2)** (3)	**Fed funds rate (-1)** (4)	**Policy rate (-1)** (5)	**Change in policy rate (-1)** (6)	**Pseudo-R^2**	**LR-statistic**	**Correct predictions (in %)**
with ECB staff macroeconomic projections										
pre-crisis period 1999- 2008	**Price stability**	**1.01** *(5.05)*	**0.98** *(4.00)*	**1.53** *(7.27)*	**1.00** *(5.32)*	**-0.68** *(-2.59)*	-	0.46	139.24	61.95
pre-ZLB period 1999-2014	**Price stability**	**0.92** *(7.45)*	**0.51** *(3.62)*	**0.38** *(3.19)*	**0.62** *(3.45)*	**-0.82** *(-3.85)*	**1.75** *(2.79)*	0.35	184.18	61.54
full sample 1999-2018	**Price stability**	**0.90** *(8.55)*	0.02 *(0.18)*	0.06 *(0.59)*	**0.44** *(3.02)*	0.20 *(1.84)*	**1.48** *(2.67)*	0.34	240.38	54.66
pre-crisis period 1999- 2008	**Growth**	-0.15 *(-1.40)*	**0.78** *(4.06)*	**-0.57** *(-4.15)*	**-0.35** *(-2.72)*	**0.46** *(2.25)*	-	0.31	103.56	55.75
pre-ZLB period 1999-2014	**Growth**	-0.04 *(-0.29)*	**1.84** *(5.95)*	**-0.48** *(-3.43)*	**-0.52** *(-3.40)*	**0.64** *(2.49)*	1.02 *(1.59)*	0.36	179.18	59.89
full sample 1999-2018	**Growth**	0.07 *(0.61)*	**1.91** *(7.57)*	**-0.26** *(-2.49)*	-0.27 *(-1.92)*	-0.10 *(-0.89)*	**1.59** *(2.67)*	0.36	207.35	61.02
with forecasts from the SPF										
pre-crisis period 1999- 2008	**Price stability**	**0.69** *(4.00)*	-0.06 *(-0.44)*	**0.77** *(3.73)*	**1.25** *(4.99)*	-0.11 *(-0.36)*	-	0.43	106.51	64.84
pre-ZLB period 1999-2014	**Price stability**	**0.97** *(7.94)*	0.18 *(1.29)*	-0.08 *(-0.54)*	**0.95** *(4.25)*	-0.43 *(-1.88)*	**3.61** *(5.07)*	0.37	170.43	62.50
full sample 1999-2018	**Price stability**	**1.20** *(9.27)*	0.02 *(0.18)*	**-0.21** *(-1.70)*	**0.78** *(4.39)*	0.01 *(0.06)*	**3.02** *(4.57)*	0.39	241.66	64.02
pre-crisis period 1999- 2008	**Growth**	-0.11 *(-0.68)*	0.25 *(1.57)*	**-0.49** *(-3.45)*	**-0.54** *(-2.95)*	**0.51** *(2.32)*	-	0.19	41.80	49.45
pre-ZLB period 1999-2014	**Growth**	-0.11 *(-0.54)*	**1.27** *(5.58)*	-0.23 *(-1.43)*	**-0.65** *(-3.16)*	0.48 *(1.72)*	**2.11** *(2.80)*	0.27	97.30	55.00
full sample 1999-2018	**Growth**	0.09 *(0.53)*	**1.38** *(6.82)*	-0.08 *(-0.68)*	**-0.41** *(-2.45)*	**-0.37** *(-2.20)*	**2.40** *(3.50)*	0.26	126.08	57.48

Notes: Risks to price stability and to growth are ordinal variables respectively and coded from the Introductory Statement; policy rate is the synthetic MRO rate; the lagged policy rate (and change) is based on its continuous rate. The regressions include the ADS index for the United States. Data have been normalised, the regression contains a constant which is not different from zero. Coefficients that are significant at the 5% level or lower are bold faced; z-statistics are in parentheses; Probit estimates use the Huber-White correction. The pseudo R^2 squared is an analog to the R^2 reported in linear regression models. The ratios of coefficients provide a measure of the relative effects on the probabilities of the various policy outcomes. The LR statistic on the overall significance of the model tests the joint null hypothesis that all slope coefficients are zero; it is never significant at the 5% level.

This interpretation is further corroborated by the results of a communication reaction function of the ECB (6). Table 4 shows that the projections for inflation (growth) had a significant impact on the ECB communications of the risks to price stability (to growth). These results are robust and tend to hold for both internal and external forecasts. In addition, it appears that communications on the risks to price stability respond to internal growth projections for the pre-crisis and pre-ZLB periods, but not to

external growth forecasts. In terms of predictability, these models have around a 50 to 65 per cent chance of correctly predicting the communication indicator. Moreover, we show that communications on the risks to price stability and to growth tended to respond to money growth and the federal funds rate with the expected signs.

We also run Probit models for communication indicators that include variables from the "quantitative risk assessment" (see Table 4a, appendix B). The results show that the variables oil prices and changes in producer prices, which are key to assess second-round effects on risks to inflation, are significant in explaining communications on the risks to price stability and to growth. Interestingly and contrary to the case of the Probit models for the policy rates, the inclusion of risk assessment variables does not generally crowd out the central assessment variables but complements them, both being significant in the regressions. This result corroborates our interpretation that the communication indicators capture both the assessment on the central economic scenario (as reflected in the Staff projections) and the risks surrounding this scenario, both determining monetary policy decisions. This is what makes the judgement of the policy-makers themselves, as summarised in the official statements, the best guide to explain or predict monetary policy decisions, beyond the performance that any indicator based on data alone can achieve. This is because the power of communication in policy-making – and its related improvements of estimated policy reaction functions – also lies in its capacity to steer expectations and prepare the markets and the general public ahead of the next policy decisions.

5. Conclusions

Based on empirical reaction functions for ECB policy rates, this paper studies the relative impact of fundamentals and judgement on the interest rate setting of the ECB's Governing Council during two decades of monetary union. Modelling discrete choices of policy-makers on interest rates, which can be done with ordered Probit techniques, allows capturing non-linearities in the interest rate setting behaviour in response to changes in the macroeconomic environment. We find that ordered Probit models match closely the policy-makers' response over the last twenty years including the financial crisis episode and that the interest rate setting behaviour of the ECB was in line with its primary objective of price stability. We classify the drivers of the ECB's reaction function as belonging to the Governing Council's central economic scenario, its quantitative risk assessment, and policy-makers' judgemental assessment of the balance of risks. Within the two-pillar monetary policy strategy, the Staff macroeconomic projections on inflation and growth appear to be the main drivers of the ECB response together with M3 growth during the pre-crisis period. The significance of the federal funds rate in the ECB reaction function confirms the relevance of international interest rate linkages for the

ECB's monetary policy decisions.

Concerning the role of communication, we contribute to the literature by showing that the post-meeting communications of the Governing Council about the risks to price stability and to growth at press conferences enhance the modelling of the ECB policy reaction function. In addition, the indications of the Governing Council about the balance of risks at press conferences provided helpful orientation to the markets and the public on where the ECB was heading to at future policy meetings. Reflecting its primary objective of price stability, ECB communications about the risks to price stability were more helpful for understanding its interest rate setting than its communications about the risks to growth. Furthermore, we show that the communication indicators on the balance of risks capture both the assessment on the central economic scenario (as reflected in the Staff projections) and the risks surrounding this scenario.

In terms of policy implications, we conclude that ECB communications at press conferences provide essential information about risks to price stability and to economic growth that summarise the information from a host of economic variables. Accounting for such communication in the case of the ECB enhances the modelling of its policy reaction function. Communications on the balance of risks provide orientation to markets and the public and increase the ECB's predictability. Moreover, the persistent role across specifications detected for the international monetary policy environment (as captured by the federal funds rate) suggests that it is taken into account in the ECB's interest rate decisions, despite the fact that the euro area is a large and relatively closed economy.

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Appendix A: Description of the dataset

Variable	Source and description
	ECB MFI statistics and ECB real-time database
Monetary aggregate M3	RTD.M.S0.N.M_M3_V_NC.E
Credit to euro area residents	BSI.M.U2.Y.U.AT2.A.I.U2.2000.Z01.A
Interest rates:	ECB statistics, Alfred database (Fed St Louis)
- MRO rate	FM.B.U2.EUR.4F.KR.MRR_FR.LEV
- DFR	FM.B.U2.EUR.4F.KR.DFR.LEV
- Synthetic MRO rate	based on the MRO rate, the DFR and the APP. We compute a nominal rate (see Table below) and an ordinal rate.
- Federal funds rate	FEDFUNDS (Alfred database), which refers to the target rate.
- Term spread	The term spread is computed as the difference between long-term (approximately ten years) government bond yield for the euro area average minus 3-week EONIA swap rate. The spread includes inflation risk premia, among other elements.
Shadow rates for the ECB:	obtained from the authors: - Lemke and Vladu (2017) - Wu and Xia (2016) and - Krippner (2019), see website: https://www.rbnz.govt.nz/research-and-publications/research-programme/additional-research/measures-of-the-stance-of-united-states-monetary-policy/comparison-of-international-monetary-policy-measures
	Eurostat, Markit Economics and ECB real-time database
HICP inflation	RTD.M.S0.N.P_C_OV.A
Real GDP	RTD.Q.S0.S.G_GDPM_TO_C.E, RTD.Q.S0.S.G_GDPM_TO_D.X
Oil prices	RTD.M.S0.N.P_OILBR.E
Negotiated wages	STS.Q.I8.N.INWR.000000.3.ANR
Producer prices	RTD.M.S0.N.P_P_CAPGO_DS.X
PMI for manufacturing	SUR.M.I8.S.NTC.MANPMI.TT (Markit Eurozone Composite Purchasing Managers' Index)
ECB staff forecasts (for inflation and growth)	hand collected from the ECB website (real-time)
SPF forecasts (for inflation and growth)	hand collected from the ECB website (real-time)
KOF Monetary Policy Communicator	ETH Zuerich KOF, https://www.kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-monetary-policy-communicator.html
ADS index	Aruoba-Diebold-Scotti (ADS) business conditions index for the United States (see Aruoba, Diebold and Scotti, 2009), available from Fed Philadelphia: https://www.philadelphiafed.org/research-and-data/real-time-center/business-conditions-index

ECB synthetic MRO rate and communication indicators:

Meeting date:	Risks to price stability	Risks to growth	Synthetic MRO rate	Meeting date:	Risks to price stability	Risks to growth	Synthetic MRO rate	Meeting date:	Risks to price stability	Risks to growth	Synthetic MRO rate
07/01/1999	0	0	3	12/01/2006	2	-2	2.25	10/01/2013	0	-2	0.75
04/02/1999	0	0	3	02/02/2006	2	-2	2.25	07/02/2013	0	-2	0.75
04/03/1999	0	-1	3	02/03/2006	1	-1	2.5	07/03/2013	0	-2	0.75
08/04/1999	0	-1	2.5	06/04/2006	2	-1	2.5	04/04/2013	0	-2	0.75
06/05/1999	0	-1	2.5	04/05/2006	2	-1	2.5	02/05/2013	0	-2	0.5
02/06/1999	0	0	2.5	08/06/2006	1	-1	2.75	06/06/2013	0	-2	0.5
15/07/1999	0	0	2.5	06/07/2006	2	-1	2.75	04/07/2013	0	-2	0.5
26/08/1999	0	1	2.5	03/08/2006	2	-1	3	01/08/2013	0	-2	0.5
09/09/1999	1	1	2.5	31/08/2006	2	-1	3	05/09/2013	0	-2	0.5
07/10/1999	2	1	2.5	05/10/2006	2	-1	3.25	02/10/2013	0	-2	0.5
04/11/1999	1	1	3	02/11/2006	2	-1	3.25	07/11/2013	0	-2	0.25
02/12/1999	1	2	3	07/12/2006	2	-1	3.5	05/12/2013	0	-2	0.25
05/01/2000	2	2	3	11/01/2007	2	-1	3.5	09/01/2014	0	-2	0.25
03/02/2000	2	2	3.25	08/02/2007	2	-1	3.5	06/02/2014	0	-2	0.25
02/03/2000	2	2	3.5	08/03/2007	2	-1	3.75	06/03/2014	0	-2	0.25
13/04/2000	2	2	3.75	12/04/2007	2	-1	3.75	03/04/2014	0	-2	0.25
11/05/2000	2	2	3.75	10/05/2007	2	-1	3.75	08/05/2014	0	-2	0.25
08/06/2000	1	2	4.25	06/06/2007	1	-1	4	05/06/2014	0	-2	0
06/07/2000	1	2	4.25	05/07/2007	2	-1	4	03/07/2014	0	-2	0
03/08/2000	2	2	4.25	02/08/2007	2	-1	4	07/08/2014	0	-2	0
14/09/2000	2	2	4.5	06/09/2007	2	-2	4	04/09/2014	-1	-2	-0.25
05/10/2000	1	2	4.75	04/10/2007	2	-2	4	02/10/2014	-1	-2	-0.25
02/11/2000	1	1	4.75	08/11/2007	2	-2	4	06/11/2014	-1	-2	-0.25
14/12/2000	1	1	4.75	06/12/2007	2	-2	4	04/12/2014	-2	-2	-0.25
04/01/2001	1	0	4.75	10/01/2008	2	-2	4	22/01/2015	-2	-1	-0.25
01/02/2001	0	0	4.75	07/02/2008	2	-2	4		-2	-1	-0.25
01/03/2001	0	0	4.75	06/03/2008	2	-2	4	05/03/2015	-1	-1	-0.75
11/04/2001	0	-1	4.75	10/04/2008	2	-2	4	15/04/2015	-1	-1	-0.75
10/05/2001	0	-1	4.5	08/05/2008	2	-2	4		-1	-1	-0.75
07/06/2001	0	-1	4.5	05/06/2008	2	-1	4	03/06/2015	-1	-1	-0.75
05/07/2001	0	-1	4.5	03/07/2008	2	-1	4.25	16/07/2015	-1	0	-0.75
30/08/2001	0	-1	4.25	07/08/2008	2	-2	4.25		-1	0	-0.75
17/09/2001	-1	-1	3.75	04/09/2008	1	-2	4.25	03/09/2015	-1	-1	-0.75
11/10/2001	-1	-1	3.75	02/10/2008	0	-2	3.75	22/10/2015	-2	-1	-0.75
08/11/2001	-1	-1	3.25	06/11/2008	0	-2	3.25		-2	-1	-0.75
06/12/2001	-1	-2	3.25	04/12/2008	-1	-2	2.75	03/12/2015	-2	-2	-1
03/01/2002	0	-1	3.25	15/01/2009	-1	-2	2	21/01/2016	-2	-2	-1
07/02/2002	0	-1	3.25	05/02/2009	-1	-2	2		-2	-2	-1
07/03/2002	1	0	3.25	05/03/2009	-2	-2	1.5	10/03/2016	-1	-2	-1.25
04/04/2002	1	1	3.25	02/04/2009	-2	-2	1.25	21/04/2016	-1	-2	-1.5
02/05/2002	1	1	3.25	07/05/2009	-2	-2	1		-1	-2	-1.5
06/06/2002	1	1	3.25	04/06/2009	-2	-2	1	02/06/2016	0	-1	-1.5
04/07/2002	1	1	3.25	02/07/2009	-2	-2	1	21/07/2016	0	-1	-1.5
01/08/2002	0	-1	3.25	06/08/2009	-2	-2	1		0	-1	-1.5
12/09/2002	0	-1	3.25	03/09/2009	-2	-2	1	08/09/2016	-1	-1	-1.5
10/10/2002	0	-1	3.25	08/10/2009	-1	-2	1	20/10/2016	-1	-1	-1.5
07/11/2002	-1	-2	3.25	05/11/2009	-1	-1	1		-1	-1	-1.5
05/12/2002	-1	-1	2.75	03/12/2009	-1	-2	1	08/12/2016	-1	-1	-1.5
09/01/2003	0	-2	2.75	14/01/2010	-1	-2	1	19/01/2017	-1	-1	-1.5
06/02/2003	-1	-2	2.75	04/02/2010	-1	-2	1		-1	-1	-1.5
06/03/2003	-1	-2	2.5	04/03/2010	-1	-2	1	09/03/2017	-1	-1	-1.5
03/04/2003	-1	-2	2.5	08/04/2010	0	-1	1	27/04/2017	0	-1	-1.25
08/05/2003	-1	-1	2.5	06/05/2010	0	0	1		0	0	-1.25
05/06/2003	-1	-1	2	10/06/2010	0	0	1	08/06/2017	0	0	-1.25
10/07/2003	-1	-1	2	08/07/2010	0	0	1	20/07/2017	0	0	-1.25
31/07/2003	-1	-1	2	05/08/2010	0	0	1		0	0	-1.25
04/09/2003	-1	0	2	02/09/2010	1	-1	1	07/09/2017	0	0	-1.25
02/10/2003	0	0	2	07/10/2010	1	-1	1	26/10/2017	0	0	-1.25
06/11/2003	0	0	2	04/11/2010	1	-1	1		0	0	-1.25
04/12/2003	0	0	2	02/12/2010	0	-1	1	14/12/2017	0	0	-1.25
08/01/2004	0	0	2	13/01/2011	1	-1	1	25/01/2018	0	0	-1
05/02/2004	0	0	2	03/02/2011	1	-1	1		0	0	-1
04/03/2004	0	0	2	03/03/2011	2	0	1	08/03/2018	0	0	-1
01/04/2004	0	0	2	07/04/2011	2	0	1.25	26/04/2018	0	0	-1
06/05/2004	0	0	2	05/05/2011	2	0	1.25		0	0	-1
03/06/2004	0	0	2	09/06/2011	2	0	1.25	14/06/2018	0	0	-1
01/07/2004	0	0	2	07/07/2011	2	0	1.5	26/07/2018	0	0	-1
05/08/2004	0	0	2	04/08/2011	2	0	1.5		0	0	-1
02/09/2004	1	0	2	08/09/2011	0	-2	1.5	13/09/2018	0	0	-1
07/10/2004	1	0	2	06/10/2011	0	-2	1.5	25/10/2018	0	0	-0.75
04/11/2004	1	0	2	03/11/2011	0	-2	1.25		0	0	-0.75
02/12/2004	1	0	2	08/12/2011	0	-2	1	13/12/2018	0	0	-0.75
13/01/2005	1	-1	2	12/01/2012	0	-2	1				
03/02/2005	1	-1	2	09/02/2012	0	-2	1				
03/03/2005	1	-1	2	08/03/2012	1	-2	1				
07/04/2005	1	-2	2	04/04/2012	1	-2	1				
04/05/2005	1	-2	2	03/05/2012	0	-2	1				
02/06/2005	1	-2	2	06/06/2012	0	-2	1				
07/07/2005	1	-2	2	05/07/2012	-1	-2	0.75				
04/08/2005	1	-2	2	02/08/2012	-1	-2	0.75				
01/09/2005	2	-2	2	06/09/2012	-1	-2	0.75				
06/10/2005	2	-2	2	04/10/2012	-1	-2	0.75				
03/11/2005	2	-2	2	08/11/2012	0	-2	0.75				
01/12/2005	1	-2	2.25	06/12/2012	0	-2	0.75				

Appendix B: Further empirical results

In order to compare the results with the propositions from Taylor-type rules, we explain the policy rate (i.e., the synthetic MRO rate) as a continuous variable and estimate the ECB reaction function with OLS.[32] In regressions explaining the level of the synthetic MRO rate, we obtain a very high R^2 in line with the high degree of autoregression as the lagged synthetic MRO rate is included (see Table 1a below). The coefficient for this lagged policy rate is in the range of [0.92; 0.98], which compares with a range of [0.8; 1.0] for the smoothing parameter in previous studies. In these regressions, there is again a significant impact of the federal funds rate, while the impact of projected inflation (and to some extent projected growth) and broad money growth on policy rates is significant in the pre-crisis period and for the full sample. We checked that the results remain fairly robust if we replace the ECB staff macroeconomic projections for inflation and output with forecasts from the SPF.

Table 1a: OLS Estimates of ECB Reaction Function

	Macro variables		**Financial variables**				
	Projected inflation (1)	**Projected real GDP growth** (2)	**Annual M3 growth (-2)** (3)	**Fed funds rate (-1)** (4)	**Policy rate (-1)** (5)	**Change in policy rate (-1)** (6)	**R^2 adjusted**
pre-crisis period 1999- 2008	**0.04** *(2.12)*	0.07 *(1.84)*	**0.05** *(2.00)*	**0.06** *(3.55)*	**0.94** *(28.95)*	**-0.03** *(-2.12)*	0.98
pre-ZLB period 1999-2014	0.02 *(1.59)*	0.03 *(1.57)*	0.01 *(0.93)*	**0.06** *(3.57)*	**0.92** *(32.56)*	0.00 *(0.09)*	0.99
full sample 1999-2018	0.01 *(1.37)*	0.00 *(0.28)*	**0.00** *(-0.74)*	**0.04** *(3.80)*	**0.98** *(125.60)*	0.00 *(0.20)*	0.98

Notes: The dependent variable is the policy rate. Policy rate is the synthetic MRO rate. The regressions include the ADS index for the United States. Data have been normalised, the regressions contain a constant which is not different from zero. Coefficients that are significant at the 5% level or lower are bold faced; t-statistics are in parentheses; we compute heteroskedastic-and-autocorrelation consistent (HAC) standard errors.

We also report results for OLS regressions of the reaction function augmented with ordinal communication indicators. Overall, as is evident from the results for the full sample, Table 3a shows that our communication indicators on the balance of risks (RP, RG) are less informative on the ECB policy reaction if misspecified with OLS.

[32] Such a comparison could also be achieved by reporting "marginal effects" for the ordered Probit model, as is done for example in Hayo and Neuenkirch (2010).

Table 3a: OLS Estimates of ECB Reaction Function with Communication Indicators

	Macro variables		Financial variables				Communication		
	Projected inflation	**Projected real GDP growth**	**Annual M3 growth (-2)**	**Fed funds rate (-1)**	**Policy rate (-1)**	**Change in policy rate (-1)**	**Risks to price stability (-1)**	**Risks to growth (-1)**	**R^2 adjusted**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
pre-crisis period	-0.01	-0.02	0.00	0.02	**0.95**	**-0.04**	**0.12**	**0.05**	0.98
1999- 2008	*(-0.77)*	*(-0.56)*	*(-0.19)*	*(1.17)*	*(32.97)*	*(-3.99)*	*(5.18)*	*(2.74)*	
pre-ZLB period	0.01	0.01	0.01	**0.04**	**0.93**	-0.01	**0.04**	**0.03**	0.99
1999-2014	*(0.44)*	*(0.31)*	*(0.59)*	*(2.60)*	*(29.64)*	*(-0.44)*	*(2.89)*	*(2.75)*	
full sample	0.00	0.00	0.00	**0.02**	**0.97**	0.00	**0.03**	0.01	0.99
1999-2018	*(-0.39)*	*(-0.23)*	*(-0.75)*	*(2.56)*	*(115.50)*	*(-0.48)*	*(4.18)*	*(1.79)*	

Notes: The dependent variable is the policy rate. Policy rate is the synthetic MRO rate. The regressions include the ADS index for the United States. Data have been normalised, the regressions contain a constant which is not different from zero. Coefficients that are significant at the 5% level or lower are bold faced; t-statistics are in parentheses; we compute heteroskedastic-and-autocorrelation consistent (HAC) standard errors.

As a check for robustness of the results of the Probit specification presented in Table 3, we replace both communication indicators by the KOF Monetary Policy Communicator for the euro area. Table 3b shows that a reaction function with this other communication indicator is inferior. Only for the pre-ZLB sample we can show at the 10% significance level that the KOF indicator helped to improve the predictability of the ECB's policy decision at the next meeting.

Table 3b: Ordered Probit Estimates of ECB Reaction Function augmented with KOF Monetary Policy Communicator

	Macro variables		Financial variables				Communication	
	Projected inflation	**Projected real GDP growth**	**annual M3 growth (-2)**	**Fed funds rate (-1)**	**Policy rate (-1)**	**Change in policy rate (-1)**	**KOF Monetary Policy Communicator (-1)**	**Pseudo-R^2**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
pre-crisis period	**0.45**	**0.78**	**0.55**	0.75	-0.67	**-0.37**	1.25	0.30
1999- 2008	*(2.83)*	*(2.35)*	*(2.21)*	*(1.92)*	*(-1.63)*	*(-2.47)*	*(1.13)*	
pre-ZLB period	0.10	**0.39**	0.15	**0.96**	**-1.03**	-0.07	1.44	0.26
1999-2014	*(0.77)*	*(2.16)*	*(1.06)*	*(3.59)*	*(-3.44)*	*(-0.54)*	*(1.88)*	
full sample	0.12	-0.07	-0.08	**0.84**	-0.39	-0.01	0.82	0.20
1999-2018	*(0.94)*	*(-0.55)*	*(-0.63)*	*(3.88)*	*(-1.91)*	*(-0.12)*	*(1.53)*	

Notes: The dependent variable is the policy rate change. Policy rate is the synthetic MRO rate, the dependent variable is ordinal, the lagged rate (and change) is based on its continuous rate. Forecasts are ECB Staff macroeconomic projections. The regressions include the ADS index for the United States. Data have been normalised, the regressions contain a constant which is not different from zero. Coefficients that are significant at the 5% level or lower are bold faced; z-statistics are in parentheses; Probit estimates use the Huber-White correction. The pseudo R^2 squared is an analog to the R^2 reported in linear regression models.

As another robustness check, we report results with an ordered Probit model replacing the latent policy rate with the shadow rate obtained from three different research teams for the full sample. We transform the change in the shadow rate into an ordinal variable based on (5). Table 3c shows that the results on the communication indicators are supportive for the risks to growth, though overall more mixed than the benchmark results, while these equations have lower explanatory power.

Table 3c: Ordered Probit Estimates of ECB Reaction Function based on Shadow Rates augmented with Communication Indicators

		Macro variables		Financial variables				Communication		
	Dependent variable (shadow rate by …)	**Projected inflation**	**Projected real GDP growth**	**Annual M3 growth (-2)**	**Fed funds rate (-1)**	**Shadow rate (-1)**	**Change in shadow rate (-1)**	**Risks to price stability (-1)**	**Risks to growth (-1)**	**Pseudo-R^2**
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
full sample 1999-2018	**Lemke/Vladu (2017)** 1999-2018	-0.03 *(-0.25)*	-0.21 *(-1.55)*	-0.03 *(-0.26)*	**0.48** *(2.81)*	-0.26 *(-1.63)*	**0.39** *(3.44)*	0.07 *(0.51)*	**0.22** *(2.12)*	0.22
full sample 1999-2018	**Krippner (2019)** 1999-2018	0.05 *(0.50)*	-0.19 *(-1.51)*	0.03 *(0.35)*	0.17 *(1.40)*	-0.12 *(-1.03)*	**0.72** *(5.80)*	0.01 *(0.07)*	0.15 *(1.76)*	0.17
full sample 1999-2018	**Wu and Xia (2016)** 1999-2018	0.11 *(0.95)*	-0.11 *(-0.77)*	-0.08 *(-0.95)*	0.16 *(1.54)*	-0.17 *(-1.55)*	-0.04 *(-0.34)*	0.16 *(1.59)*	**0.18** *(2.37)*	0.04

Notes: The shadow rate is transformed into an ordinal rate using (5), while its lagged rate (and change) is based on its continuous rate. Forecasts are ECB Staff macroeconomic projections. The regressions include the ADS index for the United States. Data have been normalised, the regressions contain a constant which is not different from zero. Coefficients that are significant at the 5% level or lower are bold faced; z-statistics are in parentheses; Probit estimates use the Huber-White correction. The pseudo R^2 squared is an analog to the R^2 reported in linear regression models.

As a further check for robustness, we report results with an ordered Probit model of the ECB communication reaction function and augment them with more granular indicators underlying the "quantitative risk assessment". We consider real-time observations for shorter-term determinants of inflation, namely the level of oil prices, negotiated wage growth and changes in producer prices. We test whether they help to improve the Probit model (6a), which we augment (6) with one indicator ζ_t each from the set $\{\text{oil}_t, \Delta w_{t-1}, \Delta pp_{t-1}\}$:

$$c_t^* = \omega_\pi \pi_t + \omega_y y_t + \omega_{M3} \Delta M3_{t-2} + \omega_{ff} ff_{t-1} + \omega_\zeta \zeta_t - \gamma i_{t-1}^m + \rho \Delta i_{t-1}^m + \varepsilon_t \quad (6a)$$

where c_t is our ordinal measure of the ECB's communication about the risks to price stability or to growth (RP, RG), the latent variable can take five values each [-2,-1,0,+1,+2], and ω_i, γ and ρ are coefficients and ε is the residual. When estimating (6a) we include the ADS index lagged by one month as control variable.

Table 4a: Ordered Probit Estimates of ECB Communication Reaction Function with "Quantitative Risk" Measures

		Macro variables		Financial variables				Quantitative risk assessment					
	Dependent variable (risks to …)	Projected inflation	Projected real GDP growth	Annual M3 growth (-2)	US Fed fund rate (-1)	Policy rate (-1)	Change in policy rate (-1)	Oil price	Negotiated wage growth(-1)	Producer price inflation(-1)	Pseudo-R^2	LR-statistic	Correct predictions (in %)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)			
pre-crisis period 1999- 2008	**Price stability**	0.22 *(1.15)*	**0.66** *(3.07)*	-	**0.66** *(3.52)*	-0.19 *(-0.74)*	-	**2.07** *(8.22)*			0.53	164.04	67.24
pre-ZLB period 1999-2014	**Price stability**	**0.71** *(4.83)*	**1.57** *(6.14)*	**0.82** *(5.73)*	**0.53** *(2.93)*	**-0.49** *(-2.01)*	0.01 *(0.12)*	**1.42** *(7.60)*			0.49	260.01	69.78
full sample 1999-2018	**Price stability**	**0.62** *(5.24)*	**0.60** *(4.42)*	**0.49** *(3.98)*	**0.47** *(3.19)*	**0.51** *(4.07)*	0.05 *(0.54)*	**1.07** *(8.53)*			0.45	312.82	63.56
pre-crisis period 1999- 2008	**Growth**	0.05 *(0.38)*	**0.76** *(3.60)*	-0.27 *(-1.21)*	-0.25 *(-1.46)*	0.37 *(1.61)*	**0.31** *(2.58)*	**-0.68** *(-1.97)*			0.35	115.50	53.98
pre-ZLB period 1999-2014	**Growth**	0.15 *(1.31)*	**1.46** *(5.02)*	**-0.64** *(-4.70)*	**-0.44** *(-2.59)*	0.45 *(1.75)*	**0.36** *(2.92)*	**-0.68** *(-3.94)*			0.41	200.13	65.39
full sample 1999-2018	**Growth**	**0.30** *(2.70)*	**1.54** *(6.31)*	**-0.48** *(-3.92)*	-0.20 *(-1.30)*	**-0.25** *(-2.09)*	**0.37** *(3.74)*	**-0.66** *(-4.33)*			0.37	235.84	60.59
pre-crisis period 1999- 2008	**Price stability**	**0.83** *(5.33)*	-0.14 *(-0.89)*	-	**0.68** *(4.07)*	0.06 *(0.25)*	-		-0.08 *(-0.51)*		0.27	83.99	53.45
pre-ZLB period 1999-2014	**Price stability**	**0.92** *(7.60)*	**0.31** *(1.97)*	**0.71** *(4.90)*	**0.39** *(2.07)*	-0.25 *(-0.96)*	**0.22** *(2.05)*		**-0.81** *(-4.54)*		0.38	200.28	56.04
full sample 1999-2018	**Price stability**	**0.94** *(8.52)*	-0.14 *(-1.26)*	**0.22** *(1.97)*	**0.39** *(2.60)*	**0.60** *(4.26)*	**0.19** *(2.19)*		**-0.54** *(-3.76)*		0.36	249.95	59.32
pre-crisis period 1999- 2008	**Growth**	-0.23 *(-1.91)*	**0.68** *(3.46)*	**-0.62** *(-4.38)*	**-0.44** *(-3.06)*	**0.54** *(2.52)*	**0.24** *(2.10)*		-0.17 *(-1.08)*		0.32	107.60	55.75
pre-ZLB period 1999-2014	**Growth**	-0.03 *(-0.25)*	**1.85** *(6.13)*	**-0.50** *(-3.27)*	**-0.50** *(-2.89)*	**0.59** *(2.08)*	0.17 *(1.61)*		0.07 *(0.39)*		0.36	179.33	59.89
full sample 1999-2018	**Growth**	0.05 *(0.44)*	**1.96** *(8.22)*	**-0.34** *(-3.12)*	-0.21 *(-1.45)*	**-0.36** *(-2.69)*	**0.27** *(2.94)*		**0.35** *(2.18)*		0.33	211.14	60.59
pre-crisis period 1999- 2008	**Price stability**	**0.52** *(2.98)*	-0.09 *(-0.62)*	-	**0.57** *(3.14)*	0.18 *(0.71)*	-			**0.58** *(4.04)*	0.31	95.57	59.48
pre-ZLB period 1999-2014	**Price stability**	**0.36** *(2.22)*	**0.62** *(4.00)*	**0.53** *(4.03)*	**0.58** *(3.04)*	**-0.80** *(-3.57)*	**0.32** *(2.83)*			**0.98** *(6.64)*	0.43	225.66	58.79
full sample 1999-2018	**Price stability**	**0.44** *(3.11)*	0.09 *(0.90)*	0.14 *(1.31)*	**0.35** *(2.34)*	**0.29** *(2.22)*	**0.21** *(2.37)*			**0.74** *(6.33)*	0.40	277.53	61.86
pre-crisis period 1999- 2008	**Growth**	-0.03 *(-0.16)*	**0.68** *(3.57)*	**-0.65** *(-4.70)*	-0.23 *(-1.57)*	0.34 *(1.66)*	**0.32** *(2.43)*			**-0.39** *(-2.00)*	0.33	111.12	54.87
pre-ZLB period 1999-2014	**Growth**	0.02 *(0.10)*	**1.85** *(6.41)*	**-0.49** *(-3.43)*	**-0.52** *(-3.31)*	**0.62** *(2.47)*	0.18 *(1.58)*			-0.08 *(-0.44)*	0.36	179.44	60.44
full sample 1999-2018	**Growth**	0.00 *(0.01)*	**1.92** *(6.91)*	**-0.24** *(-2.18)*	-0.29 *(-1.86)*	-0.10 *(-0.87)*	**0.23** *(2.36)*			0.10 *(0.60)*	0.33	207.98	63.14

Notes: Policy rate is the synthetic MRO rate. Risks to price stability and to growth are ordinal variables respectively and coded from the Introductory Statement. The regressions include the ADS index for the United States. Data have been normalised, the regression contains a constant which is not different from zero. Coefficients that are significant at the 5% level or lower are bold faced; z-statistics are in parentheses; Probit estimates use the Huber-White correction. The pseudo R^2 squared is an analog to the R^2 reported in linear regression models. The ratios of coefficients provide a measure of the relative effects on the probabilities of the various policy outcomes. The LR statistic on the overall significance of the model tests the joint null hypothesis that all slope coefficients are zero; it is never significant at the 5% level.

Table 4a shows that the projections for inflation (growth) had a significant impact on the ECB communications of the risks to price stability (to growth). As expected, communications on the risks to price stability display a positive response to oil prices and changes in producer prices, while we document a negative response to negotiated wage growth, which may be to their lagging behaviour, in particular post-crisis. Moreover, it appears that communications on the risks to growth show the expected negative response to oil prices and to changes in producer prices (pre-crisis), but negotiated wage growth was mostly not reflected therein. By comparison with the reaction function that explains the communications using macroeconomic and financial variables (Table 4), the pseudo R^2 is substantially higher when oil prices are included, while the Staff projections for inflation and growth are not necessarily crowded out by the inclusion of risk assessment variables. Thus, the variable oil price tends to be significant together with both the Staff projections for inflation and for growth in the case of the communication indicator on risks to price stability (and together with projected growth for the communication indicator on risks to growth). Similarly, producer price inflation is significant together with projected inflation in the communication indicator on risks to price stability. This suggests that the communication indicators capture information from both the central economic scenario (as reflected in the Staff projections) and the risks surrounding this scenario (oil prices and producer price inflation being often mentioned by the ECB in the context of its risk assessment).

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