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Have monetary data releases helped markets to predict the interest rate decisions of the European Central Bank?

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Abstract

This paper examines whether monetary data releases by the European Central Bank (ECB) have provided markets with additional clues about the future course of its monetary policy. It conducts a novel econometric approach based on a combination of an Ordered Probit model explaining future policy rate changes (sample 2000 to 2014) and the Vuong test for model selection. Overall, our results suggest that information contained in press releases on monetary developments for the euro area has helped markets in forming their expectations on the next monetary policy decision.

JEL codes: C34, D78, E52, E58

Keywords: Communication, monetary analysis, predictability, Probit model, Vuong test.

Non-technical summary

Several studies have shown that the monetary policy of the European Central Bank (ECB) is very predictable. The Governing Council of the ECB has various tools at its disposal to explain its monetary policy decisions. Markets obtain information about the future monetary policy stance of the central bank from a wide range of economic indicators, most prominently the inflation and output projections, but also from official communications (e.g., press conferences, speeches, and websites). Given the ECB's two-pillar monetary policy strategy, regular monetary policy assessments of ECB policy-makers aiming at price stability may benefit from the valuable information contained in monetary and credit aggregates. Therefore, if markets are efficient in processing information, they should pay attention to monetary data releases in addition to other data releases, which have a bearing on the assessment of the future risks to price stability.

Although a host of studies has suggested that markets monitor monetary developments in the euro area, a knowledge gap exists whether monetary data releases contain some form of directional information, which could help markets in their predictions of forthcoming interest rate changes of the ECB. This paper contributes to the important debate on whether markets should monitor monetary and credit aggregates with a view to predicting the ECB's monetary policy decisions. The central question that the paper is going to answer is whether the monthly publication of monetary data has helped financial markets in forming their expectations on future policy decisions of the ECB.

For the following three reasons, it seems unclear whether the publication of new monetary data is actually informative for markets. First, markets may respond to the release of new information, but they may not use it in an efficient manner. Second, information contained in the monetary press release could be redundant, since, in addition to their own assessment of the economic outlook, markets may get sufficient information about the future monetary policy stance from the ECB main communications and a wide range of other indicators, in particular its economic analysis. Third, other communications, such as forward guidance, may imply that the signal from the monetary analysis for forthcoming interest rate changes becomes redundant. Ultimately, whether the release of new monetary data helps markets to better predict the monetary policy decisions of the ECB is an empirical issue.

In order to examine the question, we conduct an empirical analysis for the euro area covering the sample 2000 to 2014. The paper conducts a novel econometric approach based on an Ordered Probit model explaining future policy rate changes in combination with the Vuong test for model selection. Our empirical analysis compares two competing forecasting models for the ECB's interest rates, one on the day before and one on the day after the publication of new monetary data. In particular, we test whether monetary data releases contain information about the correct direction of the ECB's next interest rate decision, which would allow market participants to (systematically) improve their predictions of the next policy move.

Overall, we enhance the understanding on the communication role of the ECB's monetary analysis by showing that, in the very short term, markets make use of new information from the monetary data releases and thereby improve their expectations of the next interest rate move. Markets take into account information from new releases of monetary data when forming interest rate expectations for the next meeting. Previous studies suggested that the market reaction to M3 releases was strong in the first years of monetary union. A structural change in the relationship seems to have occurred coinciding with the adoption of the ECB's non-standard monetary policy measures after June 2010 and the adoption of forward guidance in July 2013. The main result of the paper that markets can learn something about future interest rate moves from the ECB's monetary data releases is robust for both samples. At the same time, we find some evidence that a monetary surprise indicator derived from the market predictions of M3 was a relevant predictor of forthcoming interest rate changes during the first decade of monetary union, even though with the wrong sign. It is therefore likely that markets have obtained their clues in real-time from other monetary indicators reported in the press release, such as M1 and loan developments. However, in an environment of forward guidance, the results may change. Since this episode is only recent, we leave it for future research to analyse whether our results also hold during the episode of forward guidance.

1. INTRODUCTION

Today communication plays an important role in central banking (Blinder, Ehrmann, Fratzscher, de Haan, 2008). Communication by a central bank contains information beyond what a (forward-looking) monetary policy rule can provide (Sturm and de Haan, 2011). Monetary policy communications about the path of future policy rates strongly influence asset prices (Andersson, 2010). There is evidence suggesting that ECB communications have improved the predictability of interest rate decisions (Jansen and de Haan, 2009). In the case of the ECB, money serves as a communication device emphasising its commitment to price stability.

Markets obtain information about the future monetary policy stance of the central bank from a wide range of economic indicators, most prominently the inflation and output projections. They should also pay attention to monetary data releases by the European Central Bank (ECB), since these "news" can have a bearing for the ECB's assessment of the appropriate monetary policy stance. It has been shown that in the euro area a monetary policy assessment aimed at price stability can benefit from the valuable information contained in monetary and credit aggregates (e.g., Papademos and Stark, 2010; Masuch, Nicoletti-Altimari, Rostagno and Pill, 2003). There is ample evidence for the existence of a stable leading indicator relationship between broad money growth and inflation in the euro area (e.g., Nicoletti Altimari, 2001; Hofmann, 2009). Some more recent studies indicate that this relationship may be time-varying (Amisano and Fagan, 2013) or that over time the main signal has become more difficult to detect, since it requires to extract the low frequency component from the data (Assenmacher-Wesche and Gerlach, 2007; Mandler and Scharnagl, 2014).

The ECB's monetary analysis has evolved over time. In the first years of monetary union, the Governing Council of the ECB gave a lot of prominence to the broad monetary aggregate M3, which was monitored relative to a reference value that is deemed to be compatible with price stability over the medium term. Then, following an evaluation of its monetary policy strategy in June 2003, the ECB's Governing Council broadened its monetary analysis, and therefore has paid attention to a wide set of monetary and credit aggregates (see Issing, 2003). The ECB clarified its monetary policy strategy and the role plaid by the monetary analysis therein emphasising its role as a cross-check of the economic analysis from a medium to long-term horizon. Later, the ECB continued to enhance its monetary analysis, for example by developing new tools and models (see Papademos and Stark, 2010).

In the euro area, as is evident from the monetary policy assessments of ECB watchers, markets seem to closely monitor monetary developments as a complement to economic developments. In the first years of monetary union in Europe, markets reacted to M3 releases in a significant way (Ehrmann and Fratzscher, 2002). We therefore also look into the question whether M3 surprises have been a driver of the market reaction (Coffinet and Gouteron, 2009). Initially, markets understood that the ECB would closely follow the Bundesbank's approach and therefore paid more attention to M3 releases. During this episode the ECB and the Bundesbank were found to have reacted similarly to expected inflation but differently to the output gap (Hayo and Hofmann, 2007). Moreover, the literature has suggested that, in real time, monetary data in combination with economic forecasts can be useful for predicting monetary policy decisions at forthcoming meetings (Fischer, Lenza, Pill, Reichlin, 2009). In this context, the publication of monetary data appears to have had a significant influence on financial market prices in the euro area, in particular the yield curve for longer maturities of up to ten years (Coffinet and Gouteron, 2009).

For the following reasons, it seems unclear whether the publication of new monetary data is actually informative for markets, when predicting forthcoming interest rate changes. First, markets may respond to the release of new information, but they may not use it in an efficient manner. Second, information contained in the monetary press release could be redundant, since, in addition to their own assessment of the economic outlook, markets may get sufficient information about the future monetary policy stance of the ECB from its main communications (e.g., press conferences, speeches, and websites) and from a wide range of other indicators, most prominently the inflation and output projections. This argument appears to be supported by several econometric studies on the ECB's policy reaction function, which tend to reject that money growth plays a separate role in the ECB's interest rate decisions (Gerlach, 2004). Third, other communications, such as forward guidance, may imply that the signal from the monetary analysis becomes redundant at shorter horizons.

To this end, a knowledge gap exists whether in real time monetary data releases contain some form of directional information, which helps markets in their predictions of interest rate changes at forthcoming meetings of the Governing Council of the ECB. The aim of this paper is to address this gap by empirically examining whether markets have learned something from money and credit developments in the euro area with a view to predicting the ECB's monetary policy decisions.

The empirical analysis, which pursues a novel approach first applied by El-Shagi and Jung (2015) and Jung (2016) to the communications of the Bank of England and the US Federal Reserve, focuses on the question whether the monthly press release on monetary developments in the euro area has helped financial markets in forming their expectations on future policy decisions of the European Central Bank (ECB). Ultimately, whether the release of new monetary data helps markets to better predict the monetary policy decisions of the ECB is an empirical question, and the present study provides new evidence for it. Against this background, this study makes a contribution to the literature by empirically testing whether the release of new monetary data by the ECB has led markets to revise their expectations for forthcoming interest rate changes.

The present analysis uses the sample from the ECB Governing Council meeting of January 2000 to December 2014. The paper is organised as follows. Section 2 describes the data used for this analysis. Section 3 explains the approach and Section 4 presents empirical results for the ECB. Section 5 concludes.

2. DATA

Until December 2014, the Governing Council of the ECB used to meet twelve times a year to discuss monetary policy decisions in its first meeting at the beginning of the month. Effective January 2015, the Governing Council changed its meeting schedule and reduced the number of meetings at which it discusses monetary policy to eight meetings per year. When communicating about interest rates, the ECB uses standard communication tools for each meeting. It announces the decision by means of a press release, which is followed by a press conference at which the President provides an Introductory Statement with a short rationale of the decision based on the economic and monetary analysis. On this occasion, the President and Vice-President of the ECB give further clarifications during a Q&A session with journalists. The ECB publishes a Monthly Bulletin with more detailed background underlying the regular monetary policy assessment (since January 2015 the ECB has published an Economic Bulletin eight times year mirroring the revised cycle of Governing Council meetings on monetary policy). Moreover, members of the Governing Council explain their views on the monetary policy stance in speeches for which no recurring pattern exists.

On the day of a Governing Council meeting, the ECB announces its decision on interest rates with a press release at 13.45 p.m. (CET). Thereafter, the President and the Vice-President of the ECB hold a press conference with a Q&A session starting at 14.30 p.m. (CET). In addition, the ECB releases its Eurosystem/ECB staff macroeconomic projections four times a year together with a press conference. The projections cover the outlook for the euro area economy and contain (forward-looking) information about output and inflation in the euro area. They do not make specific reference to information contained in money and credit variables.

The press release on monetary developments in the euro area

The ECB press releases on monetary developments in the euro area are published twelve times a year on irregular dates, but always towards the end of a month and at 10.00 a.m. (CET) on that day. The dates are known to markets in advance, since the ECB publishes a separate release calendar on its website. The press release gives latest information on the development of monetary and credit aggregates and detailed breakdowns of the series.[2] For example, it provides detailed information on the main components of M3, the counterparts of M3 (namely credit, longer-term financial liabilities, external assets) and on sectoral breakdowns. Information provided is both in terms of annual growth rates and monthly flows.

For the present analysis, a calendar has been set up. It contains all past release dates of the (monthly) ECB press release on monetary developments since the beginning of 2000. In addition, we collected the respective meeting dates of the Governing Council at which the information was discussed.[3] The ECB's monetary data releases preceded the announcement of the policy decision. Since both the Governing Council meetings and the release calendar are time-varying, the distance between both events typically has varied from 5 days to about two weeks. Owing to lags in the production of the statistics, the reporting month in the monetary data releases refers to the month before the press release date.

[2] Euro area monetary aggregates are derived from the consolidated monetary financial institution (MFI) balance sheet (for details see ECB, 1999).
[3] Only once, at the start of monetary union (namely on 26 August 1999), the Governing Council meeting overlapped with a monetary data release date.

The role of M3 surprises

In view of the prominence of M3 as an indicator for future inflation in the euro area, markets could respond stronger to press releases which contain surprises in monetary data than to releases that are broadly in line with market expectations. We follow Coffinet and Gouteron (2009) and compute a financial market surprise indicator (MSUR). This indicator is constructed as the difference between the M3 growth outturn (source: ECB) and the mean forecast of market participants, as reported in a survey by Bloomberg (both in real-time). While the survey includes analysts from large investment banks and retail banks, it should be noted that about half of the respondents comes from Germany. The surprise indicator has been computed as:

$$MSUR_t = \Delta M3_t^{rt} - \Delta M3_t^{rt,e} \quad (1)$$

where e denotes expected variable, rt denotes real-time variable and t denotes time. In this context, it has been shown that it does not matter for the results whether the mean or the median response from the survey is used to calculate the surprise indicator (Coffinet and Gouteron, 2009). In the following, we use mean expectations to measure financial market surprises.

Figure 1 shows the (lagged) surprise from M3 releases, as calculated as the difference between annual growth rates of M3 (source: ECB) and the mean expectation of annual M3 growth by financial markets (source: Bloomberg). In line with Coffinet and Gouteron (2009), we observe that M3 surprises, which are highly correlated with M3 changes, can give noisy signals about forthcoming policy decisions.[4] While small M3 surprises were often followed by unchanged interest rates at the next meeting, large M3 surprises only occasionally preceded a change in the ECB's policy rate at the next meeting. We construct an alternative surprise measure, which interprets small surprises as indications for unchanged policy rates. To this end, we compute an ordinal measure of the monetary policy surprise, which takes the value +1 (-1), if the value of the surprise indicator is greater (smaller) than its standard deviation (of 0.5%) and otherwise zero. This measure is a better predictor of future interest rate changes. The alternative measure predicts in 70% of the meetings the right direction of the policy rate change. In particular, it shows a somewhat closer link for those days, on which the Governing Council did not change interest rates. However, the observation that M3 surprises only occasionally

[4] Note a similar indicator could be computed for credit to the private sector, since market expectations are available as of 2004.

contain helpful information for days on which the ECB changed interest rates remains robust. We calculate the conditional probability of a policy rate change at the forthcoming meeting depending on the number of dissents (Table 2, full sample). The absence of large surprises usually gave a good indication that the ECB would not change its policy rate at the forthcoming meeting, given a conditional probability of 0.90. However, changes in the ECB policy rate only infrequently coincided with large surprises. The conditional probability for an interest rate decrease (hike) in case of a downward (upward) surprise was 0.27 (0.21) compared with a probability of 0.69 (0.63) for unchanged interest rates.

Moreover, the relevance of M3 surprises as a predictor for future interest rate moves could be time-varying. Initially, markets reacted to M3 releases in a similar significant way as was observed for the Bundesbank prior to monetary union (Ehrmann and Fratzscher, 2002). There is evidence that, relative to its economic analysis, the ECB has paid continuously less attention to its monetary analysis (Berger, de Haan and Sturm, 2011). A possible turning point was the Governing Council’s evaluation of its monetary policy strategy in June 2003 (see Issing, 2003), which aimed to clarify the interplay between the ECB’s economic and monetary analysis in its monetary policy strategy. Many market participants perceived the clarification of the monetary policy strategy to imply that the Governing Council would in future base its monetary policy decisions mainly on the ECB staff macroeconomic projections. Afterwards they also paid less attention to the ECB’s monetary analysis (Geraats, Giavazzi and Wyplosz, 2008; Brunnermeier and Sannikov, 2014). Another possible regime change was the financial crisis episode during which the repair of the monetary policy transmission mechanism became an important task for monetary policy. This episode marked a shift in emphasis but this time in favour of the ECB’s monetary analysis.

As is evident from the ECB’s explanations of its monetary policy measures, information about credit developments in the euro area in particular received more attention within its monetary analysis (Papademos and Stark, 2010). While these data have provided useful information about the restoration of the credit channel, it is less evident to what extent they drove the monetary policy decisions of the ECB (e.g., Gambacorta and Marques-Ibanez, 2011). Later, in May 2009, when monetary policy started to become constrained by the zero lower bound on nominal interest rates, the ECB seems to have changed its reaction function (Gerlach and Lewis, 2014). Likewise, markets could have anticipated that the ECB would not adjust its policy rates further, regardless of the news coming from monetary and credit indicators. This behaviour would imply that markets would have ignored information from the monetary press release as a useful source of information in assessing whether the ECB could change its monetary policy stance at the next meeting.

Figure 1 suggests that M3 surprises have become noisier during some periods of the financial crisis episode. This was in particular the case since May 2009, when interest rates stood at 1.0% and were broadly maintained at this level, while non-standard measures aimed to ease the monetary policy stance beyond what could be achieved using interest rates. Nevertheless, a comparison of the conditional probabilities of a policy rate change with the probabilities for the financial crisis episode (Table 2) shows that they remained broadly unchanged for interest rate decreases and unchanged interest rates. But, positive monetary surprises did not coincide with interest rate hikes any more, since they were very infrequent in the financial crisis episode. This change in the distribution is largely related to the specific response to the shocks of the financial crisis, which required an easing of the monetary policy stance. In addition, whenever other communication tools provide the markets with information on the ECB's likely monetary policy response, the signal coming from the publication of new monetary data may become noisier. Like the Fed and the Bank of England, effective 4 July 2013 the ECB provided markets with forward guidance on the future path of its policy rates (ECB, 2013). This forward guidance signalled to markets an easing bias of the ECB. The ECB announced that it would expect the key ECB interest rates to remain at present or lower levels for an extended period of time conditional on the outlook for price stability (see ECB, 2014).

Measuring the market reaction

When measuring the impact of the publication of monetary data on expectations, an important issue is identification (Blinder, Ehrmann, Fratzscher, de Haan, 2008). The ECB's communications (such as the Introductory Statement, press conferences, Bulletin and speeches by members of the Governing Council) may provide markets with important information about the next policy decision. In addition, other macroeconomic data releases for the euro area or other important economies give clues on where the Governing Council may be heading and these data releases could coincide with the release of monetary data. For the present assessment, we are interested in the question whether monetary data releases change the market assessment under the condition that no additional news from other sources comes in.

We measure the market reaction using daily financial market data. This allows us to compare the market reaction on (trading) days before and after the release of new monetary data. The publication of new information on monetary data generally precedes the ECB's decision to change interest rates. Since monetary analysis is an important element in the regular assessment of risks to price stability, such releases should contain information that is useful for a forward-looking assessment of the ECB's monetary policy stance. Moreover, for each (monthly) meeting the Governing Council received new information on monetary data, whereas new macroeconomic forecasts only became available every third meeting (Jung, Moutot and Mongelli, 2010). In line with its monetary policy strategy, the ECB often, but not exclusively, changed interest rates when a new staff macroeconomic forecast became available (Beck and Wieland, 2007). This behaviour is evident from the fact that about 40% of the interest rate changes (sample January 2000 to December 2014) coincided with the publication of the (quarterly) staff macroeconomic forecast. By comparison, for inflation targeting central banks, inflation projections are by far a more important driver for their interest rate decisions (Jung, 2013).

When assessing the market response to the ECB's communications, for the purpose of empirical research short-term interest rate futures and OIS rates are by far the best proxies of the market reaction (see Reeves and Sawicki, 2007; El-Shagi and Jung, 2015). Conceivable alternative measures of the market response, would be equity indices, such as the Euro Stoxx 50, and exchange rate variables, such as the bilateral dollar exchange rate vis à vis the euro. But, these measures are inferior, because they can be rather volatile and respond to a host of factors other than the ECB's monetary policy. Therefore, in order to capture changes in interest rate expectations, the empirical analysis examines whether systematic changes occur, as observable in the behaviour of alternative proxies for the market response around the publication date of monetary data for the euro area relative to the policy meeting. This paper uses two basic proxies: (a) the (n-month) market spread between the interest rate implied by short-term (n-month) money market futures and the prevailing policy rate; (b) the corresponding (n-month) future spread of these money market futures between the monetary data release and one day after the announcement of the policy decision. We computed spreads for both variables using interest rate futures with different maturities n = {1, 3, 6, 12}.

We use daily data of the interest rate futures. This has the advantage that a possible overshooting of market data after the monetary data release, which is transitory by nature, does not invalidate the results of the econometric exercise. The use of daily data is normally sufficient when separating the effects of the monetary data releases from those of other relevant data releases (Reeves and Sawicki, 2007), unless other data releases are regularly made on the same day as the monetary press release.[5] A previous study (Coffinet and Gouteron, 2009) used intradaily data, thereby focusing on the immediate market reaction after the data release. These data have the advantage that they allow the researcher to construct short time windows of some 20 minutes around the data release, which could be relevant to identify the "news shock", thereby separating the response of interest rate futures to monetary data releases from those by other data releases or central bank communications. A potential drawback of the approach is that it captures only the response on impact, if the market volatility on that day is high. Moreover, markets tend to overshoot on impact and then revise their initial assessment after having digested the potential impact of the data release in more depth.

On occasion the publication of the IFO index coincided exactly with both day and time of the monetary data release. We have therefore created a dummy (IFODUM) which is zero, when there is no overlap, and 1 for those days for which there is an overlap. This helps to control in the regressions for the possible pollution of the results by other data releases (i.e., that the market response was actually triggered by the IFO release). In addition, other important data releases have to be considered. For example, the ECB's quarterly Bank Lending Survey (BLS), which contains (forward-looking) information about lending volumes and conditions in the euro area. Nevertheless, the release of the BLS is normally on a day that is different from the monetary data release date. Two exceptions are noteworthy (29 April 2009; 29 January 2010). For these overlaps a dummy (BLSDUM) has been created, which takes the value 1 on those dates and zero otherwise. In addition, we create time dummies for the monetary press release dates (MONEYDUM) and for the Governing Council meeting days (GOVCDUM).

We also control for the impact coming from (real) economic indicators as predictors of future interest rate moves. In order to do so, we collect real-time forecasts for (real) output (y^f) and inflation (π^f) from the ECB staff macroeconomic projections for the euro area (source: ECB). These indicators

[5] In addition we control for other data releases on the same day such as the IFO and the BLS.

contain information that is regularly monitored by markets (Kenny and Morgan, 2011) as well as processed in simple monetary rules like the popular Taylor rule (Sauer and Sturm, 2007). ECB projections have been published for the current year and the next year, but only once a year, in the December forecasting round, they are available at a horizon of two years ahead. We therefore use one year ahead forecasts of both variables as forward-looking indicators.

3. THE ECONOMETRIC APPROACH

In this section, we present the method of our econometric analysis, which pursues a novel approach first applied by El-Shagi and Jung (2015) and Jung (2016) to the communications of the Bank of England and the US Federal Reserve. The objective of our empirical analysis, which uses Ordered Probit models to forecast interest rates on the day before and on the day after the publication of new monetary data, is threefold. First, we test the hypothesis that monetary release days are "special" days for financial markets (in the sense that the volatility of the interest rate futures is on average significantly higher than on other days). Second, we examine whether monetary data releases contain information about the correct direction of the ECB's next interest rate decision, which would allow market participants to (systematically) improve their predictions of the next policy move. This hypothesis would require that a model predicting monetary policy using market expectations reflecting market perceptions (immediately) after the publication of new monetary data outperforms a model predicting monetary policy using expectations formed before their publication. Third, we check whether M3 surprises are separate drivers of forthcoming interest rate changes. This would require that the monetary surprise indicator is a significant predictor of forthcoming interest rate changes in a model, which also contains other indicators usually monitored in the ECB's economic analysis.

Are monetary release days special days for markets?

If markets react to monetary data releases, then days on which the ECB publishes monetary press releases could be associated with stronger responses than what is observed on other days. There are two conceivable ways to find out whether these days area special in the euro area (Wilhelmsen and Zaghini, 2011). One way is to make a comparison of the standard deviation of the daily changes in the short-term interest rate futures on those days relative to "normal" days. A distinction can be made between periods when policy rates were changed and other periods with no changes in policy rates. We examine whether the market behaviour is different on press release days than on other days by running a regression of the (absolute, daily) changes in the interest rate futures (Δi_t) on a time dummy (MONEYDUM) accounting for these days, possibly controlling for the simultaneous release of the IFO index and the ECB's bank lending survey:

$$\Delta i_{t,n} = c_n + \alpha_1 \, MONEYDUM_t + \alpha_2 BLSDUM_t + \alpha_3 IFODUM_t + \sigma_t \qquad (2)$$

where c_n is a constant, n denotes the maturity of the interest rate future (1, 3, 6, 12 months) and the estimation was done by means of a GARCH model using daily data.

An ordered Probit Model

At a meeting the Governing Council of the ECB faces three mutually exclusive choices: it can increase, lower or keep policy rates unchanged. In addition to changing its key interest rates, the ECB responded to the financial crisis by introducing a broad set of non-standard monetary policy measures, which it enhanced over time. Such measures have aimed to loosen the monetary policy stance of the ECB in an environment of very low interest rates beyond what could be achieved using its conventional interest rate policy. Given the complexity of these measures, we focus our analysis on explaining interest rate changes. Normally the ECB has changed its policy rate in multiples of 25 basis points, and changes of more (less) than 50 basis points have been rare (see Figure 2). It is therefore preferable to transform these choices into a discrete variable. Unlike the observed interest rate (i), which is continuous in time, the dependent variable (Δr) in our model is discrete and has been coded applying the following three categories: -1: interest rate decrease (≤ -25 basis points), 0: no policy change, 1: interest rate hike (≥ 25 basis points). We therefore use an Ordered Probit model to predict the ECB's policy actions and specify the following baseline Ordered Probit model (El-Shagi and Jung, 2015):

$$\Delta r^*_{t+h} = \beta_1 \, \Delta i_t + \beta_2 \; market_{X(t)\pm\tau} + \beta_3 D_{i,t} + \omega_{t+h} \qquad (3)$$

with $$\Delta r^*_{t+h} = \begin{cases} -1 \; if \; \Delta r^*_{t+h} < \mu^- \\ 0 \; if \; \mu^- < \Delta r^*_{t+h} < \mu^+ \\ 1 \; if \; \Delta r^*_{t+h} > \mu^+ \end{cases},$$

where Δr is the ordinal variable capturing the change of the policy rate, Δr^* is the corresponding latent variable, Δi refers to the (lagged) change of the interest rate in basis points as reported by the ECB, "market" is the financial market indicator used in the respective regressions, *t* is a time index which corresponds to each monthly meeting of the ECB (e.g. t+1 denotes the next meeting, t+2 the next but one meeting, etc.), $D_{i,t}$ is a set of dummies to control for occasionally overlapping releases of the BLS (BLSDUM) and the IFO index (IFODUM), ω is white noise. We control for market surprises and other macro variables, which can help to predict forthcoming policy rate changes, in our robustness check (equation 4).

In the above model, we specify the date of the last interest rate decision as t, X(t) denotes the publication date of the monetary data for discussion in the meeting at t+1, i.e., $t < X(t) < t+1$, τ is one (trading) day, i.e., ±τ indicates that our financial market data is obtained one day before the publication of the press release or one day after it respectively. The β_i are regression coefficients, ω is a Gaussian error term, and μ^- and μ^+ denote the thresholds for a change of the ordinal dependent variable. These regressions are estimated separately with $market_{X(t)-\tau}$ and with $market_{X(t)+\tau}$. In this specification we can also capture lags in the decision-making process or so called "early bird" effects (Horváth and Jonásová, 2015), which are related to the possibility that policy rate changes may be discussed in the Governing Council of the ECB at time t+1, but the committee may need some additional meetings to agree that the economic conditions have changed and a monetary policy response is warranted. Therefore, information available at the meeting in t+1 could strongly signal an interest rate change, but the decision is only taken at meeting t+2 or t+3. We address this point in the robustness checks by setting h = {2,3} instead of h=1.

Instead of specifying a conventional Ordered Probit model, as is done in this paper, interest rate changes could be modelled by means of a Zero-Inflated Ordered Probit model. For example, the use of such a model would be 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). However, this methodological advancement is not necessary here for the following reasons. First, the observed distribution of interest rate changes appears to be fairly symmetric around the choice of no change in interest rates, while after 2010 it has become slightly skewed towards the no change option (see Figure 2). In addition, the ECB's interest rate changes were mostly made in steps of 25 basis points in either direction. Although many meetings ended with the Governing Council decision to leave bank rates unchanged, the sample includes a sufficient number of changes in the dependent variable. Second, while we are analysing whether market expectations correctly anticipate the direction of a future interest rate change, we are not assessing whether these expectations fully anticipate the size of the change.

The Vuong test

By means of the Vuong test we check whether alternative specifications of an Ordered Probit model before and after the release of the minutes are similar. The Vuong test compares predicted probabilities of two non-nested models (see Vuong, 1989).[6] It tests the hypothesis that two non-nested parametric models are equally distant in the Kullback–Leibler sense from the true data distribution (Shi, 2015). In this context, the Vuong test does not allow any inference about which of the two models is the "true" model, but this is not needed for the present exercise. For the benchmark specification, the Vuong test compares model 1 (the Ordered Probit model which uses the market variable on the day before the publication of the monetary data) with model 2 (the Ordered Probit model which uses the market variable on the day after the publication). Other than using market variables from different days, model 1 and model 2 are identical. Therefore, the Vuong test would only reject the null hypothesis that both models explain the data equally well in favour of model 2, if the post-meeting market variable contains additional information that contributes to improved predictions of the ECB's future interest rate changes. In order to detect a significant improvement in the formation of market expectations to the publication of monetary data, the test therefore has to indicate that the model 2 incorporating information from the data release is significantly superior to the pre-release model 1.

While this test can show whether markets gain relevant information during the time window between the market variables used in model 1 and model 2, the newly gained information may not

[6] In this paper, we report the results with the one-step Vuong test. Given that the distribution of that test could be skewed, if the two models are partially non-nested, we made additional checks, we made a robustness check in which we excluded the lagged interest rate change from equation (3) so as to make the two models strictly non-nested. This check confirmed the above results, and the test results are available from the author. In previous papers (El-Shagi and Jung, 2015; Jung, 2015), we also performed the two-step Vuong test, which applies to overlapping models and not to strictly non-nested models. This strategy takes into account that it is sometimes difficult to judge whether the models are non-nested or overlapping. For the setting considered in this paper, tests with a two-step testing procedure described in Vuong (1989) fully confirmed the results reported.

necessarily come from the release of new monetary data prior to the ECB's monetary policy decision. The uncertainty regarding future policy changes should generally decline when moving closer to the Governing Council meeting, as more evidence from other indicators concerning the likely direction of the next move becomes available. It can be tested whether this is the case in analogy to a "Placebo" test (El-Shagi and Jung, 2015). Repeating the test for additional control windows, which are either m±1 days after the press release on monetary data or m±1 days before it, shows that the Vuong test gives no meaningful differences for the other periods, thereby confirming that merely moving closer to a Governing Council meeting is not the driving factor of the result.

Checks for robustness

One robustness check concerns the lags in the decision-making process. Sometimes, the committee may not agree on an interest rate change when some indicators change and the full picture is uncertain. This check captures the behaviour that the committee may need more time to agree on it to gain more confidence in its assessment or to have the decision more broadly supported within the committee. In order to test this hypothesis, we run equation (3) with h=(2,3) and make the Vuong test. These tests, which are not reported here for brevity of the exposition, reject for all maturities considered that monetary data releases help to improve the forecasting model for the next but one and the next but two meeting. This means that, contrary to what is sometimes claimed, news on monetary data are immediately priced in by the markets.

A second robustness check concerns the set of control variables. We augment our original specification (3) with further information on the expected evolution of the euro area economy from the ECB's economic and monetary analysis, as available to the markets in real time. For the robustness check, three additional variables are included in the above model: the inflation forecast of the ECB and its output forecast (both variables at a horizon of one year ahead) and the monetary surprise indicator (MSUR). Thereby, we consider the argument that market expectations on interest rates are mainly driven by the economic analysis or the interplay between economic and monetary analysis. We estimate the following variant of the above Ordered Probit model for the day before and after the publication of monetary data:

$$\Delta r^*_{t+h} = \beta_1 \Delta i_t + \beta_2 \ market_{X(t)\pm\tau} + \beta_3 \ D_{i,t} + \beta_4 \pi^f_t + \beta_5 \ y^f_t + \beta_6 msur_t + \upsilon_{t+h} \qquad (4)$$

with the notations as above and π^f denotes the last available (real-time) forecast for inflation at one year ahead, y^f is the last available (real-time) forecast for output at one year ahead, and msur is the market surprise on M3. Furthermore, we estimate the above specifications with alternative proxies of financial market indicators capturing different horizons of market expectations.

4. EMPIRICAL RESULTS

In this section, we present the results of our econometric analysis covering the sample 2000 to 2014. Overall, our results suggest that the ECB's monetary data releases have helped financial markets to forecast its next interest rate move. Markets take that information into account when forming interest rate expectations for the next meeting.

By estimating a conventional regression for our set of interest rate futures (n=1, 3, 6, 12) and including a dummy for Governing Council meetings (MEETDUM) that replaces MONEYDUM, it can be shown for the whole sample (2000 to 2014) that monetary press release days are normal days for short-term interest rate futures, while days with Governing Council meetings are normally found to be special days for financial markets (Vergote and Gutiérrez, 2012; Wilhelmsen and Zaghini, 2011). For the short-term interest rate proxies of up three months, Table 3 shows that in regressions of equation (2) using daily data the coefficient α_1 referring to MONEYDUM is not significant. This would mean that monetary press release days are "normal" days. However, for interest rate futures with a longer maturity of more than three months, the coefficient is significant implying systematic higher volatility in this segment on money release dates. For these segments, monetary release days are special days. We make a control check by replacing the dummy for the monetary press release with a dummy measuring Governing Council days. In this case, the test (Table 3 lower panel) detects a significant response for all maturities of the interest rate future, as it should. These control tests confirm that Governing Council days are "special" days for financial markets.

Overall, the Probit models of equation (3) and (4) display satisfactory statistical properties (see Table 4 to 7). As indicated by the pseudo R^2 statistics, which have a magnitude of between 0.10 and 0.60, the regressions display a fit that is reasonable for this type of analysis. When comparing the fit of the regressions using market expectations before and after the monetary press release, it turns out that the fit typically increases somewhat for regressions that included information after the release. This result is a first indication that the ECB's monetary data provide new information to the market assessment of its future policy changes. The parameter measuring the market response on the day before and after the monetary press release is typically significant at the 1% level. This implies that the chosen proxies to measure the market response are appropriate. However, the lagged interest rate, i.e., the variable capturing the information set underlying the last interest rate change is only sometimes significant. Despite general empirical evidence in favour of the presence of interest rate smoothing in Taylor rules for the euro area (Castelnuovo, 2007), our results could suggest that in the above specifications the ECB's monetary policy does not display a high degree of persistence in the policy rate. Though, when estimating specifications excluding the market variable, we find that the lagged interest rate is significant with the right sign.

Table 4 and 5 report the results from the comparison of the Probit models one day before the release of the monetary data with those from the day after it.[7] When using the difference between the current policy rate and the interest rate implied by short-term (one-month) money market futures as a market variable, the Vuong test indicates (at the 5%-level) superiority of the Probit model after the release of monetary data (compared with the corresponding Probit model before the release). Hence, markets appear to have improved their prediction model of the future bank rate by exploiting information on the day of the release of monetary data. Nevertheless, this finding is sensitive to how the market response is measured.[8] If proxies for the market response with a longer maturity are used, the Vuong test cannot reject that the Probit models before and after the release of monetary data are similar. Hence, the superiority of the model one day after the publication of the monetary data release is only detected when short-term (1-month) measures of the market response are used. Hence, there appears to be no transmission along the yield curve, as implied by the study of Coffinet and Gouteron (2009).

A further observation is related to the test indications from the future spread. For this indicator, the Vuong test indicates that the Probit models before and after the release of monetary data are similar.

[7] Separate tests, which are not reported for brevity of the exposition, show that the monetary surprise indicator is not significant in those regressions, which only include the lagged interest rate and the market response as determinants.

[8] Note that the test procedure is sufficiently sensitive so as to distinguish between a "placebo effect" and a genuine effect of central bank communications (see El-Shagi and Jung, 2015).

Markets continuously price in new information when forming expectations about the future monetary policy stance of a central bank. If markets are efficient, expectations about forthcoming interest rate changes are fully reflected in the pricing of interest rate futures. The Vuong test typically signals that information contained in interest rate futures in the run-up to the next Governing Council meeting on average does not improve further between the day before the data release and the day after the release compared with the day on which the next interest rate decision is announced. This supports the idea that markets are efficient in incorporating information from the monetary press release.

In this context, an important issue is whether the stability of the relationship may have been affected in an environment of very low interest rates. While the focus of the paper is on interest rate decisions, a structural change in the relationship may have occurred coinciding with the adoption of the ECB's non-standard monetary policy measures. These extraordinary measures stand out, since they involved the possibility of asset purchases (e.g., SMP in May 2010, OMT in 2012, APP in 2014/15). Such measures were often announced at one Governing Council meeting but their implementation went far beyond the next meeting. Under these circumstances, monetary data releases may contain few or no information to provide markets with additional insights on the next interest rate move. We therefore examine a subsample from the beginning of 2000 to June 2010. This comparison of the results for the longer sample (Table 4) with those from the shorter sample that ends in 2010 (Table 5) shows that the above findings on the usefulness of the monetary press releases for markets are robust and have not been affected by a potential structural break. One explanation is that the ECB's enhancement of its monetary analysis (Papademos and Stark, 2010) and the increased uncertainty during the financial crisis contributed to more prominence to the ECB's monetary analysis as a compass for markets. Another explanation is that, by contrast to other central banks, which maintained their policy rates unchanged, the ECB continued to adjust its policy rates and even shifted policy rates into negative territory. With the benefit of hindsight, this has implied that the zero lower bound was not binding.

When using additional control variables, it turns out that the main result on the usefulness of monetary press releases for short-term predictions of the ECB's interest rate setting remains robust. Table 6 and 7 show the results of the augmented Probit regressions, which control for macroeconomic forecasts in addition to M3 surprises (equation 4). These regressions have a somewhat better fit than the above regressions (equation 3), as indicated by the higher pseudo R^2 statistics. The staff forecasts on inflation and output are often significant with the correct sign. For the first decade of monetary union, we find evidence that a monetary surprise indicator derived from the market predictions of M3 was a significant predictor in a model which includes the ECB's staff forecasts (even though with the wrong sign, see below). However, when we extend the sample to include the whole financial market episode, there is no such evidence any longer.

The further robustness checks confirm the results obtained for equation (3) and provide several additional qualifications. First, as suggested above, the approach is sensitive to the measurement of the market response. When the difference between the current policy rate and the interest rate implied by short-term (three-month) money market futures is used as market proxy, the results suggest that markets have improved their forecasting model between the day before and after the release of the monetary data. Using (4) as a forecasting model, the superiority is only indicated for the 3-month market spread but not for the 1-month spread. A borderline indication is obtained for the six-month market spread, for which an improvement for our control window can still be detected at the 10%-level. Moreover, a comparison of Table 6 and 7 also suggests that the results are somewhat sensitive to the sample, i.e., whether the episode of the ECB's non-standard measures is included or not. When using the shorter sample ending in June 2010, the results also appear to suggest some improvements in the forecasting model for the one-month market spread and the six-month future spread (but only at the 10%-level).

Second, applying the shorter sample ending in June 2010, it can be shown that, in all regressions with maturities between 1 to 6 months that use the market spread, the market surprise indicator exerts a significant negative impact on the dependent variable. The result seems to indicate that past M3 surprises, i.e., money growth rates exceeding market expectations, created beliefs in the markets that the Governing Council could reduce interest rates at forthcoming meetings. The latter result is puzzling, but also appears when replacing M3 surprises by annual M3 growth, as observed in real-time. One explanation is that in line with the ECB's assessment stronger monetary expansions than expected should be a signal for increasing risks to price stability, which would make future interest rate hikes more likely. However, monetary analysis performs as a cross-check of the signals coming from the economic analysis over the medium to longer term. Hence, monetary surprises (or M3 annual growth rates) should only matter for long-term predictability, but not for short-term predictability, as it is examined in this paper. In fact, for the full sample, which includes the adoption of non-standard measures, it can be shown that the market surprise indicator has no significant impact on the dependent variable, like for the regressions (3). Another explanation could be that the M3 surprise indicator is a proxy for uncertainty. Within the sample, given the financial crisis episode, higher uncertainty often coincided with interest rate decreases of the ECB. In addition, other factors that were not linked to policy decisions, but were driving M3 growth were also at play. These factors were recognised in the ECB's analyses from mid-2001 onwards. Specifically, early 2001 marked the start of extraordinary portfolio shifts into M3, as the combination of declining equity prices and worsening economic conditions, which led to a rise in the demand for safe and liquid monetary assets (see ECB, 2004).

Third, while the market variable is typically significant for the full sample, we find that in the robustness check for the shorter sample only the market spread is significant. While the future spread is not significant, the ECB staff forecasts are significant in these regressions. This can be taken as an indication that market expectations about forthcoming interest rate changes are influenced, in particular by the indications from the ECB staff forecasts on output and inflation for which new information usually becomes available on the day of the announcement of the policy decision.

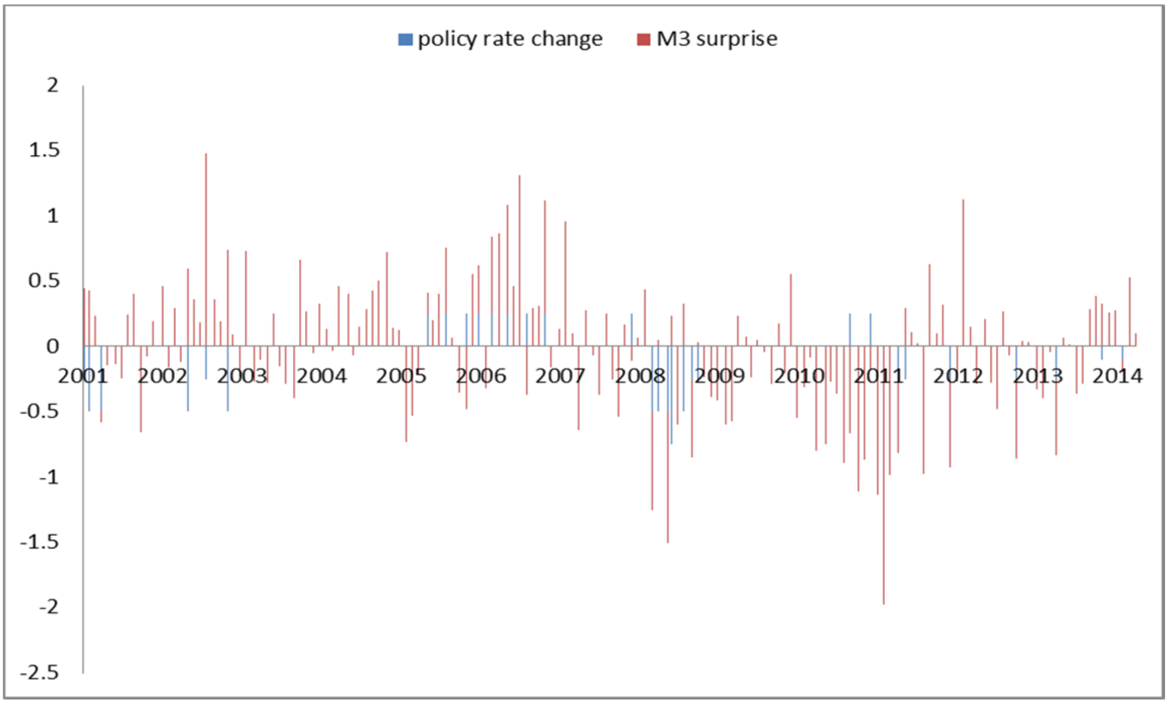
5. CONCLUSIONS

The monetary policy of the ECB is very transparent and predictable. This paper examines the question whether information from the ECB's monetary pillar has helped markets in real time to better predict its monetary policy decisions. It conducts a novel econometric approach based on a combination of an Ordered Probit model explaining future policy rate changes and the Vuong test for model selection and applies it to the sample 2000 to 2014. Through the regular provision of timely, high quality information on money and credit, the ECB not only makes a contribution to long-term predictability, as other researchers have suggested. As this paper shows, the ECB monetary data releases also support the short-term predictability of its future interest rates. Moreover, in line with an earlier study by Coffinet and Gouteron (2009), we confirm that financial markets respond to the monetary data releases by the ECB. In refinement of that study, we find that days on which new monetary data are released are "normal" days for short-term interest rate futures, since the volatility of these futures is on average not significantly higher than on other days. For longer maturities, we confirm the result that monetary press release days are "special" days.

We enhance the understanding on the communication role of the ECB's monetary analysis by showing that, in the very short term, markets make use of new information from the monetary data releases and thereby improve their expectations of the next interest rate move. In this context, markets may not use this information to revise their interest rate expectations for longer maturities. Previous studies have suggested that the market reaction to M3 releases was strong in the first years of monetary union. A structural change in the relationship seems to have occurred coinciding with the adoption of the ECB's non-standard monetary policy measures and the adoption of forward guidance. The main result that markets can learn something about future interest rate moves from the ECB's monetary data releases is robust for both samples. At the same time, we find some evidence that a monetary surprise indicator derived from the market predictions of M3 was a relevant predictor of forthcoming interest rate changes during the first decade of monetary union, even though with the wrong sign. It is therefore likely that markets have obtained their clues in real-time from other monetary indicators reported in the press release, such as M1 and loan developments. In terms of policy implications, the present analysis supports the relevance of the ECB's monetary analysis for financial markets for their assessments in real time beyond the first years of monetary union. However, in an environment of forward guidance, the results may change. Since this episode is only recent, we leave it for future research to analyse whether our results also hold during the episode of forward guidance.

FIGURE 1: ECB policy rate changes and M3 financial market surprises

(in per cent)



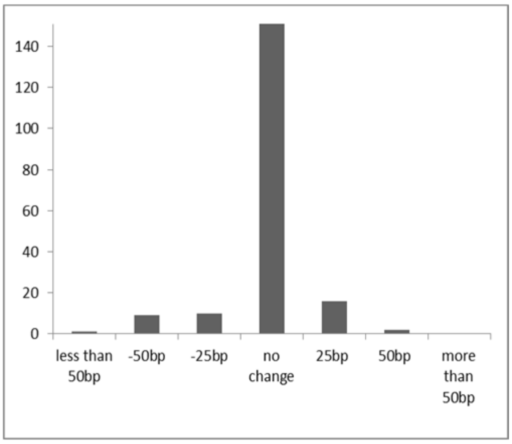
Source: ECB and Bloomberg.

Notes: The ECB policy rate has been shifted forward by one meeting. Monetary policy surprise refers to the difference between the M3 growth outturn in real-time (source: ECB) and the mean forecast of market participants, as reported in a survey by Bloomberg.

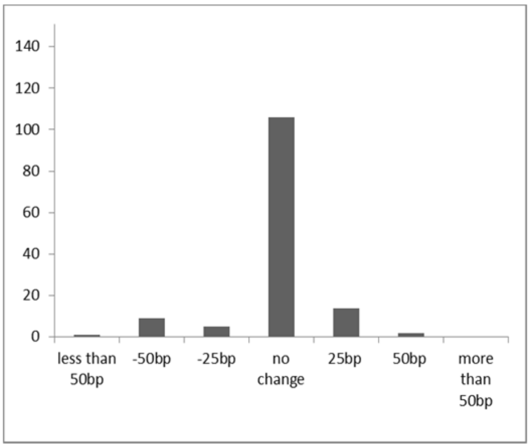
FIGURE 2: Distribution of the ECB's policy rate changes

(number of observations)

Sample 2000 to 2014



Sample 2000 to 2010



Source: ECB.

Table 1: Overview on data used in this study

Variable	Source	Explanation
Interest rate swaps	Reuters	Euro Overnight Index Swap – ask and bid prices – for 1, 3, 6 and 12 months
Monetary aggregates	ECB	Broad money M3, real time data
Policy rates	ECB	Main refinancing rate
Data release calendar	ECB, IFO	Dates of press release on monetary data for the euro area (ECB), for release of the bank lending survey (ECB), for release of IFO index on business confidence (IFO),
Financial market analysts' forecasts of M3	Bloomberg	Bloomberg survey, average observation, real time data
ECB staff forecasts for output and inflation in the euro area	ECB	Output forecast (real GDP) at one year ahead, Inflation forecast (HICP) at one year ahead, real time data

Table 2: Monetary policy surprises and the conditional probability of a policy rate change in t+1

Surprise	**Decrease**	**No change**	**Hike**
Monetary union, sample: September 2001 to December 2014			
<-0.5	0.27	0.69	0.04
-0.5< 0 <0.5	0.06	0.90	0.04
>0.5	0.16	0.63	0.21
Financial crisis, subsample: September 2008 to December 2014			
<-0.5	0.33	0.62	0.05
-0.5< 0 <0.5	0.12	0.86	0.02
>0.5	na	1.00	na

Notes: "na" means not applicable.

Table 3: Test whether monetary press release days are special (equation 2)

Interest rate future Horizon	**c**	α_1	α_2	α_3
Test for monetary press release days				
1 months	0.003** (40.24)	-0.00 (0.18)	-0.002 (1.63)	-0.003 (0.25)
3 months	0.013** (13.20)	-0.001 (0.16)	-0.001 (0.05)	-0.004 (0.02)
6 months	0.002** (44.06)	**0.002**** **(3.10)**	-0.002 (1.82)	-0.005 (0.15)
12 months	0.010** (47.23)	**-0.003**** **(2.54)**	0.002 (1.08)	-0.007 (0.18)
Test for Governing Council meeting days				
1 months	0.003** (39.60)	**0.003**** **(11.86)**	-0.002** (2.72)	-0.004 (0.27)
3 months	0.004** (57.33)	**0.005**** **(17.57)**	0.001 (0.92)	-0.00 (0.01)
6 months	0.06** (40.69)	**0.009**** **(24.53)**	0.00 (0.20)	-0.003 (0.10)
12 months	0.010** (42.02)	**0.014**** **(21.84)**	0.005** (2.76)	-0.004 (0.09)

Notes: Method GARCH; sample 2000.1 to 2014.12 with daily data; t-values are reported in parentheses; ** refers to the 1% significance level, * refers to the 5% significance level.

Table 4: Results of Ordered Probit models (equation 3): sample 2000 to 2014

Ordinal variable, maturity n	Δi(t)	n-month market spread		n-month future spread		μ-	μ+	Pseudo R squared	Vuong test
		day -1	day +1	day -1	day +1				
1	1.44*	1.86**				-1.75**	1.28**	0.17	-2.08
	(2.14)	(4.77)				(9.40)	(8.45)		[0.038]
1	1.36*		2.07**			-1.83**	1.29**	0.19	
	(1.97)		(5.14)			(9.33)	(8.37)		
1	1.45*			3.08**		-1.35**	1.40**	0.10	-0.23
	(2.14)			(3.05)		(9.56)	(9.74)		[0.821]
1	1.34*				2.96**	-1.36**	1.40**	0.11	
	(1.94)				(3.15)	(9.57)	(9.72)		
3	0.79	2.40**				-1.94**	1.40**	0.24	-1.19
	(1.09)	(5.82)				(9.21)	(8.55)		[0.234]
3	0.65		2.49**			-1.98**	1.42**	0.25	
	(0.88)		(5.93)			(9.16)	(8.51)		
3	1.30			4.74**		-1.35**	1.48**	0.14	-1.25
	(1.84)			(3.65)		(9.52)	(9.69)		[0.214]
3	1.07				5.31**	-1.39**	1.51**	0.16	
	(1.51)				(4.20)	(9.56)	(9.66)		
6	0.07	2.77**				-2.08**	1.65**	0.31	-0.68
	(0.09)	(6.42)				(8.97)	(8.54)		[0.499]
6	-0.10		2.85**			-2.13**	1.67**	0.32	
	(0.12)		(6.43)			(8.89)	(8.47)		
6	1.53*			3.56**		-1.33**	1.45**	0.12	-1.16
	(2.27)			(3.24)		(9.48)	(9.74)		[0.246]
6	1.38*				4.12**	-1.37**	1.48**	0.14	
	(2.02)				(3.70)	(9.53)	(9.67)		
12	-0.46	2.85**				-2.04**	2.12**	0.37	-0.38
	(0.55)	(6.63)				(8.66)	(8.24)		[0.706]
12	-0.63		2.84**			-2.05**	2.16**	0.38	
	(0.73)		(6.69)			(8.70)	(8.15)		
12	1.85**			1.85*		-1.31**	1.40**	0.08	-0.90
	(2.85)			(2.41)		(9.44)	(9.76)		[0.369]
12	1.77**				2.13**	-1.33**	1.42**	0.10	
	(2.71)				(3.04)	(9.47)	(9.76)		

Notes: Z-statistics are reported in parentheses; ** refers to the 1% significance level, * refers to the 5% significance level; the n-month market spread is given by: $m^{n}_{X(t)} - i_t$ where m^n_t is the interest rate implied by *n* month ahead money market futures at time *t;* the n-month future spread is given by: $m^{n}_{X(t)} - m^{n}_{t}$; the regressions contain two dummies (IFODUM, BLSDUM); μ− and μ+ denote the thresholds for a change of the ordinal dependent variable. The row "*Vuong test*" reports likelihood ratio statistics of the Vuong test and the *p* values are reported in square brackets. The null hypothesis is that both models under consideration are equally close to the true model.

Table 5: Results of Ordered Probit models (equation 3): sample 2000 to 2010

Ordinal variable, maturity n	Δi(t)	n-month market spread		n-month future spread		μ-	μ+	Pseudo R squared	Vuong test
		day -1	day +1	day -1	day +1				
1	1.17	2.56**				-1.70**	1.33**	0.22	
	(1.58)	(4.74)				(7.96)	(7.65)		-1.98
1	1.04		2.85**			-1.79**	1.37**	0.25	[0.050]
	(1.38)		(5.14)			(7.86)	(7.65)		
1	1.34			3.28**		-1.43**	1.28**	0.13	
	(1.81)			(2.77)		(8.00)	(7.83)		-0.34
1	1.21				3.21**	-1.45**	1.28**	0.13	[0.738]
	(1.60)				(2.92)	(8.03)	(7.80)		
3	0.23	3.36**				-1.91**	1.57**	0.32	
	(0.28)	(5.74)				(7.52)	(7.82)		-0.87
3	0.07		3.44**			-1.95**	1.60**	0.34	[0.384]
	(0.09)		(5.81)			(7.47)	(7.79)		
3	1.00			5.60**		-1.45**	1.39**	0.18	
	(1.28)			(3.45)		(7.96)	(7.81)		-1.39
3	0.77				6.13**	-1.50**	1.43**	0.21	[0.166]
	(0.98)				(3.95)	(7.99)	(7.79)		
6	-0.87	4.20**				-2.14**	2.08**	0.43	
	(0.92)	(5.92)				(6.87)	(7.28)		-0.26
6	-1.02		4.21**			-2.19**	2.09**	0.44	[0.797]
	(1.06)		(5.90)			(6.82)	(7.22)		
6	1.37			3.98**		-1.43**	1.34**	0.15	
	(1.86)			(3.02)		(7.95)	(7.82)		-1.52
6	1.17				4.68**	-1.48**	1.38**	0.18	[0.131]
	(1.56)				(3.43)	(8.01)	(7.73)		
12	-1.83	5.06**				-2.21**	3.31**	0.52	
	(1.68)	(5.28)				(6.10)	(5.81)		0.51
12	-1.70		4.33**			-2.08**	3.02**	0.51	[0.613]
	(1.59)		(5.69)			(6.44)	(6.22)		
12	1.79**			1.99*		-1.39**	1.28**	0.11	
	(2.59)			(2.38)		(7.94)	(7.80)		-1.05
12	1.71*				2.24**	-1.41**	1.31**	0.13	[0.297]
	(2.44)				(2.92)	(7.96)	(7.81)		

Notes: Z-statistics are reported in parentheses; ** refers to the 1% significance level, * refers to the 5% significance level; the n-month market spread is given by: $m^n_{X(t)} - i_t$ where m^n_t is the interest rate implied by *n* month ahead money market futures at time *t*; the n-month future spread is given by: $m^n_{X(t)} - m^n_t$; the regressions contain two dummies (IFODUM, BLSDUM); μ− and μ+ denote the thresholds for a change of the ordinal dependent variable. The row "*Vuong test*" reports likelihood ratio statistics of the Vuong test and the *p* values are reported in square brackets. The null hypothesis is that both models under consideration are equally close to the true model.

Table 6: Results of Ordered Probit models (equation 4): sample 2000 to 2014

Ordinal variable, maturity n	Δi(t)	n-month market spread		n-month future spread		yf(t)	πf(t)	msur(t)	μ-	μ+	Pseudo R squared	Vuong test
		day -1	day +1	day -1	day +1							
1	0.12	1.36*				0.41	0.72*	-0.22	-0.06	3.44**	0.22	
	(0.14)	(2.20)				(1.69)	(2.07)	(0.96)	(0.08)	(4.18)		-1.37
1	0.16		1.67**			0.34	0.68*	0.25	-0.31	3.26**	0.23	[0.173]
	(0.18)		(2.68)			(1.40)	(1.94)	(1.05)	(0.42)	(3.91)		
1	-0.45			1.94		0.66**	0.82*	-0.17	0.81	4.14**	0.20	
	(0.49)			(1.52)		(3.20)	(2.48)	(0.72)	(1.43)	(5.80)		0.34
1	-0.47				1.65	0.67**	0.82*	-0.16	0.81	4.13**	0.20	[0.733]
	(0.51)				(1.43)	(3.22)	(2.48)	(0.69)	(1.43)	(5.79)		
3	-0.20	2.46**				0.17	0.64	-0.29	-0.90	2.97**	0.28	
	(0.21)	(3.82)				(0.67)	(1.72)	(1.18)	(1.17)	(3.40)		-2.03
3	-0.30		2.78**			0.10	0.61	-0.31	-1.16	2.84**	0.30	[0.044]
	(0.31)		(4.12)			(0.41)	(1.62)	(1.28)	(1.46)	(3.17)		
3	-0.60			3.50*		0.64**	0.80*	-0.16	0.73	4.10**	0.22	
	(0.62)			(2.10)		(3.01)	(2.39)	(0.69)	(1.29)	(5.71)		-0.79
3	-0.68				3.85*	0.62**	0.80*	-0.16	0.67	4.07**	0.23	[0.432]
	(0.71)				(2.42)	(2.88)	(2.36)	(0.69)	(1.17)	(5.63)		
6	-0.82	3.16**				0.01	0.65	-0.27	-1.36	2.99**	0.35	
	(0.80)	(4.76)				(0.04)	(1.60)	(1.09)	(1.70)	(3.14)		-1.94
6	-1.02		3.53**			-0.06	0.64	-0.30	-1.64*	2.93**	0.37	[0.054]
	(0.96)		(4.92)			(0.23)	(1.52)	(1.18)	(1.97)	(2.95)		
6	-0.43			2.75*		0.65**	0.82*	-0.15	0.80	4.15**	0.22	
	(0.47)			(1.98)		(3.10)	(2.46)	(0.64)	(1.42)	(5.81)		-0.77
6	-0.49				3.27*	0.62**	0.82*	-0.13	0.73	4.13**	0.23	[0.442]
	(0.53)				(2.34)	(2.93)	(2.44)	(0.58)	(1.29)	(5.72)		
12	-1.32	3.37**				-0.09	0.78	-0.18	-1.27	3.61**	0.40	
	(1.19)	(5.17)				(0.33)	(1.78)	(0.70)	(1.58)	(3.46)		-0.57
12	-1.47		3.48**			-0.16	0.76	-0.18	-1.47	3.55**	0.41	[0.567]
	(1.31)		(5.29)			(0.59)	(1.70)	(0.67)	(1.76)	(3.32)		
12	-0.21			1.21		0.68**	0.83*	-0.14	0.87	4.19**	0.20	
	(0.24)			(1.32)		(3.35)	(2.50)	(0.60)	(1.56)	(5.92)		-0.51
12	-0.21				1.40	0.66**	0.83*	-0.13	0.82	4.16**	0.21	[0.613]
	(0.24)				(1.66)	(3.18)	(2.50)	(0.55)	(1.47)	(5.86)		

Notes: Z-statistics are reported in parentheses; ** refers to the 1% significance level, * refers to the 5% significance level; m^n_t is the interest rate implied by *n* month ahead money market futures at time *t*. Hence, n-month market spread refers to: $m^n_{X(t)} - i_t$; n-month future spread refers to: $m^n_{X(t)} - m^n_t$; msur refers to the monetary surprise indicator (equation 1); y^f and π^f are real-time forecasts for output and inflation respectively; μ− and μ+ denote the thresholds for a change of the ordinal dependent variable. The row "*Vuong test*" reports likelihood ratio statistics of the Vuong test and the *p* values are reported in square brackets. The null hypothesis is that both models under consideration are equally close to the true model. The regressions contain two dummies (IFODUM, BLSDUM).

Table 7: Results of Ordered Probit models (equation 4): sample 2000 to 2010

Ordinal variable, maturity n		n-month market spread		n-month future spread					μ-	μ+	Pseudo R squared	Vuong test
	Δi(t)	day -1	day +1	day -1	day +1	yf(t)	πf(t)	msur(t)				
1	-0.75	2.20*				0.60*	0.73	-0.75*	0.06	3.94**	0.33	
	(0.69)	(2.39)				(1.98)	(1.39)	(2.02)	(0.06)	(3.28)		-1.78
1	-0.72		2.63**			0.53	0.63	-0.82*	-0.34	3.67**	0.35	[0.078]
	(0.65)		(2.85)			(1.76)	(1.18)	(2.14)	(0.30)	(3.00)		
1	-1.04			1.05		0.85**	1.16*	-1.28	-0.50	5.16**	0.28	
	(0.96)			(0.68)		(2.99)	(2.47)	(1.76)	(1.50)	(1.96)		0.15
1	-1.05				0.87	0.86**	1.16*	-0.51	1.62*	5.18**	0.28	[0.883]
	(0.97)				(0.61)	(3.02)	(2.48)	(1.51)	(1.96)	(4.96)		
3	-1.70	4.06**				0.49	0.34	-0.98*	-1.41	3.29*	0.43	
	(1.33)	(3.82)				(1.51)	(0.56)	(2.31)	(1.18)	(2.48)		-2.42
3	-1.92		4.68**			0.46	0.22	-1.08*	-1.94	3.10*	0.46	[0.017]
	(1.42)		(3.98)			(1.34)	(0.35)	(2.41)	(1.53)	(2.23)		
3	-1.29			3.33		0.75*	1.13*	-0.45	1.38	4.98**	0.30	
	(1.12)			(1.54)		(2.63)	(2.36)	(1.35)	(0.83)	(4.76)		-0.77
3	-1.38				3.67	0.74**	1.10*	-0.45	1.28	4.91**	0.31	[0.442]
	(1.18)				(1.79)	(2.56)	(2.28)	(1.34)	(1.52)	(4.67)		
6	-3.70*	6.11**				0.56	0.14	-1.07*	-2.45	3.89*	0.56	
	(2.16)	(4.22)				(1.47)	(0.19)	(2.20)	(1.77)	(2.41)		-1.90
6	-4.04*		7.02**			0.52	-0.02	-1.19*	-3.24*	3.77**	0.59	[0.060]
	(2.25)		(4.24)			(1.28)	(0.03)	(2.29)	(2.10)	(2.22)		
6	-1.17			2.69		0.77**	1.18*	-0.45	1.52	5.12**	0.30	
	(1.04)			(1.54)		(2.72)	(2.48)	(1.33)	(1.87)	(4.94)		-1.01
6	-1.26				3.38	0.74**	1.16*	-0.42	1.40	5.06**	0.32	[0.313]
	(1.11)				(1.88)	(2.59)	(2.41)	(1.25)	(1.70)	(4.83)		
12	-5.87**	8.16**				0.55	0.61	-0.48	-1.91	7.06**	0.65	
	(2.57)	(3.65)				(1.23)	(0.70)	(0.90)	(1.27)	(3.14)		0.88
12	-4.00*		5.30**			0.25	0.69	-0.40	-1.29	5.29**	0.60	[0.383]
	(2.20)		(4.40)			(0.62)	(0.92)	(0.81)	(1.00)	(3.08)		
12	-0.97			1.12		0.84**	1.19*	-0.48	1.67*	5.24**	0.29	
	(0.91)			(1.03)		(3.04)	(2.54)	(1.42)	(2.09)	(5.13)		-0.63
12	-0.97				1.31	0.81**	1.19*	-0.46	1.61*	5.20**	0.29	[0.530]
	(0.90)				(1.29)	(2.90)	(2.53)	(1.35)	(2.00)	(5.05)		

Notes: Z-statistics are reported in parentheses; ** refers to the 1% significance level, * refers to the 5% significance level; m^n_t is the interest rate implied by *n* month ahead money market futures at time *t*. Hence, n-month market spread refers to: $m^n_{X(t)} - i_t$; n-month future spread refers to: $m^n_{X(t)} - m^n_t$; msur refers to the monetary surprise indicator (equation 1); y^f and π^f are real-time forecasts for output and inflation respectively; μ− and μ+ denote the thresholds for a change of the ordinal dependent variable. The row "*Vuong test*" reports likelihood ratio statistics of the Vuong test and the *p* values are reported in square brackets. The null hypothesis is that both models under consideration are equally close to the true model. The regressions contain two dummies (IFODUM, BLSDUM).

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