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EUROSYSTEM COMMUNICATION AND FINANCIAL MARKET EXPECTATIONS

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Eurosystem Communication and Financial Market Expectations

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Abstract

This paper studies the impact of Eurosystem Governing Council communication on financial markets' interest rate expectations based on evidence from bond markets, futures markets and options markets. First, we find that the level, the dispersion and the asymmetry of interest rate expectations are affected on Council meeting days. However, such effects may be relatively short-lived. Moreover, we find that interest rate expectations tend to become less volatile during the *black out period*. Second, monetary policy meetings tend to affect interest rate expectations much more strongly than data releases. Third, whereas the impact of monetary policy decisions seems to be particularly concentrated and strong around horizons of $\frac{1}{2}$ - $1\frac{1}{2}$ years, the effect of euro area data releases on rate expectations seem to unfold in a more evenly distributed manner at longer horizons as well. Fourth, *keywords* may foster the (very) short-run predictability of the Eurosystem monetary policy. However, keywords do not seem to have a systematic impact on interest rate expectations over longer horizons.

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1 Introduction

Communication has become an important part of today's monetary policy. Apart from its obvious role with regard to the accountability of monetary policy, "management of expectations"[1] has become an important ingredient of academic thinking on the effiency of monetary policy. On the one hand, as highlighted by Lucas (1976), the extent to which monetary policy actions are anticipated is key to their impact. On the other hand, as emphasised by Blinder (1998), monetary policy is influential only to the point that it shapes economically important variables like longer term interest rates. With the nominal overnight rate being the only rate directly under control by the central bank, monetary authorities can foster the link between this instrument and longer-term interest rates by communicating on the course of monetary policy.[2]

However, as several studies suggest, central banks need to communicate carefully. For example, Ehrmann and Fratzscher (2005, 2007b) claim that central banks should clearly distinguish between statements on the course of monetary policy and statements on a more general economic outlook. Moreover, D'Amato, Morris, and Shin (2003) argue that central bank communication may become "too effective". If a central bank is very successful in shaping expectations, and as a result, in shaping the market outcome, market participants might neglect other sources of information about the underlying state of the economy. D'Amato, Morris, and Shin conclude that a central bank *"[has] to recognize the inherent limitations in any disclosure and to guard against the potential damage done by noise."* Most importantly, Eurosystem monetary policy is conditional on a broad assessment of the outlook for risks to price stability and its underlying assumptions and scenarios. This conditionality might not be fully understood by market participants and forward guidance over the medium term might be mis-interpreted as a precommitment by the central bank to a specific interest rate trajectory even in the emergence of scenarios different from the benchmark. Although perfectly justified, deviations from the expected policy path, may be mis-interpreted as a policy failure and ultimately lead to lower credibility of the central bank.

The empirical literature proposes several methods to assess the impact of central bank communication on financial markets. For example, Heinemann and Ullrich (2005) and Gerlach (2004) try to assess the informational content of statements of central bank officials. However, as stressed by Brand, Buncic, and Turunen (2006), in the absence of an obvious way to identify the marginal informational content of central bank statements, it is particularly difficult to quantify the signal contained within such statements. Another strand of literature (e.g. Andersson (2007) and Ehrmann and Fratzscher (2007a)) focusses on the announcement effects of monetary policy decisions and surrounding information as measured by financial market reactions around the time of their communication to the general public. Such studies typically confirm the existence of announcement effects, but they cannot provide policy makers with precise estimates of the qualitative impact of communication (including the existence of asymmetries, non-linearities, etc.). Overall, this strand of literature typically focuses on the impact of communication on market expectations of the level of money market rates.

[1] See Woodford (2003).
[2] Woodford (1999).

The present paper studies the impact of official ECB Governing Council communication on several segments of euro area financial markets not only with regard to the average level of rate expectations, but also with regard to the distribution of such market expectations around this average and the term structure of rate expectations. For this purpose, the remainder of this paper is organised into three sections:

In section 2, we investigate the effects of ECB Governing Council communication on the level and the distribution of market expectations. For this purpose, we use indicators of market expectations derived from implied risk neutral densities (RNDs hereafter).

In section 3 we estimate implicit instantaneous forward rates to assess the impact of communication across the term structure of interest rates. By linking daily instantaneous forward rates to ECB Governing Council communication, we try to identify the horizon at which the communication of the monetary policy decision impacts on financial markets. Especially, a distinction can be made between short-term predictability and more long-term "forward guidance".

Moreover, in assessing the impact of Governing Council communication, the paper also investigates the effect of a small set of keywords often referred to in the media as the "traffic light system".[3] To maintain a close link between communication measures and their impact on financial markets while, avoiding too noisy signals in the estimation, both RNDs and implied forward rates are estimated using daily data.[4] Throughout this section, the period under study is from mid-July 2005 to mid-July 2007. The aim of the paper is to give a comprehensive overview of the impact of official ECB Governing Council communication on the level of interest rate expectations, on the dispersion and the (a)symmetry of such expectations as well as on the term structure of market expectations. In all sections, we try to compare the impact of official Governing Council communication to the effects of data releases for the euro area and the US.

2 Evidence from risk-neutral densities

2.1 Estimating risk-neutral densities

In general, expectations with regard to the level of money-market interest rates can be directly derived from interest rates futures contracts. For example, Euribor futures contracts are typically considered a particularly important instrument within the euro area. Given the institutional arrangements governing their listing on the LIFFE stock exchange, for any given Euribor futures contracts price F_{mat}, the average level of implied money-market rates at maturity can be determined as $YieldF = 100 - F_{mat}$.

However, futures prices are useful primarily for extracting average market expectations with regard to the path of expected future short-term rates, and therefore expectations regarding monetary policy, over time. Going beyond a simple point estimate, however, futures prices do not provide information on the

[3] In the media the "traffic light system" is frequently narrowed down to four explicit "codewords" i.e. *vigilance*, *monitoring closely*, *still accommodative* and *further withdrawal.*

[4] For a more detailed analysis of the impact of keywords based on intraday evidence, please consult the upcoming article *Announcement effects of the Eurosystem monetary policy: Evidence from intraday data"* in the BCL Bulletin.

distribution of expectations around the average level or the degree of uncertainty related to expectations with regard to future interest rate levels. The analysis of Euribor futures trading can be enhanced by the analysis of option prices. In particular, under the assumption of risk neutrality, risk neutral densities (RND) can be used to extract the market's perception of the probability distribution of the price of an underlying asset at the future date when the option expires. By identifying the full distribution of expectations of future short-term nominal rates, option price data may help to estimate the probability market participants attach to a certain range of interest rate levels at some future point in time, the dispersion of such interest rate expectations around their average, the probability attached to specific changes in these levels (such as a 25 bps interest rate hike), asymmetries and the risks attached to extreme changes in interest rate levels.

The estimation of RNDs is based on the option pricing theory pioneered by Fisher Black, Myron Scholes and Robert Merton in 1973. Their model has become the standard in pricing European call and put options on non-dividend paying stocks. Under the assumptions of their model, stock prices are log-normally distributed and the return of the stock is normally distributed with constant variance.[5] In their path-breaking paper, Black and Scholes (1973) showed that, for any given point in time t, prices of European call and put options on non-dividend paying stocks maturing at time T depend on the exercise price X, on the price of the underlying asset S at time t, on the remaining time to maturity $t-T$, on the expected volatility of the price of the underlying asset over the period $t-T$ and on the risk-free rate of interest i. Importantly, the resulting option price formulae do not involve any variable affected by the risk preferences of investors. With option prices being unaffected by risk preferences, any set of risk preferences can be used when evaluating option prices formulae. In particular, the simple assumption that investors are risk neutral can be made, implying that in the absence of arbitrage opportunities, the expected return on all securities is the risk-free rate of interest and the present value of future payoffs can easily be obtained by discounting their expected value at the risk free rate.

Since its publication in 1973, the Black-Scholes model has been extended to allow for the valuation of options on underlying assets other than non-dividend paying stocks, such as on foreign exchange, on indices, and on futures contracts.[6] The most prominent model used when pricing options on futures, including options whose payoffs depend on the value of the interest rate, is Black (1976). Building on the properties of the 1973 Black-Scholes model, the absence of riskless arbitrage opportunities requires that the futures' price $F0 = e^{rt}S_0$. In analogy to the non-dividend paying stock price, it is assumed that futures prices follow a geometric Brownian motion (log-normal distribution). The Black

[5]The assumptions of the model require the price of the underlying asset to follow a geometric Brownian motion. Further on, it is assumed that short selling of securities with full use of proceeds is permitted, that there are no transaction costs and that securities are perfectly divisible. Moreover, they exclude riskless arbitrage opportunities, and consider security trading continuous. See, for example, Hull (1997).

[6]See Black and Scholes (1973) and Hull (1997).

(1976) pricing formulae for options on futures are given by:

$$C = S_0 N(d_1) - Xe^{-r\tau} N(d_2) \quad (1)$$

$$P = Xe^{-r\tau} N(-d_2) - S_0 N(-d_1) \quad (2)$$

where:

$$d_1 = \frac{\ln(S_0/X) + (r + \sigma^2/2)\tau}{\sigma\sqrt{\tau}}$$

$$d_2 = d_1 - \sigma\sqrt{\tau}$$

with σ now referring to the volatility of the futures price.

Admittedly, in practice, the analysis of option prices in the spirit of Black-Scholes is subject to a number of potentially important caveats. For example, to the extent that investors do not adhere to genuine risk neutrality, in the presence of aggregate risk in the market, risk neutral densities may differ from the market's true perception of the probability distribution. However, the assumption of pure risk neutrality can be weakened without a general loss of the meaning of the results obtained. For example, as pointed out by Rubinstein (1994), under the assumption of constant relative risk aversion, the true distribution will shift to the right, but will leave the shape of the distribution almost unchanged. As the focus of this paper is on changes in market expectations, rather than on simple estimates of the level, we consider (changes in) the distributions obtained under the assumption of risk neutrality a reasonable indicator of changes in the market's perception.

Furthermore, empirical analyses of option prices (e.g. Rubinstein (1994)) have often contested, the assumption of stock prices being log-normally distributed with constant variance. Critics claim that stock returns are more peaked and display tails heavier than suggested by the lognormal distribution. Under the assumptions of the Black-Scholes model, the implied volatility is expected to be constant across different strike prices for options on a given underlying asset and with identical remaining time to maturity. In practice, however, implied volatilities tend to differ both across different strike prices and across maturities.[7] The shape of the volatility pattern, in particular its convexity and its slope, has important implications for the specification of the distribution of markets' expectations, and its deviation from the benchmark log-normal distribution.[8] In order to overcome the issue of returns not being normally distributed with constant mean and variance, RND's can be estimated using a specific parametric form for the implied distribution other than a standard single log-normal distribution. The parameters of the specification can then be estimated by fitting theoretical option prices to observed prices. The literature on RNDs has explored alternative and more flexible functional forms for estimating implied density functions based on prices of European options,

[7] More specifically, with regard to strike prices, the implied volatility tends to exhibit a specific pattern often referred to as "volatility smile", implying that the implied volatility is particularly high for in-the-money calls and out-of-the money puts.

[8] For example, on the one hand, a negatively sloped volatility curve with regard to the strike price, ceteris paribus, implies a positively skewed distribution. On the other hand, strong convexity of the volatility pattern ceteris paribus implies fatter tails relative to the log-normal distribution.

ranging from a weighted combination of multiple independent log-normal distributions, generalized gamma and exponential distributions to techniques directly based on the observed pattern of implied volatility.[9]

In this paper, risk neutral densities are derived using a double log-normal distribution which offers substantially more degrees of flexibility than the single log-normal distribution. The double log-normal distribution has become standard in the analysis of RNDs. Admittedly, a number of studies proposed to extract implied RNDs by assuming a weighted sum of three log-normal distributions (e.g. Melick and Thomas (1997)). However, by extending the analysis from 2 to 3 log-normal distributions, the number of parameters to be estimated increases more than proportionally from 5 to 8. Accordingly, the identification of three log-normal distributions requires a sufficiently large number of strike prices (i.e. at a given point in time t, the number of observations per time to maturity). In our case, the number of strike prices may be as large as 20 on some days and for some maturities, but falls to 12 for specific dates and/or in the event of implausible option price data. Also, given the high frequency at which implied distributions are estimated in this paper, it is essential to allow for a specification which yields reasonably good solutions for a large number of cases without frequent case-specific interventions. Moreover, the combination of two log-normal distributions is in general able to reproduce common features in option pricing, such as skewness and fat tails (see Figure 1 below).

As in other studies for the euro area, in this section, we estimate money-market interest rate expectations from price data on 3-month Euribor futures traded on LIFFE. These futures are among the most actively traded euro area money-market instruments. Given their high degree of liquidity, data on pricing and trading activity on 3-month Euribor futures meet high quality standards and are available at high frequency. The following analysis uses daily pricing data as reported by Bloomberg newswire services. With options being written on different Euribor futures contracts (i.e. different maturities), a distribution of interest rate expectations can be derived for various future points in time. Options are available on a number of 3-month Euribor futures contracts, the most liquid of which offer 4 maturity dates per year (March, June, September and December) and cover a horizon of around 2 years.

Given our assumption of a double log-normal distribution, the theoretical option prices are given by:

$$\begin{aligned} C(X,\tau) = e^{-r\tau}\{&\theta[e^{\alpha_1+1/2\beta_1^2}N(d_1) - XN(d_2)] \\ &+(1-\theta)[e^{\alpha_2+1/2\beta_2^2}N(d_3) - XN(d_4)]\} \end{aligned} \quad (3)$$

$$\begin{aligned} P(X,\tau) = e^{-r\tau}\{&\theta[-e^{\alpha_1+1/2\beta_1^2}N(-d_1) - XN(-d_2)] \\ &+(1-\theta)[-e^{\alpha_2+1/2\beta_2^2}N(-d_3) - XN(-d_4)]\} \end{aligned} \quad (4)$$

with:

[9] In his comparative analysis, Jackwerth (1999) highlighted that in spite of very different settings, these methods yield quite similar risk neutral densities unless the number of option prices available is very small.

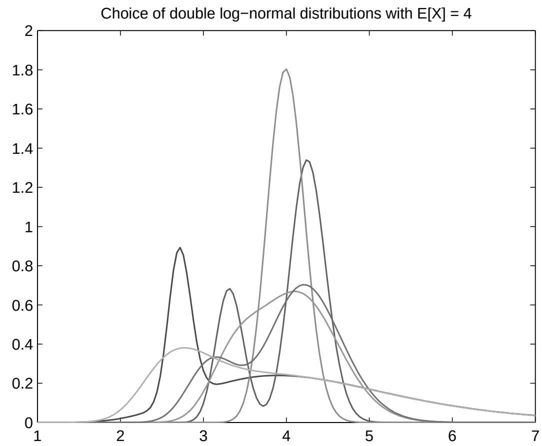

Figure 1: 'Implied risk-neutral densities' with identical mean

$$d_1 = \frac{-\ln(X) + \alpha_1 + \beta_1^2}{\beta_1}, \qquad d_2 = d_1 - \beta_1$$
$$d_3 = \frac{-\ln(X) + \alpha_2 + \beta_2^2}{\beta_2}, \qquad d_4 = d_3 - \beta_2$$

The estimation procedure consists in selecting the parameters of the distribution so as to minimise the cumulated squared deviation between the observed option prices and theoretical option prices. In the absence of arbitrage opportunities and under the assumption of risk neutrality, the futures price for the underlying asset should coincide with the mean of the implied distribution. This requirement is implemented in the optimization algorithm by augmenting the euclidian distance by the squared deviation between the observed futures price and the implied mean of the distribution such that the optimization can be written as (see Bank of England (2005)):[10]

$$\min_{\alpha_1,\alpha_2,\beta_1,\beta_2,\theta} \left\{ \sum_{i=1}^{m} (c_i - c_i^*)^2 + \sum_{i=1}^{m} (p_i - p_i^*)^2 + \gamma \right\} \tag{5}$$

with:

$$\gamma = \left[\theta e^{\alpha_1 + 0.5\beta_1^2} + (1-\theta) e^{\alpha_2 + 0.5\beta_2^2} - F \right]^2$$

To avoid potential local minima, the optimisation procedure involves five steps. In a first and a second step, we define a grid of θ parameters spanning the interval [0.01, 0.99]. Using a small grid (i.e interval 0.02), we optimise on all α and β parameters for a fairly large number of θs. In step 1, for any given time t, we apply mean starting values based on the observed futures price. In step

[10] An alternative approach to implement the mean requirement would be to include the mean conditionality directly in the optimization as a constraint. However, this constraint might become binding and thereby unduly restrict the set of solutions, Arils (2002).

2 starting values are set to the optimal parameters obtained for the preceding trading day $t-1$. In step 3, a narrow grid of θ parameters is applied based on the 5 best solutions obtained in steps 1 and 2. The total number of optimisations in step 3 is 50. In step 4, based on the optimal parameters obtained for the previous day, we optimise on all 5 parameters simultaneously.[11] Finally, in step 5, based on the optimal solution obtained from all previous steps, we optimise on all 5 parameters.

2.2 Summary indicators of interest rate expectations

The RND summary statistics used as indicators in this paper are the mean of the implied distribution, its standard deviation, selected interquantile ranges of this distribution (both used as a proxy for dispersion of expectations) and a measure of asymmetry related to the probability market participants attach to a rate rise and to a rate reduction of a specific size.

As a proxy for the level of money market rate expectations we use the mean of the implied distribution, which at time t, for a given futures contract with maturity m is defined as:

$$\mu_{mt} = \int_{-\infty}^{\infty} x f_{mt}(x) dx \tag{6}$$

In the absence of arbitrage opportunities and under the assumption of risk neutrality, the mean of the distribution should coincide with the futures price of the underlying asset. Variation in the underlying market expectations is proxied by the standard deviation of the implied risk-neutral density, which at time t, for a given futures contract with maturity m is defined as:

$$\sigma_{mt} = \sqrt{\int_{-\infty}^{\infty} (x - \mu_{mt})^2 f_{mt}(x) dx}$$

For the purpose of robustness, we also consider specific interquantile ranges of the implied distribution (e.g. 65^{th}-35^{th} percentile and 75^{th}-25^{th} percentile) as alternative measures of rate expectations variation. We also use two complementary measures of asymmetry of rate expectations. At any given point in time t, the skewness of the implied distribution is defined as:

$$skew_{mt} = \sigma_{mt}^{-3} \int_{-\infty}^{\infty} (x - \mu_{mt})^3 f_{mt}(x) dx$$

Alternatively, the asymmetry of rate expectations is measured as the likelihood of a rate hike and of a rate reduction. More specifically, changes in the probability of a 25 bps (50 bps) rate hike and a 25 (50 bps) bps rate reduction relative to the current futures price are computed.

2.3 Evidence from RND summary indicators

In estimating RNDs, we require a minimum frequency of price change when selecting the options to be considered in the estimation.[12] The working assumption is that, all else equal, for a given type of option, a higher frequency of

[11] Steps 1 and 4 are not applied to the first day of the reference period.

[12] More specifically, for any given option (i.e. specific strike price for a given futures contract) we require the daily closing price to change in four out of five days at least.

price change reflects a higher degree of liquidity. Moreover, as options close to maturity tend to become rather illiquid and usually change very little in price, observations with a term to maturity of less than 30 days were dropped. For all RND-based summary indicators presented in 2.2, fixed-effects regressions of the following form were carried out:

$$\begin{aligned} RNDInd_{it} = \beta_0 + \sum_{j=1}^{4} \beta_{jt} RNDInd_{it-j} + \beta_{5t} ID\_IS_t \\ + \beta_{6t} IDkeyWd_t + \beta_{7t} IDRel_t + \beta_{8t} DurGC_t^{+} \\ + \beta_{9t} DurGC_t^{-} + \beta_{10t} DOW_t^{-} + u_i + e_{it}, \end{aligned} \quad (7)$$

with $RNDInd_{it}$ denoting the RND-based indicators on the level, the dispersion and the asymmetry of rate expectations and u_i denoting the maturity-related fixed effect.[13] $DurGC_t^{+}$ ($DurGC_t^{-}$) denote proxies for the duration until the next (since the preceding) Governing Council meeting. In general, we find a relatively high degree of persistence with the sum of autoregressive coefficents typically in the interval $[0.8; 0.9]$ (save futures price change). Whereas the strong autoregressive component suggests a relatively limited role for genuine exogenous factors, it also reflects that risk-neutral densities (and developments therein) are generally stable.

Nevertheless, the RND summary indicators are subject to estimation error. Their use as dependent variables in equation (7) may therefore yield biased parameter estimates. For the purpose of robustness, an alternative specification is used giving less weight to the exact magnitude of the RND-based summary indicators. Instead, for a given RND-based indicator $RNDInd_i$, we use a panel logit fixed-effects model based on a boolean variable which depends on whether in period t indicator i exceeds its average (i.e. y_{it}=1) or not (i.e. y_{it}=0):

$$y_{it} = \begin{cases} 1 & \text{if} x_{it} \geq \bar{x}_i \\ 0 & \text{otherwise} \end{cases} \quad \text{with: } \Pr\left[y_{it} = 1\right] = \frac{x_{it}\beta + u_i + e_{it}}{1 + x_{it}\beta + u_i + e_{it}}, \quad \text{where:}$$

$$\begin{aligned} x_{it}\beta = \beta_0 + \sum_{j=1}^{4} \beta_{jt} RNDInd_{it-j} + \beta_{5t} ID\_IS_t \\ + \beta_{6t} IDkeyWd_t + \beta_{7t} IDRel_t + \beta_{8t} DurGC_t^{+} \\ + \beta_{9t} DurGC_t^{-} + \beta_{10t} DOW_t^{-} + u_i + e_{it}, \end{aligned} \quad (8)$$

Figure 2 below illustrates the developments in the key RND summary indicators on the level of rate expectations, the dispersion of expectations and the asymmetry of expectations over the period under study. For the sake of clarity, the illustration refers to a specific Euribor futures contract (i.e. ERM08, maturity date: 14 June 2008). The minimum bid rate for main refinancing operations is illustrated by the upper panel of Figure 2 below. The starting date is set to 14 june 2006 as no price quotes for options on this futures contract were observed prior to this date. The upper middle panel describes generally upward trending (though not necessarily continuously rising) expectations of the level of money-market rates. Interestingly, the level of money-market rates expected for mid-2008 continued to rise until the end of the reference period, i.e. approximately 3 weeks prior to the emergence of financial market turbulences related

[13] For the purpose of this exercise, the maturity is expressed in months.

to the US real estate sub-prime market. Given the mid-2008 maturity date, by the end of our reference period the rise in money-market rate level expectations are likely to reflect rising policy rates rather than anxieties related to a potential liquidity shortfall.[14] The lower middle panel illustrates the declining dispersion of money-market rate expectations over time, suggesting a general fall in the degree of uncertainty as the time to maturity declines. Finally, the lower panel of Figure 2 below illustrates the expected probability of an increase in interest rates by 25 basis points relative to the current price of the futures contract. Increased volatility around the june 2007 rate hike possibly reflects shocks to expectations related to the upcoming financial market tensions. Overall, expectations of rate increases start to strengthen around this time. However, this may be related to fears of increasing risk premia as well as expectations on policy rate developments.

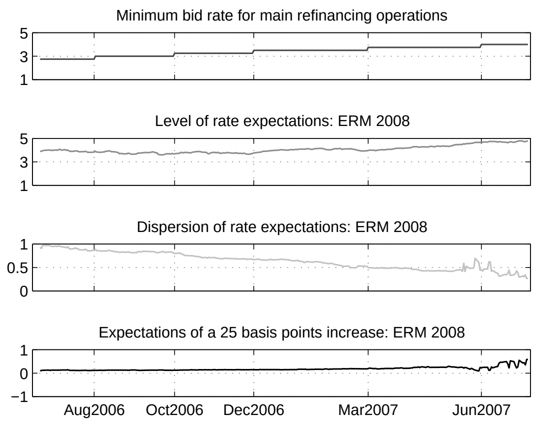

Figure 2: Key RND summary indicators for ERM08

The level of money market interest rate expectations

Our results with regard to the level of interest rate expectations suggest that changes to interest rate expectations (again, measured in absolute terms), tend to narrow five trading days ahead of a Governing Council meeting. Smaller price changes might suggest that market participants align themselves ahead of monetary policy decisions. Moreover, the significantly smaller price changes might be a result of the *black out period*. During this period, which starts one week ahead of Eurosystem Governing Council meetings, no information on Eurosystem monetary policy deliberations may be provided to the general public.[15] By contrast, changes to the expected level of money market rates are not significantly different throughout the week following a Council meeting. Furthermore, we find that the pronounciation of a keyword by itself has no substantial impact on the level of expectations. There is some preliminary evidence that keywords

[14] Futures prices suggest that, initially, market participants considered the financial turbulences to be transient and expected them to recede within a couple of months

[15] The complete regression results can be consulted in tables 2 and 3 in appendix B.1.

may significantly add to the change in the level of rate expectations when pronounced jointly. However, this finding is not particularly robust. It is driven by a small number of observations and might reflect the strong correlation of keywords with Governing Council meeting days. Furthermore, keywords seem to significantly drive changes to expectations when they are pronounced in the event of an interest rate increase (and its communication). In addition, data releases were found to significantly affect the magnitude of changes to rate expectations. A distinction into data releases by region suggests that data releases for the US do not reveal any significant impact on changes to rate expectations, whereas data releases for the euro area are fairly important.[16]

As suggested by summary statistics, Governing Council decisions have a significant impact on rate expectations. In general, changes to the expected rate level are significantly larger on days when the Governing council meets compared to common trading days. This applies to both meetings when the policy rate changed as well as meetings when policy rates were left unchanged, but, quantitatively the impact seems to be much larger in the event of a policy rate change. Finally, contrary to the RND-based indicators discussed below, the magnitude of changes to rate level expectations does not reveal a strong degree of persistence. This applies to both changes in absolute terms as well as in real terms.

Results from the panel logit fixed-effects specification suggest that the likelihood of observing an above average change to the mean of rate expectations is significantly higher on monetary policy decision days confirming the results of the baseline specification. More specifically, our estimates suggest that the odds of such an above-average change are more than twice as high as on common trading days. It seems that the odds of an above-average change to the mean of rate expectations are even higher on those days for which the policy decision led to a rate rise (more than three times as high as on common trading days). Again, we find that the odds of an above-average change are significantly lower shortly prior to a monetary policy decision day. All else equal, 3 days ahead of Governing Council meetings, the odds of an above-average change to the mean level of expectations, is approximately 35% below those of a common trading day. Finally, panel logit estimates suggest that the odds of an above-average change are significantly higher for days on which euro area data are released. All else equal, the odds of an above-average change to the mean level of expectations increase by approximately 20% on euro area data release days (compared to common trading days). On average, the impact of such data releases is somewhat smaller than the one derived for monetary policy decision days.

The dispersion of money market rate expectations

Apart from their impact on the level of interest rate expectations, Eurosytem communication efforts also affect the dispersion of those expectations. To the extent that Eurosystem communication is adding new information considered relevant for the future stance of monetary policy, all else equal, we expect such announcements to stabilise expectations (i.e. reduce their variance) around their

[16]Again, these findings are preliminary and may reflect an inappropriate choice of data releases considered. At this stage, we cannot exclude that a subset of US data releases nevertheless have a significant impact on euro area money market rate expectations whereas certain euro area data releases may not.

average level. In order to test for the stabilising impact of Governing Council decisions communicated via the Introductory Statement, we focus on the standard deviation of market expectations around Governing Council meeting days.

Our results suggest: (a) the standard deviation of rate expectations is highly persistent. Overall, the autoregressive coefficients up to lag order 3 are highly significant with the exception of the second lag. The sum of auto-regressive coefficients is approximately 0.9.[17] (b) The standard deviation of RNDs is significantly lower on Governing Council days (i.e. at the end of such meeting days). Furthermore, the lower dispersion of rate expectations "lasts" up to 3 days. While the standard deviation is also significantly lower on the day following a Governing Council decision, thereafter the reduction disappears. Moreover, we do not find a significantly lower standard deviation of market expectations on the three days prior to a Governing Council decision.

For the purpose of robustness, a number of alternative estimations were carried out. First, with regard to the dependent variable, we perform similar panel data regressions for the interquantile ranges of the implied risk-neutral densities. Our findings suggest that both narrow interquantile ranges (i.e. 65^{th}-35^{th} percentile) and broad interquantile ranges (i.e. 75^{th}-25^{th} percentile) are significantly lower following Governing Council meetings.[18] Second, with regard to the method used, for both the standard deviation and the interquartile ranges panel logit estimates are presented. Logit estimates are presented for both the likelihood of an above average standard deviation/interquantile range and an above median standard deviation/interquantile range. Across all specifications and for both dispersion measures considered, we find a somewhat lower dispersion on Governing Council days. For example, the odds of an above average/median standard deviation decline by roughly 40%-50% on Governing Council days. Moreover, all specifications seem to suggest that the impact on dispersion is relatively short-lived. We find a significantly lower likelihood of above-average dispersion on the day following the Council meeting, but not thereafter.[19]

The (a)symmetry of money market rate expectations

Although, in general, Eurosystem Governing statements do not announce any form of monetary policy bias, the decisions of the Governing Council may nevertheless affect the asymmetry of market expectations. Again, our measures of asymmetry reveal a high degree of persistence (approximately 0.7 to 0.83 de-

[17] In general, both fixed- and random-effects panel estimators are biased when lagged values of the dependent variable appear as regressors. In the case of the fixed estimator, each transformed value of the lagged dependent variable (i.e. the difference between any given observation and the mean of the corresponding cross-section) is contemporaneously correlated with the transformed error. In the case of the random effects estimator, the cross-section random intercept directly enters the composite error term and becomes a determinant of the lagged dependent variable. Issues related to the bias induced by a lagged dependent variable specification are typically teckled by means of instrumental variable or GMM estimation (for an overview of the related literature see Baltagi (2001)). A general conclusion from work on the size of the bias induced by the lagged dependent variable in a fixed effects panel specification is that for large-T panels (i.e. long panels with T > 30), the bias created by using the fixed-effects estimator is more than offset by the greater precision compared to IV and GMM estimators (See Attanasio, Picci, and Scorcu (2000)).

[18] Contrary to the standard deviation, however, the interquantile results do not suggest a significant impact on the days of the decision themselves.

[19] See tables 4,5 in apendix B.1.

pending on measure). Taking into account the new (potentially different) level of interest rates at the end of the Governing Council meeting, the asymmetry of market expectations may or may not be affected on Governing Council decision days. Obviously, in qualifying the following results, one has to bear in mind, that the period under study represents a so-called tightening cycle. Thus, expectations might in general have been skewed towards rising interest rates.

Our results suggest that on governing council days on which the interest rate was left unchanged, the probability of an increase in the near future usually increased significantly. This was also true for days following such a meeting. Similarly, the probability of a rate decrease was negatively but not significantly affected on meeting days without a rate decision. On meeting days with a rate change, an increase in the expectations of another rate hike could not be observed. However, the coefficient on days following such a meeting is close to significance. This might be related to a horizontal movement of the probability distribution.[20] Similar evidence is given by the regression on the skewness measure. It appears that skewness is significantly reduced on days following governing council decisions to raise interest rates. This may also be due to a shifting probability distribution. Interestingly, the probability of a rate decrease significantly declined on days preceding a rate hike. This suggests that decisions by the governing council to raise rates were usually expected.[21]

3 Evidence from forward rates

3.1 Deriving implied forward rates

This section analyzes the impact of Eurosystem Governing Council communication on interest rate expectations across different horizons. Interest rate expectations from the short to the long run are typically derived from implied forward rates. Forward rates essentially contain the same information as the yield curve, but they allow a more direct presentation of rate expectations in the short, the medium and in the long term (Svensson (1994)). Implied forward rate curves illustrate, for a given time t, the pattern of forward interest rates at future points in time (say from 3 months to 30 years). In the following, we derive two types of implied forward rates: (a) In section 3.2, implied forward rates for the short- to medium-term are derived from observed money market rates. These forward rates can be computed very easily and are exempt from estimation error. They reflect the tenor structure of money market rates. However, implied forward rates directly obtained from observed money-market rates only extend to one month. (b) In section 3.3, we derive implied instantaneous forward interest rate curves based on the term structure of interest rates observed in bond/bill markets. Implied instantaneous forward rates are a common way to derive measures of interest rate expectations and are easier to interpret from a policy perspective. Unfortunately, their estimates are subject to estimation error.

On a continuously compounded basis, the implied forward rate on a forward contract concluded at time t for an investment starting in τ and maturing in T

[20] As shown above, the level of rate expectations is significantly affected by rate decisions.
[21] For a complete overview see table 6 in the appendix.

is defined as:

$$f(t,\tau,T) = \frac{[(T-t)z(t,T)] - [(\tau-t)z(t,\tau)]}{(T-\tau)}, \tag{9}$$

with f, z denoting the continuously compounded implied forward rate and the zero coupon rate respectively.

The instantaneous forward rate is the rate for a forward contract with an infinitesimally short investment period, i.e.:

$$f(t,\tau) = \lim_{\tau \to T} f(t,\tau,T) \tag{10}$$

Thus, instantaneous forward rates represent the marginal increase in return stemming from a marginal increase in duration of the investment.[22] Therefore, the spot rate of an investment at time t, can also be interpreted as an average of instantaneous forward rates with settlements between t and T, i.e.:

$$i(t,T) = \frac{\int_{\tau=t}^{T} f(t,\tau,T)d\tau}{T-t} \tag{11}$$

The estimation of implied instantaneous forward rates is based on Nelson and Siegel (1987) and Svensson (1994). While these methods are by and large atheoretical in nature, they have become standard in the empirical work on instantaneous forward rates.[23] Moreover, the parsimonious modelling of the yield curve proposed by Nelson and Siegel (1987) can represent a wide range of shapes typically associated with yield curves (e.g. monotonic, S-shaped and hump-shaped curves). The extension proposed by Svensson (1994) provides an even higher degree of functional flexibility by introducing a second hump shape (or U-shape). We estimate implied forward rates based on the parametric yield curve models proposed by Svensson (1994). The impact of Eurosystem Governing Council communication on interest rate expectations is measured via changes to these expectations.

The parsimonious parametric model first suggested by Nelson and Siegel (1987) specifies a functional form for the instantaneous forward rate based on 4 parameters, $b = \{\beta_0, \beta_1, \beta_2, \tau_1\}$:

$$f(m,b) = \beta_0 + \beta_1 \exp\left(-\frac{m}{\tau_1}\right) + \beta_2 \frac{m}{\tau_1} \exp\left(-\frac{m}{\tau_1}\right) \tag{12}$$

which Svensson (1994) augmented by a fourth term and two additional parameters β_3 and τ_2:

$$f(m,b) = \beta_0 + \beta_1 \exp\left(-\frac{m}{\tau_1}\right) + \beta_2 \frac{m}{\tau_1} \exp\left(-\frac{m}{\tau_1}\right) + \beta_3 \frac{m}{\tau_2} \exp\left(-\frac{m}{\tau_2}\right) \tag{13}$$

in order to allow for a second hump and thus more flexibility. $f(m,b)$ stands for the forward rate on a specific trading day, $b = \{\beta_0, \beta_1, \beta_2, \beta_3, \tau_1, \tau_2\}$ is the

[22]Svensson (1994) points out that *[...] Whereas the yield curve can be interpreted as expected future averages of the variables in focus, the forward rate curve can be interpreted as indicating the expected future time path of these variables.[...].*

[23]See also the series of instantaneous forward rates recently published by the Eurosystem at *www.ecb.int/stats/money/yc/html/index.en.html*.

set of parameters, where β_0, β_1, β_2 and β_3 describe the strength of the long-, short- and medium-term components. τ_1 and τ_2 are constants determining the location of the humps. Finally, $m = T - t$ denotes time to maturity.

According to equation (11), for any given set of parameters b, the spot rate $i(t, t+m)$ can be obtained by integrating the forward rate $f(m, b)$ as:

$$i(m,b) = \beta_0 + \beta_1 \frac{1-\exp\left(-\frac{m}{\tau_1}\right)}{\frac{m}{\tau_1}}$$
$$+\beta_2 \left[\frac{1-\exp\left(-\frac{m}{\tau_1}\right)}{\frac{m}{\tau_1}} - \exp\left(-\frac{m}{\tau_1}\right)\right]$$
$$+\beta_3 \left[\frac{1-\exp\left(-\frac{m}{\tau_2}\right)}{\frac{m}{\tau_2}} - \exp\left(-\frac{m}{\tau_2}\right)\right] \tag{14}$$

Given the spot rate $i(t, t+m)$, for any given parameter set b, one can derive a set of theoretical bond prices according to the net present value of all coupon payments and the principal returned upon maturity:

$$P(t, t+m) = \int_{k=1}^{m} c_k d(t, t+k) + pd(t, t+m) \tag{15}$$

where c_k denotes the coupon paid in period k (with k = 1,2,...,m) and p denotes the principal returned at maturity m. $d(t, t+m)$ denotes the discount function used to discount all receipts originating from the bond contract.

For any given $b = \{\beta_0, \beta_1, \beta_2, \beta_3, \tau_1, \tau_2\}$, the discount function $d(m, b)$ (with $m = T - t$) is related to the spot rate according to:

$$d(m,b) = \exp\left(-\frac{i(m,b)}{100} m\right). \tag{16}$$

The parameters $b = \{\beta_0, \beta_1, \beta_2, \beta_3, \tau_1, \tau_2\}$ can be estimated so as to minimise either the price error or the yield error. Minimising yield errors is typically preferred to minimising price errors, in particular for short-term bonds. This reflects the different sensitivity of bond prices to yields along the maturity spectrum.[24] However, UK Debt Management Office (2000) claims that the minimisation of yield errors can improve on the poor estimation for short maturity bonds, but may lead to a slight deterioration in the fit of the curve at the long end. Moreover, the minimisation of price errors is frequently applied in order to reduce the computational burden (see, for example, Gürkaynak, Sack, and Wright (2006)).[25] Given the high frequency with which instantaneous forward rates are computed in this paper, we attenuate the *short-maturity bias* inherent in price error minimisation, by applying weights determined by the reciprocal of duration. Gürkaynak, Sack, and Wright (2006) claim that *"[...] this procedure is approximately equal to minimizing the (unweighted) sum of the squared deviations between the actual and predicted yields on all of the securities [...]"*.

The analysis uses daily market data for all outstanding nominal German and French Treasury bonds and bills as reported by Bloomberg newswire services. Again, in order to allow for a sufficiently close link with monetary policy

[24] Svensson (1994).
[25] Bolder and Streliski (1999)

communication while avoiding a very low signal-to-noise ratio, implied forward rates are estimated at daily frequency. The dataset entails prices and yields (ask and bid). As in section 2, the sample period covers all trading days from mid-July 2005 to mid-July 2007. The restriction to the securities of two euro area countries is an obvious drawback compared to other studies on instantaneous forward rates for the euro area.[26] Due to the significantly smaller number of securities considered, our estimates might be more sensitive with regard to the choice of the starting values and constraints. Nevertheless, by the end of 2003, French and German government bonds represented roughly 40% [27] of all euro area government bonds in terms of the amount outstanding and they are typically characterised by a high degree of liquidity. Furthermore, the instantaneous forward rates estimated from German and French Treasury bonds and bills generally were quite close to the more broad-based instantaneous forward rates estimated by the ECB.[28]

As with the estimation of RNDs, the computation of instantaneous forward rates may be subject to local minima in the objective function. In order to alleviate potential biases due to an inappropriate choice of starting values, we rely on a series of partial optimisation procedures very much in line with Bolder and Streliski (1999) are carried out. Throughout the optimisation procedure, the set of parameter values $b = \{\beta_0, \beta_1, \beta_2, \beta_3, \tau_1, \tau_2\}$ is distinguished into two groups of parameters, the βs ($b_\beta = \{\beta_0, \beta_1, \beta_2, \beta_3\}$) and the τs ($b_\tau = \{\tau_1, \tau_2\}$). The general idea consists in carrying out a number of optimisations where one set of parameters is fixed while optimising over the parameters of the other group (and vice versa). Bolder and Streliski (1999) claim *"[...] the advantages of estimating one subset of the parameters while holding the other constant are improved speed of convergence and increased stability [...]"*. In order to avoid that by keeping one subset of parameters fixed the solution is being constrained from its optimum, two lines of optimisation are carried out. In a first (second) line, as a first step, a series of βs (τs) is estimated from a given set of τs (βs). As a second step, within both optimisation lines we continue by estimating the same subset of parameters based on new (narrower) starting value matrices around the best solutions obtained from the first step. In a third step of the first (second) line, the subset of parameters is inversed so as to derive optimal τs (βs) from given βs (τs). In a fourth step, again, the model is estimated for a narrower grid of the fixed parameters based on the best outcomes obtained in step 3. In a fifth step, for any given line, the full model is estimated based on a subset of the best outcomes so far obtained from either step within this line. Finally, the best solutions from step 5 (from both line 1 and line 2 which overall

[26]In particular, the instantaneous forward rates recently published by the ECB. However, the ECB website figures daily instantaneous forward rates starting from 29 December 2006 only.

[27]See European Central Bank (2004).

[28]Overall, across all trading days and for horizons as long as 20 years (i.e. more than 33.000 fitted values), approximately one out of ten estimates deviate by more than 10 bps from the corresponding ECB figures. The largest deviations are observed over fairly short horizons (i.e. less than six months). The reasons for the important spread over short horizons are several. First, whereas our estimates are based on (weighted) price error minimisation, the ECB estimates are based on yield error minimisation, thereby potentially leading to more reliable estimates at the short end. Second, in order to avoid forward curve starting points being disconnected from the observed level of short-term rates, for any given time t, we require the estimated instantaneous forward rate at horizon t = 0 to be in an interval of 20-60 bps below the observed 1-month Euribor rate.

consist of 5555 outcomes) are retained as the optimal solution. Throughout all sub-steps of the optimisation a number of upper and lower bounds are imposed (the most obvious of which require τ_1 and τ_2 to be positive).

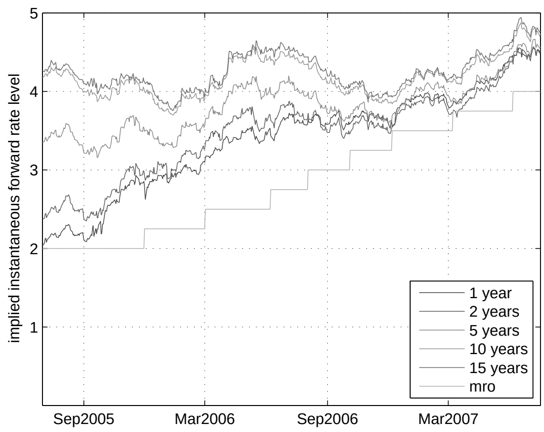

Figure 3: Implied instantaneous forward rates over horizons of 1, 2, 5, 10 and 15 years and the policy main refinancing operations rate

3.2 Evidence from implied forward rates

Figure 4 below reports the average change to the implied 1-month money market forward rate (from spot to 11 months ahead) in the event of Governing Council meetings leading to no policy rate change (top panel), meetings leading to a policy rate change (intermediate panel) and meetings without rate change but making use of the keyword *strong vigilance* (bottom panel).[29] Governing Council meetings leading to a rate change (which in our case amounts to a rate increase) lead to higher spot rates (reflecting the small likelihood market participants assigned to the "left unchanged" option) and at the same time lower the expected 1-month ahead 1-month forward rate (reflecting the lower likelihood of a rate rise at the next Governing Council meeting given the rate hike "today"). In the event of Governing Council meetings with unchanged policy rates, on average, spot and implied forward rates hardly moved. However, by making use of the keyword *strong vigilance* (and in spite of the absence of a policy rate change) the Governing Council did move implied forward rates quite substantially. First, use of this keyword drove up the implied 1-month forward rate 1-month ahead. This might lend support to the assertion that markets considered the reference to *strong vigilance* as a signal for a rate hike at the next Governing Council meeting. Second, it seems that the use of this keyword shifted rate expectations upwards not only for the next month but also

[29] The change in money market rates (actual and implied) is defined as the difference between the closing price observed on the business day following the Governing Council day and the business day prior to the Council meeting (i.e. "2-day difference"). All numbers reported refer to the average change based on all Governing Council meetings that took place throughout the 2-year sample period.

the months to follow (and more than what was observed for Council meetings leading to a rate hike).[30]

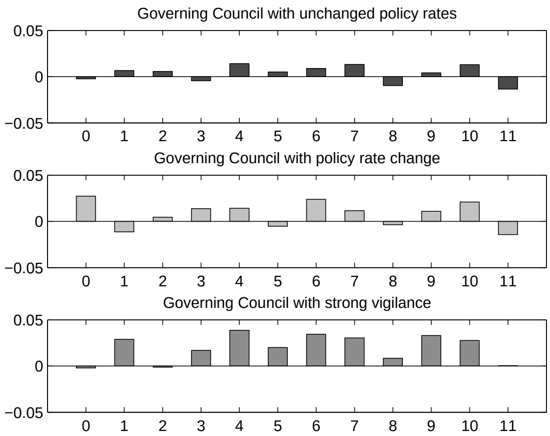

Figure 4: Implied forward rates (1-month): Spot to 11 months ahead

In order to assess the impact of the keyword *strong vigilance* on short-run implied rate expectations, the following specification is used:

$$\Delta f_t^* = \beta_0 + \sum_{j=1}^{4} \beta_j \mathrm{d}i_{t-j}^* + \beta_5 DOW_t + \beta_6 IDEvt_t + \beta_7 IDRel_t + e_{it},$$

where Δf_t^* denotes the change in the implied 1-month ahead 1-month forward rate (both in absolute terms and in real terms). Our results, reported in appendix 7, suggest that the changes to the implied 1-month ahead 1-month forward rate are significantly larger in weeks during which Governing Council meetings are held. They also tend to increase in the week preceding such a meeting, in particular on days for which data releases are scheduled. Moreover, a rate hike, all else equal, leads to smaller changes to the implied one-month-ahead 1-month money market forward rate. The use of the keyword *strong vigilance* leads to significantly larger changes to the implied 1-month-ahead 1-month forward rate, but at the same time smaller changes to the implied two-months-ahead 1-month forward rate. Similar exercises for the implied 1-month forward rate further down the road (say 3 to 10 months ahead) did not reveal any significant role for the keyword *strong vigilance*. In sum, it seems that use of the keyword *strong vigilance* prompts markets to anticipate a rate rise at (precisely) the next Governing Council meeting. To the extent that market participants at no point in time were "misled" (except in October 2005 when policy rates were hiked only two months later), this keyword might have improved the (very)

[30] This holds for all periods except for the 1-month forward rate 2 months ahead. This may reflect the impact rate hikes have on the 1-month forward rate 1 month ahead. Due to the frequency of rate hikes and the use made of the keyword *strong vigilance*, the changes to the forward rate reported for several months ahead may reflect the effects the expected rate rise for the 1-month ahead rate increase have on the subsequent forward rates.

short term predictability of the Eurosystem monetary policy. However, short-term predictability does not constitute a monetary policy objective on its own and may be of very limited use in shaping the understanding of the conduct of monetary policy.

3.3 Evidence from implied instantaneous forward rates

So far, implied forward rates had been derived from observed money market rates with monthly tenor structure (up to 12 months). As a consequence, 1-month forward rates could be computed for horizons from 0 to to 11 months ahead, measuring expected monthly averages of future short-term interest rates over a full month period. To derive measures of interest rate expectations that are easier to interpret from a policy perspective, it is common to estimate implied instantaneous forward rates. This section analyses the impact of Governing council communication on implied instantaneous forward interest rates.

The left-hand side panel of Figure 5 below illustrates the average magnitude of the change to the implied instantaneous forward rate for three types of trading days (all numbers in absolute terms). On average, we observe substantially larger changes to implied rates on Governing Council days than on common trading days. This applies to all horizons up to 20 years, though not for all medium-term horizons (in particular $t = 1.4$ to 2.2 years).[31] For common trading days, the largest changes to implied instantaneous rates were observed at horizon $t = 2.2$ years. On Governing Council days, by contrast, the largest changes are obtained for horizons around 9 - 10 months. Relative to changes on common trading days, around horizons of 6 - 13 months, the average change on Governing Council days becomes more than 50% larger. Moreover, we find substantially larger changes to instantaneous rate expectations on Governing Council days for horizons from 2.2 years onwards relative to common trading days. In addition, data releases also tend to lead to larger implied rate changes compared to common trading days. Regardless of the horizon, the average change to rate expectations is larger on days featuring data releases than on common trading days. On average, in absolute terms, the strongest impact of data releases on rate expectations is obtained for horizons of 1.5 - 3.5 years, approximately 15-35% above the corresponding mean rate changes observed for common trading days over comparable horizons.[32] The left-hand side panel of Figure 5 also compares the changes to instantaneous forward rates obtained on Governing Council days to those observed on days featuring data releases. As reported in section 2, on average, Governing Council meetings tend to affect rate expectations more strongly than data releases. For example, for all horizons between 7 and 14 months (i.e., essentially, the horizon over which both data releases and Governing Council communication reveal their strongest impact on rate expectations), the observed change to rate expectations on Governing Council days has been at least 40 to 70% higher than on data release days.

The right-hand side panel of Figure 5 above illustrates the average daily change in rate expectations depending on whether, on a given day, the keyword

[31] As already highlighted in section 3.2, however, estimates for horizons shorter than 3 months, may suffer from substantial uncertainty.

[32] Again, we cannot draw any firm conclusions for horizons shorter than 3 months.

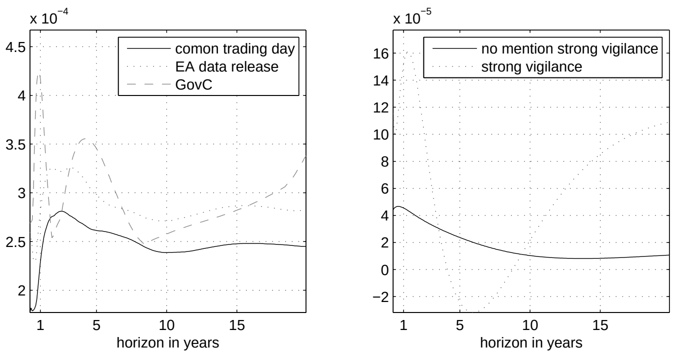

Figure 5: Mean change to implied instantaneous rate by type of trading day (in absolute terms)

strong vigilance had been uttered (or not).[33] Figure 5 suggests that, on average, the mention of *strong vigilance* coincides with large changes to rate expectations for horizons of up to 3.3 years. The largest change to expectations is obtained for horizons of around 1.5 year. At the 1.5-year horizon, on average, the mention of *strong vigilance* lead to rate rise expectations approximately 3.7 times larger than those on trading days without mention of *strong vigilance*.[34] Of course, this descriptive evidence needs to be treated with caution as implied instantaneous forward rates cannot be observed outright and given the very small number of relevant observations.[35]

Overall, the above summary statistics seem to suggest that the effects of Eurosystem communication on implied instantaneous forward rates may differ accross the interest rate path horizon. Generally speaking, compared to common trading days, both data releases and Governing Council communication tend to yield more sizeable changes to interest rate expectations over horizons up to $5\frac{1}{2}$ years, though they tend to achieve their maximum impact much earlier (up to $1\frac{1}{2}$ years). Overall, the impact on Governing Council days is much larger than on data release days, but the impact of data releases is much more equally spread across horizons. In order to assess whether the daily change in rate expectations is significantly affected on Governing Council days and/or on data release days, we estimate specification (17) below. As we would like to assess whether the impact of Governing Council communication and euro area data releases is concentrated around certain horizons, specification 17 below is estimated for all (monthly) horizons up to and including 15 years:

[33] Note that similar to the preceding sections, hereafter, the keyword *strong vigilance* is only considered when mentioned on an Governing Council day. Moreover, the focus here is on the magnitude of rate expectation changes in non-absolute terms as the mention of *strong vigilance* provides market participants with a clear unidirectional beacon concerning the Eurosystem's assessment of the outlook for price stability.

[34] Although, on days when *strong vigilance* is not used Other keywords may convey a message broadly similar with regard to the outlook for price stability.

[35] It is also against the background of the high degree of uncertainty that we have to interpret the below-average impact of the keyword *strong vigilance* on the daily change to rate expectations over horizons between $3\frac{1}{2}$ - $9\frac{1}{2}$ years as well as the impact this keyword seems to have for the expected long-term interest rate path.

$$|\Delta f|_{h,t} = \beta_{0,h} + \beta_{1,h} ISDay_t + \beta_{2,h} NRelEA_t + \beta_{3,h} NRelUS_t + \sum_{j=2}^{4} \gamma_{j,h} DOW_t + e_{h,t} \tag{17}$$

where $|\Delta f|_{h,t}$ stands for the absolute change in yield for horizon h on day t. $ISDay_t$ is a dummy identifying Governing Council meetings, $NRelEA_t$ and $NRelUS_t$ indicate the release of euro area data and US data, respectively. DOW_t controls for day-of-week effects while $e_{h,t}$ is the error term. Figure 6 below reports the coefficients $\beta_{1,h}$ to $\beta_{3,h}$ from equation (17) and the respective t-statistics and p-values for all monthly horizons h up to and including 15 years.

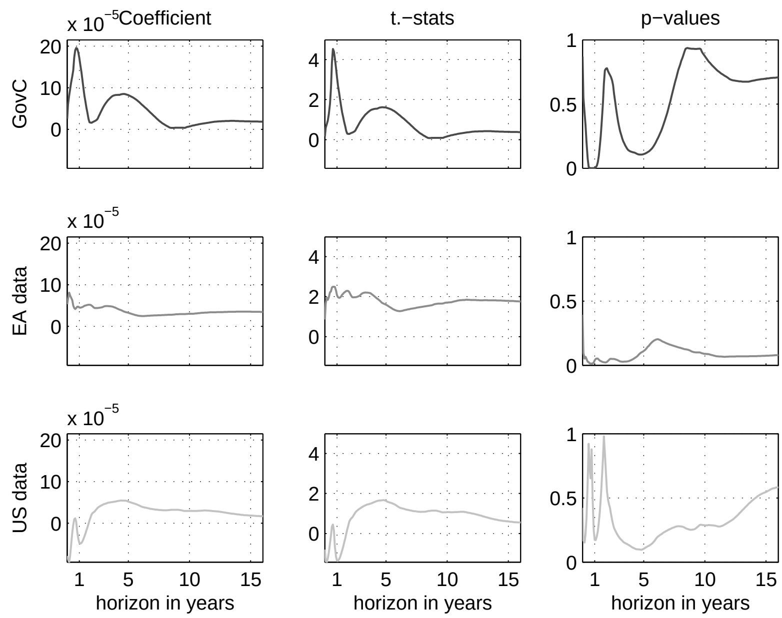

Figure 6: Coefficients, t-stats and p-values for equation 17 by horizon

Our results suggest that Governing Council meetings significantly affect the day-to-day change in rate expectations. The impact on such days becomes very strong over horizons from 7 to 13 months. Moreover, we find significantly larger changes to rate expectations on such days at horizons between 6 and 15 months (at the 5% significance level). Overall, for a horizon of $\frac{1}{2}$ to $1\frac{1}{2}$ year, it seems that the change in rate expectations on Governing Council days is significant and substantial. For both shorter and longer horizons, both the magnitude of the impact and its significance decline sharply. Furthermore, we find that the change in rate expectations may also be significantly affected on trading days featuring releases of euro area data. However, contrary to the evidence for Governing Council meeting days, the impact of such releases (to the extent significant) seems to be less concentrated at one horizon but is evenly distributed from the short to the medium term. Overall, our results suggest a significantly larger change to rate expectations for horizons of roughly 6 months to 4 years (again, at the 5% significance level). However, as already suggested by the summary statistics reported above, the magnitude of the effect on the change of rate expectations is much smaller than the impact obtained on Governing Council meeting days. Finally, our results suggest that the change to rate expectations is not significantly affected on days featuring US data releases. This applies to all monthly horizons up to and including 15 years.

The longer horizons over which euro area data releases were found to significantly affect changes to implied forward rates (relative to Governing Council days) might reflect that within the framework of a fully credible and (short-term) predictable monetary policy, macroeconomic data remain a primary determinant of medium-term expectations about the policy rate. However, more generally, the results with regard to the role of data releases (both for the euro area and the US) may be due to their lump-sum treatment within this paper. In particular, we cannot exclude that a more detailed treatment of data releases (e.g. by type of data released, by their qualitative implication for the outlook for price stability and/or according to the extent the figures released had been anticipated by market participants) may lead to results different from those reported here. Overall, the overriding impact on market participants' rate expectations over the last two years seems to have originated in the communication of the Eurosystem's monetary policy decisions. The impact of monetary policy decisions, both in terms of magnitude and significance, seems to be particularly concentrated around horizons of $\frac{1}{2}$ - $1\frac{1}{2}$ years.[36]

4 Conclusion

This paper set out to assess the impact of official Eurosystem Governing Council communication on financial markets using evidence from futures markets, options markets and bond markets. The most important findings based on both RNDs and implied forward rates suggest that Eurosystem Governing Council meetings are an important driver of interest rate expectations.

First, estimates based on RNDs suggest that the level, the dispersion and the asymmetry of interest rate expectations are significantly affected on Eurosystem Governing Council meeting days. However, some of the impacts observed on Governing Council meeting days, such as a significantly lower dispersion of rate expectations, tend to be relatively short-lived. Moreover, we find that interest rate expectations tend to become less volatile during the *black out period*.

Second, monetary policy meetings tend to affect interest rate expectations much more strongly than data releases. We do find a significant impact of euro area data releases, but US data releases do not seem to affect euro area interest rate expectations systematically. However, we cannot exclude a significant impact of specific US data releases, depending on the type of data released, the extent to which the figures had been anticipated by market participants and/or on their qualitative implications for the outlook for risks to price stability.

Third, evidence from implied instantaneous forward rates suggests that monetary policy decisions and data releases may have fairly different implications for interest rate expectations, depending on the horizon of such expectations. The impact of monetary policy decisions seems to be particularly concentrated

[36] For the full set of results, please refer to Appendix B.2.

around horizon of $\frac{1}{2}$ - $1\frac{1}{2}$ years, while the effects of euro area data releases seem to unfold at medium-term horizons.

Fourth, it seems that the use of *keywords* within the Eurosystem's monetary policy mimics the merits and the limits of central bank predictability. On theoretical grounds, the case for increased short-run predictability is fairly strong. All else equal, more short-term guidance is expected to lead to a smooth transition of the money market towards a situation of different rate levels. Evidence from implied forward rates suggests that *keywords* do contribute to the (very) short-run predictability of the Eurosystem monetary policy with a particularly strong impact on interest rate expectations over the 1-2 month horizon. By contrast, keywords do not seem to have a systematic impact on interest rate expectations over longer horizons, which might reflect the ambiguous role of forward guidance over medium- to longer-term horizons. On the one hand, forward guidance is supposed to anchor the public's long-term expectations and contribute to the understanding of monetary policy. On the other hand, the Eurosystem's monetary policy is conditional on a broad assessment of the outlook for risks to price stability and its underlying assumptions and scenarios. This conditionality might not be fully understood by market participants and forward guidance over the medium term might be mis-interpreted as a precommitment by the central bank to a specific interest rate trajectory even in the emergence of scenarios different from the benchmark. Deviations from the *forward guided* policy path, although perfectly justified, may be mis-interpreted as a policy failure and ultimately lead to lower credibility of the central bank. Overall, given a high degree of short-term predictability of the Eurosystem monetary policy, this might explain why the impact of Eurosystem Governing Council communication on interest rate expectations is concentrated on the short- to medium-term, giving a more important role to data releases over the medium term.

References

Andersson, M. (2007): "Using Intraday Data to gauge Financial Market Responses to Fed and ECB Monetary Policy Decisions," ECB Working Paper Series, n.: 726.

Arils, S. A. (2002): "A Study of Implied Risk-Neutral Density Functions in the Norwegian Option market," Norges Bank Working Paper Series, n.:13.

Attanasio, P. O., P. L. Picci, and A. Scorcu (2000): "Saving, Growth, and Investment: A Macroeconomic Analysis Using a Panel of Countries," *Review of Economics and Statistics*, 82, 182–211.

Baltagi, B. H. (2001): *Econometric Analysis of Panel Data*. Wiley: New York.

Bank of England (2005): "Do Financial Markets React to Bank of England Communication?," Quarterly Bulletin, Winter 2005.

Black, F. (1976): "The Pricing of Commodity Contracts," *Journal of Financial Economics*, (3), 167–179.

Black, F., and M. Scholes (1973): "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy*, 81, 637–659.

Blinder, A. (1998): *Central Banking in Theory and Practice*. MIT Press, Cambridge MA.

Bolder, D., and D. Streliski (1999): "Yield Curve Modelling at the Bank of Canada," Bank of Canada technical report nr. 84.

Brand, C., D. Buncic, and J. Turunen (2006): "The Impact of Monetary Policy Decisions and Communication on the Yield Curve," ECB Working Paper Series, n.: 657.

D'Amato, J., S. Morris, and H. S. Shin (2003): "Communication and Monetary Policy," BIS Working Papers, n.: 123.

Ehrmann, M., and M. Fratzscher (2005): "How should Central Banks Communicate," ECB Working Paper Series, n.: 557.

——— (2007a): "Explaining monetary Policy in press conferences," ECB Working Paper Series, n.:767.

——— (2007b): "The Timing of Central Bank Communication," *European Journal of Political Economy*, 23(1), 124–45.

European Central Bank (2004): "The Euro bond market study," ECB publication, December 2004.

Gerlach, S. (2004): "Interest Rate Setting by the ECB: Words and Deeds," CEPR Discussion Papers, n.: 4775.

Gürkaynak, R., B. Sack, and J. H. Wright (2006): "The U.S. Treasury Yield Curve: 1961 to the Present," Federal Reserve Board Staff Working papers nr. 2006-28.

Heinemann, F., and K. Ullrich (2005): "Does it pay to watch Central Bankers Lips?," ZEW Working Papers, n.: 05-70.

Hull, J. (1997): *Options, Futures and Other Derivatives.* Prentice Hall: London.

Jackwerth, J. (1999): "Option-implied risk-neutral distributions and Implied Binomial Trees: A literature Review," *Journal of Derivatives*, 7(4), 66–82.

Lucas, R. E. (1976): "Econometric Policy Evaluation: A Critique," *Carnegie Rochester Conference Series on Public Policy*, pp. 19–46.

Melick, W., and C. Thomas (1997): "Recovering an Asset's Implied Pdf from Option Prices: An Application to Crude Oil Prices," *Journal of Financial and Quantitative Analysis*, 32(1), 91–115.

Nelson, C. R., and A. F. Siegel (1987): "Parsimonious Modeling of Yield Curves," *Journal of Business*, 60(4), 473–89.

Rubinstein, M. (1994): "Implied Binomial Trees," *Journal of Finance*, 49(3), 771–818.

Svensson, L. E. (1994): "Estimating and Interpreting Forward Interest Rates: Sweden 1992-1994," IMF Working papers nr. 114.

UK Debt Management Office (2000): "The DMO's Yield Curve Model," mimeo.

Woodford, M. (1999): "Optimal Monetary Policy Inertia," NBER Working Paper no 7261.

——— (2003): *Interest and Prices: Foundations of a Theory of Monetary Policy.* Princeton University Press.

Appendix

A Data releases considered

Country	Data type	Country	Data type
EC	Unemployment	US	Unemployment
EC	PPI	US	ISM Non-Manufacturing
EC	Retail sales	US	Confidence (Uni of Michigan)
EC	ZEW	US	Retail Sales
EC	CPI	US	Trade balance
EC	Industrial production	US	CPI
EC	Business confidence	US	Industrial Production
EC	Consumer confidence	US	PPI
EC	GDP sa	US	Consumer Confidence
EC	Trade balance sa	US	ISM Manufacturing
GE	IFO Business Climate	US	ISM Prices Paid
GE	IFO Current Assessment	US	Change in NFP
GE	IFO Expectations		

Table 1: Indicators from Bloomberg Newswire. Ifo-Indices were counted as Eurozone Indicators

B Regression results

B.1 Regressions using risk neutral density indicators

The regressors *nrelea* and *nrelus* refer to news releases concerning the Euro area and the US respectively ocurring on a certain day. *is* and *isup* indicate that a rate decision and a rate increase have occurred. *dist_next* and *dist_prec* indicate the distance in days until/since the next/preceding meeting. *keynbr* counts how many of the four keywords occurred during the communication of the rate decision.

key indicates the overall number of keywords that were uttered per day. *nrel* summarizes *nrelea* and *nrelus*. *_Idow_[1-5]* are Day-of-week dummies. *ttm* stands for the term to maturity in days of a specific option. The dependant variable *df0abs* designates the absolute price change of the underlying future.

For logit regressions the variables *med[variable]* indicate whether the value of a certain variable exceeded its sample median (in which case the value switches from 0 to 1).

iq[....] measures the interquartile (or interpercentile) range. For example *iq5545* subtracts the 45th percentile from the 55th percentile. *iq[....]l[1-4]* are the lags of this variable. *sdx* is the standard deviation of the distribution while *sdxl[1-3]* represent its lags. *isl[1-3]* are the lags of introductory statement days, while *isld[1-3]* are the lead variables. *iscum* summarizes *is* and *isl1*. Similarly *nreleal1* is the lag of Euro area news releases. *ttmmth* is the term-to-maturity months as unit.

The variables *up[XX]* and *dn[XX]* indicate the estimated expectations of a rate increase of *XX* base points. *skewx* indicates the third standardized moment of the distribution of expectations while *skewxl[1-4]* are its lags. *isupl[1-2]* and *isupld[1-2]* are lags and leads of governing council meetings with a rate increase while *isNOup* indicates governing council meetings with a constant rate and *isNOupl[1-2]* are lags.

Linear regressions / Term-to-maturity absorbed

df0abs	Coef.	t-stat	p-val.	*df0abs*	Coef.	t-stat	p-val.
nrelea	0.0039	5.5526	0.000	nrelea	0.0038	5.4157	0.000
is	0.0103	3.8395	0.000	dist_next	-0.0027	-3.3443	0.001
dist_next	-0.0026	-2.9051	0.004	keyis	0.0137	6.126	0.000
dist_prec	-0.0005	-0.5636	0.573	key	-0.0002	-0.1648	0.869
keynbr	0.0018	1.9891	0.047	_cons	0.0226	48.899	0.000
_cons	0.0224	39.9472	0.000				

df0abs	Coef.	t-stat	p-val.	*df0large*	Coef.	t-stat	p-val.
nrelea	0.0039	5.5104	0.000	nrelea	0.0435	2.5519	0.011
is	0.0068	3.0541	0.002	dist_prec	0.0393	1.8007	0.072
dist_next	-0.0026	-3.3124	0.001	keyis	0.1788	2.7941	0.005
isup	0.0203	5.036	0.000	isup	0.272	3.6454	0.000
_cons	0.0225	51.8381	0.000	nrelus	0.0271	1.6279	0.104
				dist_next2	-0.0989	-2.5766	0.010
				_cons	0.3767	28.6533	0.000

Logit panel regression

df0large	Coef.	z-stat	p-val.
nrelea	1.186	2.3943	0.017
is	1.417	1.5689	0.117
dist_next	0.978	-0.2272	0.820
dist_prec	1.213	2.0555	0.040
isup	3.562	3.3144	0.001
nrelus	1.122	1.6726	0.094

Table 2: Level of rates - part 1

Linear regression / Option absorbed									
df0abs	Coeff.	t-stat.	p-val.	Coeff.	t-stat.	p-val.	Coeff.	t-stat.	p-val.
key	-0.0014	-1.25	0.212	-0.0012	-1.07	0.283	-0.0014	-1.23	0.220
nrel	0.0027	3.84	0.000				0.0024	3.08	0.002
is	0.0141	6.05	0.000	0.0141	6.1	0.000	0.0137	5.7	0.000
dist_next	-0.0026	-3.69	0.000	-0.0029	-3.93	0.000	-0.0025	-3.57	0.000
nrelea				0.0037	5	0.000			
_Idow_2							0.0004	0.42	0.678
_Idow_3							-0.0011	-1.08	0.281
_Idow_4							0.0009	0.84	0.404
_Idow_5							0.0022	1.76	0.079
_cons	0.0226	38.08	0.000	0.0229	47.52	0.000	0.0223	28.83	0.000
df0abs	Coeff.	t-stat.	p-val.	Coeff.	t-stat.	p-val.	Coeff.	t-stat.	p-val.
key	-0.0012	-1.03	0.302						
is	0.0135	5.7	0.000	0.0105	3.81	0.000	0.0105	3.81	0.000
dist_next	-0.0028	-3.86	0.000	-0.0025	-3.48	0.001	-0.0025	-3.5	0.000
nrelea	0.0036	4.97	0.000	0.0037	5.13	0.000	0.0038	5.07	0.000
_Idow_2	0.0003	0.33	0.740	0.0002	0.19	0.848	0.0002	0.21	0.833
_Idow_3	-0.001	-1.06	0.288	-0.0012	-1.19	0.235	-0.0012	-1.14	0.253
_Idow_4	0.0011	1.07	0.284	0.0009	0.87	0.385	0.0009	0.86	0.392
_Idow_5	0.0026	2.25	0.024	0.0025	2.19	0.028	0.0025	2.01	0.045
keynbr				0.001	1.05	0.292	0.001	1.05	0.294
nrelus							-0.0001	-0.1	0.920
_cons	0.0223	29.39	0.000	0.022	29.14	0.000	0.022	28.87	0.000
df0abs	Coeff.	t-stat.	p-val.	Coeff.	t-stat.	p-val.	Coeff.	t-stat.	p-val.
is	0.0087	3.32	0.001	0.0062	2.88	0.004	0.0062	2.88	0.004
dist_next	-0.002	-2.81	0.005	-0.0024	-3.43	0.001	-0.0024	-3.43	0.001
nrelea	0.0038	5.21	0.000	0.0038	5.25	0.000	0.0038	5.25	0.000
keynbr	0.0021	2.33	0.020						
nrelus	0.0004	0.62	0.537	0.0006	0.89	0.372	0.0006	0.89	0.372
df0lag1	0.0438	2.45	0.014						
ttm	0.00003	15.06	0.000	0.00003	16.59	0.000	0.00003	16.59	0.000
keyisup				0.021	5.41	0.000			
isup							0.021	5.41	0.000
_cons	0.0083	9.53	0.000	0.0093	11.1	0.000	0.0093	11.1	0.000
df0abs	Coeff.	t-stat.	p-val.						
key	-0.0011	-1.02	0.307						
is	0.0066	2.62	0.009						
dist_next	-0.0028	-3.87	0.000						
nrelea	0.0036	5.02	0.000						
_Idow_2	0.0003	0.33	0.743						
_Idow_3	-0.0012	-1.17	0.240						
_Idow_4	0.0013	1.2	0.231						
_Idow_5	0.0026	2.25	0.024						
isup	0.0204	5.03	0.000						
_cons	0.0223	29.39	0.000						

Table 3: Level of rates - part 2

Linear Regressions / ttmmth absorbed							
iq5545	Coeff.	t-stat.	p-val.	*iq6535*	Coeff.	t-stat.	p-val.
iq5545l1	0.5538	4.43	0.000	is	-0.0049	-3.02	0.003
iq5545l2	0.1278	1.42	0.157	isl1	-0.0055	-3.75	0.000
iq5545l3	0.1143	1.99	0.046	isl2	0	0.00	0.998
iq5545l4	0.0989	2.16	0.031	isl3	-0.0037	-2.51	0.012
is	-0.0026	-2.66	0.008	nrelea	-0.001	-1.63	0.104
isl1	-0.0029	-3.90	0.000	iq6535l1	0.5463	7.25	0.000
isl2	0.0009	0.46	0.648	iq6535l2	0.132	1.97	0.049
isl3	-0.0026	-2.47	0.013	iq6535l3	0.1629	2.48	0.013
nrelea	-0.0006	-1.59	0.112	iq6535l4	0.089	1.75	0.080
_cons	0.0116	3.37	0.001	_cons	0.0153	3.93	0.000
iq7525	Coeff.	t-stat.	p-val.	*sdx*	Coeff.	t-stat.	p-val.
is	-0.0061	-3.02	0.003	nrelea	0.0008	0.83	0.409
isl1	-0.0078	-3.77	0.000	sdxl1	0.5083	3.77	0.000
isl2	-0.0003	-0.13	0.900	sdxl2	0.1113	0.91	0.365
isl3	-0.0042	-2.73	0.006	sdxl3	0.3334	2.44	0.015
nrelea	-0.0013	-1.54	0.123	iscum	-0.0077	-3.71	0.000
iq7525l1	0.5693	7.12	0.000	key	-0.0022	-1.77	0.077
iq7525l2	0.1898	2.29	0.022	_cons	0.0206	2.28	0.023
iq7525l3	0.0399	0.59	0.552				
iq7525l4	0.1341	2.68	0.007				
_cons	0.0223	3.73	0.000				
sdx	Coeff.	t-stat.	p-val.	*sdx*	Coeff.	t-stat.	p-val.
is	-0.0045	-1.22	0.221	is	-0.01	-3.45	0.001
isl1	-0.0084	-3.55	0.000	isl1	-0.0093	-3.77	0.000
nrelea	0.0008	0.90	0.367	isl2	-0.0064	-2.48	0.013
sdxl1	0.5077	3.77	0.000	isl3	-0.0041	-2.55	0.011
sdxl2	0.1118	0.91	0.364	nrelea	0.0009	0.92	0.358
sdxl3	0.3326	2.44	0.015	sdxl1	0.505	3.73	0.000
vig	0.0007	0.40	0.692	sdxl2	0.1081	0.88	0.379
accn	-0.0021	-1.19	0.234	sdxl3	0.3407	2.49	0.013
mon	-0.0066	-2.00	0.045	isld1	0.0017	0.58	0.560
wtd	0.0024	0.69	0.489	isld2	0.0006	0.32	0.747
_cons	0.0209	2.30	0.022	isld3	-0.003	-0.80	0.422
				_cons	0.0207	2.25	0.025
sdxlarge	Coeff.	t-stat.	p-val.		Coeff.	t-stat.	p-val.
is	-0.035	-0.89	0.376				
isl1	-0.041	-1.01	0.314				
isl2	-0.0019	-0.05	0.962				
isl3	0.0008	0.02	0.984				
nrelea	0.0032	0.19	0.853				
nreleal1	0.0112	0.65	0.513				
nrelus	0.0089	0.51	0.613				
_cons	0.5189	36.86	0.000				

Table 4: Dispersion of expectations - part 1

Logit panel regressions							
iq5545large	Coeff.	z-stat.	p-val.	*iq6535large*	Coeff.	z-stat.	p-val.
iq5545larg 1	12.46589	17.65	0.000	iq6535larg 1	14.80316	18.3	0.000
iq5545larg 2	4.151645	8.65	0.000	iq6535larg 2	3.948315	7.91	0.000
iq5545larg 3	2.262739	4.56	0.000	iq6535larg 3	2.096634	3.94	0.000
iq5545larg 4	3.069003	6.63	0.000	iq6535larg 4	3.316575	6.81	0.000
isup	1.66013	0.78	0.438	isup	1.454494	0.59	0.556
is	0.5417165	-1.76	0.079	is	0.4345792	-2.33	0.020
isl1	0.9056037	-0.32	0.753	isl1	1.186936	0.53	0.593
nrelea	0.7499275	-2.12	0.034	nrelea	0.7137758	-2.41	0.016
nrelus	1.085223	0.6	0.549	nrelus	1.172439	1.14	0.255
iq7525large	Coeff.	z-stat.	p-val.	*mediq5545l e*	Coeff.	z-stat.	p-val.
iq7525larg 1	19.53616	19.36	0.000	mediq5545l 1	9.784451	17.83	0.000
iq7525larg 2	3.385255	6.43	0.000	mediq5545l 2	3.838709	9.34	0.000
iq7525larg 3	2.042825	3.43	0.001	mediq5545l 3	2.488424	5.97	0.000
iq7525larg 4	3.252909	6.22	0.000	mediq5545l 4	2.780109	6.99	0.000
is	0.6705585	-1.24	0.214	isup	1.688242	0.89	0.373
isl1	0.8055908	-0.65	0.515	is	0.6603429	-1.2	0.231
nrelea	0.799883	-1.54	0.123	isl1	0.7101428	-1.19	0.235
nrelus	1.226796	1.41	0.160	nrelea	0.9273822	-0.61	0.539
				nrelus	1.107508	0.82	0.410
mediq6535l e	Coeff.	z-stat.	p-val.	*mediq7525l e*	Coeff.	z-stat.	p-val.
mediq6535l 1	11.1395	18.29	0.000	mediq7525l 1	11.1488	18.49	0.000
mediq6535l 2	3.900884	9.1	0.000	mediq7525l 2	3.930742	9.25	0.000
mediq6535l 3	2.277371	5.18	0.000	mediq7525l 3	2.23407	5.13	0.000
mediq6535l 4	2.943555	7.19	0.000	mediq7525l 4	2.789212	6.87	0.000
is	0.8998759	-0.37	0.713	is	0.9239734	-0.28	0.781
isl1	0.7168585	-1.13	0.257	isl1	0.8873138	-0.41	0.680
isl2	2.537926	3.25	0.001	isl2	1.981144	2.34	0.019
nrelea	0.8930508	-0.9	0.369	nrelea	0.8244041	-1.55	0.122
nrelus	1.159849	1.15	0.249	nrelus	1.052862	0.4	0.686

Table 5: Dispersion of expectations - part 2

Linear Regression / ttmmth absorbed							
up25	Coeff.	t-stat.	p-val.	*dn25*	Coeff.	t-stat.	p-val.
up25l1	0.8186	29.94	0.000	dn25l1	0.725	18.14	0.000
isup	0.0018	0.42	0.675	isup	0.0065	1.64	0.101
isupl1	0.0095	1.93	0.053	isupl1	-0.0018	-0.50	0.616
isupl2	-0.0047	-1.22	0.222	isupl2	-0.0012	-0.44	0.657
isupld1	0.0052	1.45	0.146	isupld1	-0.0037	-1.40	0.163
isupld2	-0.0065	-1.53	0.126	isupld2	-0.0001	-0.03	0.979
isNOup	0.0114	2.16	0.031	isNOup	-0.0025	-0.43	0.669
isNOupl1	0.0077	2.09	0.037	isNOupl1	-0.0022	-0.85	0.394
isNOupl2	0.0004	0.16	0.872	isNOupl2	0.0007	0.31	0.754
nrelea	0.0009	0.73	0.466	nrelea	0.0001	0.06	0.951
_cons	0.045	6.56	0.000	_cons	0.0705	6.92	0.000
up50	Coeff.	t-stat.	p-val.	*dn50*	Coeff.	t-stat.	p-val.
up50l1	0.799	24.89	0.000	dn50l1	0.7311	18.73	0.000
isup	-0.001	-0.17	0.865	isup	0.0064	1.25	0.211
isupl1	0.0137	1.98	0.048	isupl1	-0.0083	-1.72	0.085
isupl2	-0.0045	-1.05	0.295	isupl2	0.0016	0.52	0.600
isupld1	0.0068	1.39	0.164	isupld1	-0.0063	-2.07	0.038
isupld2	-0.0001	-0.02	0.982	isupld2	0	0.00	0.999
isNOup	0.0111	2.17	0.03	isNOup	-0.0072	-1.30	0.192
isNOupl1	0.0066	2.15	0.032	isNOupl1	-0.0041	-1.61	0.107
isNOupl2	0.0016	0.76	0.445	isNOupl2	0.0015	0.57	0.570
nrelea	0.0007	0.63	0.532	nrelea	0	0.03	0.973
_cons	0.0711	6.19	0.000	_cons	0.102	6.93	0.000
skewx	Coeff.	t-stat.	p-val.				
isup	0.017	0.49	0.624				
isupl1	-0.073	-1.98	0.048				
isupl2	0.008	0.32	0.750				
nrelea	0.001	0.07	0.946				
skewxl1	0.572	10.42	0.000				
skewxl2	0.158	2.90	0.004				
skewxl3	0.024	0.38	0.704				
skewxl4	0.12	2.63	0.009				
nrelus	-0.008	-0.86	0.391				
_cons	0.042	4.11	0.000				

Table 6: Asymmetry of expectations

B.2 Regressions using implied forward rates

sv indicates use of *strong vigilance* during an introductory statement. *preweek* indicates the week preceeding the governing council and *isweek* stands for the calendar week during which the council met. The *[ ]release* variables indicate news releases that occurred during those time periods. *dist_embargo* covers the timeperiod of the communication embargo preceding governing council meetings of the ECB. *thuy* is a dummy variable indicating thursdays.

$\lvert\Delta f\rvert$ 1 month ahead			
	coeff.	t-stat	p-value
lag 1	0.1629	3.66	0
sv	0.0122	2.84	0.005
preweekrelease	0.0047	2.21	0.028
preweek	0.0025	1.62	0.107
isweek	0.0057	3.59	0
isweekrelease	-0.0041	-1.91	0.056
_cons	0.0041	5.35	0
Δf 1 month ahead			
	coeff.	t-stat	p-value
sv	0.0139	2.85	0.004
preweekrelease	0.0077	3.51	0
lag 1	0.1276	3	0.003
isup	-0.0121	-2.51	0.012
_Idow_2	-0.0019	-1	0.317
_Idow_3	-0.0012	-0.68	0.5
_Idow_4	0.004	2.1	0.036
_Idow_5	-0.0044	-2.33	0.02
nrelea	-0.0006	-0.47	0.642
_cons	0.0037	2.8	0.005
Δf 2 months ahead			
	coeff.	t-stat	p-value
sv	-0.011	-2.16	0.031
isup	0.004	0.79	0.429
nrelea	0.0015	1.24	0.216
dist_embargo	0.0029	2.27	0.024
thuy	0.002	1.24	0.214
_cons	0.0024	2.61	0.009

Table 7: Results for observed 1-month forward rates according to specification (17)

n_ea is short for *nrelea.*

Coefficients / t-stats accross horizons

	Coefficients		t-stat			Coefficients		t-stat	
mths.	GovC	n_ea	GovC	n_ea	mths.	GovC	n_ea	GovC	n_ea
3	9.7	7.41	0.96	1.84	39	6.67	4.89	1.2	2.2
4	11.26	6.91	1.28	1.97	40	6.97	4.88	1.25	2.2
5	12.73	6.31	1.78	2.21	41	7.25	4.86	1.31	2.2
6	14.21	5.02	2.55	2.26	42	7.49	4.84	1.36	2.2
7	17.31	4.4	3.86	2.46	43	7.72	4.82	1.4	2.19
8	18.98	4.17	4.54	2.5	44	7.92	4.78	1.44	2.18
9	19.54	4.41	4.41	2.5	45	8.08	4.73	1.47	2.16
10	19.41	4.73	4.06	2.48	46	8.16	4.63	1.49	2.13
11	18.46	4.75	3.57	2.31	47	8.21	4.52	1.51	2.09
12	17.14	4.54	3.11	2.07	48	8.25	4.41	1.53	2.05
13	15.49	4.51	2.69	1.97	49	8.28	4.3	1.54	2
14	13.74	4.56	2.33	1.94	50	8.29	4.19	1.54	1.96
15	11.84	4.64	1.99	1.95	51	8.28	4.08	1.55	1.92
16	9.93	4.78	1.67	2.01	52	8.34	4	1.56	1.88
17	8.13	4.95	1.37	2.09	53	8.42	3.9	1.58	1.84
18	6.72	5.02	1.14	2.14	54	8.47	3.79	1.6	1.8
19	5.28	5.1	0.91	2.2	55	8.5	3.68	1.61	1.75
20	3.87	5.16	0.67	2.24	56	8.5	3.55	1.62	1.7
21	2.52	5.2	0.44	2.28	57	8.45	3.47	1.62	1.67
22	1.72	5.21	0.3	2.29	58	8.39	3.41	1.61	1.64
23	1.61	5.17	0.28	2.28	59	8.31	3.34	1.61	1.62
24	1.6	5.02	0.28	2.23	60	8.22	3.27	1.6	1.6
25	1.74	4.79	0.31	2.13	61	8.12	3.21	1.59	1.57
26	1.87	4.59	0.33	2.04	62	8.01	3.13	1.57	1.54
27	1.97	4.43	0.35	1.97	63	7.88	3.04	1.55	1.5
28	2.09	4.42	0.37	1.96	64	7.75	2.95	1.53	1.47
29	2.3	4.42	0.41	1.97	65	7.6	2.88	1.51	1.44
30	2.58	4.43	0.46	1.97	66	7.45	2.8	1.49	1.4
31	3.13	4.44	0.55	1.98	67	7.28	2.73	1.46	1.37
32	3.66	4.48	0.65	2	68	7.1	2.67	1.43	1.34
33	4.17	4.53	0.74	2.02	69	6.91	2.62	1.39	1.32
34	4.67	4.58	0.83	2.04	70	6.7	2.57	1.36	1.31
35	5.14	4.67	0.91	2.08	71	6.49	2.54	1.32	1.3
36	5.56	4.77	0.99	2.13	72	6.27	2.52	1.28	1.29
37	5.96	4.85	1.06	2.17	73	6.04	2.49	1.23	1.28
38	6.33	4.88	1.13	2.19	74	5.81	2.48	1.19	1.27

Table 8: Evolution of coefficients and t-stats for IS-days and EA news releases over the spectrum of horizons according to specification (17). The dependant variable is $|\Delta f|$. To improve readability, coefficients were multiplied by $10 * e^5$. (See also Figure 6.)