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The Impact of Central Bank Announcements on Asset Prices in Real Time: Testing the Efficiency of the Euribor Futures Market

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Abstract
This paper examines the effect of European Central Bank communication on the price discovery process in the Euribor futures market using a *new* tick-by-tick dataset. First, we show that two pieces of news systematically hit financial markets on Governing Council meeting days: the ECB policy rate decision and the explanation of its monetary policy stance. Second, we find that the *unexpected* component of ECB explanations has a significant and sizeable impact on futures prices. This indicates that the ECB has already acquired some credibility: financial markets seem to believe that it does what it says it will do. Finally, our results suggest that the Euribor futures market is semi-strong form informational efficient.

Keywords: market efficiency, central bank communication, news shock, tickby-tick Euribor futures data, event-study analysis.
JEL classification: E52, E58, G14

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"Financial markets evidence indeed indicates that we as a central bank have managed to be understood by market professionals. (...)
One of the main goal of a responsible central bank now is to have a reliable communication guiding expectations in a rapidly changing environment."
Trichet (2005)

"A month ago Jean-Claude Trichet gave what markets see as his standard nod and wink: the European Central Bank (ECB), said its president, would continue to exercise "vigilance" against inflationary pressures. Stand by, in other words, for another increase in interest rates at the bank's next rate-setting meeting on October 5. ECB-watchers were therefore well prepared when rates duly rose, by a quarter of a percentage point, to 3.25%."
The Economist (2006)

1 Introduction

Do European Central Bank (henceforth ECB) announcements affect market expectations about the future path of its monetary policy? How long does it take for these messages to be promptly incorporated into asset prices? Is it possible to assess the effect of central bank communication without relying on the exogeneity assumption of monetary policy shocks? Is the Euribor futures market informational efficient? To address these questions, this paper uses a novel data set to present extensive evidence on market efficiency[1] in relation to central bank announcements.

The value added of this study to the empirical finance literature on the efficient market hypothesis is two-fold. First, we test market efficiency for a new type of news item, specifically for the information originating from central bank announcements, in real time, i.e. using a high-frequency tick-by-tick dataset. Second, we analyze the efficiency of a new financial market, the Euribor futures market. By doing so, we address two shortcomings of the existing literature. On the one side, we analyze a *money market* while most empirical studies focus on the foreign exchange and stock market. On the other side, we investigate the efficiency property of a *European financial market*, while most finance literature studies US markets.

Our work also contributes to the rapidly expanding literature on central bank communication. Since central banking is increasingly becoming the art of managing expectations, communication has developed into a key monetary policy instrument. In this paper we examine the real-time effects of central bank announcements on financial markets. We show that market participants respond to *two different pieces of news* rather than just one piece of news, as is commonly analyzed in the monetary economics literature. Therefore, in order to properly describe the central bank conduct of monetary policy we find that two dimensions are needed:

[1] In an efficient capital market, security prices fully reflect all available information.

both central bank actions and central bank words. Put it differently, our results suggest that Kuttner (2001) type analysis, based only on monetary policy shocks (i.e., a single factor), is not completely adequate. Nowadays, central banks are also able to affect asset prices through their bias statements, a second policy instrument.

We apply our empirical methodology to investigate the effectiveness of the ECB communication policy because of its unique institutional characteristic of first announcing its policy rate decisions (i.e. the minimum bid rate for the main refinancing operations of the Eurosystem) and then, after about 45 minutes, explaining its monetary policy stance.[2] By using a *new* intraday dataset, we are able to neatly investigate the effects on asset prices of the latter announcement separately from the policy decision. We can thus circumvent the endogeneity and omitted variables problems (i.e., interest rate changes and monetary policy shocks can be influenced by each other and by other common variables) that affect most of the previous work.

Our main findings can be summarized as follows. First, by using number of transactions and volumes data, we show qualitatively that financial markets immediately react to the two pieces of news that systematically reach them on Governing Council meeting days, that is the policy decision announcement communicated at 12:45 [3] and the ECB President monthly press conference starting at 13:30.

Second, by using a new tick-by-tick dataset, we show quantitatively that innovations in market expectations about future monetary policy can be explained by *unexpected* ECB announcements, i.e. the difference between what the ECB announces and what the market expects the ECB to announce. In particular, we find that the news shock is not only statistically and economically significant, but also quantitatively important. On the one hand, this evidence suggests that even if the ECB is a relatively young central bank, it has already acquired some credibility.[4] In other words, financial markets believe that the European Central Bank does what it says it will do. On the other hand, the econometric results presented in this paper indicate that ECB words and deeds have been consistent with each other, otherwise market participants would not have reacted to central bank announcements.

Third, futures prices incorporate the news stemming from the ECB President speech very quickly, in around one hour. Moreover, the Euribor futures market satisfies the semi-strong form

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[2] In particular, during the monthly press conference the ECB President explains the Bank's assessment of the economic situation, the risks to medium term price stability and the way in which they systematically affect policy decisions.

[3] Throughout the paper, London time is always used. We do not employ Greenwich Mean Time because it needs to be adjusted for Daylight Saving.

[4] We have in mind Blinder (1998, page 64) definition of credibility: "Matching deeds to words. (…) Credibility means that your pronouncements are believed – even though you are bound by no rule and may even have a short-run incentive to renege. In the real world, such credibility is not normally created by incentive compatible compensation schemes nor by rigid precommitment. Rather, it is painstakingly built up by a history of matching deeds to words. A central bank that consistently does what it says will acquire credibility by this definition almost regardless of the institutional structure."

definition of informational efficiency, i.e. public information cannot be used to make abnormal profits relative to the risks being borne.

The rest of the paper is organized as follows. In the next section, we discuss the measurement of the tone of ECB announcements. In Section 3, we describe the rolling 3-month Euribor futures data. And, in order to illustrate the advantages of using high-frequency data, we analyse the futures price dynamics in specific announcement days. Finally, we provide some qualitative analysis based on number of transactions and volumes of contracts exchanged during a trading day. In Section 4, we estimate the effect of the news shock using intraday tick-by-tick data from the Euribor futures market. In Section 5, we perform some important robustness checks and sensitivity analysis. In Section 6, we discuss the implications of our findings for testing the market efficiency hypothesis in real time, and for central bank communication and monetary policy. In Section 7, we suggest some important issues left for future research and conclude.

2 Measuring the tone of ECB announcements

Since its inception, the ECB has paid a great deal of attention to its announcement policy, and especially to its choice of medium, form and content. In order to properly communicate with the public, and address the informational needs of the various target groups, politicians, academics, the press, financial markets, etc., it uses many different instruments. These include the Monthly Bulletin, the President's monthly press conference (and its Questions and Answers session), the Testimony to the Committee on Monetary Affairs of the European Parliament (four times a year)[5] and frequent speeches by its President and / or members of the Governing Council.

In its Monthly Bulletin of November 2002 (page 64), the ECB said that "The monthly press conferences held by the President and the Vice-President and the Monthly Bulletin are two of the most important communication channels adopted by the ECB." In particular, the press conference is a timely instrument to communicate concisely to the public the ECB Governing Council's view of recent economic developments. Indeed, in its Monthly Bulletin of January 2006 (page 57), the ECB confirmed that the President press conference "provides a detailed explanation of the economic outlook for the euro area and the risks to price stability. This communication is aimed at improving the public's understanding of the current decision and the possible future course of policy interest rates."

For simplicity and consistency, in this paper we restrict our econometric analysis only to the wording of the press conferences. We consider this research work as a in a broader research agenda that aims to investigate the real-time effectiveness of all ECB communication channels. It

[5] Before March 2001, this was called either Hearing before the Committee on Economic and Monetary Affairs of the European Parliament or Speech at the Parliamentary Assembly of the Council of Europe. Note that before 2002 it took place twice a year.

seems to us that the introductory statement to the monthly press conference represents a natural candidate for the first step, as it is simple, relatively short compared to the Monthly Bulletin and systematic in terms of its frequency and structure.

In order to make the European monetary authority's statements suitable for statistical computation, we assign a number to each ECB monthly announcement. This number is intended to summarize the ECB overall monetary policy stance as communicated by its Governing Council.[6]

Since words are not precise quantitative data, the ranking of statements according to their assessment (tightening, neutral or easing) of ECB future policy rate setting behaviour is necessarily influenced by personal judgement. Although we acknowledge that our assessment is subjective, it should be noted that the overall tone of ECB announcements is usually unambiguous.[7]

The classification of statements is often referred to as content analysis (Krippendorf, 2004 and Weber, 2004): it consists of a set of techniques to systematically extract the content of a message.

In order to analyse the contents of the introductory statement of the ECB President monthly press conference held on Governing Council meeting days, we follow Rosa and Verga (2006) methodology based on a glossary that translates the qualitative information of the press conferences into an ordered scale.[8,9]

When more than one word or string from Table 1 (our mapping between words and numbers) features in a given press conference, our coding corresponds to the mean of the indices of each single expression used by the ECB rounded to its nearest integer. Note that the coding attributed to the relative statement (bottom panel of Table 1) constitutes one of the components of the calculated mean of indices.

The wording indicator, *Index*, is converted into a variable on a five-value scale from -2 to +2. The value of zero suggests that the current level of the Repo rate is appropriate to maintain price stability over the medium term. The value -1 characterizes an easing period: it is possible that the Repo rate will be cut in the near future. The value -2 indicates that the Governing Council is increasingly inclined to cut interest rates. The values +1 (+2) characterizes a (strong) likelihood of future monetary policy tightening.

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[6] The seminal paper of Romer and Romer (1989) pioneered this so called narrative approach. In particular, they examined the records of Federal Reserve policy deliberations in order to identify exogenous (according to their claim) monetary policy shocks.

[7] We do however exclude one press conference (June 2000) because it does not describe the ECB overall monetary policy stance, but rather it focuses on the recent (past) economic developments.

[8] For further details about the construction of the glossary, caveats, advantages and disadvantages of this methodology, see Rosa and Verga (2006) and Rosa (2006).

[9] Even if we use other people's wording indicators of the ECB monetary policy stance, such as Gies (2005), all the econometric results that we present throughout the paper are qualitatively very similar, and remain highly statistically significant.

Our assigned value of risk, *Index*, to each ECB monetary policy announcement is reported in Table A1 of the Appendix, where we also provide a few examples of introductory statements along with our coding.

3 Euribor futures market data

3.1 Description

On 1 January 1999, the Euro became Europe's main currency. Since then, new financial markets have been set up, including Euribor, [10] the Eonia (Euro OverNight Index Average) and Euro denominated short-term interest rate derivatives market. This last gives hedgers and speculators easy access to exposure to the Euribor benchmark through trading futures contracts, options on the futures contract, and a one-year mid-curve option on the futures contract.

The three-month Euribor futures contract are cash-settled short-term interest rate financial instruments with the Euribor rate for a three-month Euro deposit of a face value of € 1,000,000 as the underlying asset.

The Euribor futures contract that we consider in this study is traded at the Euronext Liffe (London International Financial Futures and Options Exchange) from 7 to 18.[11] Futures prices are quoted on a daily basis and the contracted interest rate equals 100 less the futures price. Each contract moves in fixed increments (or discrete units / ticks) of 0.005, which corresponds to a value of 12.5 €.

The last trading day of each futures contract is two trading days prior to the third Wednesday of the delivery month, while the delivery date is the first business day after the last trading day. At a given point in time twenty-five contracts are usually being actively traded. The standard delivery months are March, June, September and December, known as quarterly expiries. There are also serial expiry contracts that expire in the nearest following six calendar months and that do not correspond to the quarterly sequence. Typically serial expiry contracts exhibit lower liquidity.[12]

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[10] The Euribor (Euro Interbank Offered Rate) is a daily reference rate based on the interest rates at which banks offer to lend unsecured funds to other banks in the euro wholesale (or "interbank") money market. Euribor is determined (fixed) by the European Banking Federation (EBF) at about 10:00 each day, and is a filtered average of inter-bank deposit rates offered by a large panel of designated contributor banks (currently more than 50), for maturities ranging from one week to one year. Euribor rates can be downloaded at www.euribor.org (last accessed on 31 August 2006).

[11] Euribor futures contracts are also traded at the Eurex (see www.eurexchange.com, last accessed on 1 October 2006). However, this market displays less liquidity than the LIFFE (anecdotal evidence provided by practitioners and traders).

[12] For instance, on 6 October 2006 twenty-five different 3-month futures contracts were displayed on a Reuters screen with the following contract expiration date: 16-Oct-06, 13-Nov-06, 18-Dec-06, 15-Jan-07, 19-Feb-07, 19-Mar-07, 18-Jun-07, 17-Sep-07, 17-Dec-07, 17-Mar-08, 16-Jun-08, 15-Sep-08, 15-Dec-08,

It is possible to build two different types of futures price time series: by position and by contract. On the one hand, position time series are constructed by merging price data of different futures contracts. At a given point in time, the first position is defined as the contract which expires next in the quarterly sequence. The second position is represented by the second contract to expire in the same quarterly sequence. The third, fourth, etc. positions are constructed similarly. On the other hand, as the name suggests, the contract time series starts on the opening date of the contract and stops when the futures contract expires.

In this paper we restrict our attention to the first position 3-month Euribor futures contracts (basically 3-month rolling futures contracts) for two reasons. First, we do not need to adjust futures prices for a different number of months left to expiration and thus we avoid unnecessary complications. For example, Piccinato et al. (1999) find that the intraday statistical properties of futures prices are a function of the time left before expiry (i.e. seasonality that depends on the "time-to-maturity" effect). Second, studying futures by position can be justified on the basis of how the futures market works. In fact, in order to stay in the market, traders holding close-to-expiry contracts need to roll their position forward into the next expiry futures contract. By doing so, they are constructing a time series by position that extends beyond the expiry of each contract.

Nowadays, the first position contract displays very high liquidity. For instance, during the last quarter of 2005, the average daily volume (i.e. number of exchanged contracts) was approximately 125,400 futures contracts, with an increase of 50% compared to the same period in 2004 (83,842 futures contracts) and 68% compared to two years earlier (74,317 in the fourth quarter of 2003).[13]

The data used in this study is provided by The Institute for Financial Markets. The dataset contains several pieces of information such as transaction by transaction price,[14] time of trade execution to the nearest second (both January 1999 - June 2006), and volumes (July 2003 - June 2006). We have trade data (transaction prices) in our database. However, we do not have bid-ask quotes.

Figure 1 shows that the rolling 3-month futures rate is very similar to, almost undistinguishable from, the 3-month-forward 3-month-ahead (implicit) Euribor rate, where this rate is derived from the Euribor term structure.

16-Mar-09, 15-Jun-09, 14-Sep-09, 14-Dec-09, 15-Mar-10, 14-Jun-10, 13-Sep-10, 13-Dec-10, 14-Mar-11, 13-Jun-11, 19-Sep-11, 19-Dec-11.

[13] Also Bernoth and von Hagen (2004) recognize the importance and very high liquidity of the Euribor futures money market.

[14] Around 2,500,000 observations (transaction ticks) for the period January 1999 to June 2006.

3.2 Specific announcement days

The ECB conduct of monetary policy is characterized by the unique institutional feature that on the same day and at two different points in time, the ECB Governing Council announces its monetary policy decision and explains its monetary policy stance. At 12:45, the ECB communicates the new level of its policy rate through a press release. After 45 minutes, at 13:30, the monthly press conference starts[15] and the ECB President explains to the public the monetary policy decision taken and also the Governing Council's view of recent economic developments. The speech is very important, especially for traders, because it conveys strong hints about the future path of ECB monetary policy.

The advantages of using high-frequency data are best illustrated in Figure 2, which reports the tick-by-tick three-month Euribor futures price movements on a set of specific days:

1) On 6 April 2006 (Governing Council meeting day), financial market participants fully anticipated no change in the policy rate. In particular, there is no sharp market reaction at around 12:45 GMT. Nevertheless, the futures price jumped up at around 14:00 (this means of course that the interest rate fell sharply). Everything happened in twenty minutes: it went from a rate of 3.085 at 13:33 to 2.98 at 13:56. One explanation could be a dovish speech given by ECB President Trichet; recall that the press conference starts at 13:30. One of his answers to journalists questions (reported below) was extremely clear about ECB future monetary policy moves, and it may shed light on the immediate response of the 3-month futures price movements. In his monthly introductory statement, the President did not mention explicitly the key word "vigilant" which seems to indicate a strong risk for policy rate spikes in the near future (cf. glossary in Table 1).

> **Question:** Mr Trichet, the markets were expecting you to say vigilance in order to prepare them or prepare for an interest rate rise in May. *You did not say vigilance, was that deliberate?* And second, did the Council discuss raising rates today?
> **Trichet:** As we do in all our meetings which concentrate on monetary policy, we discussed the issue of rates. We discussed it at length. It is our responsibility to be as clear and transparent as possible with market participants, investors and savers. *I would say that the current suggestions regarding the high probability of an increase of rates in our next meeting do not correspond to the present sentiment of the Governing Council. I would also add that the sentiment that I see from time to time in some remarks or market literature concerning the perception that we do not increase rates when we are out of Frankfurt is equally not at all the sentiment of the Governing Council.* I trust that, for the sake of clarity, transparency and simplicity, it was perhaps useful to make these two remarks. And

[15] Note that the news conference is broadcast live on the ECB website and on major cable television financial news providers, such as CNBC. The intraday statement is published on the ECB website at 12:45.

> *it is true, vigilance is not mentioned in the introductory remarks, as you very wisely remarked*. [Emphasis added][16]

This example illustrates two important points. First, the ECB is able to move asset prices using words alone, without any need for implementing policy deeds. Second, the immediate response of the futures price is consistent with semi-strong form informational efficiency.

2) On 31 March 2004, financial markets assigned a probability of around 70% that the ECB would cut its policy rate in the near future.[17]

On 1 April, Trichet turned market expectations upside down. In particular, he declared that: "On the basis of our regular economic and monetary analysis, we have not changed our assessment that the current stance of monetary policy remains in line with the maintenance of price stability over the medium term". Thus, he signalled that the ECB was not going to change its policy rate in the near future by using the keyword "in line" (cf. glossary in Table 1). As shown in Figure 2 (b), the market reacted immediately: the 3-month futures rate jumped up. The probability of a policy rate cut was drastically reduced.

3) At the beginning of November 2005, the ECB left its policy rate on hold. However, Trichet said the Bank remained highly vigilant on inflation and stood ready to raise interest rates. He added: "We stand ready to move any time when it is required by our mandate and by the situation … we are very clear that we clearly could move any time."

On Friday afternoon 18 November at around 14, at the European Banking Congress in Frankfurt, Trichet told the press that: "After two years and a half of maintaining rates at a historical low, I consider that the Governing Council is ready to take a decision to move interest rates from the present level in order to take into account the level of risk." Panel (c) of Figure 2 clearly shows that traders immediately placed bets that the ECB would increase the policy rate in December: the 3-month futures rate jumped up steeply.[18]

The takeaway of this last example is that, as long as it is not fully anticipated, ECB communication is able to move asset prices on any day, not only during Governing Council scheduled meeting days.

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[16] Note that the ECB Governing Council meeting of June 2006 was held outside Frankfurt (in Madrid) and it featured a policy rate increase of 25 basis points, as Trichet anticipated in April, while in May 2006 there was no Repo change.

[17] This probability is computed by using market-based measures of monetary policy expectations, i.e. the implied rates from the Euribor yield curve, and an ordered probit regression (whose methodology is described in Section 5) with five dependent variables: policy rate increases of 50 or 25 basis points, no change in the policy rate, policy rate cuts of 25 or 50 basis points.

[18] For example, Marius Daheim, a fixed-income analyst at WestLB AG in London, commented for Bloomberg (www.bloomberg.com, last accessed on 19 November 2005): "We would be surprised if Trichet would come out with such a strong statement if he was not sure he had the backing of the entire ECB Council."

4) Finally, Panels (d) and (e) report two cases where the news is represented by ECB monetary policy actions rather than by announcements on its overall monetary policy stance. Note that futures prices adjust immediately: in both cases it took less than 60 seconds to completely price in the monetary policy shock.

Indeed, it can be shown econometrically[19] that monetary policy shocks, defined as the difference between the one-month Euribor rate quoted at 10:00 and the new Repo rate communicated at 12:45, are incorporated in less than five minutes. In this respect, it *seems* that financial markets understand numbers better than words.[20]

3.3 Qualitative analysis of volumes and number of transactions

In this subsection in order to better understand the relationship between the price discovery process and ECB communication, we present some qualitative results on average number of transactions ticks, a proxy for the market activity, and volumes by distinguishing between Governing Council meeting days and all other trading days. In other words, we analyze how futures price volatility behaves in Governing Council days compared to all other days.

Figure 3 shows that the five-minute average number of transactions is substantially higher on Governing Council meeting days (full sample January 2000 – June 2006). A value larger than zero indicates that monetary policy decisions and communication induce a larger number of transactions than could be considered "normal" had the announcements not been made. For instance, a value of one indicates that the five-minute average number of transactions in that time window has been twice as much during Governing Council meeting days compared to all other trading days. Of course, the greater the news content of an announcement, the stronger the financial market activity should be.

It is eye-catching that there are two peaks: the first one corresponds closely to the new Repo rate announcements (12:45), while the second one takes place at the starting of the ECB President press conference (13:30). Market expectations seem to be quite heterogeneous at the time of the surprise, but then they start to converge.[21] It is interesting to note that the convergence

[19] Results are available from the authors upon request.
[20] This claim should be taken with caution because the monetary policy decision and the press conference announcement are two different kinds of news items. The former concerns a fact about the immediate future, while the latter is a probability assessment about the near future.
[21] Recall that according to no trade theorems (Fudenberg and Tirole, 1991, Chapter 14) it is impossible for risk-averse agents take opposing sides of the same purely speculative bet under common knowledge. Hence, by using the contra-positive argument, if we observe trade market participants should have heterogeneous views. Note that we are abstracting from noise trader and portfolio rebalancing considerations. In particular, even if a monetary policy action or announcement is fully anticipated by market participants, it may still trigger portfolio adjustments by those agents who deviated from on average (correct) expectations.

is much faster for monetary policy shocks than for news shock. Apparently, quantitative announcements are easier to interpret than qualitative ones.

Figure 4 plots the ratio between futures price volatility on Governing Council meeting days with respect to all other days. [22] Again, two pieces of news seem to systematically hit the market. Moreover, it is clear that futures prices incorporate the first one, the monetary policy shock, very quickly.

These findings are completely corroborated if we use average volumes rather than either average number of transactions or asset price volatility. In Figure 5 we plot the ratio between average volumes on Governing Council meeting days and all other days for the sample period July 2003 – June 2006.[23] Contrary to Figure 3 and 4, financial market participants' expectations of future monetary policy actions now seem to be less heterogeneous than their expectations about ECB announcements.

This result is also confirmed by Figure 6, which plots the ratio between the average number of transactions on Governing Council meeting days and all other days restricting the sample period to July 2003 – June 2006.

A possible explanation for this phenomenon is that ECB monetary policy actions have recently become more predictable than at the beginning of its life. Indeed, Figure 7 plots the monetary policy shock[24] for the whole sample (January 1999 – June 2006) and shows that its absolute value is much smaller nowadays. Recall also that from June 2003 to December 2005 the ECB did not move its policy rate.

Hence, on Governing Council meeting days two pieces of news systematically hit financial markets: the ECB policy rate decision (standard in the literature), and the explanation of its monetary policy stance. In order to describe central bank monetary policy we need two dimensions: both the current policy rate and its future path. We conclude that, at least qualitatively, financial markets seem to pay attention to both news items.

4 Tick-by-tick data: econometric results

In this section we estimate the impact of unexpected central bank announcements on the short-end of the term structure, using a *new* tick-by-tick dataset from the Euribor futures market

Since we are interested in investigating and measuring only the innovations in expectations caused by the ECB President's press conference, we restrict our econometric

[22] We use the absolute deviation of the (5-minute window) futures prices because it better captures the autocorrelation and the seasonality of the data (Piccinato et al., 1999) compared to the more usual standard deviation definition. For completeness, the latter measure of the volatility is also computed. There are no significant differences between the two definitions.
[23] Recall that we do not have volume data before July 2003.
[24] In Figure 7, we shift down monetary policy shocks by 0.11, which captures the equilibrium (liquidity and risk) spread between the one-month Euribor and the Repo rate.

analysis to Governing Council meeting days. In other words, we apply a standard event-study approach.[25]

The initial task of conducting an event study is to identify the so-called event window, the period over which the asset price involved in the event is examined.

We first introduce some definitions and notations. Let the event take place today (date *t*) at time *t2* and define the event window between the interval *t1* and *t3*. The timing sequence is illustrated in Figure 8.

Our goal is to analyse the abnormal asset price change between *t3* (post-event window) and *t1* (estimation period). The abnormal asset price change is defined as the difference between actual ex-post security price change over the event window and its normal change. In turn, the normal change is defined as the change that would be expected if the event did not take place. In the literature, there are two common choices for modelling the normal return (cf. Campbell et al., 1997, p. 153): the constant-mean-price-change model (used later in this chapter) and the market model. The first model assumes that the mean change is constant over time. The second posits that there is a stable linear relationship between the market movements and the security return.

In order to check whether financial markets react to ECB communication, it is crucially important to realize that the news does not consist of the ECB announcement itself but rather by its unexpected component, i.e. the difference between what the ECB declares and what the market expects the ECB to declare. Therefore, to verify empirically the effectiveness of ECB words, we need to proceed in two steps. First, we have to pin down what the market expects the ECB to declare. Second, we investigate the sensitivity of asset prices to the news shock.

We first posit and then verify empirically that the market tries to predict the ECB announcement through the following regression:

$$E_{t1}\,[Index_{t2}] = \alpha + \gamma_1\,(f_{t1} - R_{NEW}) + \gamma_2\,Index_{t1} \qquad (1)$$

where $E_{t1}\,[.]$ stands for the expectation conditional on time *t1* information set, that is immediately before the ECB President press conference takes place. α is a constant and γ are regression coefficients. f_{t1} stands for the Euribor futures rate quoted on day *t* from *t1* averaged over a 15-minute window.[26] R_{NEW} stands for the new Repo rate level communicated at time 12:45.

[25] See Mackinlay (1997) and Campbell et al. (1997, Chapter 4) for a survey of the event study methodology. In this case, a clear advantage of using an event-study analysis is that it can attenuate or even eliminate the joint hypothesis problem intrinsic in all statistical tests of the market efficient hypothesis (i.e., market efficiency must be tested jointly with an asset pricing model). In other words, we do not need to specify a model of market equilibrium. Moreover, the way we measure daily abnormal innovations in market expectations (our dependent variable) has little impact on inferences (cf. Brown and Warner, 1985).

[26] We use a 15-minute average quotation rather than specific ticks, since the initial reaction of bond prices to the "unexpected" ECB announcement may be larger (overshooting) than its "true" effect (cf. Faust et al., 2004). Asset prices should incorporate news instantaneously but actually do not. This procedure may introduce a possible bias in our estimations (cf. Blume and Stambaugh, 1983). Nevertheless, we think that

We assume that *Index* follows an AR (1) process: the economic environment usually does not change too much in the course of one month

Moreover, if the futures rate (net of the risk premium already captured by α [27]) is higher than the new level of the Repo rate, then the market expects the ECB to increase its policy rate in the near future. Hence, other things being equal, it expects a greater value of *Index* to be announced. In other words, if the very short-end of the term structure is upward sloping, a hawkish declaration is likely. Vice versa, if the short-end of the term structure is downward sloping, then the market expects the ECB to cut its policy rate in the near future. It expects a dovish announcement.[28]

Note that to be successful, an event study has to identify precisely both the date of the event and the new (unexpected) information released. Obviously, in a rational marketplace, prices do not respond to old information. The issue of anticipated announcements is successfully dealt by our approach, since we use the very latest (indeed, real-time) information to construct market expectations about ECB declarations, viz. the slope of the term structure immediately before the ECB President press conference takes place..

In order to have a straightforward interpretation of our empirical results we have firstly used Ordinary Least Squares (OLS) estimation with White-t statistics (White, 1980). Table 2 reports the estimated OLS coefficients of Equation (1) for the period January 2000 – June 2006.[29]

The independent variables explain 80% of the announced tone of ECB President's declaration. The coefficient on the previous month announcement (γ_1) belongs to (0,1) implying a stable AR process. The coefficient on the slope of the term structure is around one and is also statistically significant at the one percent level. Hence, a difference between the futures rate and the ECB policy rate of 100 basis points (i.e., 1%) implies that financial market participants expect, ceteris paribus, a higher level of our wording indicator of around 1 point. Furthermore,

---

this bias is not important since we consider a very liquid market. Ideally, we want to give more importance to a quotation price that corresponds to a high traded volume. However, we can not construct average futures prices weighted by volumes, since volume data are available only from July 2003.
Note that none of the econometric results reported in this paper would change if we used a 30-minute window rather than a 15-minute one to compute average futures rates (results not reported but available upon request).

[27] On the one hand, the futures contract is different from a Repo contract stipulated with the central bank. On the other, the futures contract refers (more or less) to a three-month-ahead three-month-forward rate, while the Repo refers to an immediate one-month-forward rate. Hence, a more sophisticated approach would consider a risk premium that varies over time. In this case, business cycle indicators, such as the default spread (i.e., a return increase from high-grade to low-grade bonds, from bonds to stocks, and from large to small stocks) and term spread (i.e., premium for maturity risks form long-term to short-term securities), track risk premium dynamics.

[28] Of course, our implicit maintained hypothesis is that financial markets form expectations rationally using all available information.

[29] Our dataset starts in January 1999. However, on the one side we consider the year 1999 as a learning period to well interpret ECB announcements. On the other, the practitioners whom we consulted suggested us that the Euribor futures market was not very liquid in the beginning. This fact is confirmed by volume and number of tick data in 1999 compared to the following years.

the constant is very close to zero, indicating that there is no bias in the ECB assessment of the balance of risks.

Figure 9 shows the futures rate response to unexpected hawkish, neutral and dovish announcements made by the ECB President during the monthly press conference. A statement is defined hawkish when the news surprise, the difference between $Index_{t2}$ and $E_{t1}[Index_{t2}]$ as given by Equation (1), is higher than the median of the positive news shocks observed in our sample period (i.e. 0.184). Vice versa, a statement is defined dovish when the news surprise is lower than the median negative news shock observed in our sample period (i.e. -0.367). In the remaining cases, the central bank statement is classified as neutral.[30]

Overall, the price response is consistent with the sentiment of the news. Indeed, futures rate increase after an unexpected hawkish announcement, decrease after a dovish one, and are basically unaffected by neutral declarations.

However, there are marked differences in the pattern and magnitude of the responses. In particular, the reaction to future monetary tightening announcement is much stronger (almost double size) than to monetary easing statements. Moreover, dovish announcements are usually followed by a small and quick reversion: it seems that market participants need more time, around one hour, to correctly interpret monetary easing announcements. This phenomenon can be due to the difficulty of market participants in understanding the de facto almost lexicographic ECB utility function, where price stability represents the primary objective. Only without prejudice to it, the European monetary authority can legitimately pursue other objectives such as employment and output.[31]

So far, a dovish ECB statement has been characterized by two components (see, for example, the excerpts reported in the Appendix): no risk to price stability together with contemporaneous downward economic danger. It turns out that traders need not only the information contained in the introductory statement to the monthly press conference, but also its questions and answers, and some additional processing time, to correctly distinguish a neutral statement, where only no risk to price stability is reported, from a dovish declaration.

We now test econometrically the effectiveness of ECB communication by estimating the following regression:

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[30] Note that Figure 9 is qualitatively unaffected if we use the third quartile (75%), rather than the median, to define the unexpected tone of the announcement.

[31] Article 105 of the Maastricht Treaty states: "The primary objective of the ESCB shall be to maintain price stability. Without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Community with a view to contributing to the achievement of the objectives of the Community as laid down in Article 2" [i.e., "the objectives of the Union are a high level of employment and sustainable and non-inflationary growth"]. Moreover, according to the ECB website (http://www.ecb.int/mopo/intro/html/objective.en.html, last accessed on 15 August 2006): "The Treaty establishes a clear hierarchy of objectives for the Eurosystem. It assigns overriding importance to price stability. The Treaty makes clear that ensuring price stability is the most important contribution that monetary policy can make to achieve a favourable economic environment and a high level of employment."

$$f_{t3} - f_{t1} = \alpha + \beta\, NS_{t2} + \varepsilon_{t3} \qquad (2)$$

where NS_{t2} stands for news surprise just after ECB announcements. The rest of the notation is the same as above.

Table 3 reports the estimations for three different time windows, specifically for *t3* = 14:45, 15:45 and 16:45, and *t1* = 13:15 (all averaged for a 15-minute interval).

It turns out that the coefficient on the news shock (β) is always positive (as expected), and statistically significant at the 1% level: the news shock can systematically explain the futures price change around the time of ECB President's announcements.

Table 3 suggests that the ECB can influence the money market interest rates to some extent simply by using words, rather than deeds, such as a change in its policy rate. For example, when the ECB President declares: "It is imperative to contain upward pressure to price stability", while the market is expecting a value of *Index* of zero, the futures rate jumps up on average by about 4 basis points.[32] This finding shows that the ECB unexpected announcements have a significant and sizeable impact on futures prices.

So far, we have shown that asset prices react to ECB communication, but how long does it take? In other words, what is the degree of efficiency (i.e., the speed with which prices incorporate information) of the Euribor futures market? We answer this question, and hence we measure the speed of futures price response to ECB announcements, by estimating the following regression for different f_t:

$$f_{17:00} - f_{13:15} = \alpha + \beta\, NS_{t2} + \gamma\,(f_t - f_{13:15}) + \varepsilon_{t3} \qquad (3)$$

where f_t stands for the (15-minute average) futures rate at time t.

Table 4 clearly indicates that as time unfolds futures rates incorporate more and more the news shock. At around 15:00, unexpected announcements are no longer significant. In other words, in about one hour after the ending of the press conference, futures prices have completely incorporated the news originating from the ECB President monthly press conference.[33]

The seemingly quick adjustment in asset prices is consistent with the semi-strong form of market informational efficiency. In particular, widespread profitable trading opportunities do not persist for long.

---

[32] Because of attenuation bias due to measurement error in the explanatory variable (Johnston and DiNardo, page 154) of Equation (2) (also due to the artificial discreteness of our wording indicator), this number should be interpreted as a lower bound on ECB ability in moving asset prices by simply making announcements.

[33] These results should not be taken as completely definitive. Our relatively small sample size leads to higher standard errors, making it difficult to estimate the precise speed of price adjustment and, specifically, when the adjustment is completely over.

To further illustrate this last finding, we also estimate the effect of news shocks after 15:00. In Table 5 we report the estimations of the following regression:

$$f_{t4} - f_{t3} = \alpha + \beta NS_{t2} + \varepsilon_{t3} \quad (4)$$

where both *t4* and *t3* are placed after the ECB President's announcement. More precisely, *t3* is the 15-minute average price quotation starting at 15:00 and *t4* is the 15-minute average starting at 17:30, and 9:00 and 11:00 of the day after the ECB Governing Council meeting.

As we expect, neither the constant nor the news shock can systematically explain the futures price change.

5 Robustness checks: Ordered Probit and generated regressor issue

5.1 Ordered Probit on *Index*

There is a logical problem in estimating Equations (1) by OLS. The wording indicator variable, $Index_{t2}$, takes only discrete values (i.e., integers from -2 to +2). But OLS predicts by construction a continuous dependent variable. We check whether our results hold even if we estimate expected ECB announcements using ordered probit regression.

Before presenting empirical results, in order to understand the mechanics of discrete dependent variable models, we briefly review the underlying econometric methods.

Ideally, we want to estimate the following regression:

$$[Index_{t2}]^{OPT} = \alpha + \gamma_1 (f_{t1} - R_{NEW}) + \gamma_2 Index_{t1} + \varepsilon_t \quad (5)$$

where ε_t is assumed to be normally distributed $N(0,\sigma^2)$ and captures ECB "communication" errors and potential regression misspecifications. $[Index_{t2}]^{OPT}$ stands for the Governing Council's optimal announced hawkish level at time t_2.

However, we cannot estimate Equation (5) directly, because $[Index_{t2}]^{OPT}$ is not observed by market participants (i.e., it is a latent variable). Instead, both the public and the econometrician observe the realized $[Index_{t2}]$, which as we mentioned earlier takes five different values (and hence is a censored variable). In particular,

$[Index_{t2}] = -2$ if $[Index_{t2}]^{OPT} \leq \delta_1$

$[Index_{t2}] = -1$ if $\delta_1 < [Index_{t2}]^{OPT} \leq \delta_2$

$[Index_{t2}] = 0$ if $\delta_2 < [Index_{t2}]^{OPT} \leq \delta_3$

$[Index_{t2}] = +1$ if $\delta_3 < [Index_{t2}]^{OPT} \leq \delta_4$

$[Index_{t2}] = +2$ if $\delta_4 < [Index_{t2}]^{OPT}$

The realized $Index_{t2}$ depends on the magnitude of the optimal $Index_{t2}$ with respect to the threshold parameters δs, which are estimated jointly together with the regression coefficients of Equation (5).

Since we use an ordered probit model, the probabilities of observing $Index_{t2} \in \{-2,-1,0,+1,+2\}$ can be shown to be (cf. Ruud, 2003, chapter 27):

$$
\begin{aligned}
&\text{Prob}\,(Index_{t2} = -2) = \Phi((\delta_1 - \gamma_1 (f_{t1} - R_{NEW}) - \gamma_2 Index_{t1})/\sigma) \\
&\text{Prob}\,(Index_{t2} = -1) = \Phi((\delta_2 - \gamma_1 (f_{t1} - R_{NEW}) - \gamma_2 Index_{t1})/\sigma) - \Phi((\delta_1 - \gamma_1 (f_{t1} - R_{NEW}) - \gamma_2 Index_{t1})/\sigma) \\
&\text{Prob}\,(Index_{t2} = 0) = \Phi((\delta_3 - \gamma_1 (f_{t1} - R_{NEW}) - \gamma_2 Index_{t1})/\sigma) - \Phi((\delta_2 - \gamma_1 (f_{t1} - R_{NEW}) - \gamma_2 Index_{t1})/\sigma) \\
&\text{Prob}\,(Index_{t2} = +1) = \Phi((\delta_4 - \gamma_1 (f_{t1} - R_{NEW}) - \gamma_2 Index_{t1})/\sigma) - \Phi((\delta_3 - \gamma_1 (f_{t1} - R_{NEW}) - \gamma_2 Index_{t1})/\sigma) \\
&\text{Prob}\,(Index_{t2} = +2) = 1 - \Phi((\delta_4 - \gamma_1 (f_{t1} - R_{NEW}) - \gamma_2 Index_{t1})/\sigma)
\end{aligned}
\tag{6}
$$

where $\Phi(.)$ denotes the standard normal cumulative distribution function. Moreover, we assume that $\delta_0 = -\infty$ and $\delta_5 = +\infty$.

The log-likelihood function is:

$$
L \equiv \sum_t \sum_{j=-2}^{+2} 1\{Index_{t2} = j\} \cdot \log \left[\Phi\left(\frac{\delta_{j+3} - \gamma_1 (f_{t1} - R_{NEW}) - \gamma_2 Index_{t1}}{\sigma} \right) - \Phi\left(\frac{\delta_{j+2} - \gamma_1 (f_{t1} - R_{NEW}) - \gamma_2 Index_{t1}}{\sigma} \right) \right] \tag{7}
$$

where $1\{.\}$ stands for the indicator function, which takes value one when the event specified in brackets is true and zero otherwise.

We can now estimate the regressor coefficients by maximizing (7) numerically with respect to them. Note that the constant term in (5) cannot be identified separately from the δs. Moreover, all coefficients are identified up to a proportionality factor: as standard in the literature, we normalize σ to one.

Since the empirical reaction function is formulated in terms of the latent policy rate, the parameter estimates do not have the usual interpretation: the marginal effect depends both on the dependent variable and on the time t of the explanatory variables, making them cumbersome to report.

The goodness of fit can be measured by the pseudo R^2, also known as McFadden's likelihood ratio index, which is given by:

$$\text{pseudo } R^2 \equiv 1 - \ln(L/L^*) \quad (8)$$

where L^* stands for the value taken by the likelihood function when there are no time-varying regressors.

Note that (8) takes values ranging from 0 and 1 (as the standard R^2). Moreover, it is related to a likelihood ratio test of the null hypothesis that all slope parameters are zero (i.e., $-2\ln(L/L^*)$).

In Table 6 we report the estimation of Equation (1) using ordered probit regression. In particular, we have jointly estimated six regression coefficients: specifically γ_1 and γ_2 (see Equation 1), and four threshold parameters δs.

All regressor coefficients are significantly different from zero much below the 1% critical level. The goodness of fit as measured by pseudo-R^2 is also quite high.

We construct market participants' expectations about the ECB announcement as follows:

$$E_{t1}[Index_{t2}] = \sum_{i=-2}^{2} \Pr(Index_{t2} = i) \cdot i \quad (9)$$

where $\Pr(Index_{t2})$ is computed analytically as shown in Equation (6).

We first redefine the news shock as the difference between our wording indicator, $Index_{t2}$, and market expectations, $E_{t1}[Index_{t2}]$, derived in Equation (9). We then re-estimate all equations of Section 4 using our new measure of central bank unexpected declaration.

In general, all the econometric results presented in Section 4 hold both qualitatively and quantitatively (cf. Table 7, 8, and 9).

Interestingly, the magnitude of the coefficient of the news shock of Table 7 is systematically larger than in Table 3. Moreover, its significance level is also higher. These facts seem to suggest that the ordered probit regression copes better with the measurement error problem of the explanatory variable news shock.

5.2 Generated regressor issue

So far the econometric estimations have been carried out in two steps. First, we determine market expectations about ECB announcements immediately before the start of the press conference. Then, we use the news shock to explain the futures price discovery process. In other words, in the second step we employ generated regressors (cf. Oxley and McAleer, 1993).

This fact may give rise to underestimated standard errors and hence to spurious significant regressor coefficients. In order to solve this issue and to check the statistical validity

of our conclusions, we also re-estimate the same regressions of the previous subsection all in one step. More formally, we estimate the following regression by OLS:[34]

$$f_{t3} - f_{t1} = c_1 + c_2 \cdot (Index_{t2} - c_3 \cdot (f_{t1} - R_{NEW}) - c_4 \cdot (Index_{t1})) + \varepsilon_{t3}$$

$$f_{17} - f_{13:15} = c_1 + c_2 \cdot (f_t - f_{13:15}) + c_3 \cdot (Index_{t2} - c_4 \cdot (f_{t1} - R_{NEW}) - c_5 \cdot (Index_{t1})) + \varepsilon_{t3}$$

$$f_{t4} - f_{t3} = c_1 + c_2 \cdot (Index_{t2} - c_3 \cdot (f_{t1} - R_{NEW}) - c_4 \cdot (Index_{t1})) + \varepsilon_{t3}$$

where *c*s are regressor coefficients, and the rest of the notation is the same as before.

Tables 10, 11, and 12 show that all the econometric results continue to hold both qualitatively and quantitatively.

6 Discussion

6.1 Testing the market efficiency hypothesis in real time

In this paper we investigate the effect of a new type of news item, specifically the information originating from central bank announcements (cf. next subsection), in real time.

Since the early studies of market efficiency,[35] many changes have taken place in security markets. In particular, the technology revolution of the last decade has dramatically accelerated the pace at which information becomes publicly available and at which market participants operate. For this reason, even though in practice prices do not respond instantaneously to news, nowadays market efficiency should really be gauged in real time (Busse and Green, 2002).

One major contribution of this paper consists in providing a methodology to pin down the *true real-time news*. Obviously, in a rational market place, prices do not respond to old information.

We address this issue by defining the news (shock) as the difference between what the ECB announces and what the market expects the ECB to announce. Notice that in our empirical exercise market participants form expectations rationally (using all available information) and in real time, just immediately before the press conference takes place.

European money market rates should not be driven by the tone of the ECB declaration, but rather by its unexpected component. For instance, if the ECB had been dovish in the last three months, a further dovish announcement today would not be completely unexpected.

[34] Alternatively, bootstrap methods can be used to artificially introduce more uncertainty in the standard error estimations.
[35] For two excellent surveys, see Fama (1991 and 1970).

To test this hypothesis, we re-estimate the regressions reported in Tables 3 and 4 by adding the tone of ECB announcements, our wording indicator $Index_{t2}$, as right-hand side explanatory variable. More formally, we estimate the following equations:

$$f_{t3} - f_{t1} = \alpha + \beta_1 NS_{t2} + \beta_2 Index_{t2} + \varepsilon_{t3}$$
$$f_{17:00} - f_{13:15} = \alpha + \beta_1 NS_{t2} + \beta_2 Index_{t2} + \gamma (f_t - f_{13:15}) + \varepsilon_{t3}$$

We find (see Table 13 and 14) that the coefficient of the news shock is statistically and economically significant as before. Instead, in only one case the coefficient on *Index* is marginally significant (p-value 0.047), however it has the wrong sign (i.e. an hawkish ECB announcement decreases market rates).

The news shock is equal to *Index* in only one special case, i.e. when the market expects a neutral ECB announcement. In general, if we use *Index*, instead of the news shock, as explanatory variable our model is misspecified and of course the estimations are biased.

The above observation, namely only unexpected announcements move asset prices, has important implications for studying the price adjustment process that follows other news events, such as analysts' recommendations. In particular, in this latter case the news is not represented by the face value of the broker's recommendation, viz. buy or sell, but rather by its unexpected component, the difference between the recommendation and what the market expects to be recommended. In other words, in order to have consistent and unbiased estimates, we need to construct a (real-time) measure of the news that is free of endogenous and anticipatory movements.[36]

Our study also adds to the empirical finance literature by assessing the degree of informational efficiency of a *new European money market*. By doing so, we address two shortcomings of the existing literature.

First, we analyze a *money market* while most empirical studies focus on the foreign exchange and stock market. Understanding the price formation process in the short-term interest rate market is crucial for central bankers, consumers and producers alike. On the one side, the efficacy of the transmission mechanism of monetary policy relies on a well developed financial system, and in particular on the existence of an efficient money market. On the other side, short-term interest rates are important for households and firms saving and investment decisions because of the expectations hypothesis of the term structure[37] and because of various forms of contractual indexation.

[36] Note that Busse and Green (2202, page 422) recognize this problem but do not solve it. In fact, they observe: "The small response to positive [analysts'] reports during the Morning Call suggests that the segment provides information that is (…) not new."

[37] This states that the d-day market interest rate can be expressed as the average of current and expected future overnight rates, plus a risk-liquidity premium. In other words, by an arbitrage argument, two

Second, we investigate the efficiency property of a *European financial market*, while most finance literature studies US markets. Even though the euro area is a relatively new integrated economic region, nowadays euro-denominated financial assets are not only highly liquid and traded in well developed financial markets but also enough data are available for reliable econometric analysis.

6.2 Central bank communication and monetary policy making

Central bank communication and its effects on financial markets have recently received increasing attention in the monetary economics literature both theoretically (Woodford, 2005) and empirically (Ehrmann and Fratzscher (2005a,b,c) Gerlach (2004), Heinemann and Ullrich (2005), Kohn and Sack (2003), Jansen and deHaan (2006a,b, 2005)).

A possible explanation may be the substantial change in the way central banks communicate with the public, and more specifically with financial markets.[38] Only twenty years ago monetary policy was surrounded by secrecy (Goodfriend, 1986), while nowadays there is a strong emphasis on central bank transparency (Ferguson, 2002 and Bernanke, 2004).

Central bankers motivate the need for transparency on the basis of two main reasons (see, for example, Issing, 2005).[39] First, since central banks are granted by legal status (at the very least instrument) independence, and their board is not democratically elected, good governance practices call for them to be accountable. In order to fulfill the basic requirement of accountability, central banks should be transparent. Second, transparency is a necessary ingredient to enhance the efficiency of monetary policy. Central banks can directly control only the very short-run nominal interest rates, but aggregate-spending decisions are closely related to interest rates of all maturities.[40] Therefore, the management of financial market expectations has become a crucial instrument in monetary authority's hands to affect the overall course of the economy. Sound credibility and good communication skills (to direct market expectations) are essential tools for the effective working of a modern central bank.

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equivalent borrowing options should have the same expected cost (cf. for example Dotsey and Otrok, 1995).

[38] In turn this may be due to a paradigm shift in central bank practices. In fact, as Woodford (2003, page 3) notes: "The adoption of 'inflation targeting' (…) is characterized not only by public commitment to an explicit target, but also by a commitment to explain the central bank's policy actions in terms of a systematic decision-making framework that is aimed at achieving this target". In other words, transparency and communication have become an integral element in the definition of monetary policy.

[39] Carpenter (2002) and Geraats (2002) provide an excellent overview of the theoretical and empirical literature on the transparency of monetary policy.

[40] Blinder (1998, page 30) notices: "the interest-sensitive components of aggregate demand react mainly to the real long rate while the central bank controls only the nominal short rate." Indeed, Woodford entitles one paragraph of his monograph (2003) "Central banking as management of expectations". Moreover, he explains (ibid., page 15): "Not only do expectations about monetary policy matter, but, at least under current conditions, very little *else* matters… the current level of overnight interest rate *as such* is of negligible importance for economic decisionmaking."

We provide clear and easily interpretable evidence that the conduct of modern monetary policy can be best described on two dimensions: both central bank actions and central bank words.[41]

The type of analysis made by Kuttner (2001), based only on monetary policy shocks, (i.e., a single factor), seems to be not completely adequate to describe central bank interest rate setting behaviour. Nowadays, central banks have adopted a more and more transparent conduct of monetary policy up to pre-announcing their future policy moves. Hence, central banks mostly affect asset prices through their bias statements (a second policy instrument) by influencing financial market expectations of their future policy actions, rather than by unexpected deeds, i.e. monetary policy shocks. We show that the former effect is not only significant but has also a sizeable impact on futures prices.

Like Rosa and Verga (2006), in this paper we also examine the effect of ECB communication on the price discovery process for the European money market rates. However, we use *high-frequency intraday data* rather than daily data.[42] This is a crucial improvement because it allows to fully exploiting the unique institutional feature of ECB monetary policy conduct (i.e. on the same Governing Council meeting day, the ECB announces its policy decision and explains its monetary policy stance in two different points in time). Hence, we can distinguish one surprise, monetary policy shock, from the other, news shock.[43] So, on the one side, we do not need to worry about the exogeneity assumption of the monetary policy shock. On the other, we do not need to implement complicated identification procedures.[44] Moreover, on a typical Governing Council meeting day a large, potentially uncountable, number of news items hit the financial market, which make our estimates much more efficient, resulting in smaller standard errors in the coefficients of the news shock.[45]

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[41] Also Bomfim (2003) and Gurkaynak et al. (2005) find that at least two factors are required in order to capture adequately the effects of U.S. monetary policy on asset prices. They interpret the first one as the current federal funds target rate and the second one as the future path of policy, which is closely associated with FOMC announcements. We solve a related empirical exercise. However, as we use a very intuitive and simple approach, our results are much more straightforward to interpret.

[42] Moreover, we look at the Euribor *futures* market, instead of the Euribor market.

[43] Since writing this paper, we have learned that a very recent paper by Brand et al. (2006) also investigates the impact of ECB monetary policy decisions and communication on the yield curve by using high-frequency data. However, there remain important differences with the present work. First, the methodology is different: we show that the news shock explains innovations in futures prices, while they extract surprise measures from the money market yield curve. The dataset used is also different: we use futures tick-by-tick data from LIFFE (and we complement our analysis by studying volumes and number of transactions data), while they use real time quotes of deposit and swap rates from Reuters observed at five minute intervals.

[44] In this respect, Rigobon and Sack (2004) and Guimaraes and Goncalves (2006) solve the simultaneity problem through a heteroskedasticity-based method of identification. They exploit the fact that on days of FOMC meetings the variance of policy shocks increase. Cochrane and Piazzesi (2002) and Faust et al. (2003) both propose a high-frequency identification procedure.

[45] However, note that the regressor coefficients estimated using daily data are not biased as long as the kind of news that hit the market during Governing Council meeting days is not systematic.

Romer and Romer (2004) also develop a measure of *unanticipated* policy deliberations. They regress their previous (1989) measure of Federal Reserve's intentions for the Federal funds rate around FOMC meetings on the Federal Reserve's internal forecasts. However, they use simply one dimension to describe monetary policy conduct.

In Figure 7 we show that the absolute magnitude of the monetary policy shocks has substantially decreased over time, and this is true even when the official rate has been changed. In the year the source of the surprise was often represented by the President press conference rather than by the announcement of the monetary policy decision. In this respect, a change in emphasis within the press conference has also taken place. In particular, in recent months the introductory statement has simply conveyed the overall monetary policy stance communicated by the Governing Council, and its content was similar to what the market expected, while through the Questions and Answers section the ECB now sends fairly unambiguous signals about the likely future dynamics of policy rates (see Table 15).

There is an open question that this paper brings to the fore: if the words of the ECB President can be easily and unambiguously quantified in the way we suggest, then the question presents itself why this piece of information is not presented in a precise numerical form, analogous to the ECB policy rate decision.

At the moment there is a debate in central bank circles and academic economists alike about the optimality of explicitly announcing the future path of policy rates (Svensson (2006a)[46], Giavazzi and Wyplosz (2006a, b), and Goodhart (2006, 2005); see Table 16 for a highlight of the pros and cons).

We think that the ECB is following Svensson's advice of publishing conditional policy rate forecasts. On the one hand, by using sentences such as "[we] never pre-commit to any kind of level" or "as far as we are concerned, we will do what is necessary to do in our own judgement" or "we will do what is necessary to do",[47] the ECB is clearly pointing out the *conditional* nature of its bias announcements. On the other hand, even though the ECB employs words rather than fan charts to announce its future policy intentions, this difference of form is more philosophical than substantial given the high uncertainty surrounding quantitative policy rate projections published in fan charts (they usually feature large confidence bands).

It seems to us that the ECB is also following Goodhart's suggestion (2005) to be cautious. In fact, it announces policy rate intentions only for the very near future, anticipating that

[46] He notes that the Reserve Bank of New Zealand and the Norges Bank have set a model for other central banks. These two banks publish projections two years ahead, with fan charts indicating the degree of uncertainty and with ample discussion and justification of the projections, including alternative scenarios, cross-checking with alternative policy rules, and the application of a list of criteria of optimal instrument-rate projections.

[47] Cf. for example the press conference held on 31 August 2006, available at http://www.ecb.int/press/pressconf/2006/html/is060831.en.html (last accessed on 1 October 2006).

after this period the uncertainty of the economic environment is getting too large: after all central banks are not omniscient!

As we mentioned at the beginning of this subsection, central banks directly control only a very short-term interest rate, while they need to influence interest rates at all maturities in order to conduct an effective monetary policy and thus achieve their aims. Moreover, monetary policy makers are much more interested in the futures price impact of their announcements over longer horizons, rather than the precise estimates of the timing and impact of news, i.e. its initial reaction.

Table 17 provides the futures price change for four weeks, 22 trading days, following the ECB President press conference. Unexpected hawkish or dovish announcements are defined as in Section 4, specifically as in Figure 9.

It is interesting to see that the initial impact to ECB statements is part of a larger, long-term reaction. However, the evidence indicates that there is an asymmetric long-term response. On the one hand, the futures price change becomes increasingly negative and increasingly significant during the month after a dovish announcement. This statistical pattern is uncovered despite standard errors increase with the measurement interval, and so even if the multi-day tests lack power against the alternatives that the price react permanently to the tone of the central bank declaration over the following month.[48] On the other hand, futures prices increase, but not in a statistically significant way, by about 3-4 basis points after an hawkish announcement and maintain the new level over the following month.

Overall, we provide strong and economically relevant evidence that central bank communication impacts futures prices permanently, and not only transitorily. Hence, central bankers' announcements seem to be a very powerful tool to systematically drive market expectations and eventually, through it, the actual evolution of the real economy.

7 Conclusions

Event study analysis is now an important part of finance, especially corporate finance where it is used to highlight empirical regularities in the response of stock prices to investment decisions, financing decisions, and changes in corporate control. In this paper, we apply its methods in order to investigate the reaction of asset prices to unexpected central bank announcements.

Given the unique institutional features of ECB monetary policy conduct, we think that high-frequency intraday is the proper frequency for our event-study analysis. Since the news shock and monetary policy shock hit the financial market in two different point in time, not only

[48] Technically, future prices follow a unit-root process, thus the variance of futures price changes between date t and $t+m$ is proportional to m.

we can tell apart one surprise from the other, but we can also investigate their effect independently.

The interpretation of central bankers' statements and actions is of considerable importance to monetary policymakers, financial market participants, and more generally the overall public.

In this paper we analyze the relationship between central bank words and deeds and changes in asset prices. More specifically, we examine the effect of European Central Bank communication on the price discovery process in the Euribor futures market using a *new* tick-by-tick dataset.

First, we find that the number of transactions and the number of exchanged futures contracts (volume) data confirm that two news items systematically hit financial markets on Governing Council meeting days: ECB policy rate decision and the explanation of its monetary policy stance.

Second, we show that when the tone of the press conference is different from what the market expects, the futures rate experience a statistically and economically significant quick (less than an hour) reaction. Put it differently, we show that communication is an important tool in the process of conducting monetary policy stance.

Finally, our results suggest that the Euribor futures market is semi-strong form informational efficient.

The fact that the ECB is able to move asset prices by simply using words seems to indicate that financial markets believe that the European Central Bank does what it says it will do. In other words, even if it is a relatively young central bank, the ECB has already acquired some reputation for telling the truth. Hence, the ECB has already built up some credibility capital. However, credibility is a matter of degree and this paper does not answer the question of how credible the Central Bank is.

There are of course several important issues not considered here, which require further study.

To interpret an event study, we need to assess quantitatively our ability to detect the presence of an abnormal asset price change. In other words, we also need to evaluate the power of the test, that is the probability of rejecting a false null hypothesis (i.e., ECB unexpected announcements have no impact on the behaviour of asset prices).

In this paper we make specific assumptions about the distribution of abnormal price changes. Hence we use parametric estimation methods. Alternatively, non parametric methods (such as either the sign or the rank test), which are free of specific distributional assumptions, are available and can be used.

As a first step, we restricted our sample to Governing Council meeting days. It would be interesting to extend our analysis to include all ECB President speeches. We would thus be able

to break down news shocks further into two separate factors: path (change in the near-term path of policy expectations) and time (changes in the expected timing of policy speeches). Moreover, we could also disentangle and separate news about the future path of monetary policy from news about the future economic outlook i.e., the evolution of macroeconomic or monetary variables, such as output, price indexes, exchange rates, M3 growth, etc.

We test market efficiency in real time. We look at the effects of ECB President announcements on Euribor futures rates using a new high-frequency dataset. We explain price changes but we do not statistically investigate the informational content of the number of observations and volumes (number of exchanged contracts) within a specific time interval (Demos and Goodhart, 1996).

We apply standard event study econometric methods, but at the same time we overlook market microstructure issues, such as non-synchronous trading effects (transactions usually take place at time intervals of irregular length and thus transaction data are sampled at irregular random intervals) and price discreteness (prices are always quoted in discrete units). We believe that the three-month futures market institutional structure can be safely ignored for our purpose of assessing the response of asset prices to ECB unexpected announcements. However, it is possible that our results could be biased (cf. Campbell et al., 1997, Chapter 3), the computation of further diagnostic tests could be particularly fruitful to gauge the robustness of our preliminary findings.

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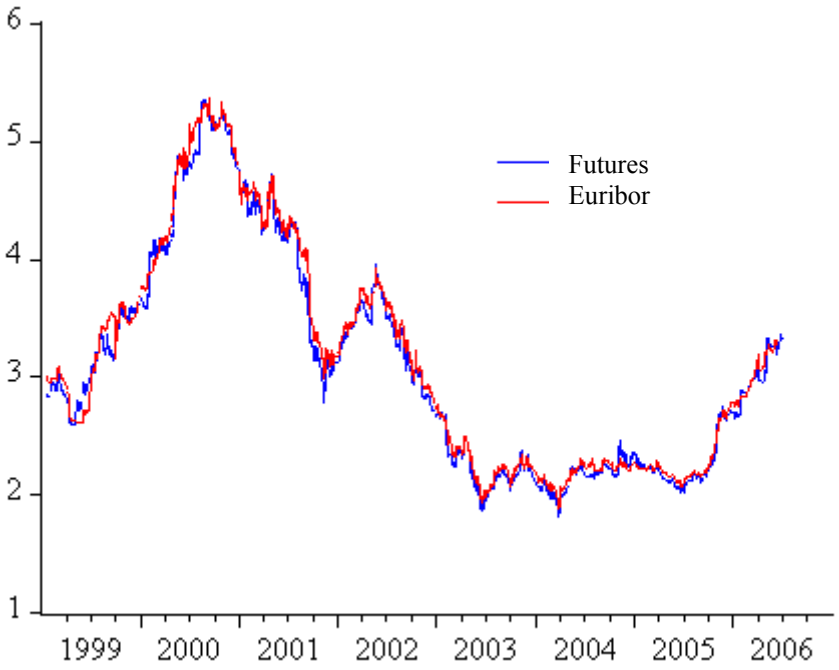
Table 1. *– Glossary of ECB's official statements and their ranking*

ECB's main statements: the most important keywords	*Index*
Imperative that upward pressure to be contained – Risks [to price stability] are upward (upside) – The risks to price stability are confirmed (or: remain) – Vigilant (vigilance) [with regard to upside risks to price stability]– Close monitored (or: continuous close attention) [upside risks] – Several [upward] factors need to be monitored carefully	+2
Both confident and vigilant (or: Good however vigilant) [upside risks] – Upward pressure remains contained – A number of (or: Some) upside risks need to be carefully monitored – Alert to emerging of upward risks – Vigilance with regard to the materialisation of upside risks	+1
Appropriate – Favorable – Compatible – Consistent – In line – Balanced – Absence of significant (or: No strong) pressures either upwards or downwards – The downside risks have disappeared –	0
Favorable, but there are some [downside] risks – Appropriate but remain downside risks – Downside risks are not vanished – Some of the downward risks had materialised	-1
Consistent, but carefully monitor all [downside] risks to economic growth – Balanced but monitor closely all [downside] factors – Monitor carefully all [downside] factors relevant to economic growth – Downside risks are still relevant – Economic slowdown is still cause for concern – [Strong] downside risks for economic activity – Monitor closely the downside risks to economic growth.	-2

ECB's main statements: Comparisons	*Index*
Somewhat less favorable – [Price perspectives are] less satisfactory but further evidence is needed – move towards the upside	+1
Confirmed – not altered – not changed (or: no fundamental changes)	0
More balanced – Inflationary pressures have further diminished (or: are lower, are easing)	-1

NOTE: Source: Rosa and Verga (2006)

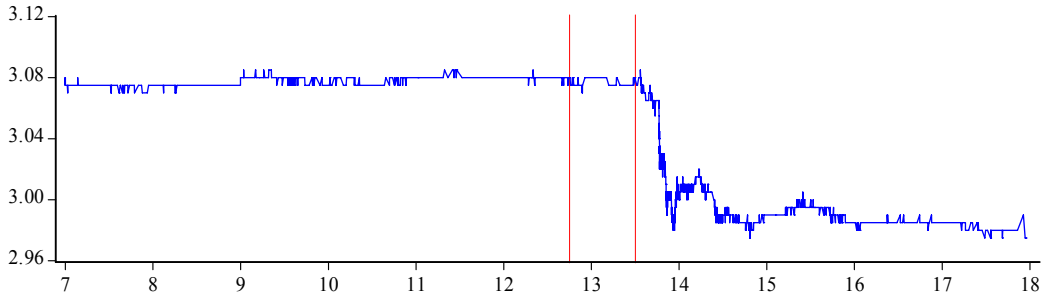
Figure 1. *– Plot of 3-month implicit Euribor and its futures contract*



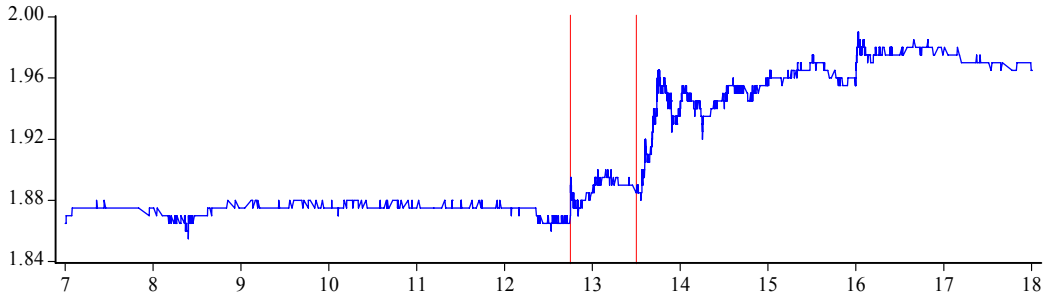
NOTE: Daily observations, January 1999 – June 2006. The 3-month-forward 3-month ahead Euribor is quoted at 10, while the plotted 3-month futures rate is quoted at its closure price.

Figure 2. *– 3-month Euribor futures tick-by-tick rate:*

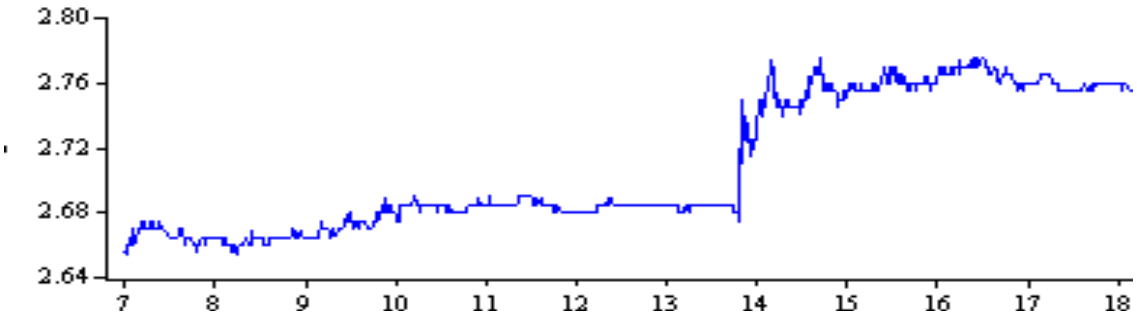
a) 6 April 2006



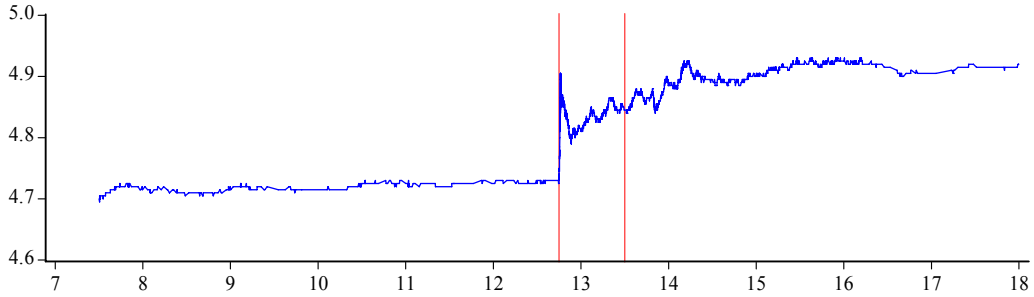
b) 1 April 2004



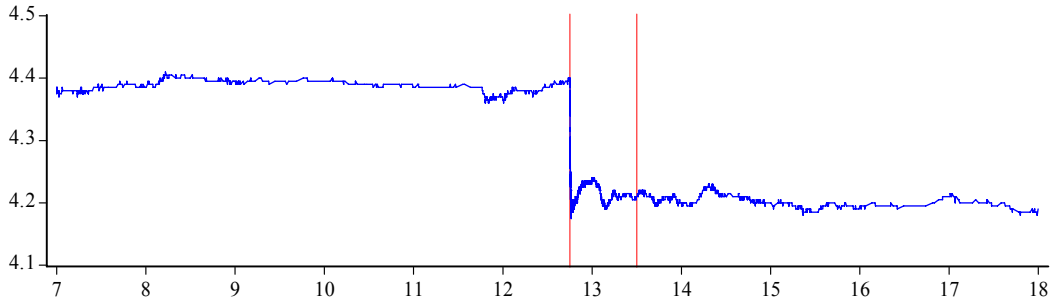
c) 18 November 2005



d) 8 June 2000

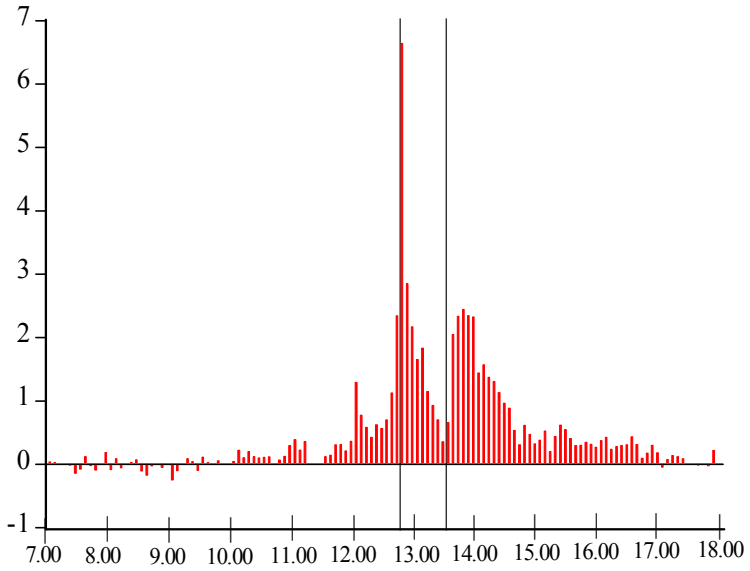


e) 10 May 2001



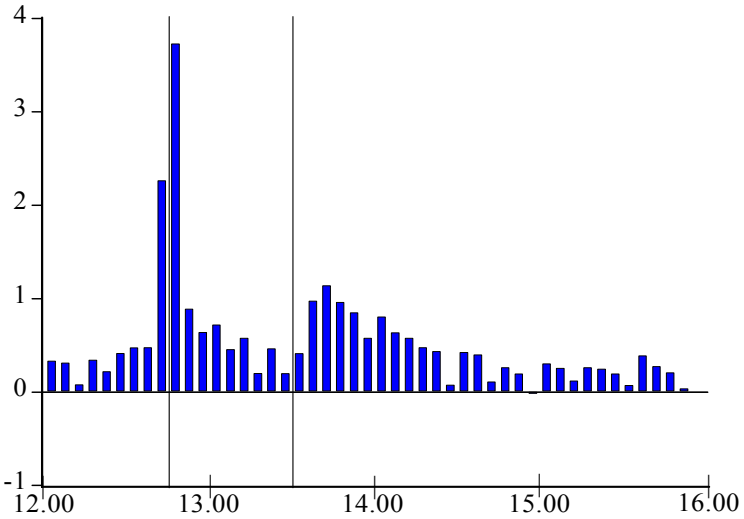
NOTE: The contracted futures rate equals 100 less the futures price.

Figure 3. *– Ratio of average number of transactions per quarter of an hour (from January 2000)*



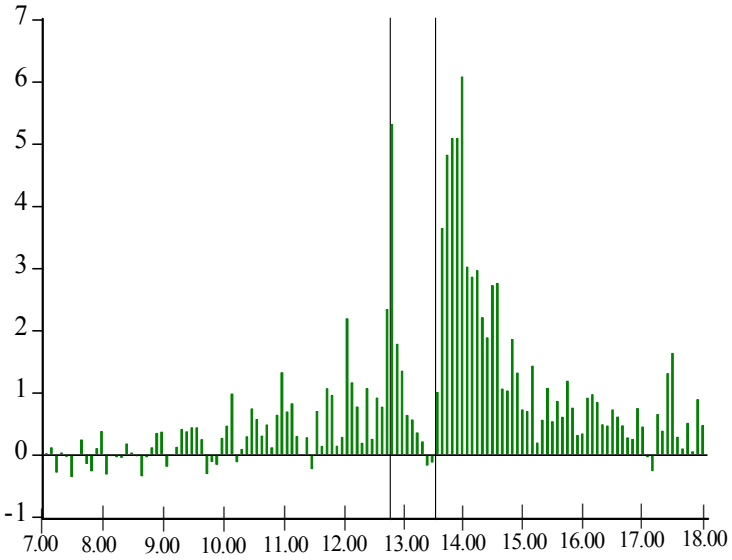
NOTE: Plot of the ratio between the average number of transaction on Governing Council meeting days and all other days. Two vertical lines indicate 12:45 and 13:30 London time.

Figure 4. *– 5-minute futures price volatility (from January 2000)*



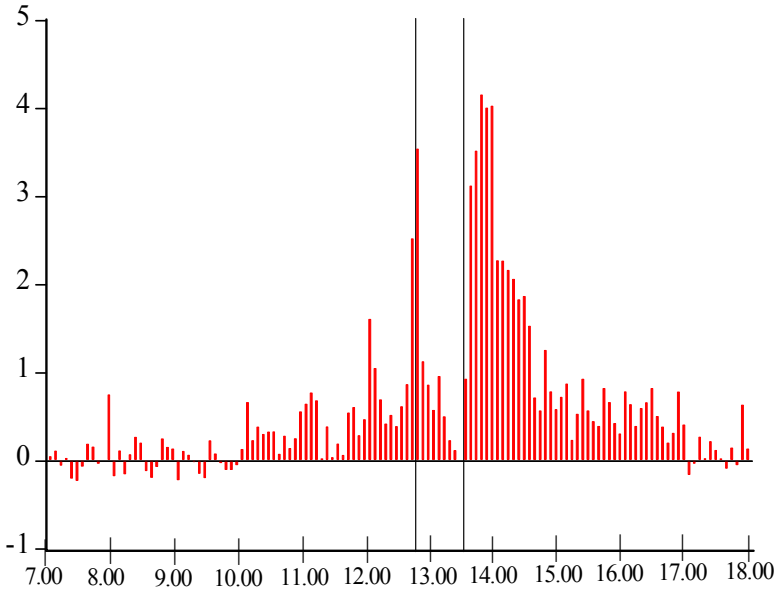
NOTE: Plot of the ratio between futures price volatility (measured as the 5-minute absolute deviation) on Governing Council meeting days with respect to all other days.

Figure 5. *– Ratio of average volume (from July 2003)*



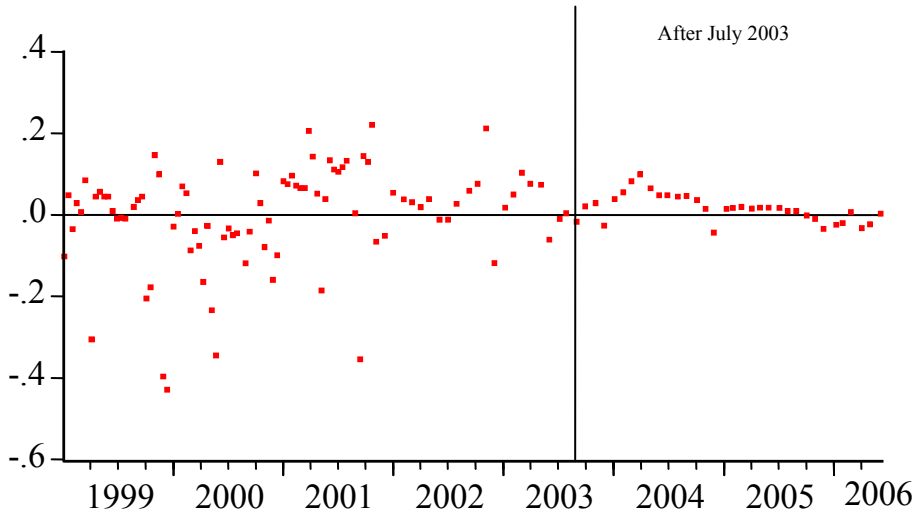
NOTE: Plot of the ratio between the average number of transaction on Governing Council meeting days and all other days. Two vertical lines indicate 12:45 and 13:30 London time.

Figure 6. *– Ratio of average number of transactions per quarter of an hour (from July 2003)*



NOTE: Plot of the ratio between the average number of transaction on Governing Council meeting days and all other days. Two vertical lines indicate 12:45 and 13:30 London time.

Figure 7. *– Monetary policy shocks*



NOTE: The monetary policy shock is defined as the difference between the new Repo rate communicated at 12:45, and the one-month Euribor rate quoted at 10:00. We also subtract the mean equilibrium spread (0.11) between the Repo and the one-month Euribor rate.

Figure 8. *– Time line for the event study on ECB announcements*

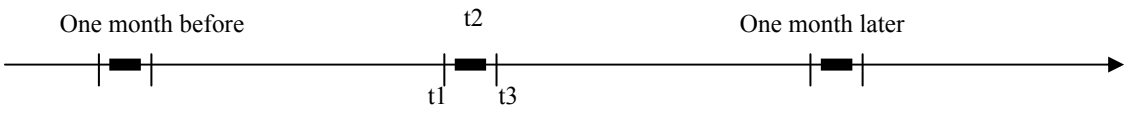
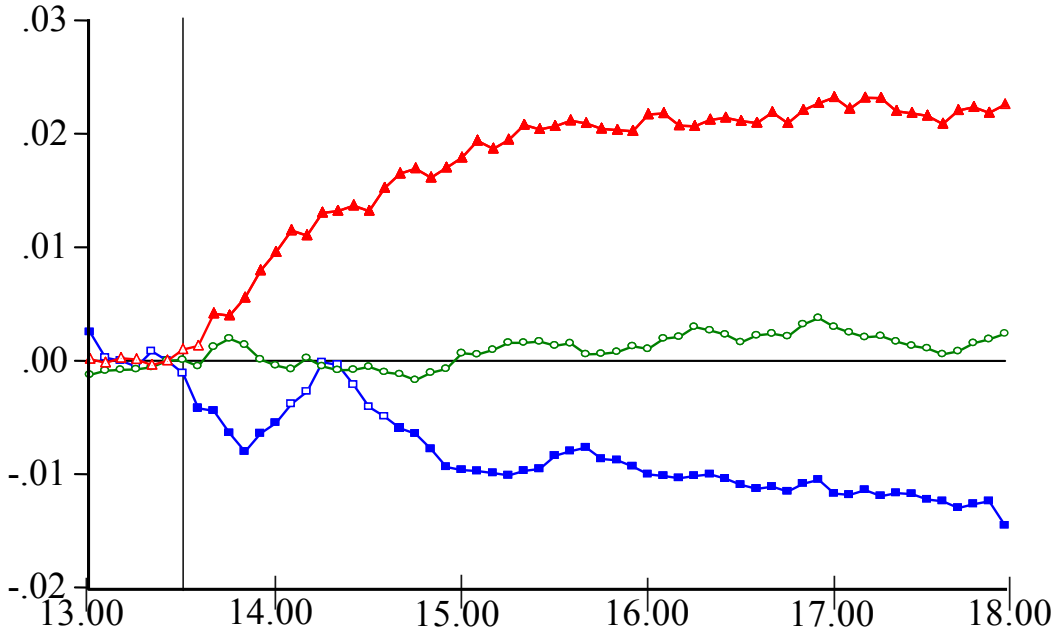


Table 2. *– Auxiliary regression to measure the expected ECB announcement (Futures rates)*

Constant	0.043 (0.010)
$F_{13:15} - R_{New}$	1.008** (0.261)
$Index_{t1}$	0.649** (0.076)
R^2	0.791
Adj. R^2	0.785
Observations	69

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.

Figure 9. *– Futures rate reactions to central bank announcements*



NOTE: The chart plots average futures rate changes following unexpected hawkish (red line - triangle), neutral (green line – circle), and dovish (blue line - square) ECB announcements on Governing Council meeting days. A statement is defined hawkish when the news surprise, the difference between $Index_{t2}$ and $E_{t1}\,[Index_{t2}]$ as given by Equation (1), is higher than the median of the positive news shocks observed in our sample period (i.e. 0.184). A statement is defined dovish when the news surprise is lower than the median negative news shock observed in our sample period (i.e. -0.367). In the remaining cases, the central bank statement is classified as neutral. A solid marker denotes that the futures price change is significantly different from zero at the five percent level.

Table 3. *– Explanation of innovation in expectations (Future rates), dependent variable* $f_{t3} - f_{t1}$

	t3 = 14:45 *t1 = 13:15*	*t3 = 15:45* *t1 = 13:15*	*t3 = 16:45* *t1 = 13:15*
Constant	0.002 (0.003)	0.004 (0.004)	0.006 (0.004)
NS_{t2}	0.016* (0.007)	0.019* (0.008)	0.021** (0.007)
R^2	0.091	0.010	0.112
Adj. R^2	0.077	0.086	0.099
Observations	69	69	69

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.

Table 4. *– Time needed to incorporate the news shock (Future rates), dependent variable* $f_{17} - f_{13:15}$

	t = 14:15	*t = 14:30*	*t = 14:45*	*t = 15:00*
Constant	0.002 (0.002)	0.003 (0.002)	0.003* (0.002)	0.002 (0.002)
$f_t - f_{13:15}$	1.112** (0.092)	1.068** (0.080)	1.064** (0.064)	1.055** (0.058)
NS_{t2}	0.015** (0.005)	0.010** (0.003)	0.006 (0.003)	0.002 (0.003)
R^2	0.752	0.804	0.829	0.863
Adj. R^2	0.744	0.798	0.813	0.859
Observations	69	69	69	69

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.

Table 5. *– Explanation of innovation in expectations (Future rates), dependent variable* $f_{t4} - f_{t3}$

	t4 = 17:30 *t3 = 15:00*	*t4° = 9:00* *t3 = 15:00*	*t4° = 11:00* *t3 = 15:00*
Constant	0.001 (0.002)	-0.001 (0.003)	-0.000 (0.003)
NS_{t2}	0.005 (0.003)	0.010 (0.006)	0.010 (0.006)
R^2	0.027	0.057	0.051
Adj. R^2	0.012	0.043	0.037
Observations	69	69	68

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.
° stands for the morning of the day after the Governing Council meeting.

Table 6. *– Auxiliary regression to measure the expected ECB announcement using Ordered Probit*

$f_{t1} - R_{NEW}$	2.688** (0.713)
$Index_{t1}$	1.374** (0.224)
δ_1	-2.681** (0.399)
δ_2	-1.680** (0.352)
δ_3	0.974** (0.283)
δ_4	3.038** (0.447)
Log Likelihood	-48.322
Pseudo-R^2	0.529
Observations	69

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is ML – Ordered Probit (Quadratic hill climbing). One and two stars denote significance at the five and one percent level, respectively.

Table 7. *– Explanation of innovation in expectations (Future rates), dependent variable $f_{t3} - f_{t1}$*

	t3 = 14:45 t1 = 13:15	*t3 = 15:45 t1 = 13:15*	*t3 = 16:45 t1 = 13:15*
Constant	0.002 (0.003)	0.005 (0.004)	0.006 (0.004)
NS_{t2}	0.017** (0.006)	0.022** (0.007)	0.023** (0.006)
R^2	0.112	0.137	0.139
Adj. R^2	0.099	0.124	0.126
Observations	69	69	69

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.

Table 8. *– Time needed to incorporate the news shock (Future rates), dependent variable* $f_{17} - f_{13:15}$

	t = 14:15	*t = 14:30*	*t = 14:45*	*t = 15:00*
Constant	0.002 (0.002)	0.003 (0.002)	0.003 (0.002)	0.002 (0.002)
$f_t - f_{13:15}$	1.097** (0.091)	1.055** (0.081)	1.053** (0.064)	1.049** (0.058)
NS_{t2}	0.016** (0.005)	0.011** (0.003)	0.007 (0.003)	0.003 (0.003)
R^2	0.732	0.809	0.821	0.863
Adj. R^2	0.754	0.803	0.826	0.860
Observations	69	69	69	69

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.

Table 9. *– Explanation of innovation in expectations (Future rates), dependent variable* $f_{t4} - f_{t3}$

	t4 = 17:30 *t3 = 15:00*	*t4° = 9:00* *t3 = 15:00*	*t4° = 11:00* *t3 = 15:00*
Constant	0.001 (0.002)	-0.001 (0.003)	-0.000 (0.003)
NS_{t2}	0.005 (0.003)	0.009 (0.006)	0.009 (0.006)
R^2	0.028	0.050	0.045
Adj. R^2	0.013	0.036	0.030
Observations	69	68	68

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.
° stands for the morning of the day after the Governing Council meeting.

Table 10. *– Explanation of innovation in expectations (Future rates), dependent variable* $f_{t3} - f_{t1}$

	t3 = 14:45 *t1 = 13:15*	*t3 = 15:45* *t1 = 13:15*	*t3 = 16:45* *t1 = 13:15*
c_1	0.006 (0.004)	0.008* (0.004)	0.009 (0.004)
c_2	0.016* (0.006)	0.019** (0.006)	0.021** (0.006)
c_3	2.548* (1.222)	2.111 (1.065)	2.096* (0.945)
c_4	0.649** (0.182)	0.732** (0.192)	0.638** (0.202)
R^2	0.177	0.169	0.162
Adj. R^2	0.139	0.131	0.123
Observations	69	69	69

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.

Table 11. *– Time needed to incorporate the news shock (Future rates), dependent variable* $f_{17} - f_{13:15}$

	t = 14:15	*t = 14:30*	*t = 14:45*	*t = 15:00*
c_1	0.001 (0.002)	0.002 (0.002)	0.002 (0.002)	0.001 (0.002)
c_2	1.110** (0.108)	1.073** (0.088)	1.074** (0.071)	1.061** (0.060)
c_3	0.148** (0.005)	0.010** (0.003)	0.005 (0.004)	0.002 (0.003)
c_4	0.921 (0.869)	0.959 (1.097)	1.077 (1.993)	2.841 (4.991)
c_5	0.714** (0.217)	0.605* (0.280)	0.422 (0.552)	-0.283 (1.840)
R^2	0.753	0.805	0.820	0.866
Adj. R^2	0.737	0.793	0.809	0.858
Observations	69	69	69	69

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.

Table 12. *– Explanation of innovation in expectations (Future rates), dependent variable* $f_{t4} - f_{t3}$

	t4 = 17:30 *t3 = 15:00*	*t4° = 9:00* *t3 = 15:00*	*t4° = 11:00* *t3 = 15:00*
c_1	0.001 (0.002)	-0.003 (0.003)	-0.001 (0.003)
c_2	0.005 (0.003)	0.010* (0.006)	0.010 (0.006)
c_3	2.743 (2.483)	-0.307 (1.353)	0.535 (1.232)
c_4	0.185 (0.689)	0.811** (0.299)	0.739* (0.330)
R^2	0.045	0.078	0.054
Adj. R^2	0.001	0.035	0.009
Observations	69	68	68

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.
° stands for the morning of the day after the Governing Council meeting.

Table 13. *– Explanation of innovation in expectations (Future rates), dependent variable* $f_{t3} - f_{t1}$

	t3 = 14:45 *t1 = 13:15*	*t3 = 15:45* *t1 = 13:15*	*t3 = 16:45* *t1 = 13:15*
Constant	0.006 (0.004)	0.009* (0.004)	0.009* (0.004)
NS_{t2}	0.023** (0.006)	0.026** (0.007)	0.027** (0.007)
$Index_{t2}$	-0.007* (0.003)	-0.008 (0.004)	-0.006 (0.004)
R^2	0.157	0.160	0.148
Adj. R^2	0.131	0.135	0.122
Observations	69	69	69

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.

Table 14. *– Time needed to incorporate the news shock (Future rates), dependent variable* $f_{17} - f_{13:15}$

	t = 14:15	*t = 14:30*	*t = 14:45*	*t = 15:00*
Constant	0.002 (0.002)	0.002 (0.002)	0.002 (0.002)	0.001 (0.002)
$f_t - f_{13:15}$	1.104** (0.097)	1.074** (0.083)	1.078** (0.068)	1.069** (0.058)
NS_{t2}	0.015* (0.006)	0.009* (0.004)	0.004 (0.004)	0.001 (0.004)
$Index_{t2}$	-0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)
R^2	0.751	0.804	0.820	0.864
Adj. R^2	0.739	0.795	0.811	0.858
Observations	69	69	69	69

NOTE: Monthly observations on days of ECB Governing Council meetings, January 2000 – June 2006. The econometric method is Ordinary Least Squares. Heteroskedasticity - Consistent standard errors in brackets. One and two stars denote significance at the five and one percent level, respectively.

Table 15. *– Excerpts from the Questions and Answers section of the ECB President press conference*

Date	Excerpts
6 October 2005	*Question: My first question involves your choice of the words "strong vigilance". We have not heard that phrase for several months and today I counted that we heard it four times ...* Trichet: I said "strong vigilance" and I said that the present level of interest rates was "still appropriate". **And this is a little bit different from the previous language**, you might remember, in the previous Governing Council meeting. **You have to take that into account**.
3 November 2005	*Question: Mr Trichet, can you tell us please: are you preparing for an interest rate rise?* Trichet: I already said several times that we were not promising anybody that we would not move. And that we stand ready to move at any time when it is required by our mandate and by the situation. **Today, and as I said in Athens – and we referred explicitly to the Athens judgement and assessment - we think that present interest rates are still appropriate, that strong vigilance is of the essence in the present situation and that inflationary risks are on the upside. I will only mention that. We are very clear that we can move at any time.** *Question: Did any Council members at today's meeting propose increasing interest rates today? And, secondly, the ECB has repeated over and over again over the past month the need for strong vigilance. And you said today that it is of the essence that the outlook for price stability is maintained. Are you nevertheless concerned that inflation expectations, both measured by inflation-linked bonds and also measured by surveys of households and consumers, are nevertheless still rising?* Trichet: **First we did not repeat again and again. In Athens we said "strong vigilance", and I repeat "strong vigilance". But before Athens we did not use this adjective.** Second, we considered the pros and cons of increasing rates or leaving rates unchanged. And we concluded that the present level was still appropriate. Third, we are monitoring expectations very closely. And, as I said on behalf of the Governing Council, the solid anchoring of inflation expectations is of the essence not only to fulfil our primary mandate to which we are inflexibly faithful, because it is the Treaty requirement, but also to continue benefiting from favourable market interest rates, particularly medium, long-term and very long-term, which incorporate this solid anchoring of inflation expectations. **From that standpoint we are looking at all possible information, particularly the break-even inflation. And we could observe during the last months a certain tendency to go up. We are looking at this element very carefully.**
2 February 2006	*Question: Mr Trichet, you said today that risks to inflation are on the upside and that growth appears to be strengthening in line with your scenario, and* ***you have used the word "vigilance" three times*** *by my count. Why did the Governing Council not decide to raise interest rates today?* *And my second question is: Markets are expecting another rate increase in the first quarter and yet another one – at least one more, anyway – by the end of the year. Would you repeat again this month, as you did last month, that markets have taken your message well?* Trichet: First**, I have mentioned the word "vigilance" three times and I am happy that you have noticed that.** Second, as regards **the market expectations** for future action in a short period of time – what I am observing **seems to be reasonable**.

4 May 2006	*Question: The markets' expectations of a rate hike of 25 basis points in June: Is this in line with the feelings of the Governing Council today? ...* Trichet: Answering to your first question, I stick to what I have already said. **Vigilance** is of the essence. **I have already used that word several times**, and **I have already said that**, contrary to what some would think, **there is no rule to exclude a decision when we are not in Frankfurt.**
31 August 2006	*Question: The phrase "ongoing withdrawal of monetary accommodation" seems to indicate that we are talking about more than one rate move, but maybe, that is a misinterpretation on my part. The markets, which often get it wrong, have priced in at least another two. Would they be far wrong?* Trichet: I will not comment more on that as **it seems to me that we are clear enough**. I have underlined the phrase "progressive withdrawal of monetary accommodation", and what has happened in the past seems to provide all the appropriate keys to understanding how we act. **As I have said several times, we are in a posture of strong vigilance today**

NOTE: Emphasis added.

Table 16. *– Pros and cons of publishing optimal instrument-rate plans*

Pros	**Cons**
• Markets need to form a precise view on the probabilities of different paths of future interest rates in order to price a wide range of financial instruments correctly • By making explicit interest-rate assumptions underlying published projections of inflation and other target variables it is possible to bypass the risk of being inconsistent when central banks use either unchanged interest rates or market expectations of future central bank actions • Where forecasts are presented as conditional on current information, central bank credibility is not lost. It is rather enhanced if a detailed explanation of which new piece of information has led to a change of view is provided	• Imperfect forecasts may be over-interpreted by the markets (Morris and Shin, 2002) • Members of a monetary policy committee would find it very difficult to agree on a future path of interest rates • Central banks would lose credibility when their interest forecasts were proved inaccurate

NOTE: The construction of this Table is based on our reading of Giavazzi (2006a, b), Goodhart (2006, 2005), and Svensson (2006).

Table 17. *– Futures price response over longer horizons*

Days	Hawkish	Dovish
0	-0.015*	0.023**
1	-0.028*	0.027*
2	-0.034*	0.020
3	-0.033	0.027
4	-0.041	0.027
5	-0.047	0.037
6	-0.062*	0.046
7	-0.065*	0.051
8	-0.075*	0.048
9	-0.084*	0.039
10	-0.089*	0.039
11	-0.094*	0.039
12	-0.117**	0.021
13	-0.120*	0.020
14	-0.128**	0.023
15	-0.123*	0.021
16	-0.135**	0.023
17	-0.127*	0.013
18	-0.140*	0.017
19	-0.149**	0.025
20	-0.148*	0.051
21	-0.154*	0.042
22	-0.162**	0.039

NOTE: We compute futures price changes as the difference between the one-hour average futures rate (between 16 and 17, London time) on trading day t after the press conference and the 30-minute average futures rate (between 1300 and 1330, London time) taken on Governing Council meeting days, that is immediately before the press conference takes place. A statement is defined hawkish when the news surprise, the difference between $Index_{t2}$ and $E_{t1}\,[Index_{t2}]$ as given by Equation (1), is higher than the median of the positive news shocks observed in our sample period (i.e. 0.184). A statement is defined dovish when the news surprise is lower than the median negative news shock observed in our sample period (i.e. -0.367). In the remaining cases, the central bank statement is classified as neutral. One and two stars denote significance at the five and one percent level, respectively.

Appendix – Coding of ECB President press conferences

Table A1. *– ECB President announcements about future monetary policy moves*

Date	Index
05/01/2000	2
03/02/2000	2
02/03/2000	2
13/04/2000	2
11/05/2000	2
6/8/2000	
06/07/2000	2
NA	
14/09/2000	2
05/10/2000	2
02/11/2000	2
14/12/2000	2
NA	
01/02/2001	1
01/03/2001	1
11/04/2001	1
10/05/2001	0
07/06/2001	0
05/07/2001	0
NA	
30/08/2001	-1
11/10/2001	-2
08/11/2001	0
06/12/2001	0

Date	Index
03/01/2002	0
07/02/2002	0
07/03/2002	0
04/04/2002	0
02/05/2002	0
06/06/2002	1
04/07/2002	0
NA	
12/09/2002	-2
10/10/2002	-1
07/11/2002	-2
05/12/2002	-2

Date	Index
09/01/2003	-1
06/02/2003	-2
06/03/2003	-1
03/04/2003	0
08/05/2003	-1
05/06/2003	-1
10/07/2003	-1
NA	
04/09/2003	0
02/10/2003	0
06/11/2003	0
04/12/2003	0

08/01/2004	0
05/02/2004	0
04/03/2004	0
01/04/2004	0
06/05/2004	0
03/06/2004	1
01/07/2004	1
NA	
02/09/2004	1
07/10/2004	1
04/11/2004	1
02/12/2004	1

13/01/2005	1
03/02/2005	1
03/03/2005	1
07/04/2005	1
04/05/2005	1
02/06/2005	1
07/07/2005	1
NA	
01/09/2005	1
06/10/2005	2
03/11/2005	2
01/12/2005	1

Date	Index
12/01/2006	2
02/02/2006	2
02/03/2006	2
06/04/2006	2
04/05/2006	2
08/06/2006	2

NOTE: January 2000 - June 2006. We report the overall monetary policy stance communicated by the ECB Governing Council, *Index*. Note that we have considered only the first press conference of each month. We were not able to codify the press conference of 08/06/2000 because the wording of the ECB President referred to the past and was not forward-looking.
NA indicates that the press conference did not take place.

Examples of Introductory statements and their coding

It should be noted that the excerpts reported in this Appendix only provide some references to the classification but do not completely exhaust the information we use to pin down the ECB future policy inclination (see Rosa and Verga, 2006 for further details). Emphasis has been added.

Date: 2 March 2000
The Governing Council also concluded that **the balance of risks to price stability in the medium term remains on the upside. These upside risks will need to be monitored and assessed continuously** in order to ensure that timely action can be taken, if and when required. (…)
The Governing Council concluded that **vigilance is required** and pointed to several factors.
Coding: +2

Date: 14 September 2000
The annual rate of increase in the Harmonised Index of Consumer Prices (HICP) was 2.4% in July 2000. Recent consumer price developments in the euro area have been very much influenced by the strong rise in oil prices and the depreciation of the exchange rate of the euro.
While monetary policy cannot address short-term developments in prices, **it is imperative for monetary policy that medium-term upward pressure on prices be contained**. The risk that the current pressure on the HICP might spill over onto costs and prices determined in the domestic economy must be taken seriously. This holds true in particular in the context of the favourable prospects for economic growth.
Coding: +2

Date: 6 June 2002
The Governing Council undertook a comprehensive examination of monetary, financial and economic developments and considered the evidence that has become available since its last meeting on 2 May 2002. Notwithstanding the recent decline in inflation, **the outlook for price stability** in the medium term remains **less satisfactory than expected** a few months ago. However, the economic outlook is still subject to uncertainty. **Further evidence is needed before we can fully assess the upward risks to price stability** over the medium term. Against this background, the Governing Council decided to leave the key ECB interest rates unchanged.
At this juncture it is therefore **particularly important for monetary policy to remain vigilant** with regard to the further evolution of the key factors determining the outlook for prices.
Coding: +1

Date: 1 February 2001
The decision to keep interest rates unchanged reflects the Governing Council's assessment that the **risks to price stability in the medium term now appear more balanced** than at the end of last year. Factors which might pose **upward risks to price stability in the medium term are still present** and as such will be subject to **ongoing close monitoring**.
(…) The assessment that the **risks to price stability are now more balanced, there are still factors posing upside risks which therefore require continued attention.**
Coding: +1

Date: 7 March 2002
As usual, at today's meeting we examined recent monetary, financial and economic developments. The Governing Council concluded that the information which had become available in recent weeks confirmed that the current level of key ECB interest rates remains **appropriate** for the maintenance of price stability over the medium term. Against this background, the Governing Council decided to leave the key ECB interest rates unchanged.
Coding: 0

Date: 4 March 2004
Overall, the Governing Council confirmed its previous assessment of a **favourable outlook for price stability** in the euro area over the medium term. Against this background, we concluded that the **current stance of monetary policy remains appropriate**. The key ECB interest rates have therefore been left unchanged at their low levels. Our monetary policy stance provides support to the economic recovery in the euro area. (…)
To sum up, the economic analysis continues to indicate that the main scenario for price developments in

the coming years **is in line with price stability**. Cross-checking with the monetary analysis does not alter this picture for the time being.
Coding: 0

Date: 19 July 2003
Following our regular economic and monetary analysis, we have concluded that the current **monetary policy stance is appropriate** in view of the **favourable outlook for price stability** over the medium term. Accordingly, we have decided to leave the key ECB interest rates unchanged. Interest rates in the euro area are low by historical standards, both in nominal and real terms, thus lending support to economic activity and helping to safeguard against downside risks to economic growth. The Governing Council will continue **to monitor carefully all factors that might affect this assessment.**
In the context of our economic analysis, the latest data and information continue to suggest that **economic growth in the euro area remained subdued** in the second quarter of the year, after virtually stagnating in the first quarter. The indicators available broadly point to a stabilisation of activity but there are **no signs as yet of an underlying strengthening in production and confidence**. At the same time, financial market developments seem to reflect a somewhat more optimistic assessment of the economic outlook both inside and outside the euro area. On the whole, **we continue to expect a gradual strengthening of economic activity in the euro area**. This should be supported by lower inflation and thus higher real disposable income, the low level of interest rates, and a recovery in external demand for euro area goods and services. This assessment is in line with all available forecasts and projections.
Nevertheless, downside risks to this main scenario are still relevant. While concerns over the SARS virus have faded, there are risks relating in particular to the accumulation of macroeconomic imbalances outside the euro area and to the extent of the adjustment still needed in the euro area corporate sector to enhance productivity and profitability. (…)
To sum up, our economic analysis confirms the expectation **that price dynamics will remain moderate** in the euro area in the context of a gradual economic recovery and the strengthened euro exchange rate. The monetary analysis indicates that the strong expansion of M3 should, for the time being, not be seen as adversely affecting this outlook. Hence, cross-checking the information from the two pillars leads to the conclusion that **the outlook for price stability** over the medium term **remains favourable**.
Coding: -1

Date: 30 August 2001
Following its regular examination of monetary and economic developments and analysis of their implications for the maintenance of price stability in the euro area, the Governing Council decided to lower the key ECB interest rates by 25 basis points. The Governing Council considers that the available evidence points to an **improvement in the outlook for price developments**. This is particularly apparent from the information under the second pillar of the ECB's monetary policy strategy, while that related to the first pillar remains consistent **with a favourable outlook for price stability** in the medium term. (…)
Regarding the second pillar, there are clear signals of lower inflationary pressures from the demand side. Recent data on economic activity indicate **that real GDP growth in 2001 will most likely be lower than was expected a few months ago**. This is due in part to external demand, which has remained weak and below expectations, owing to slow growth in economic activity in the United States and persistent economic weakness in Japan, which have spilled over to other regions of the world. In addition, consumption growth in the euro area has been dampened by losses in real disposable income related to past increases in consumer prices. **All these factors also had a negative impact on investment.** (…)
Overall, as several indicators are pointing to an **abatement of inflationary pressures**, the new level of interest rates is **compatible with the maintenance of price stability** over the medium term, which, in turn, is essential to create a favourable environment for sustainable economic growth.
Coding: -1

Date: 7 November 2002
We have reviewed monetary, financial and economic developments and updated our assessment in the light of the information available. In view of the high uncertainty on future growth, and its implication for medium-term inflationary developments, the Governing Council **has discussed extensively the arguments for and against a cut in the key ECB interest rates**. The view has prevailed to keep interest rates unchanged. However, the Governing Council **will monitor closely the downside risks** to economic growth in the euro area.
Coding: -2

Date: 11 October 2001
As usual, the Governing Council conducted its examination of monetary and economic developments and analysis of their implications for the maintenance of price stability in the euro area. Based on its assessment under both the first and second pillar, the Governing Council decided to keep the key ECB interest rates unchanged. The level of the key ECB interest rates at the current juncture is therefore seen as **consistent** with maintaining price stability over the medium term. Given the high level of uncertainty in the international environment, **we will continue to monitor [downward] developments very closely** and thoroughly, and we will assess new information in the context of our medium-term-oriented monetary policy strategy aimed at delivering price stability in the euro area.
With regard to economic growth in the euro area ... we will **continue to monitor downside risks** to the current situation.
Coding: -2

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