ECB Communication and the EUR-US Dollar Exchange Rate

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Abstract

In this article we investigate the effects of the communication of the European Central Bank (ECB) on the level and volatility of the EUR vs. US Dollar (EUR-$) exchange rate. We focus on the effects of the ECB's monthly announced interest rate decisions. These decisions are made publicly available via a press release launched at 13.45 CET and a press conference scheduled for 14.30 CET. As market participants follow such releases carefully, it is valuable to analyze how these releases are digested. We find that the ECB press release has a significant impact on the level and volatility of the EUR-$ exchange rate. The effect on the volatility can be explained by the surprise the decision created among market participants. The press conference impacts the volatility only and this effect is correlated with the BHS communication index as well as with the explicitness in which the exchange rate was addressed during the press conference.

Keywords: ECB communication, exchange rate, expectations, long memory GARCH processes.

JEL Classification: C22.

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1 Introduction

There is a long history of studies that discuss the impact of macroeconomic shocks on exchange rates. Results are derived from daily or — more recently — high frequency data and from various different exchange rates.

In a seminal paper Andersen and Bollerslev (1998) highlight three factors that influence the volatility movement of exchange rates: calender effects, macroeconomic announcements and intra-day volatility dependencies. While they observe rather quick adjustments to announcements in mean, the volatility adjusts gradually. Andersen et al. (2003) emphasize the importance of macroeconomic *news* affecting fundamentals for high frequency movements in the exchange rate conditional mean and volatility. The impact of real news that is the difference between expected figures and newly released information became topical over the recent years.In this spirit among others Ehrmann and Fratzscher (2005) as well as Faust et al. (2006) refine those earlier results with respect to time variation and macroeconomic circumstances.

Surprisingly little attention has been paid to macroeconomic shocks/announcements stemming from central banks. Possible shocks are: open market transactions, interest rate changes and central bank communication. Standard models of exchange rate determination reason two channels how central bank interventions might influence exchange rates. The first is the portfolio channel and the second is the signalling channel (see Mussa (1981)). However, direct exchange rate interventions, as noted by Fratzscher (2005), have almost stopped in 1995 in the US and the EURO zone.[1] Changes in interest rates affect exchange rate via theories of uncovered/covered interest rate parities and arbitrage opportunities. Overall, a monetary tightening of the ECB should lead to an appreciation of the EURO. Nevertheless, there are two qualifications to make in that respect. First, the exchange rate might react differently over a specific horizon and second the reaction depends on the market's interpretation of reasons for this decision of the monetary authority. Finally, central bank communication can affect exchange rates. Since the central bank's officials present their assessment of current and future fundamentals of the economy respectively the world economy.[2] Obviously, this argument is related to the interest rate change as it is announced before the actual action takes place and this action is often qualified within a statement in depth. Central bank communication as such can be divided into irregular statements by different officials and the main communication instrument: the regular press statements after the governing council meeting representing the univocal judgement of its members.[3]

Jansen and de Haan (2005a) discuss the role of the European Central Bank (ECB) statements to speak up the EURO and discover only a volatility effect using daily exchange rate data. Switching to high frequency, Jansen and de Haan (2005b) find both a mean and a volatility effect. However, the

[1] Only Japan uses this instrument until now.

[2] Often the effect of fundamentals is summarized using following specification:$s_t = \sum_{j=0,\infty} \lambda^j E_t(z_{t+j})$. Where s denotes the exchange rate λ^j is a discount factor and z are fundamentals. While this theory seems appealing evidence that exchange rates move accordingly is weak for the short to medium run predictions. For a survey see Mark (1995)

[3] Although this is especially true for the ECB other central bank have similar procedures.

mean effect is comparatively small and rather short lived. Fratzscher (2004) provides evidence that oral intervention affect the mean as well as the volatility and find that oral interventions during actual interventions reduce volatility while direct interventions increase the movement of exchange rates. Finally, Beine et al. (2004) show some support that comments during official exchange rate interventions were partially effective.

While research effort to analyze the impact of the key communication channel on financial market significantly increased (see for instance Heinemann and Ullrich (2005), Lamla and Rupprecht (2006) on the ECB and Andersson et al. (2004) for the Sveriges Riksbank) nothing has been said concerning its effect on the exchange rate.

With this article we intend to close this gap. For this purpose we employ five-minute high frequency EUR-$ exchange rate data provided by OLSEN-data for a time span from December 1998 to October 2006 and hence are able to make reasonable inference over the first years of the ECB. Overall, we study the impact of 89 press conferences.

The big advantage of employing high frequency data is that we can directly monitor the impact of central bank communication on the market in real time. Hence there is no identification problem whether the movement in the exchange rate is driven by other factors than monetary policy announcements.[4] The usage of such intraday data requires an approach which allows to separate the announcements effects from the typical intraday patterns and volatility persistence. Following Andersen and Bollerslev (1997) we deseasonalize in a first step the high-frequency returns using a control sample containing non-announcement days from which the seasonal pattern is extracted. Second, the deseasonalized absolute returns show a clear pattern of long memory and persistence and hence a model for the conditional variance of the exchange rate should take into account this property. We therefore estimate a ARMA-FIGARCH type of specification for the five-minutes returns whereby we control for the surprise in the policy decision using three alternative regressors in the mean and variance.

We focus on the impacts of verbal statements and announcements of the ECB on the Euro-US-Dollar (EUR-$) exchange rate. In particular we examine the development on meeting days for the ECB in an intra day setting.[5] On meeting days the ECB announces the new key interest rates at 13.45 (CET) and holds a press conference at 14.30 (CET). While the 13.45 event is simply an announcement concerning the interest rate, the press conference at 14.30 explains the assessment of the governing council in greater detail. Since at least from a theoretical perspective the exchange rate is driven by fundamentals the announcement of the new key interest rates as well as the judgement of the governing counsel on the future of the economy should affect both the mean as well the volatility of the exchange rate. Concerning

[4] Ehrmann and Fratzscher (2005) argue that news may leak into the markets before the official release date. However, this argument against high frequency data has low applicability for central banks. For instance central bank officials are not allowed to speak one week ahead of the official press release about the upcoming decision meeting. Hence, there is low probability that this information comes into the market short before the official meeting.

[5] Five minute intervals are used.

the first, we not only want to focus on the change or the level effect of the announced interest rate change but also survey the impact if the announced interest rate is unexpected and corresponds to what is called "news" in a narrower sense. As Andersen et al. (2003) prove it is the surprise or the news effect that matters most. Hence, we will dwell on this in greater detail. However, as Ehrmann and Fratzscher (2005) note the reasoning matters. Hence, a response of a unexpected interest rate change affects exchange rate, but also the qualification via the press conference and the in detail assessment should matter as well. In our case the news effect is calculated by subtracting the change in the interest rate with the expected value of the Reuters survey. [6] To assess the impact of the press conference we rely on the Berger-DeHaan-Sturm (BHS) communication indicator as discussed in Berger et al. (2006). This index measures on a scale ranging from -3 to +3 the risk to price stability. [7]

We show that interest rate announcement effects level and volatility of the EUR-$ exchange rate. The volatility effect is driven by the surprise generated by the interest rate decision. On the other hand the press conference affects the volatility only. In addition, the communication indicator as well as the an explicit statement of the assessment of the current developments of the exachange rate matter.

The remainder is organized as follows. Section 2 exemplifies the structure and the form of press releases on announcement days. Section 3 deals with the adjustments to seasonal patterns to the exchange rate data and the FI-GARCH specification. Section 4 provides the estimated output while section 5 concludes.

2 ECB Announcement Days

On the respective days, the ECB launches a press release on its monetary policy decisions at 13:45 CET. This announcement encompasses the interest rate decision of its main instruments. Shortly after the announcement a press conference starts at 14:30 CET where the president of the ECB explains the decision and gives a future outlook and assessment of the overall risks to price stability. The exact wording of the press release and the press conference can be obtained from the ECB's website.[8] Next, we provide an example.

Press release:

> **5 October 2006 - Monetary policy decisions**
>
> At todays meeting, which was held in Paris, the Governing Council of the ECB took the following monetary policy decisions:

[6] One week in front of an governing counsel meeting Reuters asks many professional for their expected central bank decision.

[7] Since the impact of communication is often driven by the so-called "reading between the lines" this index does not count a bunch of signal words, but portrays an overall sentiment driven by discussed risks in the real, the monetary and the price developments. For a discussion concerning different types of wording indicators used in recent papers see also Lamla and Rupprecht (2006) and Fratzscher (2005)

[8] http://www.ecb.de/press/html/index.en.html

1. The minimum bid rate on the main refinancing operations of the Eurosystem will be increased by 25 basis points to 3.25%, starting from the operation to be settled on 11 October 2006.
2. The interest rate on the marginal lending facility will be increased by 25 basis points to 4.25%, with effect from 11 October 2006.
3. The interest rate on the deposit facility will be increased by 25 basis points to 2.25%, with effect from 11 October 2006.

The President of the ECB will comment on the considerations underlying these decisions at a press conference starting at 2.30 p.m. (CEST) today.

Press Conference:

Introductory statement with Q&A

Jean-Claude Trichet, President of the ECB, Paris, 5 October 2006

Ladies and gentlemen, the Vice-President and I are very pleased to welcome you to the press conference here in Paris. I would particularly like to thank Governor Noyer for his kind hospitality and express our special gratitude to the staff of the Banque de France for the excellent organisation of the meeting of the Governing Council.

Let me now report on the outcome of our meeting, which was also attended by the President of the Eurogroup, Prime Minister Juncker, and Commissioner Almunia.

At todays meeting, we decided to increase the key ECB interest rates by 25 basis points. This decision reflects the upside risks to price stability over the medium term that we have identified through both our economic and monetary analyses. Todays decision will contribute to ensuring that medium to longer-term inflation expectations in the euro area remain solidly anchored at levels consistent with price stability. Such anchoring is a prerequisite for monetary policy to make an ongoing contribution towards supporting sustainable economic growth and job creation in the euro area. Also after todays increase, the key ECB interest rates remain at low levels, money and credit growth are strong, and liquidity in the euro area is ample by all plausible measures. Our monetary policy therefore continues to be accommodative. If our assumptions and baseline scenario are confirmed, it will remain warranted to further withdraw monetary accommodation. The Governing Council will therefore continue to monitor very closely all developments so as to ensure price stability over the medium and longer term....

3 Data

Our original sample consists of irregularly spaced tick-by-tick quotes of the EUR-$ exchange rate for 182 days in the period 07. January 1999 to 05. October 2006 obtained from Olsen and Associates.

Half of the days are ECB announcement days and the other half are non-announcement days. The non-announcement days will be used as control days from which we estimate the typical intraday seasonal pattern. Since almost all announcement days are Thursdays, we also chose the non-announcement days to be Thursdays. We follow this strategy since we intend to use the non-announcement days as control days with exactly the same intraday seasonal pattern as that of the non-announcement days apart from the effects of the announcements themselves. Moreover, focusing on Thursdays for the control days as well avoids problems associated with day-of-the-week effects. We also have to make sure that on the control days no other announcements are made at 13:45 or 14:30 CET either in Europe or in the US. Since Euro Area announcements are usually made around 10:00 CET (e.g. M3) or 12:00 CET (e.g. Harmonized CPI, Industrial Production) we do not have to worry about those. In the US some important announcements (e.g. GDP, Personal Income, Producer Price Index, Consumer Price Index) are made at 8:30 EST which is 14:30 CET. To avoid influences of such announcements in the US we choose the control days as either one/two weeks before or after the corresponding announcement day.[9] Using control days in the neighborhood of the press release has the advantage that the economic structure should be very similar. Alternatively, we also employed all Thursdays in the sample period as control days. This, however, does not affect our results in any way.

Control sample days were chosen under the assumption that ECB monetary policy decision announcement days have the same intraday seasonal pattern as non ECB announcement days apart from the specific effect of the announcement itself. Therefore, the seasonal pattern which is needed to seasonally adjust the 5-minute returns will be extracted from the control days. This procedure takes into account intraday seasonality but at the same time ensures that we do not explain away what we are actually interested in.

Each quote contains a bid and an ask price along with the time to the nearest second. Taking the last quotation in a five minute interval we obtain the log price at each five-minute mark by computing the average of the log bid and the log ask. Five-minute returns are then constructed as the change in these five-minute log prices. The returns are denoted by $R_{k,n}$, $k = 1, \dots, K$ and $n = 1, \dots, N$, where K is the number of days in our sample and $N = 288$ is the number of five-minute intervals per day.

First, we focus on non-announcements dates. The summary statistics show that returns have almost zero means, with large standard deviations, distribution is symmetric but non-Gaussian due to excess-kurtosis. Significant first order autocorrelation in $R_{k,n}$ and correlation in squared returns.

Figure 1 shows the average absolute returns over the 5-minutes intervals. From this it is clear that the return series displays a pronounced intraday volatility pattern. At 1:00 CET volatility begins to increase reflecting the opening of the Singapore and Hong Kong markets which are followed by the Tokyo market one hour later and by the Sydney market two hours later. The decline in volatility around 4:00 to 5:30 CET reflects the lunch hour in the Tokyo and Hong Kong markets. Volatility then sharply increases with the opening of the European markets around 8:00 CET and tails off again with European lunch time

[9] Information on US announcements were drawn from the Economic Indicators Calendar provided by the Federal Reserve Bank of New York: http://www.newyorkfed.org/research/national_economy/nationalecon_cal.html

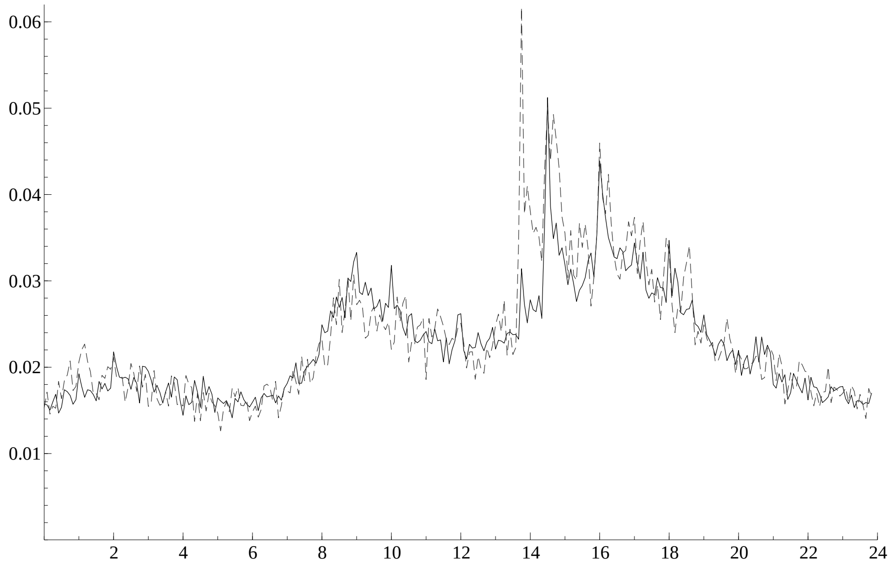

Figure 1: Average absolute five-minute EUR-$ returns for each five minute interval. Solid: control days, dashed: communication days.

around 12:00 CET. The U.S. markets open 14:00 CET. Between 14:00 CET and 16:00 CET both the European and American markets are open simultaneously and volatility is highest during the day. Finally, after the close of the European markets around 17:00 CET volatility starts to decline monotonically back to the level associated with the Pacific segment. The solid line reveals two volatility spikes during the trading day. The first one is at 14:30 CET and the second one at 16:00 CET. Both time points correspond to major macroeconomic news announcements in the US (see Andersen et al., 2003).

3.1 Modeling the periodic intraday pattern

Figure 2 shows the autocorrelation of the absolute return series. There is clear indication of intraday seasonality. Similarly, as Andersen and Bollerslev (1997) and Andersen and Bollerslev (1998). As argued in Andersen and Bollerslev (1997) it is indispensable for any meaningful analysis employing the intraday returns to first estimate and extract the intraday periodic component of return volatility.

We assume the following structure for the intraday returns

$$R_{k,n} = \mathbf{E}(R_{k,n}) + \frac{\sqrt{h_k} s_n Z_{k,n}}{\sqrt{N}}, \tag{1}$$

where $\mathbf{E}(R_{k,n})$ denotes the unconditional mean of the 5-minutes returns, h_k is the conditional variance of day k, s_n a deterministic period component for the n-th intraday interval and $Z_{k,n}$ is *i.i.d.* with mean zero, unit variance and assumed to be independent of h_k. Note, that we assume that the period component s_n does not depend on k. This is motivated by the fact that (almost) all the days we consider are Thursdays and so no day of the week effects need to be modeled.

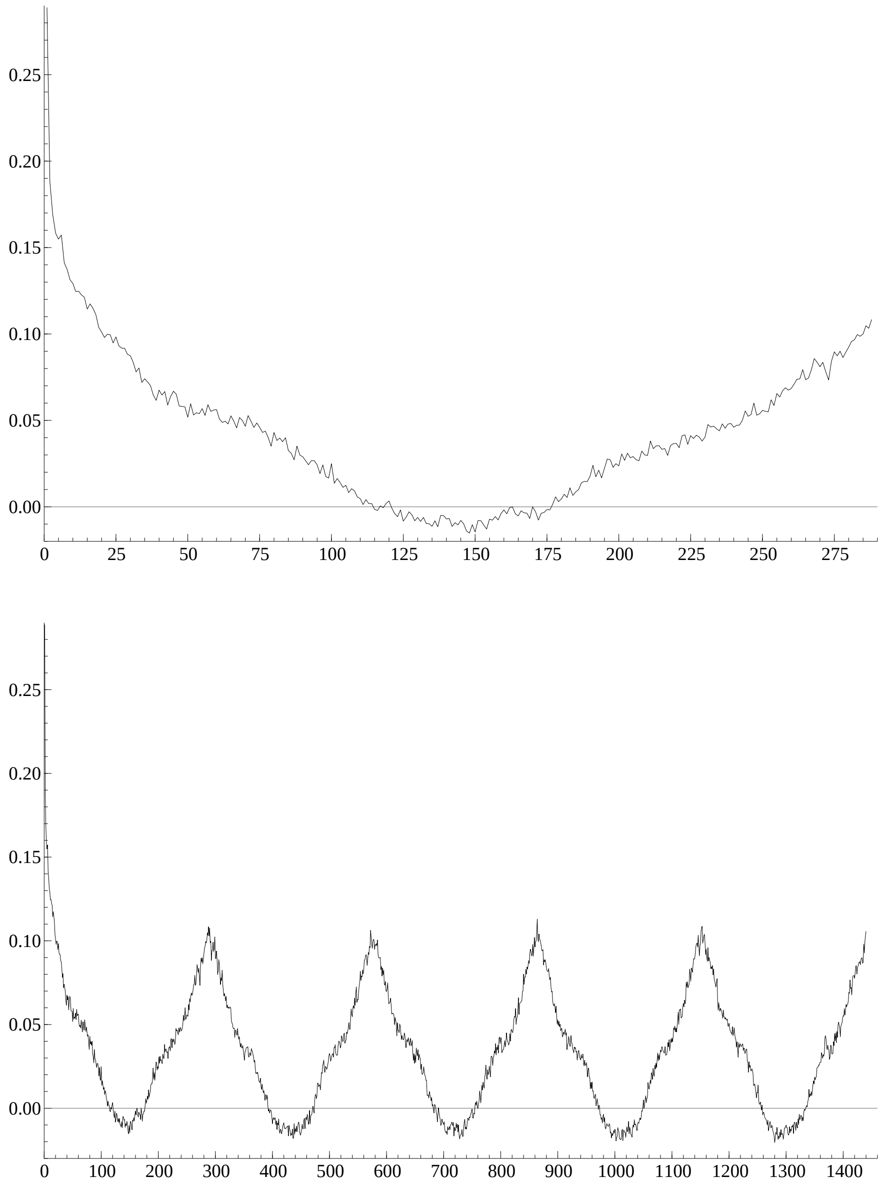

Figure 2: ACF of five-minute absolute returns for one day (upper panel) and five days (lower panel).

Next, our aim is to obtain estimates of the seasonal component s_n. As suggested by Andersen and Bollerslev (1998) we estimate the season component from a regression using a log-transformation of equation (1) which is more robust to extreme outliers in the five minute return series than a regression in terms of, say $R_{k,n}^2$. Equation (1) can be rewritten as

$$r_{k,n} \equiv 2\log(|R_{k,n} - \mathbf{E}(R_{k,n})|) - \log(h_k) + \log(N) = \log(s_n^2) + \log(Z_{k,n}^2) \quad (2)$$

$$= f(n) + u_{k,n}, \quad (3)$$

with *i.i.d.* mean zero error term $u_{k,n} \equiv \log(Z_{k,n}^2) - \mathbf{E}(\log(Z_{k,n}^2))$. An estimable version of equation (3) is obtained by replacing $\mathbf{E}(R_{k,n})$ with the sample mean of the returns and h_k with estimates $\widehat{h}_k$. We estimate h_k by the realized volatility of the respective day, i.e. by $\widehat{h}_k = N^{-1}\sum_{n=1}^{N} R_{k,n}^2$. Alternatively, h_k could be estimating a GARCH model to the daily return series. This approach is problematic because of possible misspecification.

Replacing $\mathbf{E}(R_{k,n})$ and h_k by their estimates leads to a generated $\widehat{r}_{t,n}$ series. The Andersen and Bollerslev (1997) approach assumes that $f(n)$ can be represented by a parametric function $f(n|\theta)$ which is specified as a flexible Fourier form and additional dummy variables capturing calender, day-of-the-week and announcement effects. In this framework an estimate of the seasonal component can be obtained by regressing $\widehat{r}_{k,n}$ on $f(n|\theta)$ by ordinary least squares. This in particular requires first a subjective election of possibly important announcements (to keep the number of dummies small) and second the knowledge of the exact timing of each particular announcement. We rule out calender days and need not take into account day-of-the-week effects. Moreover, since we are only interested in the shape of the *typical* seasonal component of a Thursday and not in coefficient estimates for particular announcements, we follow a different approach. To obtain an estimate of the seasonal component we regress $\widehat{r}_{k,n}$ non-parametrically on a grid $x = 1, \ldots, N$ of 5-minute intervals over the trading day. This can be naturally done by using a Naradaya-Watson kernel estimator of $f(x)$ which is given by

$$\widehat{f}_b(x) = \frac{\sum_{k=1}^{K}\sum_{n=1}^{N} K_b(n-x)\widehat{r}_{k,n}}{K\sum_{n=1}^{N} K_b(n-x)}, \tag{4}$$

where $K_b(\cdot) = b^{-1}K(\cdot/b)$ with K being a kernel function and bandwidth parameter b. The non-parametric estimate of $f(n)$ implicitly captures the effects of announcements without requiring the subjective choice of the most important announcements and without paying attention to their exact timing. The smaller we choose the bandwidth the more sensitive our estimate will be towards announcements and the larger we choose the bandwidth the smoother will be our estimate. For the practical estimation we choose a normal kernel and determine the bandwidth parameter by Silverman's rule-of-thumb.

The upper panel of Figure 3 graphs the fit to the average values of $\widehat{r}_{k,n}$ across the 24-hour trading day and the corresponding average sample values. The lower panel graphs the corresponding fit of the transformed series in comparison to the average demeaned absolute returns.[10]

Finally, the filtered 5-minutes returns are obtained as $\widetilde{R}_{k,n} \equiv R_{k,n}/\widehat{s}_n$. In order to examine their autocorrelation properties in comparison to the autocorrelation properties of the raw returns we plot in Figure 4 the ACF of the filtered series. Obviously, there is dramatic reduction in the periodic pattern although some periodicity remains. Interestingly, the autocorrelations of the absolute values of the filtered series first decay rapidly, but are then characterized by an extremely slow rate of decay. This type of

[10] To compare the estimates with the absolute returns we have to convert the intraday seasonality pattern through the transformation

$$|R_{k,n} - \mathbf{E}(R_{k,n})| = \frac{\sqrt{h_k}\exp\left(f(n)/2\right)\exp\left(u_{k,n}/2\right)}{\sqrt{N}}.$$

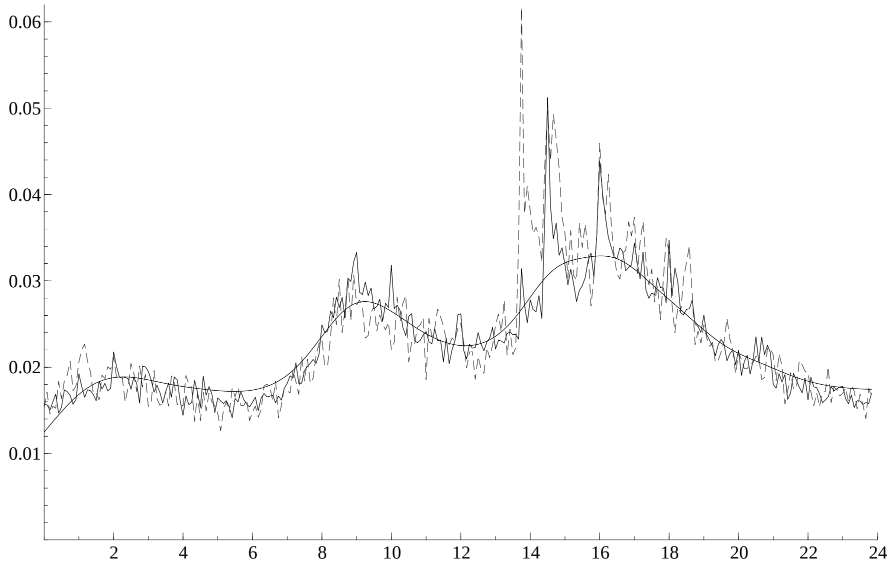

Figure 3: The figure graphs the nonparametric fit to the intraday seasonality of all Thursdays in the sample. The average absolute returns for all Thursdays is plotted as the solid line, the average absolute returns for all announcement days is plotted as the dashed line.

decay is typical for long memory processes associated with autocorrelations decaying as j^{2d-1}, where d denotes the order of fractional integration. To illustrate this point we run the regression $\log(\hat{\rho}_j) = c_0 + c_1 \log(j) + u_j,\ j = 5, 6, \ldots, 1440$, where $\hat{\rho}_j$ denotes the sample autocorrelation of the absolute five-minute returns (see Andersen and Bollerslev, 1998). Figure 4 shows that the rate of hyperbolic decay implied by the estimated persistence parameter of $\widehat{d} = (\widehat{c}_1 - 1)/2 = 0.42$ fits very well with the autocorrelations of the absolute returns. Hence, an appropriate model for modeling the conditional variance must allow for such long memory behavior. This requirement clearly rules out the class of stationary GARCH(p, q) models which are characterized by exponentially decaying autocorrelations.

3.2 The FIGARCH Model

We now denote by $Y_t,\ t = 1, \ldots, T$, the stacked version of the matrix $R = (\widetilde{R}_1 \widetilde{R}_2 \cdots \widetilde{R}_K)$ with $\widetilde{R}_k = (\widetilde{R}_{k,1} \cdots \widetilde{R}_{k,N})^T$. For the mean equation we assume the following autoregressive structure.

$$Y_t = \mu + \sum_{j=1}^{P} \varphi_j Y_{t-j} + \sum_{i=1}^{I} \delta(L) X_{t,i} + \varepsilon_t \tag{5}$$

The innovations $\{\varepsilon_t\}$ follow a FIGARCH(p, d, q) process as introduced by Baillie et. al (1996) Baillie et al. (2004) defined via the equations

$$\varepsilon_t = Z_t \sqrt{h_t}, \tag{6}$$

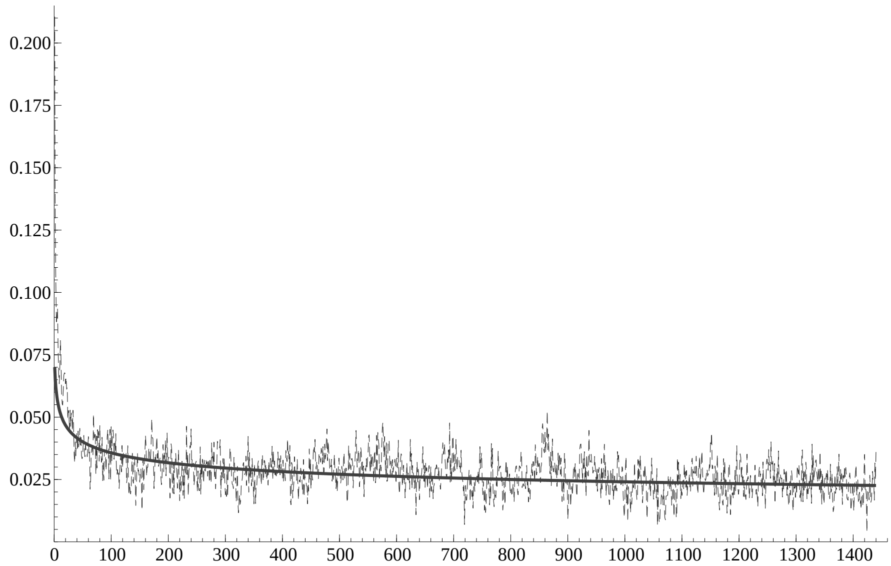

Figure 4: ACF of the filtered absolute return series (dashed) and fitted hyperbolic decay (bold).

where $\{Z_t, t \in \mathbb{Z}\}$ is a sequence of independent and identically distributed random variables with $\mathbf{E}(Z_t) = \mathbf{E}(Z_t^2 - 1) = 0$, and

$$(1-L)^d \Phi(L) \varepsilon_t^2 = \omega + B(L) v_t, \tag{7}$$

for some ω, lag polynomials $\Phi(L) = 1 - \sum_{i=1}^{q} \phi_i L^i$ and $B(L) = 1 - \sum_{i=1}^{p} \beta_i L^i$ and $0 \leq d \leq 1$ being the fractional differencing parameter and with $v_t = \varepsilon_t^2 - h_t$. The FIGARCH implies the ARCH(∞) representation

$$h_t \quad = \quad \frac{\omega}{B(1)} + \left(1 - \frac{(1-L)^d \Phi(L)}{B(L)}\right) \varepsilon_t^2 = \frac{\omega}{B(1)} + \sum_{j=1}^{\infty} \psi_j \varepsilon_{t-j}^2 \tag{8}$$

Alternatively, we allow for exogenous regressors.

$$h_t \quad = \quad \frac{\omega}{B(1)} + \frac{1}{B(L)} \sum_{i=1}^{I} \lambda_i(L) X_{t,i} + \left(1 - \frac{(1-L)^d \Phi(L)}{B(L)}\right) \varepsilon_t^2 = \frac{\omega}{B(1)} + \sum_{j=1}^{\infty} \psi_j \varepsilon_{t-j}^2 \tag{9}$$

Typically for high-frequency data the Bollerslev and Ole Mikkelsen (1996) condition is violated while Conrad and Haag (2006) is satisfied.

4 Estimation

As expected, on the control days only the dummy at 14:35 CET is significant in the volatility reflecting the effect of the macroeconomic announcements released in the US at 8:30 EST. In particular no effect on the mean of the exchange rate is evident. Neither of the 13:50 CET dummies is significant at any

Table 1: Mean value of five-minute EUR-$ returns.

	CD	AD	NS	SD	CE
13.40	0.0065	0.0022	*0.0016*	**0.0066**	0.0034
13.45	0.0032	-0.0013	*-0.0034*	**0.0157**	0.0076
13.50	-0.0066*	-0.0157***	-0.0196***	**0.0159**	*-0.0251*
13.55	0.0013	0.0003	-0.0046	**0.0387***	*-0.0083*
14.00	-0.0046	0.0014	**0.0023**	*-0.0059*	-0.0012
14.05	*0.0007*	0.0129**	0.0112**	0.0261	**0.0360*****
14.10	*-0.0074****	-0.0056	-0.0063	**0.0003**	0.0010
14.15	-0.0061	-0.0069	-0.0032	*-0.0362*	**0.0021**
14.20	**0.0016**	-0.0047	-0.0041	-0.0095	*-0.0178*
14.25	0.0066*	0.0062	0.0059	**0.0082**	*0.0047*
14.30	*-0.0069***	0.0095	**0.0112****	-0.0037	0.0068
14.35	0.0038	0.0082	0.0098	*-0.0040*	**0.0345****
14.40	0.0014	0.0030	0.0038	*-0.0030*	**0.0327***
14.45	**0.0005**	-0.0106	-0.0093*	*-0.0203*	-0.0110
14.50	**-0.0042**	-0.0060	-0.0058	*-0.0070*	-0.0055
14.55	-0.0056	0.0070	0.0076	0.0030	0.0050
15.00	0.0004	-0.0026	0.0011	*-0.0317*	0.0030
15.05	0.0026	-0.0049	-0.0031	*-0.0190*	-0.0061
15.10	*0.0009*	0.0061	0.0016	**0.0416*****	0.0044
15.15	0.0021	0.0069	0.0077	*0.0007*	**0.0165**
15.20	-0.0065	0.0005	**0.0035**	*-0.0231*	0.0028
15.25	-0.0039	-0.0039	**-0.0012**	*-0.0255*	-0.0174
15.30	**0.0021**	-0.0126*	-0.0092	*-0.0398***	-0.0206
average[13.40-15.30]	-0.008	-0.011	-0.005	-0.055	0.033
average[all day]	0.044	0.052	0.105	-0.366	0.196

Notes: CD: control days, AD: announcement days, NS: no surprise days, SD: surprise days, CD: comments on exchange rate days. Bold and italic numbers indicate the highest and lowest return in each row respectively. ***, ** and * indicate the absolutely highest, second highest and third highest return in each column.

conventional significance level. The picture for the announcement days is very different. We observe a significant 13:50 CET dummy in the mean with a negative sign, i.e. monetary policy decisions as made public by the press release tend have a negative effect on the level of the exchange rate immediately after the press release. No effect on the level is evident after the press conference. In the volatility we find significant increases at 13:50 CET as well as 14:35 CET. When an additional dummy at 13:55 CET is included the jump in volatility at 13:50 becomes much more pronounced with an immediate

Table 2: Mean absolute value of five-minute EUR-$ returns.

	CD	AD	NS	SD	CE
13.40	0.024	0.022	0.022	**0.025**	0.023
13.45	0.024	0.035	0.032	**0.056**	0.026
13.50	0.028	0.062***	0.043	**0.213*****	0.068***
13.55	0.025	0.038	0.035	**0.063**	0.045
14.00	0.025	0.041	0.035	**0.085***	0.056*
14.05	0.023	0.038	0.036	**0.059**	0.055
14.10	0.024	0.036	0.033	**0.054**	0.047
14.15	0.023	0.036	0.030	**0.086****	0.047
14.20	0.027	0.035	0.032	**0.061**	0.048
14.25	0.027	0.032	0.029	**0.055**	0.037
14.30	0.041**	0.043	0.043	**0.046**	**0.046**
14.35	0.046***	0.050**	0.049***	**0.056**	0.050
14.40	0.035*	0.044	0.044	0.045	**0.064****
14.45	0.033	0.049*	0.048**	0.056	**0.068*****
14.50	0.041**	0.046	0.046*	0.053	**0.054**
14.55	0.035*	0.043	0.040	**0.066**	0.048
15.00	0.030	0.037	0.034	**0.061**	0.044
15.05	0.032	0.035	0.035	0.032	**0.037**
15.10	0.025	0.030	0.028	**0.047**	0.040
15.15	0.027	0.036	0.035	0.041	**0.047**
15.20	0.031	0.031	0.030	0.039	**0.040**
15.25	0.026	**0.030**	**0.030**	0.028	0.029
15.30	0.028	0.036	0.036	0.039	**0.042**

Notes: CD: control days, AD: announcement days, NS: no surprise days, SD: surprise days, CD: comments on exchange rate days.

Table 3: AR(3)-FIGARCH$(1, d, 1)$ models for filtered five-minute EUR-$ returns.

	μ	φ_1	φ_2	φ_3	$\omega \cdot 10^{-4}$	ϕ_1	β_1	d	ν	$Q^2(20)$
CD	0.001	0.123	-0.065	-0.024	1.390	0.727	0.824	0.298	5.506	10.33
	(2.438)	(17.02)	(-10.08)	(-3.816)	(6.884)	(24.44)	(37.31)	(16.83)	(29.52)	
AD	0.001	0.094	-0.056	-0.028	1.341	0.708	0.803	0.310	5.446	10.08
	(2.283)	(13.41)	(-9.018)	(-4.871)	(6.753)	(22.44)	(34.04)	(15.45)	(29.86)	

Notes: Robust standard errors are given in parenthesis. CD: control days (89). AD: announcement days (89). The seasonal pattern is obtained from all Thursdays.

decrease at 13:55 CET. These results deliver overwhelming evidence for the hypothesis that the press release launched at 13:45 CET on announcement days has a significant impact on the level as well as the volatility of the EUR-$ exchange rate. The effect on the volatility observed at 14:35 CET is twice as large as for the control days, showing the that ECB press conference impacts the EUR-$ exchange rate in addition to the usually announced macroeconomic news in the US. Next, we analyze the announcement days more closely by grouping them in surprise days and no-surprise days. The regressions run include all announcement days but the time dummies take the value of one only for the surprise days or no-surprise days, respectively. The results for the no-surprise days are very similar to the ones for all announcement days. As one would expect, the effect at 13:50 CET in the volatility is less pronounced, indicating that this effect is merely driven by surprise news. Turning to the surprise days, it is the 13:50 CET dummy in the volatility which is dominating. The volatility increase at 13:50 CET is dramatic compared to the no-surprise days and again best captured by two dummies at 13:50 and 13:55 CET. This also highlights the fact that this effect is very strong, but rather short lived. Surprisingly, we do not find an effect on the mean of the exchange rate. However, this may be explained by the fact that the dummy approach does not control for positive or negative surprises and not for the size of the surprise.

Table 4: AR-FIGARCH-Dummy models for filtered five-minute EUR-$ return data.

	$D^m_{13.50}$	$D^m_{13.55}$	$D^m_{14.00}$	$D^m_{14.35}$	$D^v_{13.50}$	$D^v_{13.55}$	$D^v_{14.35}$	$D^v_{14.45}$
CD	-	-	-	-	-	-	0.0020***	-
							(0.0007)	
AD	-0.0210**	-	-	-	0.0036***	-	0.0041***	-
	(0.0087)				(0.0011)		(0.0013)	
	-0.0210**	-	-	-	0.0106*	-0.0069	0.0041***	-
	(0.0093)				(0.0055)	(0.0044)	(0.0012)	
NS	-0.0203**	-	-	-	0.0026***	-	0.0040***	-
	(0.0084)				(0.0009)		(0.0013)	
SD	-	-	-	-	0.0459***	-	-	-
					(0.0233)			
	-	-	-	-	0.3291*	-0.2550*	-	-
					(0.1701)	(0.1368)		

Notes: Robust standard errors are given in parenthesis.

Next, we use the surprise data to investigate whether the movements the mean and variance can be explained by the size and sign of the surprise. Mean surprises as well as median surprises are constructed as the mean, $MeaS_k$, or median, $MedS_k$, of $S_{k,s}$, $s = 1, \ldots, S$, which is the difference between the realized policy instrument and the expectation of market participant s. For the control days none of the variables is significant, i.e. the movements in the level and volatility of the none announcement days can not be explained by surprises which occur on announcement days. The absolute mean and median surprise do very well explain the rapid increase in volatility at 13:50 CET on announcement days. However, the surprise variables do not explain the movements in the level of the exchange rate. The BHS communication index has some week power in explaining the volatility movements around 14:35 CET. More successful is a dummy variable which directly measures whether the exchange rate was discussed within in the press conference.

Table 5: AR-FIGARCH-Expectation models for filtered five-minute EUR-$ return data.

	$D^m_{13.50}$	$D^m_{14.00}$	$D^m_{14.35}$	$AbsMeaS^v_{13.50}$	$AbsMedS^v_{13.50}$	$Comm^v_{14.35}$	$CE^v_{14.40}$
CD	-	-	-	-	-		-
AD	-	-	-	0.1824⋆⋆	-	-	-
				(0.0902)			
	-	-	-	-	0.3085⋆⋆⋆	-	-
					(0.0794)		
	-	-	-	-	-	0.0009⋆⋆	-
						(0.0004)	
	-0.0184⋆⋆	-	-	-	0.2861⋆⋆⋆	-	0.0064⋆
	(0.0078)				(0.0805)		(0.0064)

Notes: Robust standard errors are given in parenthesis.

Another interesting approach is to investigate to which extent the realized volatility, RV_t, can explained by the surprises of market participants, the communication index and the word 'exchange rate' mentioned in the press conference. A simple regression leads to an $\bar{R}^2 = 0.46$.

$$RV_t^{Comm} = \underset{(0.029)}{0.292} + \underset{(0.258)}{1.523} AbsMeanSurp_t + \underset{(0.012)}{0.033} CommIndex_t + \underset{(0.042)}{0.099} CommentExch_t + \eta_t \quad (10)$$

5 Conclusion

We analyze the effect of ECB monetary policy decisions in conjunction with its communication on the level and variance of the EUR-$ exchange rate. The ECB press release has a significant impact on the level and volatility of the EUR-$ exchange rate. The effect on the volatility can be explained by the surprise the decision created among market participants. The press conference effects the volatility only and this effect is correlated with the BHS communication index as well as with the explicitness in which the exchange rate was addressed during the press conference. This enforces the impression that the

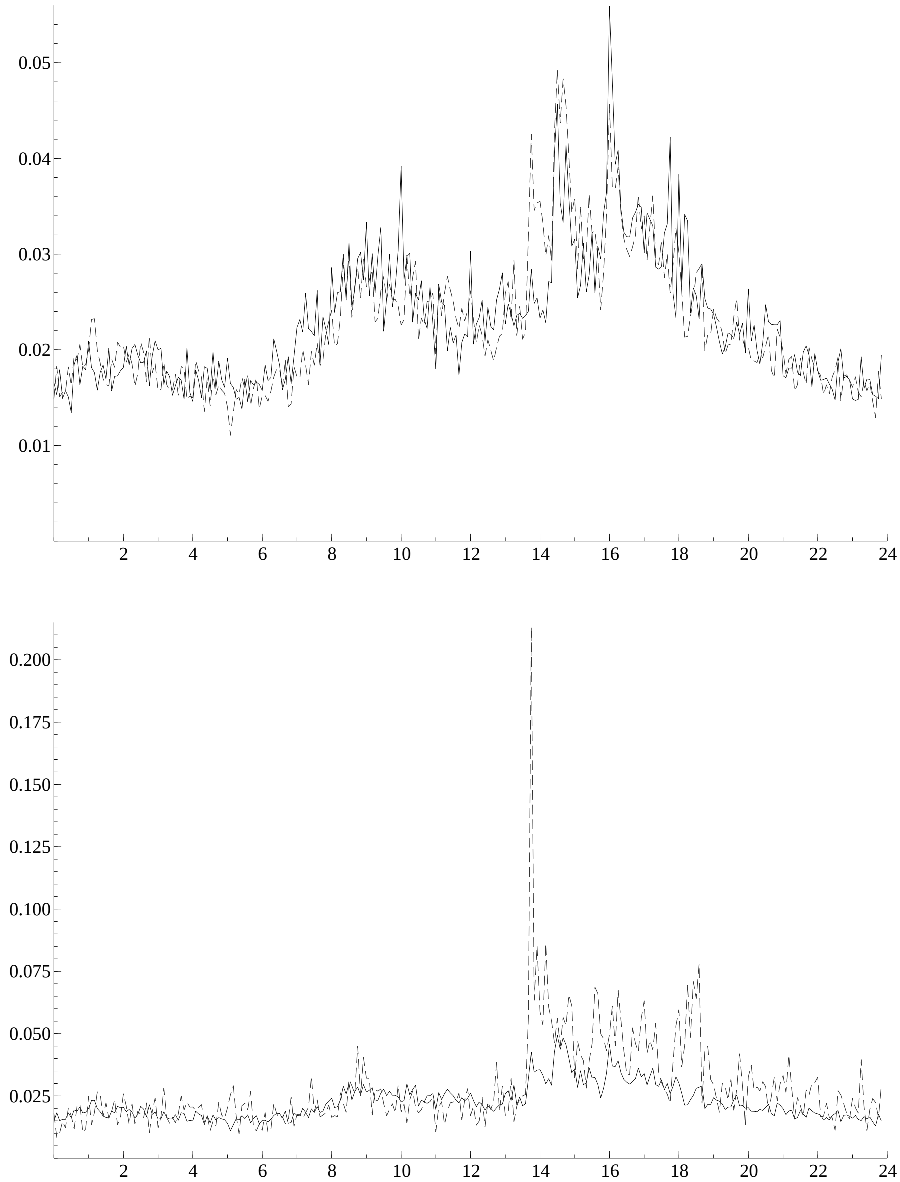

Figure 5: Average absolute five-minute EUR-$ returns for each five minute interval. The upper panel compares control days (solid line) with communication days with no policy surprise (dashed line). The lower panel compares communication days with policy surprise (dashed line) and without policy surprise (solid line).

assessment of the governing council is of special importance for the public. Overall, we find overwhelming evidence that announcements of the ECB indeed matter for the movement of exchange rates.

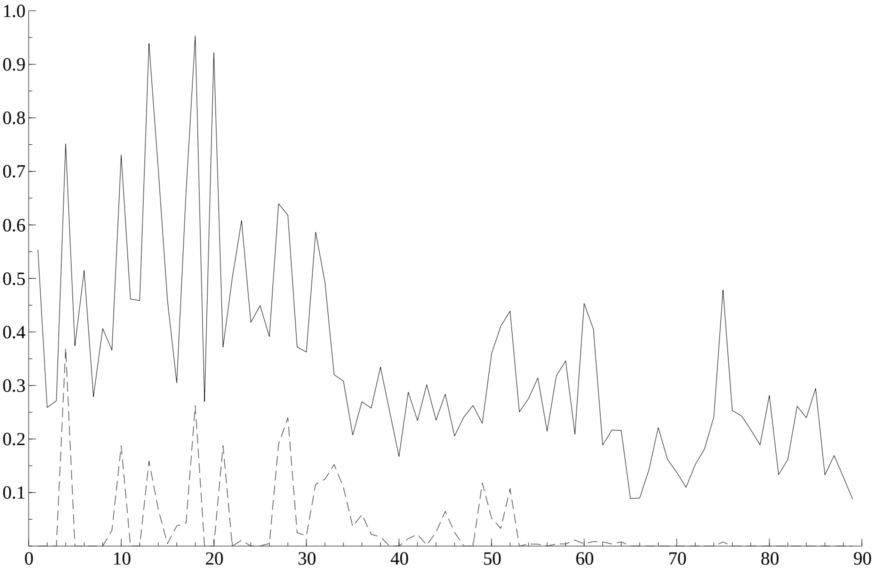

Figure 6: The figure shows the realized volatility (solid line) over the 89 communication days together with the mean surprises (dashed line).

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