Monetary Policy Implementation and Volatility in the Euro Area Money Market

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Abstract

This paper studies the effects of monetary policy implementation on the euro area money market. In particular, volatility of interest rates with various maturities and volatility transmission along the yield curve is analyzed. It is found that the way how monetary policy is implemented affects volatility of most money market rates, except the twelve-month rate. These effects are strongest at the short end of the yield curve. However, for firms' investment and households' consumption decisions longer term rates are most relevant, which indicates that the real effects of the operating procedure in place are limited. Furthermore, some calendar day effects are documented.

JEL classification: E52; E58; E43.

Keywords: Money markets; EONIA rate; Volatility transmission; Central bank operating procedures.

1 Introduction

Nowadays most central banks target a short-term interest rate in order to achieve their primary objectives, like price stability. By signalling its target rate and managing the liquidity situation in the money market a central bank steers short-term money market rates. This paper describes how the European Central Bank manages the liquidity situation in the money market and its implications for interest rates of various maturities. In particular, volatility of interest rates and its transmission along the yield curve is discussed extensively.

Central banks differ substantially in how they manage the liquidity situation in the money market. These differences in the operational framework may have implications for the behavior of interest rates, in particular for their volatility.

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Central banks are eager to avoid high volatility, especially for interest rates with long maturities. Firstly, high volatility of money market rates may give market participants confusing signals on the monetary policy stance. However, the central bank wants to communicate its monetary policy stance clearly, without unnecessary noise, and, therefore, avoid high volatility. Secondly, and maybe even more important, long-term interest rates are relevant for firms' investment and households' consumption decisions. High volatility of an asset's price requires, in general, higher returns on this asset and, therefore, increases the costs of an investment. Again, there are benefits of avoiding high volatility.

High volatility of interest rates at the short end of the yield curve is less of a concern. Volatility at the short end - as long as it is not transmitted along the yield curve - is mainly interpreted as money market noise, without affecting the real side of the economy. This paper analyses volatility in money market rates and its transmission from the short to the long end of the yield curve. It provides insights into the operational framework of the European Central Bank and the effects of this framework on money market rates.

This paper is not only important for the conduct of monetary policy, but also to understand better the term structure of interest rates. It is widely accepted that short-term rates explain a large part of the movements in longer term rates. In this paper money market rates of various maturities are modelled carefully. The empirical model specifications for both, conditional mean and volatility are tested extensively for omitted variables.

There exists very little empirical evidence for euro area money markets rates and transmission of volatility along the yield curve. Related work has been done for the UK (e.g. Wetherilt, 2002 and Panigirtzoglou et al, 2000) and for some other countries. The sample period in most of these other studies ends in or before 1998, the year preceding the creation of the European Monetary Union (e.g. Cohen, 1999 and Ayuso et al, 1997). The only publications dealing with the euro area money market are Cassola and Morana (2003 and 2004). These papers contain many insights, nevertheless, the present study improves on them in several respects. First of all, it bases the analysis on a careful theoretical model of the overnight interest rate. The overnight interest rate is the starting point of the yield curve and plays a crucial rule in explaining interest rates further out on the yield curve. In addition, the overnight interest rate is closely related to the conduct of monetary policy, especially to the operating procedures in place. The present study tests explicitly for the effects of the operating procedure on the behavior of interest rates. Furthermore, a different methodology is used and the sample period is extended considerably.

The next section discusses the data used and the general methodology. Section three provides a model of the euro area overnight rate, the so-called EONIA rate. The EONIA rate is a very important rate in the conduct of euro area monetary policy. The EONIA rate represents the short end of the money market yield curve and it is heavily influenced by the European Central Bank's policy decisions. Section four models interest rates of longer maturities. The conditional volatility of the EONIA rate is included as an explanatory variable for the volatility of all other interest rates. This is a straightforward way to test for transmission of volatility along the yield curve. Section five concludes. The appendix contains all tables and figures.

2 Data and Methodology

The interest rates used in this study are an overnight rate (EONIA rate), and EONIA swap rates with maturities of two weeks, and one, three, six and twelve months. Ideally repo rates should have been chosen, because repo transactions are based on collateral and, therefore, do not involve any credit risk. After all, there is still no unified repo market for the euro area. Instead EONIA swap rates have emerged as a benchmark for the euro area money market. The EONIA swap market is very liquid and the risk involved is very small. In an EONIA swap two parties agree to exchange the difference between the agreed fixed interest rate and the EONIA rate, accrued over a given period and for an agreed notional amount. Since the principal amount is not exchanged, the credit risk involved in swap transactions is very low.

The sample starts at 24/03/1999 and ends at 19/02/2004. Daily averages of bid and ask quotes from Reuters (for all money market rates, except the six and twelve-month swap rates) and Bloomberg (for the six and twelve-month swap rates) are used. Descriptive statistics for all money market rates are provided in table 1, in the appendix.

The model applied for all interest rates follows closely Moschitz (2004).[1] Both, conditional mean and volatility of the respective interest rate are estimated jointly. The specification takes into account the operational framework of the euro area, models it carefully and tests extensively for omitted variables.[2] Standard unit root tests confirm that all interest rates, within the sample, are integrated of order one. Furthermore, they are co-integrated with the target rate, i_t^*. The target rate is assumed to be the fixed rate (until June 27, 2000) and the minimum bid rate (after June 27, 2000) at which the European Central Bank conducts its weekly open market operations.[3] Therefore, all interest rates, i_t, are modelled in first differences, $\Delta i_t \equiv (i_t - i_{t-1})$, and a unit co-integrating vector, $(i_{t-1} - i_{t-1}^*)$, is imposed.[4] The model then is:

$$
\begin{aligned}
\Delta i_t &= c + \phi(i_{t-1} - i_{t-1}^*) + x_t\beta + h_t\eta_t \\
\ln(h_t^2) &= z_t\lambda + \sum_{j=1}^{q} \delta_j \left(\ln(h_{t-j}^2) - z_{t-j}\lambda\right) + \alpha\left\{|\eta_{t-1}| - E|\eta_{t-1}| + \gamma\eta_{t-1}\right\} \\
\eta_t &\sim iid(0, p + (1-p) * \sigma^2).
\end{aligned}
$$

[1] See the references therein. Hamilton (e.g. 1997) was one of the first authors to study the behavior of short-term interest rates by using advanced time-series techniques.

[2] Selected results for tests on omitted variables are discussed in the relevant sections below. The full set of results is available from the author.

[3] The target or policy rate, as defined here, coincides with the mid-point of the deposit and marginal lending rate. Only for the first few weeks in 1999 the corridor formed by deposit and lending rate was not symmetric around the policy rate.

[4] Results on tests for the order of integration and co-integration are not reported. All test results are available from the author.

The parameter ϕ captures how fast the interest rate, i_t, returns to its long-run value, the target rate i_t^*. The mean equation includes a constant, c, and other explanatory variables, x_t. The vector x_t contains lags of the dependent variable and the target rate, as well as variables related to the operating procedure and to calendar days. The conditional standard deviation of the interest rate is given by h_t. The vector z_t contains explanatory variables for the conditional volatility equation. Of particular interest are variables related to the operating procedure and calendar days. Standardized residuals are denoted by η_t. Some of the interest rates are characterized by frequent small changes and occasional large moves. This behavior is modelled with a mixture of two normal distributions. The probability to come from the first distribution with variance one is p, and the probability to come from the second distribution with variance σ^2 is $(1-p)$. The exponential GARCH model applied here allows to estimate the different impact good and bad news have on the volatility, which is given by the parameter γ.[5] Further details of the models are explained in the respective sections.

3 Overnight interest rate (EONIA)

The EONIA rate is a volume-weighted average of interbank rates in the euro area and is a particularly important interest rate. It is important for the conduct of monetary policy, but also to understand the term structure of interest rates. It defines the short end of the yield curve and potentially influences all other interest rates further out the maturity spectrum.

The EONIA rate is the price paid for reserves held at the central bank. On the interbank market commercial banks actively trade these reserve holdings. The main reasons for holding reserves are transaction purposes and to meet the reserve requirement imposed by the central bank. The reserve requirement has not to be met on a daily basis, but on average over one month, the reserve maintenance period (RMP).[6] Profit maximizing banks, therefore, hold reserves when they are relatively cheap, and lend reserves to other banks when they are relatively expensive. Hence, the expected future interest rate is an important explanatory variable for today's reserve holdings, and, thus, today's interest rate. The expected future interest rate depends mainly on two factors, the expected supply of reserves and the expected target interest rate.

The central bank is the sole net supplier of reserves, in consequence, it has a strong influence on this market. Nevertheless, the central bank cannot control the reserve supply perfectly. Supply shocks hit the reserve market, moving the reserve supply unexpectedly. After all, the institutional details of how and when the central bank supplies reserves have an important - and expected - impact on the EONIA rate, both on mean and volatility. Supply of reserves is executed

[5] See e.g. Bollerslev et al (1992) for an overview of models for conditional volatility.

[6] Throughout the sample period, the reserve maintenance period starts at the 24th of each month and ends at the 23rd of the following month. From March 2004 onwards begin and end of the reserve maintenance periods will be related to the European Central Bank's Governing Council meetings.

through open market operations, in general, via a weekly auction. Usually, on every Tuesday the respective amount is allotted and settled on Wednesday. In what follows these days are labelled allotment and settlement days.

The empirical model for the EONIA rate follows closely Moschitz (2004). His specification is based on a theoretical model for both supply and demand for reserves, which recognizes that the EONIA rate is the equilibrium interest rate in the market for reserves.

Parameter estimates for this model are given in table 2, in the appendix. Figure 1 plots the conditional log volatility for the EONIA rate. To get a better intuition for the driving forces of volatility, Figure 2 zooms in the previous graph and shows the volatility starting in 2003. Volatility increases around the end of the reserve maintenance period, as well as around the end of the month and around policy rate changes -March and June 2003- are clearly visible.

Since June 2000 the ECB performs its weekly auction with a minimum bid rate. Whenever there are expectations of an imminent cut in this minimum bid rate, the policy rate, commercial banks may want to postpone reserve holdings till the next week. Therefore, demand for reserves can fall short of the amount the central banks plans to allot. This so-called underbidding has led to higher volatility, as can be seen in panel G of table 2.

The mean of the EONIA rate moves in reaction to permanent changes in supply (see e.g. Moschitz, 2004, for further details). Supply of reserves may be endogenous, therefore, supply shocks are used as instruments to measure correctly the slope of the demand curve. Any supply shock occurring after the last open market operation of the reserve maintenance period is a permanent change in supply since it affects the reserve situation for the entire maintenance period. This is so, because the central bank is not able anymore to make up for past supply shocks. Although, at any other open market operation, except the last one, the central bank neutralizes past supply shocks. The slope of the demand curve is estimated to be roughly eight basis points per one billion of euro. A permanent change of reserves by one billion euro moves the EONIA rate by eight basis points into the opposite direction. Interestingly, supply shocks occurring after the last open market operation, but before the last day of the RMP do not have any immediate effect. They impact on the EONIA rate only at the last day of the RMP, as can be seen in panel A of table 2. Lagrange multiplier tests show that supply changes occurring at any other day do not affect the EONIA rate. A test for the significance of the respective parameter has a p-values of 0.5. This is consistent with the theoretical prediction. Supply changes at any other day are temporary, and, therefore, should not have an effect on the interest rate.

Besides changes in reserves also the expected future target or policy rate influences the EONIA rate. The future expected policy rate is measured by a forward rate.[7] Only changes in the policy rate which occur in the current RMP are relevant for the current EONIA rate. Therefore, the expected future policy

[7] The two and one-week EONIA swap rates are used to construct the one-week rate in one week. In Moschitz (2004) rates with other maturities have been used, but results are almost identical.

rate is easiest to approximate at the first day of each RMP. As the end of the RMP is approached expectations of policy rate changes in the following RMP become more important for the forward rate. Indeed, the parameter for the expected future policy rate is only significantly different from zero at the first day of the RMP.

The only calendar day effects found in the present study are related to the end and begin of a month. The EONIA rate increases at the last day of each month by 5 basis points. At the end of the second quarter the increase is 18 basis points and at the end of the year 30 basis points. These increases are completely reversed at the first day of the following month. These calendar day effects are not easily explained in a theoretical model (e.g. Moschitz, 2004). These effects are likely to be the result of window dressing, i.e. companies adjusting their balance sheets at the end of the month. There is not much the central bank can do to counteract these end of the month effects. Changes in reserves supply at these days would be seen as temporary changes and, therefore, not affect the interest rate. Explicit tests for liquidity effects around the end of the month confirm this intuition (see table 9).

The here discussed model has been tested extensively for omitted variables. Tables 9 to 12 give the potentially omitted variables for which both, mean and volatility equations have been tested for. A few results are worth mentioning in more detail. Throughout the sample period the number of days which pass after the last allotment until the last day of the reserve maintenance period varies every month. In general, the last allotment is performed on Tuesday and the last day in a reserve maintenance period is the 23rd of each month. However, there have been some recent changes in the operational framework of the ECB, becoming effective from March 2004 onwards (see e.g. ECB, 2004). Now, there are always five (business) days after the last allotment until the last day of the RMP. It is therefore interesting to test if the volatility increase at the end of the RMP depends on the number of days after the last allotment day. Lagrange multiplier tests, as outlined in panels D to G of table 10, indicate that the number of days after the last allotment day does not matter for volatility.

4 Money market interest rates

4.1 Model specification and estimation results

One of the main motivations for this paper is to test for the transmission of volatility from the short end of the yield curve to the long end. As has been seen in the previous section the operating procedures, i.e. institutional details of how monetary policy is implemented, explain a considerable part of both mean and volatility of the EONIA rate. In this section it is investigated how much of the EONIA volatility is transmitted to interest rates with longer maturity. This is an important question to answer. Central banks are concerned of keeping volatility low, especially at the long end of the yield curve. Therefore, it is crucial to know if certain operating procedures imply high volatility across the term spectrum of interest rates, or if high volatility is limited to the short end. Furthermore, financial agents are equally interested in learning more about the behavior of money market rates.

In what follows money market rates with maturities from two weeks up to one year are analyzed. The basic model is closely related to the one applied for the EONIA rate. However, the conditional volatility of the EONIA rate, as estimated in the previous section, is included as an explanatory variable for the conditional volatility of all other rates. This is a straightforward way of testing for volatility transmission along the yield curve.

The mean equation is very similar for all rates. All potential variables, as outlined in tables 9 to 12, have been tested for. The only significant variables are a constant, the error-corretion term, lagged changes in the policy rate and one lag of the dependent variable. The volatility equations are more interesting and below the explanatory variables for each rate are explained in detail. Standard specification tests for each money market rate are shown in the respective tables. All models seem to be well specified. There is no evidence of serial correlation neither in residuals nor in squared residuals.

The estimated model for the two-week rate is given in table 3. Indeed, there is considerable transmission of volatility. More than 30 percent of the EONIA rate volatility is transmitted to the two-week rate. Before November 2001 monetary policy decisions were, in general, made at any of the Governing Council meetings. However, after this date policy decisions were, as a rule, only made at the first meeting of every month. This change reduced the volatility of the two-week rate significantly.

Weekdays have been tested for volatility effects. On Thursdays the log volatility of the two-week rate increases by about 0.7. It has been seen in the previous section that underbidding had a considerable effect on the EONIA rate, both on mean and volatility. The allotment day, on which underbidding occurred, increases substantially the volatility of the two-week rate as well. However, there is no effect of underbidding on the mean of the two-week rate.

Some negative parameters show up in panel B and C of table 3, in particular around the end of the maintenance period and around the end of a month. The volatility of the EONIA rate is very high at these days. As has been seen a substantial part of the volatility of the EONIA rate is transmitted to the two-week rate, but on these special days, the volatility of the two-week rate does not increase as much as the volatility of the EONIA rate. The negative parameter values capture this effect. Lagrange multiplier tests do not provide any evidence that volatility transmission is different at other days, than at the days just mentioned (see table 12 for details).

Furthermore, besides the days already discussed no other calendar days or days of the reserve maintenance period affect the volatility of the two-week rate (see tables 10 and 11).

Table 4 provides the estimated model for the one-month rate. There is still significant volatility transmission, however, it is lower than for the two-week rate. About 14 percent of the EONIA volatility is transmitted to the one month rate. In addition, volatility is higher at the days of a press conference and at days of a change in the policy rate. Underbidding in the open market operations also led to an increase in volatility. Again, volatility decreased after November 2001, when policy decisions were taken, in general, only once a month. Figure 3 shows the conditional log volatility for the full sample. It shows very nicely the decrease of volatility after November 2001, as discussed above. Figure 4 zooms in the previous graph, starting in 2003. Increases in volatility around policy rate changes (March and June 2003) and towards the end of the RMP are clearly visible.

Transmission of volatility is not different across days of the RMP or on specific calendar days (see table 12). There are no other effects on the conditional volatility, neither (see tables 10 and 11).

Table 5 contains the parameter estimates for the three-month rate. Volatility transmission is highly significant and amounts to 13 percent. Furthermore, the day of the press conference and the policy rate change increase volatility. The change in the frequency of the policy decisions has had no effect on the three-month rate. A significant part of volatility is transmitted form the overnight maturity to the three months maturity. However, this transmission is partly reversed on the last settlement day in a RMP and at the last day of a semester, which can be seen by the negative parameters in panels B and C of table 5.

Besides the above mentioned effects, no other explanatory variables have been found to explain a significant portion of the volatility of the three-month rate (see tables 10 to 12).

Results for the six-month rate are given in table 6. Volatility transmission stands at 14 percent. However, it is not the contemporaneous EONIA volatility, rather the one day lagged volatility, which is transmitted. Again, the day of the press conference increases volatility. Interestingly, the change in the frequency at which policy rate decisions are generally made had an effect. Recall that this effect is not present for the three-month rate, although it is significant for the two-week and one-month rates. Volatility decreased after the frequency of policy decisions were reduced to monthly.

No other variables have been found to explain significantly the volatility of the six-month rate (see tables 10 to 12).

It has been documented that there is substantial transmission of volatility along the yield curve, up to a maturity of six months. The twelve-month rate is different, as can be observed in table 7. The EONIA volatility has no effect on the twelve-month rate. The only significant parameter for the volatility equation are those on the day of the press conference and the day of a policy rate change. Figure 5 shows the conditional log volatility for the twelve-month rate, starting in 2003. No clear pattern can be observed, except for the policy rate changes in March and June 2003. In other words, volatility is transmitted along the yield curve, but not too far out. The twelve-month rate seems to be the inflection point. None of the numerous other explanatory variables which are tested are found to be significant (see tables 10 to 12).

4.2 Volatility curve

One way of summarizing the results of this paper is to plot the volatility curve of the euro area money market rates. A volatility curve shows a measure of volatility for interest rates with different maturities, plotted against their maturities. The here estimated volatility curve has a U-shape, as can be observed in figure 6. This pattern has been documented also for the US (e.g. Piazzesi, 2001). Volatility is high at the short end of the yield curve, decreases up to six-month maturity and then increases again. The increase in volatility beyond the six-month rate may be related to interest rate smoothing of the central bank. Central banks usually adjust the target interest rate in several small steps. Financial markets, therefore, expect a change in the interest rate to be followed by another change. However, there is uncertainty when this change actually will occur. This uncertainty is then reflected in the volatility of interest rates with maturity larger than six months. High volatility at the short end of the yield curve is related mainly to money market noise. Money market noise summarizes the effects of short-term changes in liquidity in the money market and uncertainty about imminent policy rate changes.

The entire volatility curve shifts up at days of the central bank's policy meetings. At these days volatility for all money market rates is higher than at "normal" days. Figure 6 plots the volatility curve for policy meeting days and the remaining, "normal", days. From the beginning of 1999 up to November 2001 policy decisions were made (in general) at each of the bi-weekly ECB's Governing Council meetings. From November 2001 onwards the frequency of policy decisions changed to monthly. Only the first Governing Council meeting in each month, which coincides also with the Press Conference, is a policy meeting. Note that this change in the frequency of policy meetings seems to have reduced volatility in the money market, especially at the short end.

5 Conclusions

This paper studies the effects of monetary policy implementation on the euro area money market. In particular, volatility of interest rates with various maturities and volatility transmission along the yield curve is analyzed. It has been shown that the operating procedure explains a substantial part of the behavior of interest rates. The further out the term structure, the less important is the operating procedure. Nevertheless, money market rates up to six months maturity are significantly affected by the way how the central bank implements its monetary policy decisions. The one year rate is the inflection point. Press conferences and changes in the target rate are the only events which affect its volatility. Notwithstanding, firms' investment and households' consumption decisions depend more on longer term rates, which indicates that real effects of the operating procedure in place are limited.

A natural extension of this work is to look at rates further out the maturity spectrum, or to include other money market rates, like repo or Euribor rates.

Most likely the results presented here will be confirmed. The one year rate is disconnected from the operating procedure, therefore, it seems likely that rates with longer maturities are largely independent from operating procedures as well. Macroeconomic news are the probable candidates to explain volatility of long-term rates, not the operating procedure. In the present analysis swap rates have been used, because they have emerged as a euro area benchmark for the money market. It would be interesting to use repo rates, since they do not involve credit risk. However, for the time being there does not exist a unified repo market. The use of Euribor rates is more complex, because the credit risk is substantially higher than for swap rates. This credit risk then would have to be modelled somehow. Nevertheless, there are no obvious reasons why operating procedures should affect other money market rates, like repo or Euribor rates, but not affecting swap rates, and vice versa. Therefore, it is likely that the results presented here will be confirmed.

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A Basic statistics and estimation results

Table 1

Basic statistics for euro area money markets

	Maturity					
	Overnight	Two weeks	One month	Three months	Six months	Twelve months
	Level					
Mean	3.343	3.342	3.345	3.352	3.378	3.480
Std. dev.	0.931	0.901	0.905	0.916	0.933	0.951
Skewness	0.283	0.277	0.280	0.268	0.231	0.137
Kurtosis	2.043	1.896	1.894	1.901	1.937	1.949
Maximum	5.750	4.945	4.935	5.065	5.145	5.275
Minimum	1.340	1.981	2.012	2.005	1.943	1.825
	First differences					
Mean	0.000	-0.001	-0.001	-0.001	-0.001	-0.001
Std. dev.	0.143	0.043	0.040	0.038	0.037	0.040
Skewness	0.884	-0.581	-0.549	-0.717	-1.073	0.248
Kurtosis	16.745	22.882	26.257	42.201	88.475	5.042
Maximum	1.160	0.268	0.285	0.370	0.525	0.180
Minimum	-0.980	-0.420	-0.368	-0.415	-0.580	-0.188

NOTE: All statistics are computed for EONIA swap rates, except for the overnight maturity, which is the EONIA rate itself. The EONIA rate is a volume-weighted average of interbank rates in the euro area. Sample: All business days from 24/03/1999 to 19/02/2004, both included.

Table 2

Parameter estimates for the Overnight Interest Rate (EONIA)

Model: $\Delta i_t = c + \phi(i_{t-1} - i^*_{t-1}) + x_t\beta + h_t\eta_t$

$\ln(h_t^2) = z_t\lambda + \Sigma_j \delta_j \{ \ln(h_{t-j}^2) - z_{t-j}\lambda \} + \alpha\{|\eta_{t-1}| - E|\eta_{t-1}| + \gamma\eta_{t-1}\}$

$\eta_t \sim iid(0, p + (1-p)*\sigma^2)$.

Sample: All business days from 24/03/1999 to 19/02/2004, both included.

Variable	Parameter	Std. Error	p-value
Mean equation			
(A) Liquidity effects at the last day in a RMP, t = T			
u_{T-1}	-0.077	0.014	0.000
u_{T-2}	-0.055	0.009	0.000
$u_{T-3} + u_{T-4} + u_{T-5}$	-0.052	0.009	0.000
u_T	-0.046	0.009	0.000
(B) Expected future policy rate			
$E_t[i^*_{t+k}]$ at the first day in a RMP, t = 1	0.628	0.060	0.000
$E_t[i^*_{t+k}]$ at other days, t = 2,…,T	0.000	0.007	0.946
(C) Calendar day effects			
End of month, reversed begin of month; except end of semester	0.051	0.002	0.000
End of 2nd quarter, reversed begin of 3rd quarter	0.178	0.020	0.000
End of 4th quarter, reversed begin of 1st quarter	0.310	0.033	0.000
(D) Other variables			
First day in a RMP, t = 1	0.030	0.005	0.000
dunderbidding	-0.303	0.014	0.000
$(i_{t-1} - i_{t-2})$*(1 - first day - begin of month)	0.067	0.011	0.000
Constant	0.001	<0.001	0.173
Error correction term $(i_{t-1} - i^*_{t-1})$ at the first day in a RMP, t = 1	-1.000	-	-
Error correction term $(i_{t-1} - i^*_{t-1})$ at all other days, t = 2,…T	-0.040	0.008	0.000

Table 2 (continued)

Variable	Parameter	Std. Error	p-value
Volatility equation			
(E) Days of reserve maintenance period			
First day, t = 1	1.516	0.194	0.000
Last allotment day	0.841	0.250	0.001
All days after last allotment	3.045	0.381	0.000
Next to last day, t = T-1	1.850	0.393	0.000
Last day, t = T	2.315	0.510	0.000
(F) Calendar days			
End of month and the day before	0.471	0.171	0.006
Begin and end of a quarter, additionally	1.500	0.665	0.024
Begin and end of a semester, additionally	2.170	0.455	0.000
Policy rate change and the day after	1.087	0.287	0.000
(G) Other dummy variables			
dunderbidding	1.754	0.195	0.000
GC meeting after last allotment (Sep and Oct 1999)	4.028	0.291	0.000
Underbidding at end of RMP (Dec 2003)	1.047	0.356	0.003
January 2002 (Cash changeover)	3.175	0.725	0.000
(H) EGARCH parameters			
Constant	-6.394	0.151	0.000
α	2.403	0.211	0.000
δ	0.678	0.037	0.000
γ	0.089	0.033	0.007
σ	0.203	0.011	0.000
p	0.324	0.003	0.000
Standardised residuals:			
Mean	0.019		
Variance	0.368		
Skewness	0.599		
Kurtosis	12.657		
Q(20), p-value	0.023		
Q(20) for squared residuals, p-value	0.970		

NOTE: i_t = volume-weighted average of interbank rates in the euro area, the EONIA rate. i^*_t = policy rate, or target rate, which is defined as the fixed rate (until June 27, 2000) and the minimum bid rate (after June 27, 2000) at which the European Central Bank conducts its weekly open market operations. Any change in the policy rate is assumed to become effective at the day of announcement, not at the day when the next open market operation is settled. All rates are quoted as annual rates, e.g. i_t = 5 means a five percent annual interest rate. Liquidity effects in panel A are estimated using the relevant supply changes, i.e. those occurring at or after the last allotment day in each RMP. See appendix B and the main text for a detailed description of the variables used in the estimation. The parameters in the variance equation represent the effect on the log of the conditional volatility. A zero liquidity effect is tested for and then imposed at two underbidding episodes and after Easter 2003. The respective days are 23/10/2001, 23/12/2002 and 23/04/2003. Q(j) denotes the Ljung-Box test for serial correlation at lag length j.

Table 3

Parameter estimates for the Two-week EONIA Swap Rate

Model: $\Delta i_t = c + \phi(i_{t-1} - i^*_{t-1}) + x_t\beta + h_t\eta_t$

$\ln(h_t^2) = z_t\lambda + \Sigma_j \delta_j \{ \ln(h_{t-j}^2) - z_{t-j}\lambda \} + \alpha\{|\eta_{t-1}| - E|\eta_{t-1}| + \gamma\eta_{t-1}\}$

$\eta_t \sim iid(0, p + (1-p)^*\sigma^2)$.

Sample: All business days from 24/03/1999 to 19/02/2004, both included

Variable	Parameter	Std. Error	p-value
Mean equation			
Constant	0.001	0.001	0.173
Error correction term ($i_{t-1} - i^*_{t-1}$)	-0.029	0.011	0.010
Lagged change of the policy rate	0.256	0.045	0.000
Lagged dependent variable	-0.085	0.025	0.001
Volatility equation			
(A) Transmission of volatility			
Conditional EONIA volatility	0.311	0.039	0.000
(B) Days of maintenance period			
Policy decisions bi-weekly	1.491	0.224	0.000
Last day, t = T	-1.936	0.294	0.000
Next to last day, t = T-1	-1.416	0.311	0.000
First day, t = 1	-0.781	0.235	0.001
(C) Calendar days			
End of month	-0.959	0.217	0.000
Thursday	0.801	0.128	0.000
(C) Other variables			
Underbidding allotment day	2.516	0.837	0.003
Constant	-4.651	0.372	0.000
α	1.026	0.165	0.000
δ	0.907	0.021	0.000
γ	0.047	0.051	0.356
σ	0.339	0.022	0.000
p	0.174	0.003	0.000
Standardised residuals:			
Mean	0.000		
Variance	0.282		
Skewness	0.096		
Kurtosis	10.793		
Q(10), p-value	0.395		
Q(20), p-value	0.010		
Q(20) for squared residuals, p-value	0.557		

NOTE: i_t = two-week EONIA swap rate. i^*_t = policy rate, or target rate, which is defined as the fixed rate (until June 27, 2000) and the minimum bid rate (after June 27, 2000) at which the European Central Bank conducts its weekly open market operations. Any change in the policy rate is assumed to become effective at the day of announcement, not at the day when the next open market operation is settled. All rates are quoted as annual rates, e.g. $i_t = 5$ means a five percent annual interest rate. See appendix B for a detailed description of the variables used in the estimation. The parameters in the variance equation represent the effect on the log of the conditional volatility. Q(j) denotes the Ljung-Box test for serial correlation at lag length j. Conditional EONIA volatility stands for the logarithm of the conditional EONIA volatility as estimated with the model described in table 2.

Table 4

Parameter estimates for the One-month EONIA Swap Rate

Model: $\Delta i_t = c + \phi(i_{t-1} - i^*_{t-1}) + x_t\beta + h_t\eta_t$
$\ln(h_t^2) = z_t\lambda + \Sigma_j \delta_j \{ \ln(h_{t-j}^2) - z_{t-j}\lambda \} + \alpha\{|\eta_{t-1}| - E|\eta_{t-1}| + \gamma\eta_{t-1}\}$
$\eta_t \sim iid(0, p + (1-p)*\sigma^2)$.
Sample: All business days from 24/03/1999 to 19/02/2004, both included

Variable	Parameter	Std. Error	p-value
Mean equation			
Constant	-0.001	0.001	0.013
Error correction term ($i_{t-1} - i^*_{t-1}$)	0.008	0.007	0.232
Lagged change of the policy rate	0.176	0.084	0.037
Lagged dependent variable	-0.065	0.023	0.005
Volatility equation			
(A) Transmission of volatility			
Conditional EONIA volatility	0.134	0.033	0.000
(B) Days of maintenance period			
Press conference	0.938	0.265	0.000
Policy rate change	2.879	0.542	0.000
Policy decisions bi-weekly	1.611	0.168	0.000
First day, t = 1	0.726	0.237	0.002
(C) Other variables			
Underbidding allotment day	3.010	0.550	0.000
Constant	-6.227	0.335	0.000
α	1.434	0.199	0.000
δ	0.800	0.052	0.000
γ	-0.103	0.052	0.047
σ	0.277	0.017	0.000
p	0.185	0.002	0.000
Standardised residuals:			
Mean	0.008		
Variance	0.254		
Skewness	0.702		
Kurtosis	13.221		
Q(20), p-value	0.050		
Q(20) for squared residuals, p-value	0.991		

NOTE: i_t = one-month EONIA swap rate. i^*_t = policy rate, or target rate, which is defined as the fixed rate (until June 27, 2000) and the minimum bid rate (after June 27, 2000) at which the European Central Bank conducts its weekly open market operations. Any change in the policy rate is assumed to become effective at the day of announcement, not at the day when the next open market operation is settled. All rates are quoted as annual rates, e.g. $i_t = 5$ means a five percent annual interest rate. See appendix B for a detailed description of the variables used in the estimation. The parameters in the variance equation represent the effect on the log of the conditional volatility. Q(j) denotes the Ljung-Box test for serial correlation at lag length j. Conditional EONIA volatility stands for the logarithm of the conditional EONIA volatility as estimated with the model described in table 2.

Table 5

Parameter estimates for the Three-month EONIA Swap Rate

Model: $\Delta i_t = c + \phi(i_{t-1} - i^*_{t-1}) + x_t\beta + h_t\eta_t$

$\ln(h_t^2) = z_t\lambda + \Sigma_j \delta_j \{ \ln(h_{t-j}^2) - z_{t-j}\lambda \} + \alpha\{|\eta_{t-1}| - E|\eta_{t-1}| + \gamma\eta_{t-1}\}$

$\eta_t \sim iid(0, p + (1-p)*\sigma^2)$.

Sample: All business days from 24/03/1999 to 19/02/2004, both included

Variable	Parameter	Std. Error	p-value
Mean equation			
Constant	-0.002	0.000	0.000
Error correction term ($i_{t-1} - i^*_{t-1}$)	0.020	0.003	0.000
Lagged change of the policy rate	0.091	0.048	0.056
Lagged dependent variable	-0.036	0.019	0.059
Volatility equation			
(A) Transmission of volatility			
Conditional EONIA volatility	0.132	0.025	0.000
(B) Days of maintenance period			
Press conference	1.001	0.243	0.000
Policy rate change	1.534	0.444	0.001
Last settlement day	-1.262	0.186	0.000
(C) Calendar days			
End of semester	-1.257	0.347	0.000
(D) Other variables			
Constant	-4.462	0.328	0.000
α	2.126	0.289	0.000
δ_1	-0.128	0.091	0.157
δ_2	0.290	0.079	0.000
δ_3	0.451	0.089	0.000
δ_4	0.324	0.076	0.000
γ	-0.058	0.040	0.147
σ	0.217	0.016	0.000
p	0.081	0.001	0.000
Standardised residuals:			
Mean	0.006		
Variance	0.134		
Skewness	1.634		
Kurtosis	35.309		
Q(20), p-value	0.118		
Q(20) for squared residuals, p-value	0.994		

NOTE: i_t = three-month EONIA swap rate. i^*_t = policy rate, or target rate, which is defined as the fixed rate (until June 27, 2000) and the minimum bid rate (after June 27, 2000) at which the European Central Bank conducts its weekly open market operations. Any change in the policy rate is assumed to become effective at the day of announcement, not at the day when the next open market operation is settled. All rates are quoted as annual rates, e.g. $i_t = 5$ means a five percent annual interest rate. See appendix B for a detailed description of the variables used in the estimation. The parameters in the variance equation represent the effect on the log of the conditional volatility. Q(j) denotes the Ljung-Box test for serial correlation at lag length j. Conditional EONIA volatility stands for the logarithm of the conditional EONIA volatility as estimated with the model described in table 2.

Table 6

Parameter estimates for the Six-month EONIA Swap Rate

Model: $\Delta i_t = c + \phi(i_{t-1} - i^*_{t-1}) + x_t\beta + h_t\eta_t$

$\ln(h_t^2) = z_t\lambda + \Sigma_j \delta_j \{ \ln(h_{t-j}^2) - z_{t-j}\lambda \} + \alpha\{|\eta_{t-1}| - E|\eta_{t-1}| + \gamma\eta_{t-1}\}$

$\eta_t \sim iid(0, p + (1-p)*\sigma^2)$.

Sample: All business days from 24/03/1999 to 19/02/2004, both included

Variable	Parameter	Std. Error	p-value
Mean equation			
Constant	-0.002	0.001	0.000
Error correction term (i_{t-1} - i^*_{t-1})	0.013	0.002	0.000
Lagged change of the policy rate	0.063	0.025	0.011
Lagged dependent variable	-0.059	0.029	0.042
Volatility equation			
(A) Transmission of volatility			
Conditional EONIA volatility, lagged one day	0.142	0.023	0.000
(B) Days of maintenance period			
Press conference	0.781	0.287	0.007
Policy decisions bi-weekly	0.763	0.219	0.001
(C) Other variables			
Constant	-5.825	0.280	0.000
α	0.995	0.164	0.000
δ_1	0.207	0.071	0.004
δ_2	0.658	0.077	0.000
γ	0.101	0.078	0.192
σ	0.417	0.025	0.000
p	0.250	0.011	0.000
Standardised residuals:			
Mean	0.008		
Variance	0.389		
Skewness	0.514		
Kurtosis	8.478		
Q(20), p-value	0.509		
Q(20) for squared residuals, p-value	0.336		

NOTE: i_t = six-month EONIA swap rate. i^*_t = policy rate, or target rate, which is defined as the fixed rate (until June 27, 2000) and the minimum bid rate (after June 27, 2000) at which the European Central Bank conducts its weekly open market operations. Any change in the policy rate is assumed to become effective at the day of announcement, not at the day when the next open market operation is settled. All rates are quoted as annual rates, e.g. $i_t = 5$ means a five percent annual interest rate. See appendix B for a detailed description of the variables used in the estimation. The parameters in the variance equation represent the effect on the log of the conditional volatility. Q(j) denotes the Ljung-Box test for serial correlation at lag length j. Conditional EONIA volatility stands for the logarithm of the conditional EONIA volatility as estimated with the model described in table 2.

Table 7

Parameter estimates for the Twelve-month EONIA Swap Rate

Model: $\Delta i_t = c + \phi(i_{t-1} - i^*_{t-1}) + x_t\beta + h_t\eta_t$

$\ln(h_t^2) = z_t\lambda + \Sigma_j \delta_j \{ \ln(h_{t-j}^2) - z_{t-j}\lambda \} + \alpha\{|\eta_{t-1}| - E|\eta_{t-1}| + \gamma\eta_{t-1}\}$

$\eta_t \sim iid(0, p + (1-p)^*\sigma^2)$.

Sample: All business days from 24/03/1999 to 19/02/2004, both included

Variable	Parameter	Std. Error	p-value
Mean equation			
Constant	-0.004	0.001	0.000
Error correction term $(i_{t-1} - i^*_{t-1})$	0.009	0.002	0.000
Volatility equation			
(A) Transmission of volatility			
Conditional EONIA volatility	-0.012	0.026	0.641
(B) Days of maintenance period			
Press conference	0.509	0.219	0.020
Policy change and the day after	1.016	0.332	0.002
(C) Other variables			
Constant	-7.109	0.227	0.000
α	0.242	0.046	0.000
δ_1	0.380	0.215	0.077
δ_2	0.566	0.211	0.007
γ	-0.062	0.093	0.502
σ	2.033	0.188	0.000
p	0.832	0.247	0.000
Standardised residuals:			
Mean	0.037		
Variance	1.546		
Skewness	0.334		
Kurtosis	4.626		
Q(20), p-value	0.075		
Q(20) for squared residuals, p-value	0.494		

NOTE: i_t = twelve-month EONIA swap rate. i^*_t = policy rate, or target rate, which is defined as the fixed rate (until June 27, 2000) and the minimum bid rate (after June 27, 2000) at which the European Central Bank conducts its weekly open market operations. Any change in the policy rate is assumed to become effective at the day of announcement, not at the day when the next open market operation is settled. All rates are quoted as annual rates, e.g. $i_t = 5$ means a five percent annual interest rate. See appendix B for a detailed description of the variables used in the estimation. The parameters in the variance equation represent the effect on the log of the conditional volatility. Q(j) denotes the Ljung-Box test for serial correlation at lag length j. Conditional EONIA volatility stands for the logarithm of the conditional EONIA volatility as estimated with the model described in table 2.

B Data description

Table 8

Description of variables used in the empirical models

Dummy variable	**Takes value one at:**
T	The last day of each reserve maintenance period (RMP)
T-1	The next to last day of each RMP
First day, t = 1	The first day in a RMP
Last allotment day	The last day in a RMP at which a regular main refinancing operation is allotted (usually a Tuesday)
Last settlement day	The last day in a RMP at which a regular main refinancing operation is settled (usually a Wednesday)
Underbidding allotment day	All allotment days when underbidding occurred. These days are 14/02/01, 11/04/01, 10/10/01, 07/11/01, 04/12/02, 18/12/02, 04/03/03, 04/06/03, 26/11/03
dunderbidding (Volatility equation)	All allotment days when underbidding occurred. Additionally, some underbidding settlement days are also included. Namely, all underbidding settlement days for February, April and October 2001, and both for December 2002 (4th and 18th). Furthermore, this dummy takes value one at days 19/12/02 till 24/12/02, to take into account volatility increase from underbidding close to the end of the RMP
dunderbidding (Mean equation)	This variable takes into account the underbidding effects for the mean, in 2002 and 2003. It takes value one at Wednesdays for underbidding at December 4, 2002, June 4, 2003 (settlement days), the day after settlement March 5, 2003 and the settlement following the underbidding week, March 12, 2003
January 2002	The last four days in the first RMP of 2002. Euro cash changeover
GC meeting after last allotment	Governing Council meeting after the last allotment and policy rate change expectations. Takes value one the days before the last allotment, 20/9/1999 and 18/10/1999 and the days before and after it, i.e. 17/9/99 and 19/10/1999
Policy decisions bi-weekly	All days until November 7, 2001. From this time onwards policy decisions are made only once a month (in general)
Press conference	The day of the press conference held after the ECB's Governing Council meeting
Governing Council meeting	The day of the European Central Bank's Governing Council meeting
Underbidding at end of RMP	Allotment and settlement days of the last regular main refinancing operation in the December 2003 RMP, 16 and 17/12/2003
Policy rate change	The day at which a change in the policy rate is announced

Other variables	
i_t	Money market interest rate of the respective maturity
i^*_t	Policy rate, or target rate, which is defined as the fixed rate (until June 27, 2000) and the minimum bid rate (after June 27, 2000) at which the European Central Bank conducts its weekly open market operations. Any change in the policy rate is assumed to become effective at the day of announcement, not at the day when the next open market operation is settled
$E_t[i^*_{t+k}]$	Expected future policy rate. Proxied by a forward rate constructed with one and two-week EONIA swap rates
u_t	Supply shock, which is approximately the forecast error on autonomous factors

C Specification tests

Lagrange multiplier tests for all variables listed in the following tables have been performed for all money market rates, both on mean and volatility equations. Test results indicate that at the 1% significance level almost all of these variables are correctly omitted from the models as outlined in the tables above. There are no obvious ways of including the few remaining significant variables.

Table 9

Lagrange multiplier tests for omitted variables; Only for EONIA rate

Liquidity effects and lagged dependent and explanatory variables

Omitted variable
(A) Lagged dependent variable:
$D_t = \Delta i_{t-2,}$ for all days, t = 1,..,T
$D_t = \Delta i_{t-22}$, when t = T
(B) When t is the first day in a RMP and
$D_t = \Delta i_{t-1}$
$D_t = \Delta i_{t-2}$
$D_t = \Delta i_{t-3}$
$D_t = i_{t-1} - i^*_{t-1}$
$D_t = i_{t-2} - i^*_{t-2}$
$D_t = i_{t-3} - i^*_{t-3}$
(C) Lagged policy rate changes:
$D_t = \Delta i^*_{t-1}$
$D_t = \Delta i^*_{t-2}$
(D) Liquidity effects around end of month; $D_t = u_{t-1}$ when t falls on:
Begin of month
End of month
Begin of quarter
End of quarter
(E) Liquidity effects at the end of a reserve maintenance period:
$D_t = u_{t-1}$, when last allotment was before t and
t equals T-1
t equals T-2
t equals T-3
$D_t = u_{t-2}$, when last allotment was before t-1 and
t equals T-1
t equals T-2
t equals T-3
(F) Liquidity effects before the last settlement day of a RMP:
$D_t = u_{t-1}$, when t is before the last settlement day

NOTE: See appendix B for a detailed description of the abbreviations used. The variable D_t takes value zero unless otherwise specified. H0: D_t is correctly omitted from the original model specification.

Table 10

Lagrange multiplier tests for omitted variables

Days of the reserve maintenance period

Omitted variable
(A) $D_t = 1$ at days after last allotment and when t equals:
T
T-1
T-2
T-3
T-4
(B) $D_t = 1$ at days before last settlement and when t equals:
T-1
T-2
T-3
T-4
(C) $D_t = 1$ at all days after last allotment, if last allotment is at:
T-5
T-4
T-3
T-2
(D) D_t = number of days after last allotment minus one and t equals:
T
T-1
T-2
T-3
(E) D_t = five minus number of days after last allotment and t equals:
T
T-1
T-2
T-3
(F) $D_t = 1$ when t equals T and:
T is a settlement day
T is NOT a settlement day
T-1 is a settlement day
T-1 is NOT a settlement day
T-2 is a settlement day
T-2 is NOT a settlement day
(G) $D_t = 1$ when t equals T-1 and:
T-1 is a settlement day
T-1 is NOT a settlement day
T-2 is a settlement day
T-2 is NOT a settlement day
(H) $D_t = 1$ when t falls on:
The last settlement day in each RMP
The last announcement day in each RMP
The last announcement day in each RMP

Table 10 (continued)

Omitted variable
(I) $D_t = 1$ for $t = T - k$, with k:
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
(J) $D_t = 1$ when t is the first day in a RMP and falls on:
Monday
Tuesday
Wednesday
Thursday
Friday
(K) $D_t = 1$ when t is the last day of a RMP and falls on:
Monday
Tuesday
Wednesday
Thursday
Friday
(L) $D_t = 1$ when t falls on:
The day of a Governing Council meeting
The day of a press conference
The day of a press conference, before December 2001
All days before November 9, 2001 (bi-weekly policy decisions)
The day of a policy rate change
The day after a policy rate change

NOTE: See appendix B for a detailed description of the abbreviations used. The variable D_t takes value zero unless otherwise specified. H0: D_t is correctly omitted from the original model specification.

Table 11

Lagrange multiplier tests for omitted variables

Calendar days

Omitted variable
(A) $D_t = 1$ when t falls on:
Friday
Thursday
Wednesday
Tuesday
Monday
(B) $D_t = 1$ when t is:
End of month, except end of semester
End of 1st quarter
End of 2nd quarter
End of 3rd quarter
End of 4th quarter
End of any quarter
End of 2nd and 4th quarter
End of 1st and 3rd quarter
Begin of 1st quarter
Begin of 2nd quarter
Begin of 3rd quarter
Begin of 4th quarter
Begin of any quarter
(C) $D_t = 1$ for t being the day after:
Begin of month
Begin of month, except begin of quarter
Begin of 1st quarter
Begin of 2nd quarter
Begin of 3rd quarter
Begin of 4th quarter
Begin of any quarter

NOTE: See appendix B for a detailed description of the abbreviations used. The variable D_t takes value zero unless otherwise specified. H0: D_t is correctly omitted from the original model specification.

Table 12

Lagrange multiplier tests for omitted variables

Transmission of conditional EONIA volatility

Omitted variable
(A) D_t = conditional EONIA volatility when t equals:
T
T-1
T-2, T-3 or T-4
(B) D_t = conditional EONIA volatility when t falls on:
End of 2nd quarter
End of 4th quarter
Begin of 1st quarter
Begin 3rd quarter
End of month
Begin of month
Day after begin of month
First day in a RMP
The day of a policy rate change
The day after a policy rate change
The last allotment day in a RMP
The allotment day at which underbidding occurred
The day after an underbidding allotment
Two days after an underbidding allotment
Three days after an underbidding allotment
(C) D_t = 1 when t falls on:
The day of an underbidding allotment
The day after an underbidding allotment
Two days after an underbidding allotment
Three days after an underbidding allotment
The last day of a RMP at which underbidding occurred
The next to last day of a RMP at which underbidding occurred
Two days before the end of a RMP at which underbidding occurred

NOTE: See appendix B for a detailed description of the abbreviations used. The variable D_t takes value zero unless otherwise specified. H0: D_t is correctly omitted from the original model specification.

D Figures

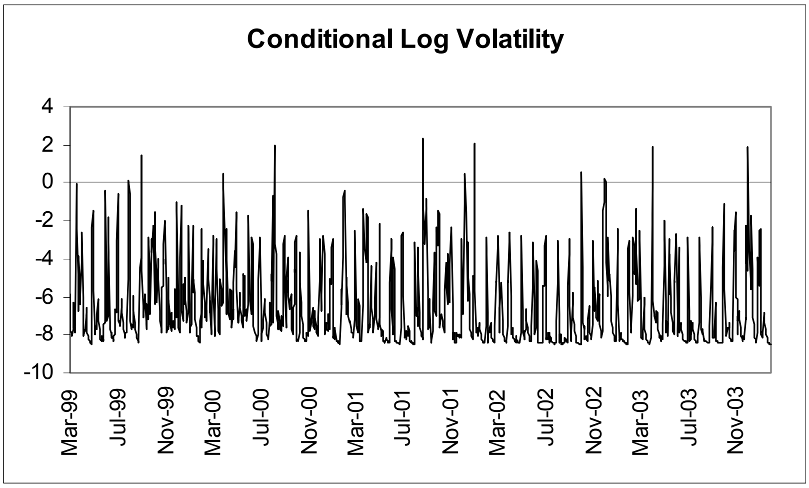

Figure 1: Logarithm of Conditional Volatility of the EONIA rate. Estimated with the model as described in table 2.

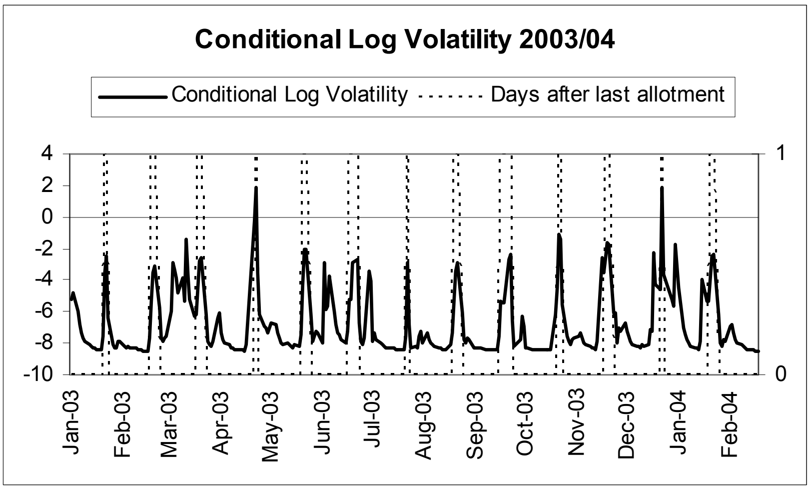

Figure 2: Logarithm of Conditional Volatility of the EONIA rate (left scale). Estimated with the model as described in table 2. Dotted lines represent a dummy variable taking value one on all days after the last allotment day until the last day of a RMP and value zero otherwise (right scale).

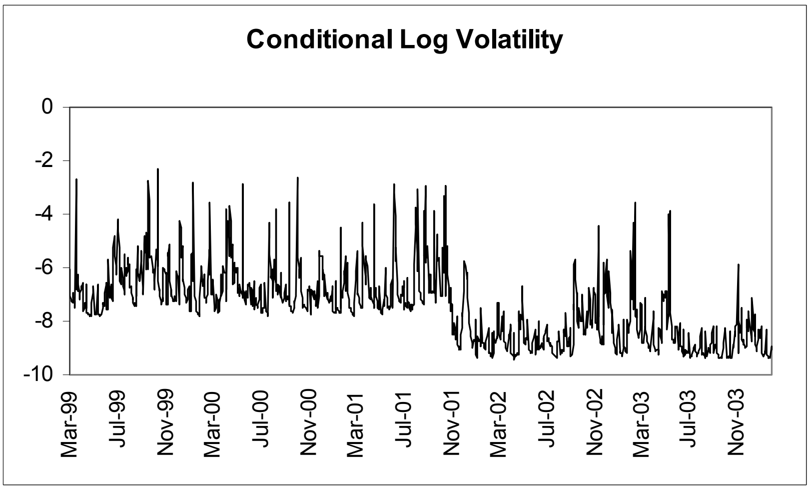

Figure 3: Logarithm of Conditional Volatility of the One-month EONIA Swap Rate. Estimated with the model as described in table 4.

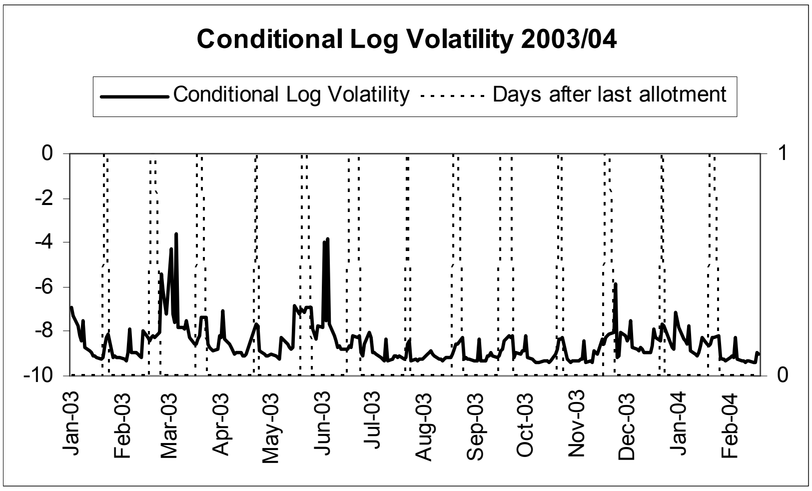

Figure 4: Logarithm of Conditional Volatility of the One-month EONIA Swap Rate (left scale). Estimated with the model as described in table 4. Dotted lines represent a dummy variable taking value one on all days after the last allotment day until the last day of a RMP and value zero otherwise (right scale).

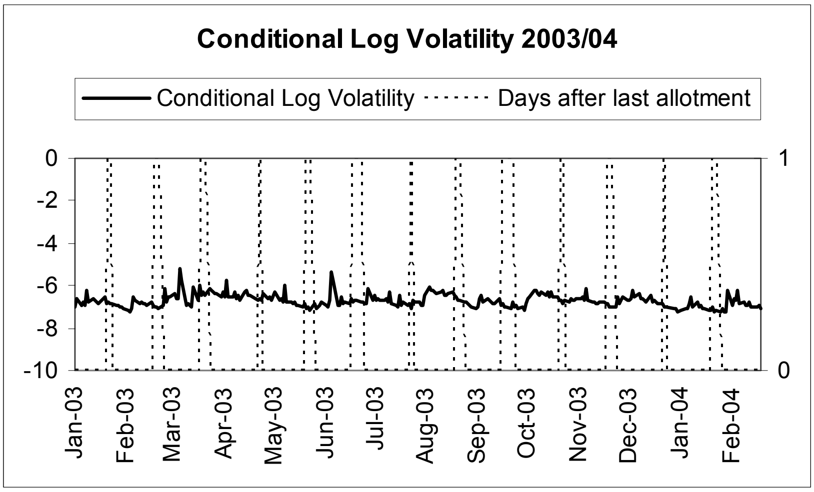

Figure 5: Logarithm of Conditional Volatility of the Twelve-month EONIA Swap Rate (left scale). Estimated with the model as described in table 7. Dotted lines represent a dummy variable taking value one on all days after the last allotment day until the last day of a RMP and value zero otherwise (right scale).

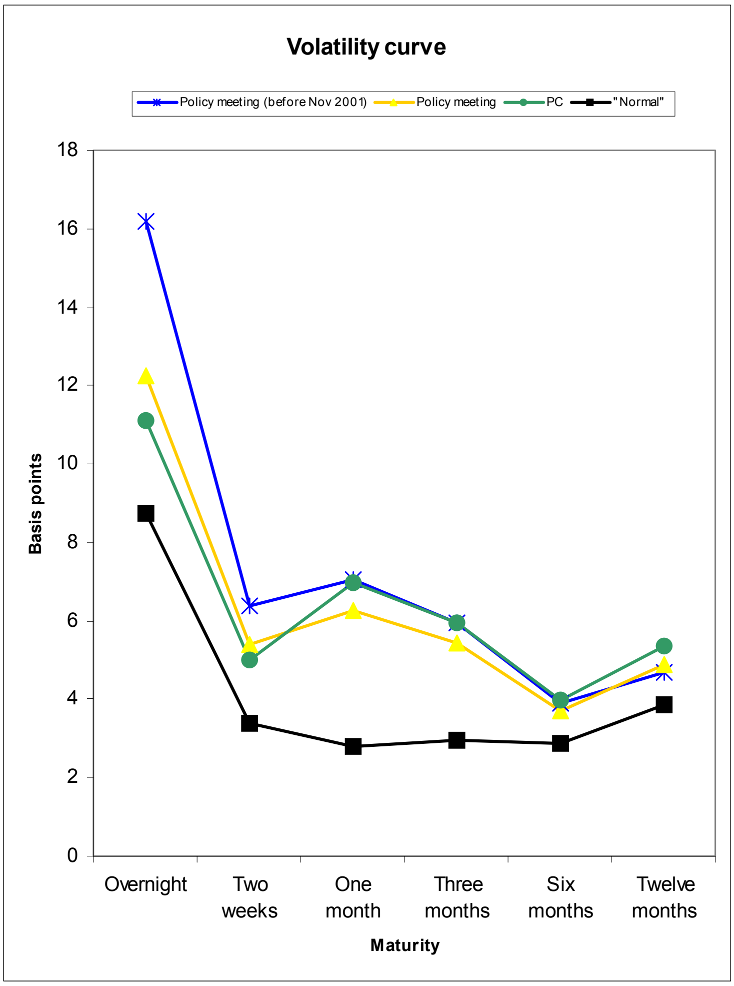

Figure 6: Volatility curves for different days of the reserve maintenance period. The blue line (with stars) represents the volatility curve for the ECB's Governing Council (GC) meeting days, before November 2001. Up to this date monetay policy decisions were made (in general) at every GC meeting. From November 2001 onwards monetary policy decisions were made (in general) only at the first GC meeting of each month, coinciding with the press conference (PC). The volatility curve for days of the press conference is given by the green line (with circles). The volatility curve for all policy meetings, i.e. all GC meetings before November 2001 and the first GC meeting in each month afterwards, is plotted in yellow (with triangles). The volatility curve for days which are not policy meeting days is shown as a black line (with cubes). Volatility is measured as the average conditional standard deviation, as estimated from models outlined in tables 2 to 7.