Box 2

THE EUROSYSTEM'S OPERATIONAL FRAMEWORK AND THE VOLATILITY OF THE OVERNIGHT INTEREST RATE

This box updates the analysis previously presented in a box entitled "The volatility of the overnight interest rate from a medium-term perspective" which was published in the March 2005 issue of the Monthly Bulletin. Using the most recent data and alternative measures of volatility in the overnight interest rate, the exercise presented here provides further evidence in support of the conclusion that the volatility of the overnight interest rate has declined since the introduction of changes to the operational framework in March 2004.

The ECB implements monetary policy by steering short-term money market interest rates. In this context, the overnight interest rate plays a key role in signalling the stance of monetary policy. It is therefore essential for the overnight interest rate to stand close to the minimum bid rate in the main refinancing operations as determined by the Governing Council and for its volatility to remain well contained. Thus, the Eurosystem's operational framework – the procedures and rules governing the implementation of monetary policy – was designed with the desire to ensure that the volatility of the overnight rate does not reach levels which would blur this crucial signalling mechanism.

Unlike money market interest rates with longer maturities, the overnight interest rate is not usually directly responsive to macroeconomic factors. Instead, within the current design of the operational framework, the movements of the overnight interest rate tend to be influenced mostly by the balance between the supply of and demand for liquidity in the overnight money

market. In the case of the Eurosystem, the existence of an averaging mechanism for reserve requirements over a predetermined period (called the reserve maintenance period) means that the overnight interest rate's volatility tends to be relatively low throughout the maintenance period, usually with the exception of the last few days, namely those between the last main refinancing operation (MRO) and the end of the maintenance period. This systematic increase in volatility is a direct consequence of the increase in the sensitivity of the overnight interest rate with regard to changes in the liquidity situation towards the end of the maintenance period, when individual banks' positions as regards the fulfilment of reserve requirements become clearer and those requirements thus become more stringent.

The changes to the Eurosystem's operational framework in March 2004

Since the introduction of the euro in January 1999 the Eurosystem's operational framework has functioned smoothly overall. However, some challenges have emerged on occasion and procedures have been adapted to nullify – or at least limit – their impact in the money market. The most recent changes took effect in March 2004. Those changes were, inter alia, intended to reduce operational risks implied by underbidding in the weekly refinancing operations. Underbidding took place when market expectations of a cut in key ECB interest rates materialised. Counterparties in the Eurosystem's regular open market operations chose to bid less than their liquidity needs, in the hope that they would subsequently be able to fulfil those needs at a lower interest rate cost once key ECB interest rates had been reduced. In such circumstances, the volatility of the overnight interest rate increased to undesirable levels, endangering the signalling mechanism.

The changes introduced in March 2004 have been extensively described in the Monthly Bulletin.[1] Nonetheless, it is useful to briefly recall the main elements of these changes. First, the maturity of the Eurosystem's main refinancing operations was shortened from two weeks to one week, with the bulk of the banking sector's liquidity needs being met through single and non-overlapping weekly operations. Second, the starting dates of the maintenance periods for holdings of required reserves were linked to the timing of those Governing Council meetings for which decisions on policy rates are scheduled. Third, it was decided to apply the new level of key ECB interest rates as set by the Governing Council as of the start of the new reserve maintenance period. The first measure was aimed at better segmenting maintenance periods through non-overlapping operations, whereas the second and third were intended to eliminate the impact that any expectations of changes in the key ECB interest rates might have on counterparties' bidding behaviour in MROs.

Realised volatility and conditional volatility

In financial markets, asset prices and returns are characterised by movements which are more or less marked depending on the nature of the assets. How to measure the corresponding volatility represents a key issue in the analysis of financial markets. Although various methods are available, this box considers two alternative measures: realised volatility and conditional volatility.[2]

1 See, for instance, the articles entitled "Changes to the Eurosystem's operational framework for monetary policy" and "Initial experience with the changes to the Eurosystem's operational framework for monetary policy implementation", published in the August 2003 and February 2005 issues of the Monthly Bulletin respectively.

2 Another widely used measure of volatility in financial yields is implied volatility, which is derived from the price of options on the underlying instrument. However, this approach cannot be applied to the overnight interest rate owing to the lack of traded options on the overnight rate in the euro area money market (options only exist for three-month EURIBOR futures).

Realised volatility is calculated as the sum of the squared differences between high-frequency (generally five-minutely) returns offered by a given financial asset. When applied to the overnight rate, it simply measures the high-frequency movements of overnight yields. Realised volatility has the advantage that it can be measured independently of the mean level of the time series in the sample, and can thus provide meaningful estimates of volatility even in time series which show trend behaviour. Moreover, it is not based on a specific model and can be calculated in all circumstances, even when the series may be subject to structural breaks owing to changes made to the institutional framework governing the implementation of the ECB's monetary policy.[3]

By contrast, *conditional volatility* is computed on the basis of a model which describes the dynamic pattern of the variance of the returns for a given financial asset as a function of its own past values and, in some cases, as a function of other variables which may influence its evolution over time. Prominent among the models used to construct conditional volatility measures are (Generalised) Autoregressive Conditional Heteroscedasticity or (G)ARCH models.[4] Conditional volatility measures have some advantages. In particular, they rely on a relatively standard econometric framework which facilitates the estimation of models and their testing on data and allows forecasts to be computed. However, as stressed above, one weakness in the models underlying the construction of conditional volatility is their potential lack of robustness in cases where structural changes occur, as models typically respond slowly to breaks in time series and need a certain amount of data before model misspecifications can be identified.

Construction of the two measures and the data used

As described above, the measure of daily realised volatility was constructed as the sum of the squared returns for the overnight interest rate across each five-minute interval between 8 a.m. and 7 p.m. over the period 29 November 2000-14 June 2006.[5]

For the conditional volatility measure, a model was estimated using the daily euro overnight index average (EONIA) over the same period, i.e. using data both before and after the March 2004 changes to the operational framework. The conditional mean of the EONIA taken in the first difference (Δ) was modelled using its own lagged values (up to two lags), plus some dummy variables, i.e.:

$$\Delta EONIA_t = \phi_0 + \phi_1 \Delta EONIA_{t-1} + \phi_2 \Delta EONIA_{t-2} + \gamma_1 MP\_change + \gamma_2 month\_end + res_t$$

where *MP_change* indicates days when key ECB interest rates were changed and *month_end* indicates the last trading day of the month. The variance was modelled using the lagged variance and once lagged squared residual from the previous model (res^2_{t-1}), plus some indicator variables, i.e.:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \beta_1 res_{t-1}^2 + \lambda_1 lastdays_t$$

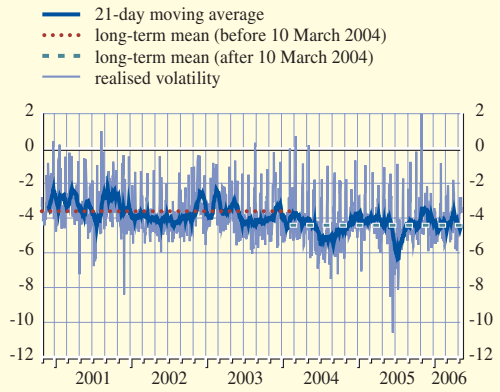
3 For more details and a technical description of the measure and properties of realised volatility, see T. G. Andersen and T. Bollerslev (1997), "Intraday periodicity and volatility persistence in financial markets", *Journal of Empirical Finance*, pp. 115-158.

4 For details, see R. F. Engle (1982), "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation", *Econometrica*, Vol. 50(4), pp. 987-1008. For the GARCH extension, see T. Bollerslev (1986), "Generalized Autoregressive Conditional Heteroskedasticity", *Journal of Econometrics*, Vol. 31, pp. 307-327.

5 For technical reasons – specifically, to avoid the measure being inherently non-negative and asymmetrical (which would complicate the statistical analysis) – the exercise presented in this box focuses on the logarithm of this measure. The same transformation is made for the results of the conditional volatility model to ensure comparability between the two measures.

Chart A Realised volatility of the overnight interest rate returns

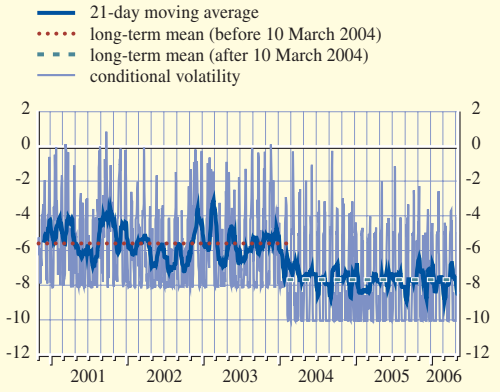
(logarithm of the realised volatility)



Sources: Reuters and ECB calculations.

Chart B Conditional volatility of the EONIA computed from GARCH models

(logarithm of the conditional volatility)



Sources: Reuters and ECB calculations.

where *lastdays* indicates the days between the last MRO allotment and the end of the reserve maintenance period, to account for the increase in volatility at the end of the reserve maintenance period. The conditional volatility corresponds to the series σ_t^2.

The dummy variables in the two equations account for some factors which have a systematic impact on the level of either the conditional mean or the conditional variance to improve the statistical quality of the estimates.

Of the various specifications tried, the one eventually chosen ensured a good overall statistical fit with the daily EONIA series both prior to and since March 2004, in terms of both the statistical significance of the estimated model parameters and the standard test statistics measuring the presence of autocorrelation in the model residuals.[6]

Results

Chart A shows the evolution of the overnight interest rate's realised volatility since November 2000. To reveal the more persistent developments in the realised volatility series, a 21-day (corresponding approximately to one trading month) moving average of daily realised volatility is also shown in the chart. Finally, long-term averages are displayed for both before and after the changes introduced in March 2004.

Chart A suggests that the volatility of the overnight interest rate has fallen significantly since the introduction of the changes to the operational framework. With some exceptions, notably the last few months of 2005, realised volatility has generally been more subdued than was observed before March 2004. More specifically, the level of (log) realised volatility declined from an average of -3.61 before the changes to the operational framework were introduced to

6 The decision to specify the same model structure before and after March 2004 was motivated by a desire to ensure some degree of comparability in terms of results, even in the presence of a possible structural break. Owing to space constraints, the results of the two models cannot be reported in detail here. The estimates of the three parameters in the conditional model for the variance of the EONIA are significantly higher for the sub-sample including data before the changes than for the other sub-sample. This reflects the observation that volatility has declined in the period following the introduction of the changes to the operational framework.

Descriptive statistics and t-tests for the difference in means of log-realised volatility

	All days		Days between the last allotment and the end of the reserve maintenance period	
	Before 10 March 2004	After 10 March 2004	Before 10 March 2004	After 10 March 2004
Mean	-3.61	-4.42	-2.56	-3.32
Standard deviation	1.22	1.29	1.33	1.47
Number of observations	834	583	158	157
T-statistics (difference in means)		11.89 (1,203 degrees of freedom)		4.86 (309 degrees of freedom)
P-value (unilateral test)		1.00		1.00

an average of -4.42 thereafter. When one considers only the days between the last MRO allotment and the end of the maintenance period, the comparison of volatility levels still suggests a decline after March 2004, although to a somewhat lesser extent (with the long-term mean declining from -2.56 before the changes to -3.32 thereafter).

A standard statistical test of whether or not mean realised volatility was higher prior to the introduction of the changes to the operational framework confirms that this was indeed the case both in general and for the last few days of the maintenance period. As shown in the table above, the hypothesis that the average level of volatility was higher prior to the changes is accepted in both cases because the t-statistics are larger than the critical value for both samples, as indicated by the high P-values.

Further confirmation of this conclusion emerges from an analysis of the conditional volatility measure. Chart B shows the evolution of the conditional volatility of the overnight interest rate. The decline in the level of conditional volatility after the changes to the operational framework (visible in the daily conditional variance of the EONIA) is amplified as a consequence of the lower parameter estimates in the conditional variance model when estimating the model for the sub-sample after March 2004.

As with realised volatility, the chart also shows a smoothed series for conditional volatility (again calculated as a 21-day moving average). The picture of how conditional volatility has evolved since November 2000 is broadly similar to that for realised volatility. The decline in average conditional volatility since March 2004 is more marked than for realised volatility, with the average level decreasing from -5.59 before the changes to the operational framework to -7.68 afterwards. As regards the last few days of the reserve maintenance period, the long-term average also declined, from -3.56 before the changes to -4.74 thereafter.[7]

Concluding remarks

The results presented in this box update a similar analysis published in the March 2005 issue of the Monthly Bulletin. The new data and techniques employed here confirm the earlier findings. Indeed, the conclusions drawn from the exercise presented are more authoritative

7 Given the conditional nature of the series, a t-statistic to test the difference between long-term averages would be less meaningful than for the previous measure. A more correct comparison is that referred to in the previous footnote on the parameter estimates of the two GARCH models.

because they are based on a larger dataset (which includes approximately one and a half years of additional data) and on a wider set of volatility measures.

In conclusion, when viewed from a long-term perspective, the volatility of the overnight interest rate has declined, in particular after the introduction of the changes to the operational framework in March 2004.

In judging these changes from a broader perspective, however, some caution is required. Indeed, some of the conditions (e.g. market expectations of interest rate cuts) which fomented volatility prior to March 2004 have not emerged subsequently. In this respect, it may be that a true test of the robustness of the new procedures has yet to take place, and any firm conclusions on the changes to the operational framework should be regarded as tentative.