ARTICLES

THE ANALYSIS OF THE EURO MONEY MARKET FROM A MONETARY POLICY PERSPECTIVE

The ECB has a strong interest in an effective and well-functioning euro money market. The money market is the initial step in the transmission of monetary policy from the Governing Council's decision regarding key ECB interest rates to yields and rates in a broader set of financial markets more relevant for private sector investment and saving decisions, monetary dynamics and, ultimately, the outlook for price stability. By using its ability to steer market interest rates at the shortest maturities close to the minimum bid rate in the Eurosystem's main refinancing operations and by communicating its strategy and policy intentions in a clear and transparent manner, the ECB can influence money market interest rates at longer maturities. At the same time, the ECB recognises that developments in money market interest rates beyond the shortest maturities reflect market forces and thus that this market segment is beyond the ECB's direct control. This is particularly evident during specific periods of financial market stress, when changes in risk and liquidity premia may affect longer-term money market rates and thus interfere with the transmission of monetary policy. It is therefore of paramount importance for the ECB to analyse money market developments to assess their implications for the appropriate setting of the monetary policy stance and to decide whether any intervention is needed in order to contribute to a smooth functioning of the euro money market.

1 INTRODUCTION

The euro money market is the market in which short-term funds are raised by banks, investment funds and other financial intermediaries (see Box 1 for a description of the key features of the euro money market). Credit institutions are particularly active in this market (including the associated derivatives markets) given their demand for refinancing, their desire to hedge short-term positions and their need to obtain central bank liquidity so as to meet reserve requirements.

The money market is important for monetary policy in a number of respects. For the ECB, controlling short-term money market rates is the initial step in the transmission of monetary policy from the Governing Council's decision regarding key ECB interest rates[1] to yields and rates in a broader set of financial markets more relevant for private sector investment and saving decisions, monetary dynamics and, ultimately, the outlook for price stability. By using its ability to steer money market rates at the shortest maturities close to the minimum bid rate in the Eurosystem's main refinancing operations (MROs) and by communicating its strategy and policy intentions in a clear and transparent manner, the ECB can influence interest rates and yields at longer maturities. Well-functioning money markets are therefore fundamental to the ECB's ability to meet its primary objective of maintaining price stability in the euro area. Section 2 explains the interest of the ECB in contributing to a well-functioning, efficient and transparent money market.

In normal circumstances, the transmission of monetary policy through the money market is very smooth and effective. This is testimony to the design of the tools and procedures used to implement monetary policy decisions, and to the effectiveness of the liquidity operations conducted by the ECB and the ECB's communication of its policy. However, it is important to guard against complacency. On occasion, tensions may emerge in the money market which interfere with the smooth transmission of monetary policy. Examples include the transition to the new millennium ("Y2K"); the terrorist attacks on 11 September 2001; and the recent concerns about bank exposures to US sub-prime mortgage defaults that have hindered interbank trading. Moreover, at least in principle, the inevitable

1 The most prominent key ECB interest rate is the minimum bid rate, which represents the floor for the price of central bank liquidity in the open market operations and signals the monetary policy stance. The two other key interest rates, on the marginal lending facility and the deposit facility, define the corridor within which the overnight interest rate can fluctuate.

volatility at the very short end of the money market maturity spectrum (induced, for example, by the difficulty in forecasting some of the autonomous factors influencing the liquidity situation, such as the demand for banknotes and government deposits held with the Eurosystem[2]) could create undesirable "noise" at the longer maturities. Section 3 of this article describes a number of tools, techniques and indicators that are employed at the ECB to monitor the effectiveness of monetary policy transmission through the money market.

Aside from its key role in the transmission process, the money market can also be an important source of information for monetary policy-makers. Over the past two decades, it has increasingly been recognised that private sector expectations play an important role in the assessment of monetary policy. To the extent that money market rates embody expectations of the future path of key ECB interest rates (and, implicitly, market participants' interpretations of the ECB's monetary policy strategy and statements, of macroeconomic data releases, and of financial market developments), policy-makers are interested in how and why they evolve. Section 4 describes a number of tools used to extract these monetary policy expectations in the regular monitoring of money markets' understanding of the ECB.

2 For more details, see the article entitled "The Eurosystem's experience with forecasting autonomous factors and excess reserves" in the January 2008 issue of the Monthly Bulletin.

Box 1

KEY FEATURES OF THE EURO MONEY MARKET

This box presents the key features of the euro money market, which is one of the largest and most liquid money markets in the world. The term "euro money market" refers to the market for euro-denominated short-term funds and related derivative instruments.

Credit institutions account for the largest share of the euro money market. They rely on the euro money market for the management of their short-term liquidity positions and for the fulfilment of their minimum reserve requirements. The other important participants besides credit institutions are money market funds, other financial intermediaries (such as investment funds other than money market funds), insurance companies and pension funds, as well as large non-financial corporations. The participation of other financial intermediaries, hedge funds in particular, has increased over recent years in some market segments.

The most important money market segments are the unsecured deposit markets and the secured repo markets. Besides those traditional market segments, the derivatives markets have become increasingly important over recent years. The derivative money market segments can be grouped into exchange-traded instruments, such as short-term interest rate futures and options, and instruments that are typically traded over the counter (OTC), e.g. overnight index swaps (OISs), interest rate swaps (IRSs), foreign exchange (FX) swaps and forward rate agreements (FRAs).

It is important to note that all these instruments exhibit different risk profiles. When providing unsecured interbank deposits, for example, a bank transfers funds to another bank for a specified period of time. During this time it assumes the full counterparty credit risk, i.e. the risk that the counterparty is unable to repay the nominal amount (plus interest) at the maturity of the deposit. In the secured repo markets, this counterparty credit risk is mitigated by the fact that the bank

which provides liquidity receives collateral (e.g. bonds) in return. In the event of a credit default, the liquidity-providing bank is entitled to utilise the collateral received to satisfy its claim against the defaulting bank. Because of the significantly lower credit risk, secured repo rates are usually somewhat lower than unsecured deposit rates. The magnitude of the spreads between these two rates depends on the maturity of the transaction. It reflects banks' desire to borrow, their willingness to lend on an unsecured rather than a secured basis, and their assessment of the credit risk. These factors can vary significantly over time, as evidenced in the recent period of turmoil.

The credit risk in derivative instruments is usually fairly low, as no nominal amounts are exchanged and this risk is therefore limited to the replacement risk, in the event that the derivative position has generated a positive market value by the time of a counterparty default. The pricing of these instruments can nevertheless also be indirectly affected by credit risk considerations, namely by the credit risk embedded in the instrument underlying the derivative. This effect is less pronounced for OISs, which are based on an unsecured interbank overnight lending rate (for euro-denominated swaps, the euro overnight index average, EONIA), as this underlying rate includes by definition only a one-day credit risk, even if the OIS's maturity is several months. For other derivative instruments, this impact can however be substantial, as a three-month EURIBOR future, for example, relates to an unsecured three-month deposit rate at a future point in time. Any development with an impact on interbank credit risk assessments, and thus the pricing in the unsecured deposit markets, can therefore be expected to also be reflected in the pricing of the aforementioned future – as has been the case in recent months.

The relative importance of the various money market segments can best be assessed by looking at turnover data. While the volumes of the exchange-traded markets are well-known (owing to the transparency of the futures and options exchanges),[1] the size of the euro money market segments which are traded OTC is much harder to gauge. The best sources in this respect are periodic surveys such as the ECB's annual euro money market survey and the International Capital Market Association's semi-annual European repo market survey. However, the latter only provides data on outstanding amounts in one specific market segment,[2] while the former, at least so far, does not reveal the overall size of the different market segments. Instead, it concentrates on their relative sizes and developments over time.

The main findings of the ECB's latest euro money market survey (which was published in November 2007 and covered turnover data for the second quarter of 2007, i.e. before the recent money market turmoil) are as follows:

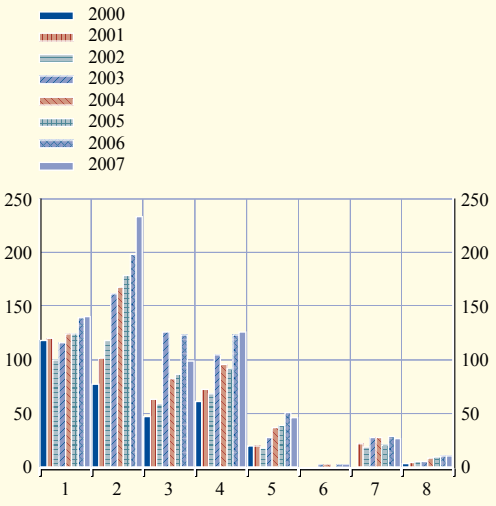
– The aggregated turnover of all euro money market segments continued to expand in the second quarter of 2007, recording a 4.5% year-on-year increase. The increase in turnover in the secured market was particularly strong, at 19.6%. Trading volumes in the FX swap market and the unsecured market also increased by 10.5% and 5.5% respectively. By contrast, turnover in the OIS market, which had displayed a very strong increase of 52% in 2006, decreased by almost 20%, and trading also declined by around 8.5% in both the FRA and the other IRS markets.

1 For example, the turnover in three-month EURIBOR futures on Euronext.liffe reached a new record of 27.4 million contracts in August 2007, which represents an increase of 54% compared with the year before.

2 According to the International Capital Market Association's survey number 13, the total value of repo contracts outstanding on the books of 77 institutions at close of business on 13 June 2007 was €6,775 billion. Using samples of institutions which participated in several surveys, the report estimates that the outstanding amount increased by 7-15% (depending on the sample) over the year to June 2007.

Chart A Daily turnover traded in each money market segment from 2000 to 2007

(volume of unsecured transactions in Q2 2002 = 100)

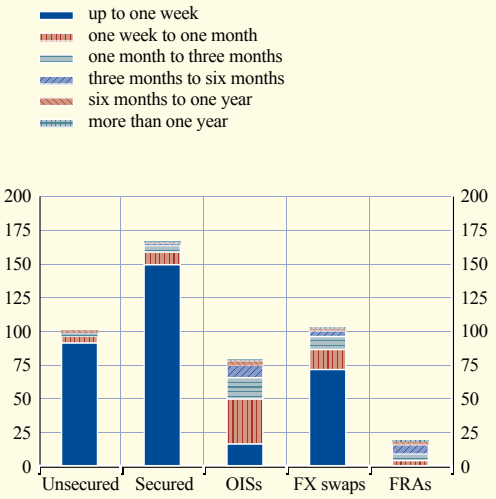


1 Unsecured
2 Secured
3 OISs
4 FX swaps
5 Other IRSs
6 Cross-currency swaps
7 FRAs
8 Short-term securities

Source: ECB.
Note: The data are taken from a panel of 85 banks for 2000 and 2001 and 114 banks thereafter.

Chart B Total unsecured, secured, OIS, FX swap and FRA turnover for the different maturity breakdowns in 2007

(volume of unsecured transactions in Q2 2007 = 100)



Source: ECB.
Note: The data are taken from a panel of 169 banks.

– The secured segment further extended its leading position, accounting for 35.0% of the total turnover (Chart A). Turnover in the secured market has continuously increased since the second quarter of 2001. This confirms a trend towards limiting credit risk exposure and also reflects the constraints that result from capital adequacy requirements. The unsecured market remained the second most active market segment in the second quarter of 2007 (with a share of 21.0%), while the share of FX swaps rose to 18.1%, putting this segment in third place, ahead of the OIS market, which accounted for 14.1%.

– Activity in unsecured, secured and FX swap markets continued to be largely concentrated at very short-term maturities, as can be seen in Chart B. The consistent trend towards liquidity concentration at very short maturities for these instruments has been made possible by technological developments, e.g. via increased electronic trading and an increasing use of automated collateral management and straight-through processing. The OIS market also showed a greater concentration at shorter maturities compared with previous years ("maturity" in this case is defined as the time between the start and end dates of an OIS). Almost two-thirds of the average daily turnover in OISs was concentrated at maturities of up to one month. This is seen to reflect the length of the ECB's reserve maintenance periods, with an increasing share of turnover being related to OISs starting and ending at the same time as the ECB's reserve maintenance periods.

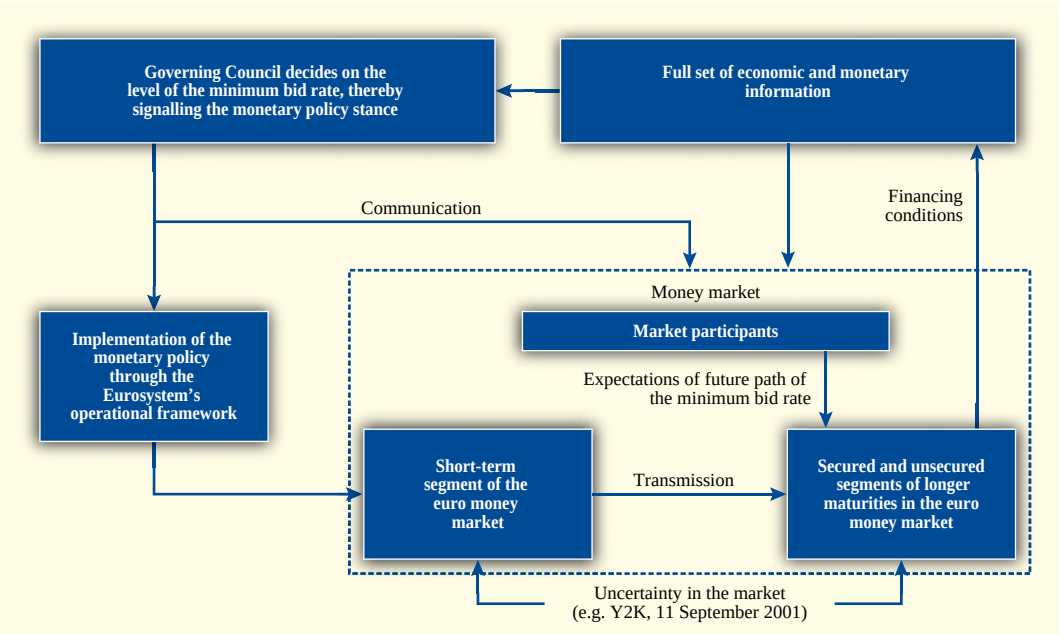
2 THE MONEY MARKET FROM THE MONETARY POLICY PERSPECTIVE

In the euro area, the Governing Council of the ECB decides on the appropriate level of the key ECB interest rates following a comprehensive assessment of the outlook for price stability and the associated risks, based on its economic and monetary analyses. These decisions are then implemented under the responsibility of the ECB's Executive Board through the Eurosystem's operational framework. More specifically, the Governing Council sets the level of the minimum bid rate in the Eurosystem's weekly MROs, which constitutes the main signal of the monetary policy stance. In the MROs, the ECB aims to supply the liquidity necessary for the banking system to operate smoothly, in such a way that very short-term market interest rates remain appropriately aligned with the policy stance signalled by the Governing Council (see Chart 1). Through the money market yield curve, the monetary policy stance is transmitted to financial instruments and credit conditions more generally. These will in turn influence saving and investment decisions and monetary dynamics, and thus, in the end, affect price developments in the euro area.

The operational framework is the initial link between the key ECB interest rates and market rates. It provides the ECB with sufficient tools and procedures to exert a significant influence on the market price of euro-denominated funds in the shortest-maturity segment of the money market. The ECB seeks to keep the shortest-maturity market interest rates stable at levels close to the minimum bid rate.

Narrow spreads between short-term money market interest rates and the minimum bid rate are to be expected owing to differences in maturity and to risk premia, as well as transaction costs. However, an excessively wide or volatile spread would undermine the clarity of the signal provided by the minimum bid rate and, ultimately, the credibility of the operational framework in its implementation of Governing Council decisions. It is also desirable that volatility in short-term interest rates – caused

Chart 1 Schematic view of the interactions between money markets and monetary policy in the euro area



by their sensitivity to liquidity conditions – does not propagate throughout the money market yield curve. This is a prerequisite for the term maturities to genuinely reflect market expectations of the future path of the minimum bid rate and hence to have the desired influence on the outlook for price stability.

The money market is thus characterised by both institutional and market dynamics. The shortest maturities (covering the days until the next monetary policy decision is implemented) are under normal conditions mostly affected by liquidity conditions, whereas maturities extending beyond the next monetary policy decision reflect market expectations of the future path of the minimum bid rate and thus depend on the full set of available information which enters into the Governing Council's monetary policy-making process. In this context, an analysis of the longer maturity rates can shed light on the overall functioning of the money market and on whether market participants have a clear understanding of the monetary policy strategy and its implementation over time.

At the same time, it has to be recognised that the money market can also be adversely affected by turmoil in the financial markets. This is particularly evident during periods when heightened uncertainty and a lack of confidence among banks and investors result in spillover effects on the money market. Such periods include Y2K; the days after the terrorist attacks on 11 September 2001; and the tensions in financial markets starting in the second half of 2007. A particular characteristic of these periods is that, while they interfere with the determination of interest rates in the money market, they do not originate from the evolution of liquidity conditions or reflect a change in market participants' perceptions of the monetary policy stance. Under such circumstances, the ECB's liquidity management may need to be adjusted in order to support market confidence and to steer the shortest-maturity segment in the money market. Measures of this type were indeed implemented in each of the three episodes mentioned above.

Hence, both under normal circumstances and in the case of financial turmoil, it is important to maintain a clear distinction between monetary policy decisions taken to maintain price stability and liquidity management decisions related to the implementation of the monetary policy stance and the distribution of liquidity within maintenance periods and across maturities.

Summing up, the ECB's primary objective is to maintain price stability. The ECB can directly affect the shortest-maturity segments of the money market, whereas the term maturities can only be influenced through its credibility and communication. While recognising that its actions can only have limited effects on freely operating markets, the ECB has a strong interest in contributing to a smooth functioning of the euro money market. In this context, a clear distinction should be maintained under all circumstances between interest rate decisions taken to maintain price stability (i.e. the determination of the monetary policy stance) and liquidity management decisions taken when implementing this stance.

3 STEERING SHORT-TERM MONEY MARKET INTEREST RATES

Once the levels of the key ECB interest rates have been set by the Governing Council, the Executive Board is empowered to implement them in the money market through the Eurosystem's operational framework. In this framework, the open market operations and standing facilities serve to steer very short-term money market interest rates and, if necessary, to limit their volatility around the minimum bid rate. In addition, the ECB requires credit institutions to hold minimum reserves with the Eurosystem central banks, the level of which is determined in relation to their reserve base. The most important function of the reserve requirement is to stabilise money market rates through the averaging mechanism over each reserve maintenance period.[3]

3 For a description of the operational framework, see the article entitled "Changes to the Eurosystem's operational framework for monetary policy" in the August 2003 issue of the Monthly Bulletin.

The Eurosystem's approach to monetary policy implementation relies largely on self-regulating market mechanisms. One good example of this is the ECB's limited presence in the market – i.e. its "hands-off" approach with very few direct interventions in the market, typically only once a week, and more frequently only in periods of financial market stress.

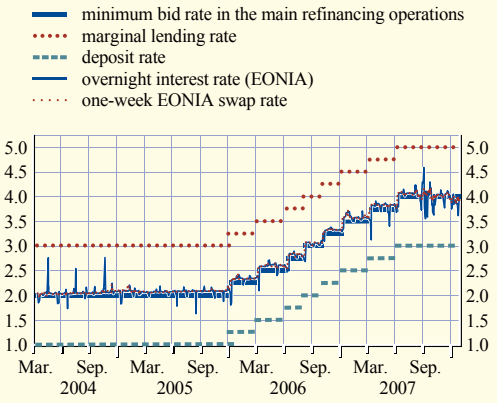
Although the ECB targets neutral liquidity conditions at the end of each maintenance period (zero net recourse to standing facilities), deviations from a balance between the demand for and the supply of liquidity can cause short-term interest rate fluctuations. In particular, the overnight interest rate is likely to fluctuate within the corridor around the minimum bid rate. For instance, deviations in the supply of liquidity may arise owing to the difficulty of forecasting some of the autonomous factors influencing the liquidity situation (e.g. the demand for banknotes and government deposits held with the Eurosystem).[4] The demand for liquidity may also be affected by exogenous shocks, such as periods of financial stress that lead to heightened uncertainty about the liquidity needs of banks (e.g. the three episodes mentioned in Section 2).

Given the relevance from a monetary policy perspective of assessing how effectively short-term market interest rates are steered around the minimum bid rate, the ECB monitors a number of indicators. These address two issues: first, how close are short-term market interest rates to the minimum bid rate; and second, how stable are they around this level? These issues reflect the design of the operational framework, the policy choices made within it (e.g. liquidity decisions) and the framework's robustness to shocks.

Since March 2004, when a number of changes to the Eurosystem's operational framework were introduced,[5] the spreads between money market interest rates at the shortest maturities and the minimum bid rate have, in general, been small and their volatility has been contained (see Box 2 for a discussion of various volatility measures monitored by ECB staff in this context).

Chart 2 Key ECB interest rates and the shortest segment of money market rates

(percentages per annum; daily data)



Sources: ECB and Reuters.

Chart 2 shows the evolution of key ECB interest rates and short-term market interest rates since 10 March 2004, and Table 1 summarises some of the statistical features. On most days the euro overnight index average (EONIA) settled slightly above, but very close to, the minimum bid rate. The small spread of 6 to 7 basis points over the minimum bid rate reflects the difference in maturities and the fact that the EONIA is an unsecured interbank rate and thus includes a small premium for credit risk and transaction costs.

On specific days, spreads are larger, with the EONIA both above and below the minimum bid rate on occasion. These larger spreads normally occur at the end of the reserve maintenance period. The existence of an averaging mechanism for reserve requirements over a maintenance period has a straightforward effect on the pattern of volatility in the overnight rate. Volatility tends to be rather low throughout most of the maintenance period and rises considerably in the days between the last MRO and the end of the period when the need to fulfil the reserve requirement becomes more binding. Although

4 For details on the forecasting process, see the article entitled "The Eurosystem's experience with forecasting autonomous factors and excess reserves" in the January 2008 issue of the Monthly Bulletin.

5 For more details on the operational framework, see the article referred to in footnote 3.

Table 1 Spread of the EONIA and the one-week EONIA swap rate over the minimum bid rate

(basis points; 10 March 2004-31 December 2007)

	EONIA	one-week EONIA swap
Standard deviation		
All days[1)]	9	5
Excluding the last week of each maintenance period	6	4
Average spread		
All days[1)]	6	8
Excluding the last week of each maintenance period	7	8

Sources: Reuters and ECB calculations.
1) The spread between the one-week EONIA swap rate and the minimum bid rate is affected by markets gradually pricing in the interest rate increases during the review period. Hence, the spread increased in the days between an announced increase in the minimum bid rate and the start of the maintenance period in which it was implemented.

there is no clear criterion to determine the ideal size of these spreads, excessively large and persistent spreads are undesirable as they would obscure the level of interest rates set by the Governing Council. Since October 2004 the ECB has more frequently conducted fine-tuning operations at the end of maintenance periods and this has served to reduce the size of spikes in the EONIA spread.[6]

Similarly, fine-tuning operations have served to smooth the functioning of the overnight market at specific points in time when uncertainty about the liquidity needs of credit institutions has been particularly high, such as after the terrorist attacks of 11 September 2001 and on certain days during the tensions in the money market in the second half of 2007.

6 For more details of the stabilising effect on the overnight interest rate from fine-tuning operations at the end of the maintenance period, see the article entitled "The Eurosystem's experience with fine-tuning operations at the end of the reserve maintenance period" in the November 2006 issue of the Monthly Bulletin.

Box 2

MEASURING VOLATILITY IN THE MONEY MARKET

Volatility is a key indicator for monitoring overall money market performance, especially in relation to two issues: (i) assessing how monetary policy decisions are perceived in financial markets; and (ii) analysing how well the market functions, in particular as regards the transmission of the monetary policy signal from the short end to the long end of the interest rate maturity spectrum.

As far as the former issue is concerned, central banks strive to ensure that their policy actions and communication do not foster unnecessary uncertainty (i.e. add "noise" to the economy), which would typically manifest itself in higher volatility in financial markets.

As regards the latter issue, analysing volatility offers insights into the microstructure of money markets and the efficiency with which they operate. For instance, comparing the volatility of interest rates at specific maturities with the average level of volatility across the whole maturity spectrum may allow the central bank to detect atypical movements in some segments of the money market, which, in turn, could be related to imperfections in the market's structure and might impinge on the effective transmission of the monetary policy impulse.

Against this background, an issue of great importance for central banks is how to measure adequately the volatility of interest rates and financial yields.

Volatility measures

Several methods to construct measures of money market volatility are used regularly at the ECB, each with advantages and disadvantages. A broad distinction can be made between, on the one hand, measures which simply rely on transformations of the data (typically, descriptive statistics for the time series of money market returns) and, on the other hand, measures which are derived from mathematical or econometric models.[1]

Within the first class of measures, historical volatility represents common statistical measures of spread for historical (often monthly) time series of financial market returns. A typical measure of historical volatility in money market interest rates is the standard deviation of the time series of money market returns around its sample mean. Other possible measures of spread used to construct historical volatility include the absolute or mean square error, the range between maximum and minimum values and the inter-quartile range.

Historical volatility measures have several advantages. First, they are very simple to compute. Second, their interpretation is intuitive and straightforward. Third, at least for financial data, the relatively long time series required to construct the measures are normally available. Fourth, historical volatility is independent of any specific model. This improves the generality of results and, by avoiding dependence on any specific model specification or econometric technique, will be robust to specification and estimation errors. However, the model-free character of historical volatility also has drawbacks, e.g. the measure is a purely descriptive tool, which has limited direct application for either modelling or forecasting purposes.

In recent years high-frequency intraday financial data have become increasingly available, permitting the construction of additional volatility measures. One such measure is realised volatility.[2] Realised volatility is usually defined as the sum of intra-daily squared returns of a (financial) time series. As such, it simply transforms the time series of returns and thus, conceptually, is not too distinct from the measures of historical volatility described above. However, realised volatility has the advantage that it is independent of the mean level of the time series in the sample. This may help to provide meaningful estimates of volatility even in time series which show trend behaviour.

The second class of measures gauge volatility using a specific model or econometric framework. One of the main approaches is to estimate conditional volatility, which captures the variance of a time series for financial yields conditional on the behaviour of certain deterministic variables which can interact with each other and with the past levels of volatility. In the academic literature, the specification of these models is extremely heterogeneous.

1 For a comprehensive survey of various parametric and nonparametric measures of volatility, see T. Andersen, T. Bollerslev and F. X. Diebold (2002), "Parametric and nonparametric volatility measurement", National Bureau of Economic Research Technical Working Paper No 279.

2 For a definition and a discussion of the theoretical properties of this volatility measure, see T. Andersen and T. Bollerslev (1997), "Intraday periodicity and volatility persistence in financial markets", *Journal of Empirical Finance*, Vol. 4, pp. 115-158.

One of the most prominent models for constructing conditional volatility measures is the Auto Regressive Conditional Heteroscedasticity (ARCH) model.[3] Over the past 25 years, this basic framework has spawned numerous variants and extensions, such as Bollerslev's GARCH model or other variants which introduced more flexible functional forms of the volatility equation.

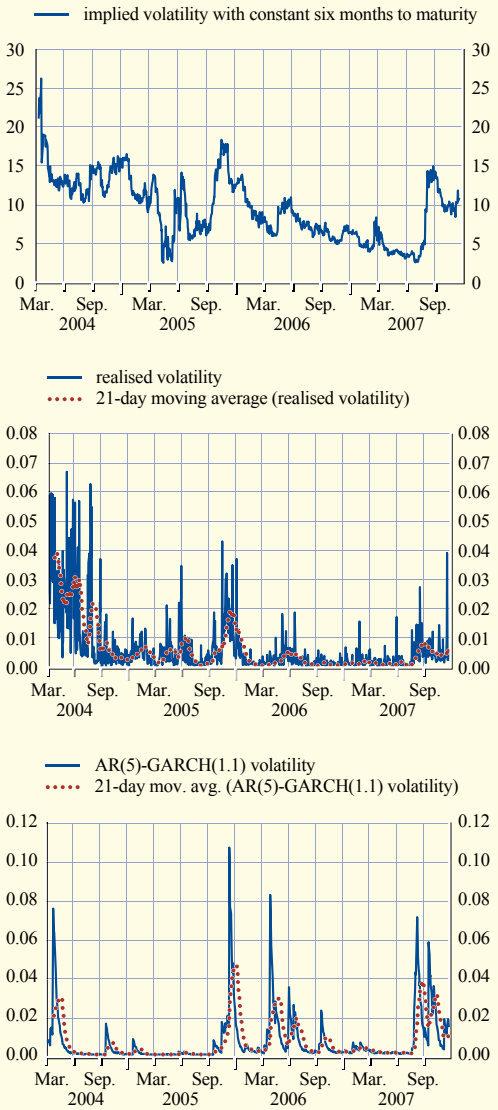
Conditional volatility measures have several advantages. First, by imposing some structure on the way the time series of returns is interpreted and developed over time, they use the available information more efficiently to extract the pattern of volatility. Second, standard econometric tools are used to estimate and test the models on which these measures are based.

In financial markets, another widely used tool to measure volatility is implied volatility. Similar to the measures of conditional volatility, implied volatility is derived from a model, which transforms the prices of options on a specific security into a measure of the volatility of the returns on that security. However, by contrast with the empirical econometric models underlying conditional volatility, the option pricing model – which emerged from the seminal Black and Scholes formula for valuing bond options used to derive implied volatility – is not data-based.

Despite their popularity among practitioners, implied volatility measures have some limitations. First, not all instruments of interest have options associated with them. For example, in the specific case of the euro money market, implied volatility can only be computed for the three-month EURIBOR futures. Second, they require a specific option pricing model. Even assuming that a particular pricing model is accurate, these models are typically based on theoretical assumptions that may be difficult to verify in practice. Third, because implied volatility is a proxy for the uncertainty of the return on a financial instrument, it is very sensitive to the maturity of the option contract and mechanically decreases as the maturity of the contract approaches. Fourth, the length of time series for implied volatility is limited by the fact that this

Implied, realised and ARCH(1) volatility of three-month EURIBOR interest rates [1)]

(percentages per annum; daily observations)



1) The analysis starts on 10 March 2004 after the introduction of the new operational framework. For further details, see the box entitled "The volatility of the overnight interest rate from a medium-term perspective" in the March 2005 issue of the Monthly Bulletin.

3 For details on a typical ARCH model structure, see the seminal article by R. F. Engle (1982), "Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation", *Econometrica*, Vol. 50(4), pp. 987-1008.

measure can only be calculated for the life of a specific contract, which is normally limited to one year in the case of money market contracts. However, on the positive side, implied volatility has been proved to have good forecasting properties for realised volatility, as shown by findings in the empirical literature. It thus offers a forward-looking measure of volatility, which – although it is approximate – may be useful in many contexts.

The chart shows these three volatility measures computed over the period from March 2004 (i.e. after the introduction of the changes to the Eurosystem's operational framework) to December 2007. Since no single three-month EURIBOR futures contract was actively traded over the entire sample period, the top panel of the chart shows an implied volatility with a constant six months to maturity. This is an artificial measure computed for the sole purpose of allowing a numerical comparison of the three measures over the whole sample. To improve readability of the realised and conditional volatility time series, together with the daily time series of volatility, the chart also displays their respective 21-day moving averages (i.e. approximately corresponding to one trading month), which helps to smooth out idiosyncratic daily movements.

Despite the differences between the three measures, they tend to follow the same pattern. The evolution of the three volatility measures in the chart tends to suggest that the ECB's monetary policy has been sufficiently clear and transparent to financial markets and has not had a negative impact on volatility dynamics, as shown by the overall limited level of volatility over most of the period considered. At the end of the period, the sharp rise which is visible in all three measures considered coincides with the tensions associated with the financial turbulence in the euro area money market.

The evolution of the one-week EONIA swap rate is much smoother than that of the EONIA itself (the former reflects the expected average level of the EONIA over one week)[7] and provides initial evidence that most of the volatility in the EONIA is contained within the overnight segment (see Table 1). As has previously been demonstrated, this assessment is confirmed by econometric models, which show that under normal conditions there has not been a noticeable transmission of volatility from the overnight interest rate to the term maturities.[8] At times of tension, volatility at both overnight and longer maturities can increase and the causality of the transmission of volatility may be less clear. Consequently, volatility in overnight rates might be caused by volatility in the term segment of the money market rather than vice versa. In this context, it is useful for policy-makers to monitor a broad set of volatility measures, as described in Box 2.

Overall, it seems that, under normal conditions, rates in the shortest-maturity segment of the euro money market have so far been successfully steered close to the minimum bid rate, and fluctuations have been concentrated on specific days close to the end of maintenance periods or when liquidity conditions have changed. In this environment, there has been little evidence of a transmission of volatility to the term maturities. During the recent periods of tension in the money market, the ECB's liquidity management has served to stabilise overnight rates around the minimum bid rate and may have contributed to some limited smoothing of tensions at longer maturities, although tensions persist.

7 For more information on the technical features of EONIA and EURIBOR interest rates, see the box entitled "The information content of the main money market instruments in the euro area" in the June 2001 issue of the Monthly Bulletin.

8 For further details, see the box entitled "Volatility of the overnight interest rate and its transmission along the money market yield curve" in the August 2007 issue of the Monthly Bulletin.

4 ASSESSING INFORMATION IN THE MONEY MARKET YIELD CURVE

For the policy-maker, money market interest rates at longer maturities contain a broad set of information about market participants' expectations of the future path of short-term market interest rates and, ultimately, the minimum bid rate. By monitoring expectations, monetary policy-makers can assess the transmission process of the monetary policy stance to overall financing conditions.

When extracting expectations, it is necessary to distinguish between the different characteristics of the instruments in the money market as they contain different information. As described in Box 1, secured instruments (e.g. EUREPO repurchase agreements) or instruments that only involve an exchange of interest payments (e.g. EONIA swaps) are less exposed to counterparty default risks and are therefore, other things being equal, closest to the minimum bid rate. Unsecured instruments, such as some interbank deposits (e.g. the benchmark euro interbank offered rate (EURIBOR)), contain a more pronounced premium, compensating for the potential risk that the counterparty is unable to repay the loan. This also implies that changes in the EURIBOR may reflect changes in the level of trust between banks or investors rather than changes in the expected path of the minimum bid rate. When assessing information in the money market, it is therefore essential to distinguish between changes in the expected path of the minimum bid rate and the evolution of other elements, such as time-varying risk premia. At the same time, monitoring expected future levels of unsecured interbank rates is relevant from a financing conditions perspective as these are expected to affect MFI loan and deposit rates as well as other market rates across the maturity spectrum.

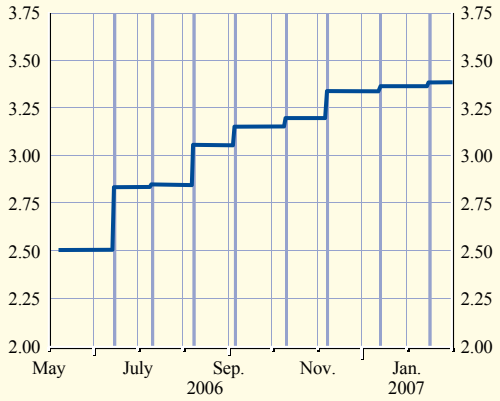
From a policy perspective, it is important to monitor whether market interest rates reflect a future path of the minimum bid rate that is consistent with the Governing Council's own views and communication. For this purpose, the most accurate indicator is forward rates computed on the basis of the EONIA swap curve. The risk premium embedded in these rates is considered negligible for maturities up to several months, and banks and investors commonly use them for hedging purposes.[9] The forward rates are constructed to account for the starting and ending date of each reserve maintenance period. Assuming that market participants expect the minimum bid rate to be changed only at the start of a new maintenance period (in line with the scheduled dates of the meetings at which the Governing Council regularly makes monetary policy decisions), the forward rates are constructed as steps, indicating the average expected level of the EONIA rate in each maintenance period. The expected level of the minimum bid rate is obtained by subtracting the premia corresponding to the EONIA's normal spread over the minimum bid rate. This is typically assumed to be constant over the forecast horizon, except for certain times such as the periods around the end of calendar years, when premia are usually assumed to be somewhat higher. These ECB date-adjusted forward rates have gradually come to be commonly used by private banks and are now regularly reported on wire services.

To illustrate such a step chart, Chart 3 presents data collected on 5 May 2006, a day following a Governing Council meeting. It shows the nine subsequent maintenance periods, from the period starting on 10 May 2006 to that starting on 17 January 2007. At the time that this chart was originally constructed, the level of the minimum bid rate in the maintenance period starting in May was already known (2.50%). Along the curve, there was a strong consensus in the market that the ECB would increase the minimum bid rate to 2.75% at the meeting in June and leave it unchanged in July. Further increases to 3.00% and 3.25% were fully priced in by the market by August and November 2006 respectively.

9 For a detailed discussion of the liquidity in money market instruments, see the "Euro money market study 2006", ECB, February 2007.

Chart 3 Expectations of the minimum bid rate in future maintenance periods extracted from the EONIA swap curve (5 May 2006)

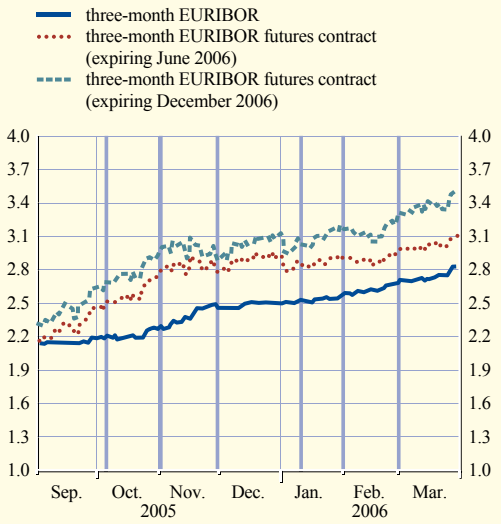
(percentages per annum; daily data)



Source: Reuters.
Note: A constant spread between the EONIA and the minimum bid rate has been subtracted. Furthermore, owing to end-of-year effects 1 additional basis point has been subtracted from the maintenance period starting in December. Vertical bars indicate the beginning of maintenance periods.

Chart 4 Evolution of three-month money market interest rates and interest rates implied by three-month EURIBOR futures contracts

(percentages per annum; daily data)



Sources: ECB and Reuters.
Note: Vertical bars indicate the first Governing Council meeting of the month.

Based on such information, monetary policy-makers can assess whether they are content with the path of the minimum bid rate as reflected in rates at longer maturities. Such an assessment can assist in refining communication so as to maintain, if desired, a high degree of predictability, both in the short term (e.g. the decision at the next interest rate-setting meeting) and possibly over the longer term.[10] At the same time, the quality of the analysis is dependent on an assumption of a constant spread between the EONIA and the minimum bid rate, which highlights the importance of an overall stable evolution of the EONIA.

Another commonly used set of indicators is extracted from the EURIBOR curve, and from derivatives linked to the three-month EURIBOR that allow for a richer analysis than the EONIA swap and EURIBOR curves. In particular, futures contracts provide information about the expected level of the interbank rate at longer horizons. In addition, options on futures contracts facilitate an analysis of the dispersion surrounding the expected level implied by the futures price, and are thus an indicator of market uncertainty regarding the level of future market rates.

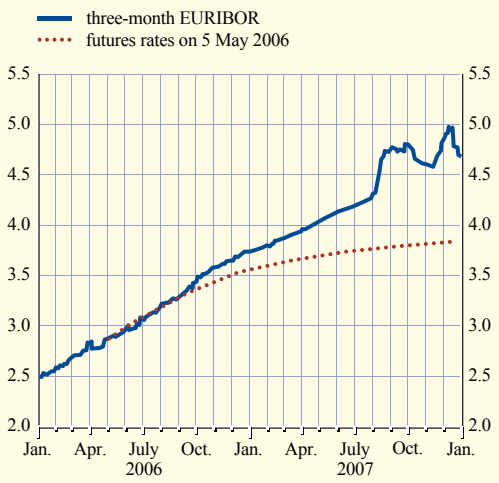
Although EURIBOR rates include sizeable risk premia which are broadly constant under normal conditions, risk premia can increase in periods when the financial sector is affected by specific shocks or increased uncertainty, e.g. as seen in the transition to the new millennium. From a monetary policy perspective, it is important to monitor developments in risk and liquidity premia, as well as in market expectations of key ECB interest rates.

To illustrate how developments in indicators based on EURIBOR rates can be monitored, Chart 4 provides an example of the evolution of the spot three-month EURIBOR and three-month deposit rates implied by the futures contracts expiring in mid-June and mid-December 2006. It shows how the market derives its expectations on

10 For a detailed discussion, see the article entitled "The predictability of the ECB's monetary policy" in the January 2006 issue of the Monthly Bulletin.

Chart 5 Three-month interest rates and futures rates in the euro area

(percentages per annum; daily data)



Source: Reuters.
Note: Three-month futures contracts for delivery at the end of the current and next six to seven quarters as quoted on Euronext. liffe.

the basis of the continuous flow of information. While the three-month EURIBOR gradually increased following two ECB interest rate increases (in December 2005 and March 2006), expectations of future interest rates gradually shifted upwards, reflecting growing market expectations of further increases in the minimum bid rate later in 2006. In particular, the upward shifts in expectations appeared in the periods between monetary policy-relevant Governing Council meetings (indicated by vertical bars) and show how the market in real time evaluates incoming information and adjusts its perceptions of future ECB action.

This gradual evolution of expectations is also supported by model-based tools, which show that monetary policy decisions made in 2005 and 2006 were well anticipated by the market and that the information conveyed in the ensuing press conferences had a small, although visible, impact on market expectations at the medium-term horizon.[11] The tools thereby provide evidence that the interest rate decisions made by the Governing Council are highly predictable. In this context, the high degree of predictability is considered to reflect that monetary policy decisions are being made in a credible and transparent manner that is well explained to the public.

At the same time, data for EURIBOR futures contracts provide a useful indicator of expected three-month rates over the coming four to eight quarters. An example of a futures curve observed on 5 May 2006 is presented in Chart 5. It shows how future market interest rates, derived from three-month EURIBOR futures contracts expiring in the second half of 2006 and in 2007, were expected to increase. At the same time, the realised spot three-month EURIBOR turned out to be relatively close to the expected level in 2006, while the discrepancy rose for the longer forecast horizons. This supports the overall view that the ECB's monetary policy is rather predictable in the short term, while greater uncertainty is attached to longer-term forecasts of interest rates, largely because of the greater uncertainty surrounding the evolution of the economy over longer horizons.

From a monetary policy perspective, it is also essential to assess the dispersion of market participants' opinions – or the uncertainty in the market – in parallel with measures of expected interest rates. Extracting the level of expected interest rates in periods of low uncertainty does not provide the same information content as expectations extracted in a high-uncertainty environment. A low-uncertainty environment usually reflects higher confidence of market participants about the future developments in the economy and can contribute to reducing risk premia. By the same token, if uncertainty in the market remains moderate along the money market yield curve following the policy announcement, it usually suggests that market participants have a sound understanding of the future path of the minimum bid rate, and thus of the central bank's strategy and the latest data on which the central bank will base its decisions.

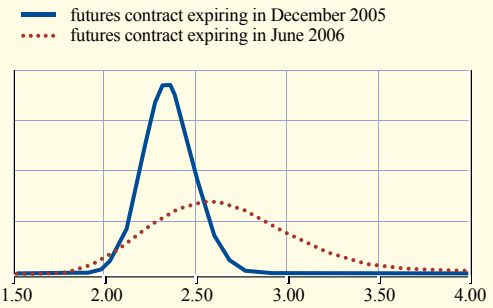
11 See the articles entitled "The predictability of the ECB's monetary policy" in the January 2006 issue of the Monthly Bulletin and "Communicating monetary policy to financial markets" in the April 2007 issue.

For the purpose of assessing the dispersion of uncertainty, a commonly used measure is risk-neutral densities (RNDs) implied by options on EURIBOR futures.[12] The RNDs provide an approximation of what the market would perceive as the probability distribution of the price of the underlying futures contract, if market participants were risk-neutral. Since market participants are generally risk-averse, RNDs most likely differ from the "true" perceptions of the market. However, assuming that risk premia mainly influence the mean of the distribution (which corresponds to the price of the futures), the RNDs are normally considered as useful measures of the dispersion surrounding the price.

An example of such densities is presented in Chart 6, which illustrates the RNDs derived from options on the futures contracts expiring in mid-December 2005 and mid-June 2006 based on data collected on 27 October 2005. The probability distribution derived from the December 2005 contract is less dispersed than that derived from the June 2006 contract, reflecting the increasing uncertainty when looking further ahead. At the same time, both probability distributions were skewed slightly towards higher rates, indicating that market participants attached an upward bias to the average level of expected three-month EURIBOR rates.

All in all, money market instruments provide policy-makers with a large selection of highly informative tools when assessing whether the markets have a genuine understanding of the outlook for short-term interest rates, and thereby the monetary policy stance at each point in time.

Chart 6 Risk-neutral densities for the three-month EURIBOR on 27 October 2005



Sources: Reuters and ECB calculation.
Note: Estimates are based on a mixture of lognormals for the implied risk-neutral density, applied to quotations of the three-month EURIBOR futures options traded on Euronext.liffe.

5 CONCLUSION

The euro money market is of paramount importance to the ECB for the transmission of its monetary policy stance to the broader financial markets, from where it influences private sector investment and saving decisions, monetary dynamics and, ultimately, the outlook for price stability.

The levels of the key ECB interest rates are decided by the Governing Council of the ECB with the objective of ensuring price stability in the euro area. The operational framework for monetary policy and the liquidity management decisions made by the Executive Board of the ECB are efficient tools to ensure that interest rates in the shortest-maturity segment of the euro money market remain in a narrow range close to the minimum bid rate. This normally contains fluctuations to a few days at most per month and prevents volatility at short-term maturities from being transmitted throughout the money market yield curve. At the same time, the ECB recognises that developments in longer-term money market interest rates reflect market forces and that this market segment is beyond the ECB's direct control. This is particularly evident during specific periods of financial market stress, when changes in risk premia and mistrust among banks and investors affect these longer-term rates and may thus interfere with the transmission of the monetary policy stance.

When assessing the transmission of the monetary policy stance to the financial markets, the ECB therefore monitors a broad set of indicators derived from various money market instruments. These indicators are included in the economic and monetary analyses underlying the ECB's monetary policy decisions.

12 More information on RNDs can be found in the article entitled "The information content of interest rates and their derivatives for monetary policy" in the May 2000 issue of the Monthly Bulletin.