Box 2

Measures of implied volatility derived from options on short-term interest rate futures

Measures of the expected volatility of short-term interest rates can provide valuable information on the uncertainty prevailing in the market with regard to future developments in short-term interest rates. In the euro area, a useful measure of the overall uncertainty associated with future movements in short-term interest rates is the implied volatility derived from options on futures contracts on the three-month EURIBOR.

Given appropriate assumptions, implied volatility is normally calculated on the basis of option pricing models to obtain an estimate of the expected dispersion of future percentage changes in short-term interest rates. A value of implied volatility equal to 20%, for instance, indicates that the best estimate of the market's expected dispersion of the implied percentage change in the interest rate over the remaining life of the futures contract is, on an annual basis, 20% of the current level of the interest rate.[1]

1 See the article entitled "The information content of interest rates and their derivatives for monetary policy" in the May 2000 issue of the ECB's Monthly Bulletin (as well as Box 4 on page 23 in the December 1999 issue of the ECB's Monthly Bulletin) for a discussion on the derivation of implied volatility and the underlying assumptions.

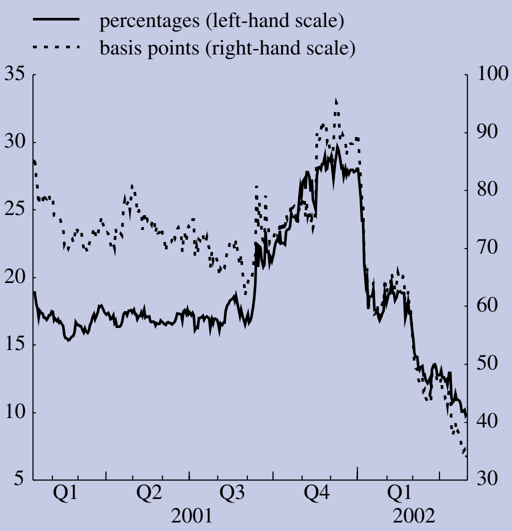
This box analyses issues related to the usual percentage measure of implied volatility and the "time-to-maturity" effect. By addressing these issues, it is possible to obtain a richer set of information on the uncertainty of the market with regard to the evolution of short-term interest rates.

The first issue stems from the fact that it is sometimes of interest to derive a measure of the uncertainty surrounding future movements in interest rates expressed in basis points (rather than in percentage terms). Implied volatility expressed as a percentage per annum measures the expected volatility of future percentage changes in interest rates. The same level of implied volatility may thus hide very different levels of volatility of the *percentage point* changes in futures interest rates, as these depend on the level of the (implied) interest rate itself.

In order to address this issue, it is possible to obtain an estimate of the expected dispersion of future changes in interest rates, measured in basis points, by multiplying the volatility measure as a percentage per annum by the level of the implied interest rate.[1] An implied volatility of 20%, for instance, is equal to an annualised expected standard deviation of 80 basis points in interest rate changes if the futures rate is 4%, while it indicates an expected standard deviation of only 60 basis points in a situation where the prevailing futures rate is 3%. The analysis of implied volatility expressed in percentage terms therefore only provides a partial picture of the evolution of the uncertainty regarding interest rate changes.

Chart A: Implied volatility from options on June 2002 three-month EURIBOR futures

(percentages per annum; basis points; daily data)



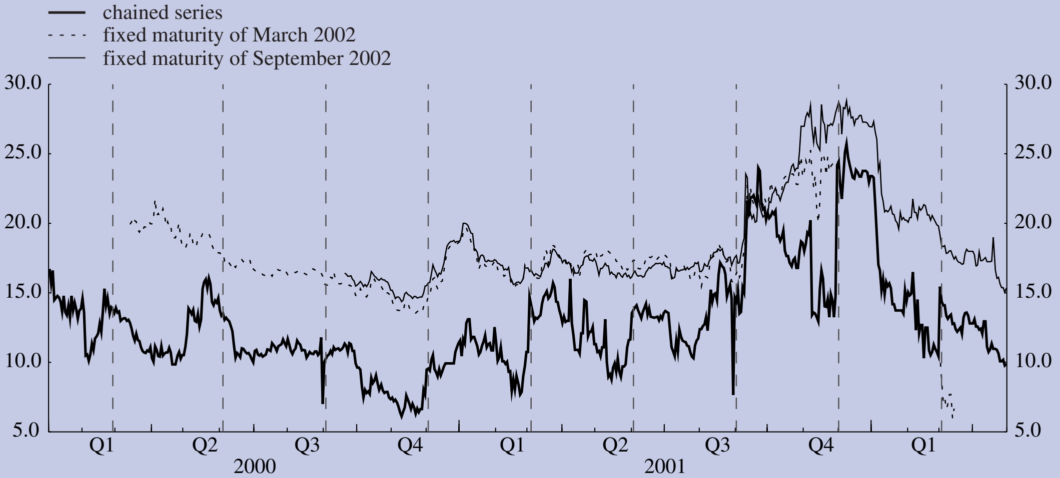
Sources: Bloomberg and ECB calculations.

Chart A illustrates the difference between the two measures. Implied volatility in percentage terms remained broadly stable in 2001, until the terrorist attacks in September. However, according to the basis point measure, it tended to decline over the same period. The decreasing trend in this series reflected expectations of declining interest rates, as reflected in the futures rates. Following the terrorist attacks, implied volatility as a percentage per annum rose dramatically. This also held true in the case of the basis point measure, albeit to a lower extent, as the rates implied in futures prices also decreased significantly. The monitoring of implied volatility expressed as a percentage per annum can signal variations in the perceived "regime" of uncertainty, as measured over longer periods. The measure in basis points, by contrast, is useful when analysing the dispersion in expectations for future changes in money market rates expressed in those units in which markets usually operate.

A second issue is related to what is known as the time-to-maturity effect. It is a widely acknowledged empirical phenomenon that the implied volatility tends to decline as time passes and the expiration time of the option approaches, especially during the last few weeks of the life of the option contract. This phenomenon relates to the decline in uncertainty as the horizon of the option contract becomes shorter. This could make the analysis of developments in implied volatility through time misleading as monitoring volatility derived from contracts with a fixed maturity date will underestimate the "true" level of uncertainty as time goes by. In order to correct for this in longer-term time series analysis, chained series of the implied volatility on the nearest maturity futures contract are sometimes used. For example, in the chained series in Chart B, the implied

1 *For an analysis of the derivation of measures of uncertainty from option contracts, see, for example, J. Hull, Options, Futures and Other Derivatives. (Englewood Cliffs, New Jersey: Prentice-Hall, Fourth Edition, 2000), Chapters 11 and 20.*

Chart B: Implied volatility from options on three-month EURIBOR futures
(percentages per annum; daily data)

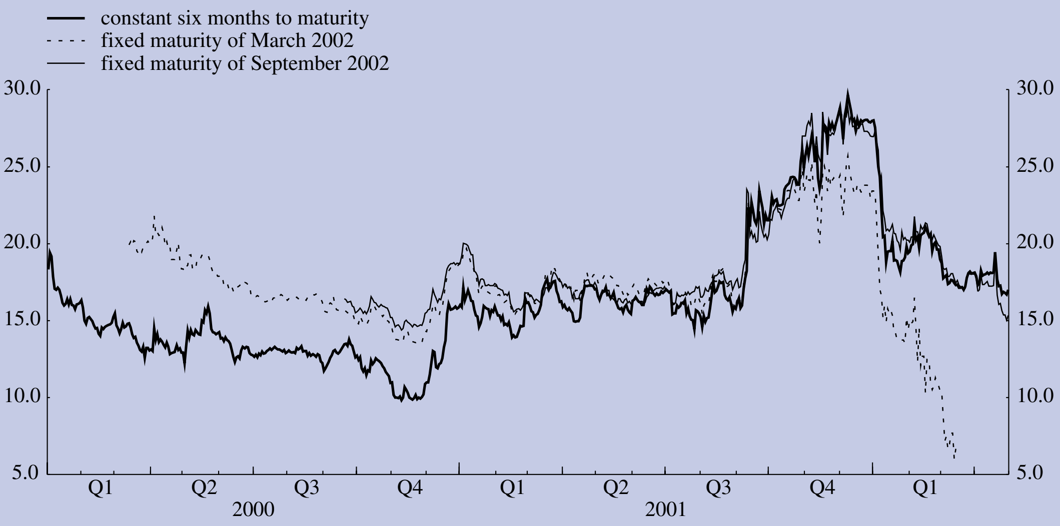


Sources: Bloomberg and ECB calculations.
Note: The chained series represent the nearby implied volatility on the nearest contract, rolled over two weeks before maturity. The vertical lines indicate these shifts.

volatility computed on the nearest maturity contract is replaced two weeks prior to the maturity date (as the liquidity of the contract becomes relatively low this close to maturity) with that computed on the contract with the next shortest maturity.

One problem that is encountered when using chained series is that there are significant jumps at the times of the replacements, as indicated by the vertical lines in Chart B. In addition, the time-to-maturity effect is not entirely eliminated. An alternative formulation is the derivation of a constant maturity measure, obtained on the basis of an interpolation of an implied volatility term curve. This involves two steps. First, the implied volatility curve is interpolated across the observed implied volatility data for different maturities. Second, after interpolation, it is straightforward to compute a time series for implied volatility with a constant time to maturity of, for instance, six months ahead. This volatility series smoothly follows the pattern of other implied

Chart C: Implied volatility with constant time to maturity
(percentages per annum; daily data)



Sources: Bloomberg and ECB calculations.

volatility series with comparable maturities and does not have any declining time-to-maturity trend. Chart C plots this measure of volatility against the volatility implied in the contracts maturing in March and September 2002. The volatility with constant time to maturity lies below the level of the implied volatility derived from the March and September 2002 contracts until early 2001. Further on, it remains at similar levels, when the maturity dates of the two contracts are still far away. From late 2001 onwards, the constant time-to-maturity volatility series is higher than that implied in the March 2002 contract, as the latter contract approaches expiration, but remains close to the level implied by the September contract. Close to maturity, the volatility of the March 2002 contract declines significantly.

Overall, Charts B and C illustrate that the time-to-maturity effect can be strong and may distort the analysis even if chained series are used. The implied volatility is little distorted only if the maturity of the contract is far away. In order to deal with the time-to-maturity effect, measures of implied volatility with a constant horizon may turn out to be useful, particularly when the analysis extends over periods longer than a few months.