## Box 4

## Inferring expected interest rate volatility from options prices

Measures of the expected volatility of future short-term and long-term interest rates can provide a central bank with valuable information about the dispersion of market expectations or uncertainty regarding future interest rate developments. One particularly useful measure of expected volatility is implied volatility, which can be extracted from options prices. Given the observed market price of an option, the implied volatility can be extracted using a standard option pricing formula, which explicitly depends on, inter alia, the expected volatility of the underlying asset price. The implied volatility may, given appropriate assumptions, be interpreted as the market's expectation of volatility during the remaining life of the option.

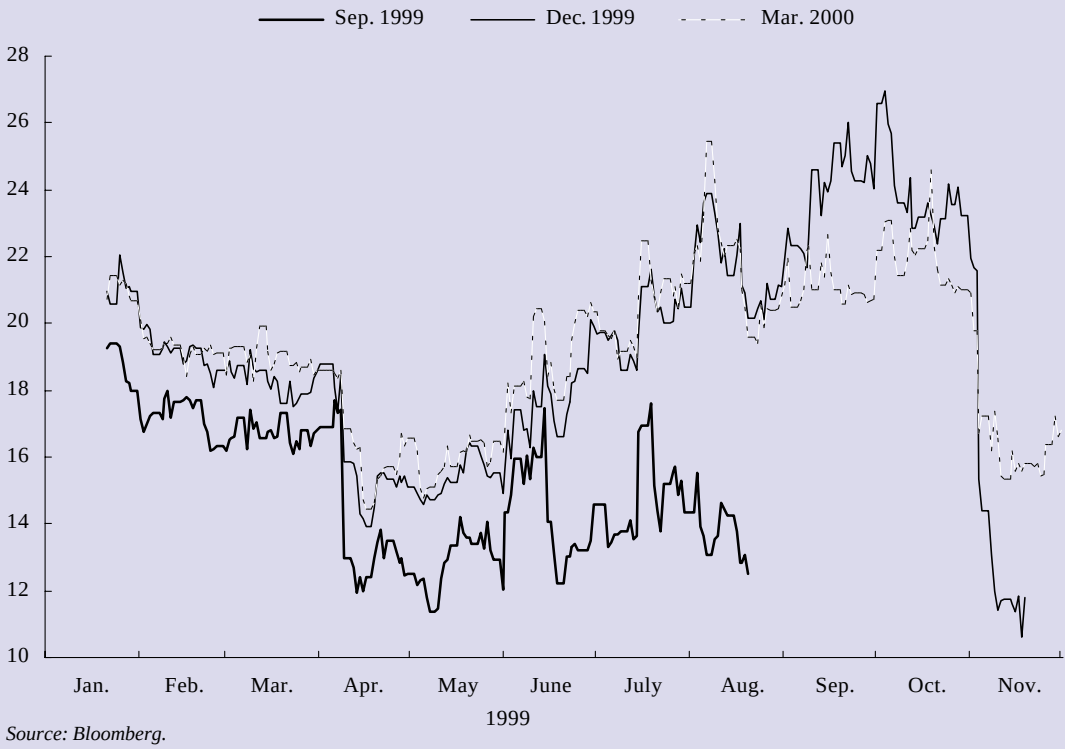
Implied volatility can complement measures of expectations of the evolution of financial variables in the future, such as forward interest rates and futures prices, by providing a measure of the uncertainty surrounding these expectations. The implied volatility of short-term interest rates and that of long-term bond prices are considered in more detail below. The first measure refers to the uncertainty surrounding the evolution of short-term interest rates over the life of the option. Furthermore, as long-term nominal interest rates reflect market expectations regarding inflation and real interest rates over a longer horizon, the latter measure could be seen as an indicator of the uncertainty surrounding the future evolution of these factors.

**Money market implied volatility**

Indications of the uncertainty regarding the future evolution of short-term interest rates in the euro area can be obtained from the implied volatility derived from options on three-month EURIBOR futures. The evolution of money market volatility implied in options prices derived from contracts maturing in September and December 1999, as well as in March 2000, is displayed in the chart below, starting in January 1999.

### Implied volatility from options on three-month EURIBOR futures

*(traded on LIFFE)*




*Source: Bloomberg.*

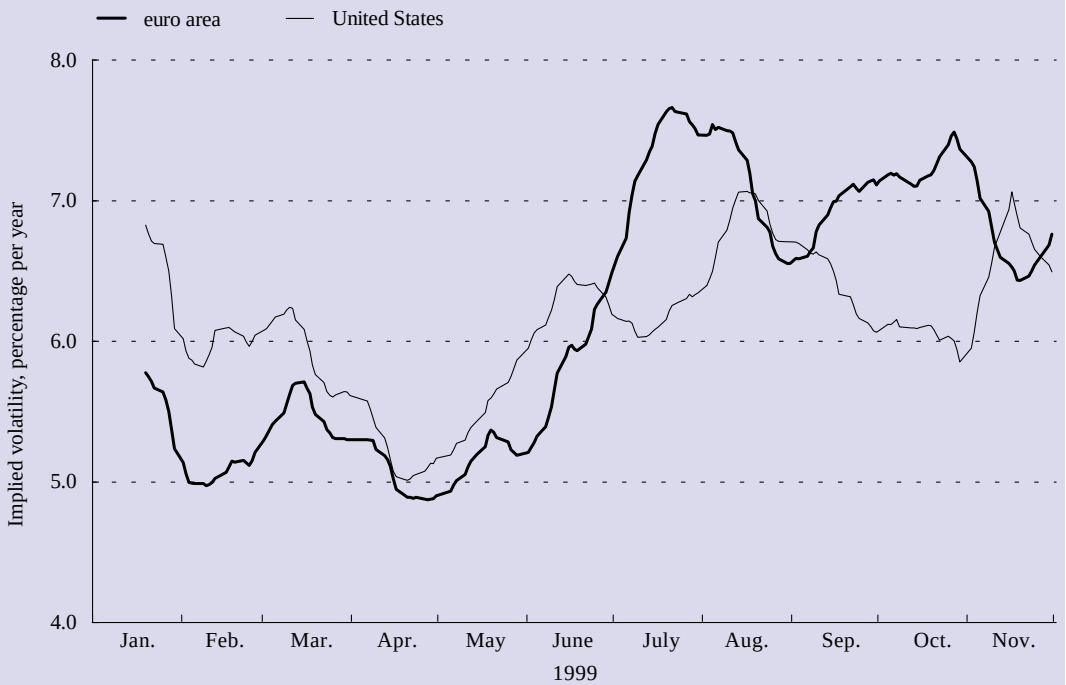
After the launch of the euro, the implied volatility obtained from each of these options contracts gradually declined. There was a small temporary increase in expected volatility in the period preceding the decision of the Governing Council of the ECB on 8 April 1999 to reduce ECB interest rates, but, following the announcement of the decision, implied volatility dropped significantly for all maturities. From May 1999 onwards implied volatility began to creep up slowly at a time when short-term interest rates implied in futures contracts were also moving upwards, since the progressively stronger signs of a pick-up in economic activity in the euro area were leading to new uncertainties regarding the evolution of interest rates. The chart also shows that around the time of the increase in ECB interest rates announced on 4 November 1999, the drop in implied volatility was very pronounced at all maturities. This indicates that the move has considerably reduced market uncertainty regarding policy moves in the near term.

**Long-term bond market implied volatility**

By contrast with implied volatility on short-term money market futures, which is closely associated with market uncertainty regarding future short-term interest rates, and in particular future monetary policy moves, implied volatility on long-term bond futures is more related to short-term uncertainty regarding long-term fundamentals, in addition to other factors such as spillovers from international bond markets. In particular, the implied volatility extracted from options contracts on a long-term bond provides an indication of the degree of uncertainty regarding the long-term real interest rate, average inflation rate and risk premia expected by market participants at the expiry of the options contracts. The fact that expectations regarding all these components affect the pricing of options on long-term bonds makes it somewhat more challenging to extract and interpret the relevant forward-looking information from implied volatility on long-term fixed income instruments.

**Implied volatility for futures contracts on the ten-year German Bund and the ten-year US Treasury note respectively**

(*percentages per annum; ten-day moving average of daily data*)




*Source: Bloomberg.*

*Note: The implied volatility series in the above chart represent the nearby implied volatility on the near contract generic future, rolled over 20 days prior to expiry, as defined by Bloomberg. This means that 20 days prior to expiry of the contracts, a change in the choice of contract used to obtain the implied volatility is made, from the contract closest to maturity to the next contract.*

For the euro area, the implied volatility derived from options on ten-year German Bund futures appears to be the best proxy available for euro area long-term bond market implied volatility. During the first half of 1999 implied volatility in euro area bond markets appeared broadly to follow developments in the implied volatility of US ten-year bonds (see the chart above). However, over the summer the implied volatility of the ten-year Bund contract increased to levels that were considerably higher than the corresponding implied volatility in US bonds. During that time the increases in bond yields in the euro area were more pronounced than in the United States in the light of growing expectations regarding the economic recovery in the euro area. This combination of increasing bond yields and higher implied volatility suggests that these more optimistic expectations were, however, coupled with increasing uncertainty regarding the strength and sustainability of this pick-up as well as its implications for price stability. During the autumn the upward trend in euro area bond yield volatility appears to have ended as the uncertainty surrounding the outlook for the euro area economy diminished. With regard to developments during recent weeks, it appears that the increase in ECB interest rates, which was increasingly anticipated by market participants in the course of the week prior to 4 November, lowered the degree of uncertainty in respect of the evolution of long-term bond yields in the near future. However, during the second half of November implied volatility again started to increase somewhat, in an environment where long-term interest rates rose in the United States and the sharp downturn in euro area bond yields was also reversed (see the main text on bond market developments).