

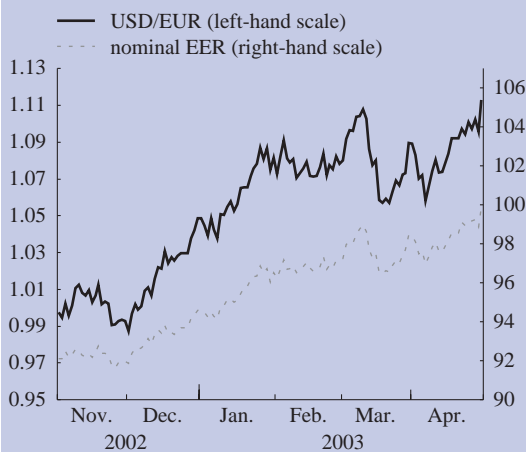
Box 6

Using currency options-based indicators to assess sentiment in the foreign exchange markets

Since the second quarter of 2002, the euro has appreciated against other major currencies. Having been relatively stable in the summer months of 2002, the euro experienced a renewed appreciating momentum against the US dollar, strengthening by 11.6% between 1 November 2002 and 30 April 2003 (see Chart A).¹ Since late February 2003, however, the currency pair has experienced rather substantial fluctuations. This box assesses developments in market expectations and sentiment over the last six months, as captured by data derived from currency options prices, focusing on the USD/EUR exchange rate.

Chart A: USD/EUR exchange rate and the effective euro exchange rate

(daily data)



Source: ECB.

The properties of the Black and Scholes options pricing model can be used to extract useful information from European-style options prices.² Since all the components of the Black and Scholes pricing formula are directly observable from quoted currency options prices – apart from the expected volatility of the underlying exchange rate – it is possible to derive the market's estimate for future volatility simply by inverting the Black and Scholes formula. Volatility derived from the options prices is called "implied volatility", which is a measure of the degree of uncertainty that the options market attaches to future movements in the exchange rate in any one direction over the lifetime of the option. Risk reversal in turn is an options strategy that consists of a simultaneous purchase of a call option and a sale of a put option with similar characteristics³; it is usually quoted as the difference between the implied volatilities of the two options. The risk reversal can be used to assess how the market sees the balance of risks between a large appreciation and a large depreciation in the exchange rate. A large positive reading of a risk reversal on the USD/EUR options suggests that higher probabilities are attached to a sizeable appreciation of the euro, whereas a large negative reading indicates expectations skewed in favour of a considerable euro depreciation.

Data on currency options prices make it possible to estimate a wide set of indicators for future exchange rate movements. First, it is possible to extract expected future volatility of the underlying currency pair, which provides a measure of the uncertainty that the market attaches to future developments in the exchange rate. Second, options-based data can be used to infer whether the market perceived the uncertainty to be symmetric or largely focused on a specific direction. Finally, using extensive interpolation and extrapolation techniques, it is possible to obtain a measure of the market's entire perceived probability distribution for the future exchange rate. The ECB often uses indicators based on currency options data to monitor and analyse developments in the foreign exchange markets.

¹ The appreciation of the single currency was broadly based, as witnessed by the appreciation of the euro nominal effective exchange rate index by 8.5% over the same period.

² In the Black and Scholes formula, European-style currency options are determined by the current spot exchange rate, domestic and foreign interest rates, the price and date of maturity of the options contract, and the volatility of the underlying exchange rate over the lifetime of the options contract. A European-style option cannot be exercised prior to the maturity, while an American-style option can be exercised at any date between the purchase and the maturity date.

³ With a European put option an investor buys a right, but not an obligation, to sell the currency at a specified exchange rate at the terminal date of the contract. Similarly, a European call option provides a right, but not an obligation, to purchase currency at a specified rate.

Chart B shows the developments in implied volatility and risk reversals that are derived from options contracts with one-month maturity on the USD/EUR exchange rate. Implied volatility declined throughout November 2002 to reach a low point in early December. Thereafter, in line with the increasing momentum of appreciation of the euro vis-à-vis the US dollar, it rose rather sharply throughout the rest of December. This surge in implied volatility coincided with a movement in risk reversals from a near neutral (zero) reading to a range that indicates expectations of near-term euro appreciation. It seems therefore that once the appreciation of the euro gained pace, the options market started to assign a higher probability to a further near-term strengthening of the euro.

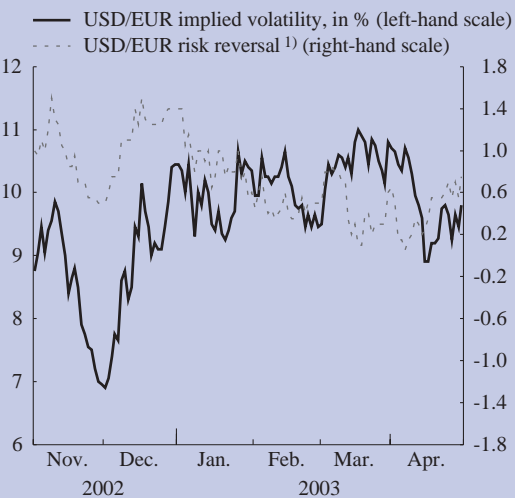
In the first four months of 2003, implied volatility fluctuated around the higher level before dropping substantially in the second half of April. These developments were closely associated with the war in Iraq and took place amid relatively large exchange rate fluctuations and a gradual decline in risk reversals towards zero. Taken together, such movements suggest that, while the options market remained concerned about the possibility of large near-term swings in the USD/EUR exchange rate, until early April they attached steadily lower probability to these being associated with an appreciation of the euro. A typical effect of the short-term impact of geopolitical tension during this period was the temporary depreciation of the euro in the week following the US administration's announcement on 13 March of the start of military operations in Iraq. This coincided with an upward jump in implied volatility and, a few days later, a more pronounced drop in risk reversals (see Charts A and B).

The information extracted from options prices can be enhanced by estimating the entire probability distribution for the exchange rate. In particular, a measure of the implied risk-neutral density (RND) can be obtained from the data on implied volatilities, risk reversals and strangles (another options strategy that consists of a simultaneous purchase of a put and a call option with similar characteristics). The implied RND reflects the markets' perception of the probability distribution of the underlying exchange rate at the future date when the option expires, if market participants were risk-neutral.⁴ Despite the caveats related to the assumption of investor risk-neutrality, the implied RND should provide a useful indication of other aspects of the distribution, such as the dispersion of uncertainty as well as the possible asymmetries in the shape of the distribution.

In Chart C, the implied RND functions are plotted for selected dates. In the left-hand panel, the appreciation of the one-month forward exchange rate of the euro relative to the US dollar throughout December 2002 is shown as a rightward shift in the mean of the function. The appreciation was also associated with a rather marked increase in uncertainty, as shown by the increased standard deviation of the RND between 2 and 31 December 2002. The RND on 31 December is also clearly more asymmetric: the thicker right-hand tail shows that expectations became skewed towards euro appreciation. The right-hand panel shows developments during the last two weeks of the military operations in Iraq (early April 2003). While the forward exchange rate did

Chart B: USD/EUR implied volatility and risk reversals

(daily data)

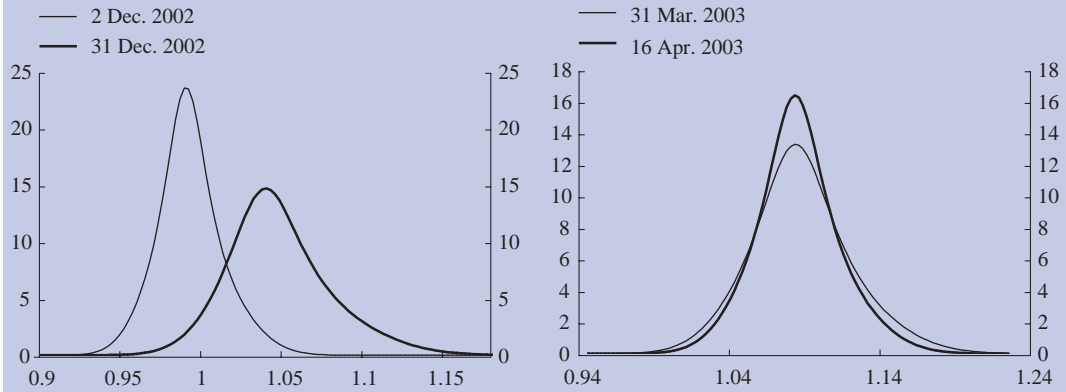


Source: Citibank.

1) Risk reversal is measured as the difference in implied volatility between a put and a call option with similar characteristics.

⁴ Since the implied RND is risk-neutral, the mean of the distribution corresponds to the forward exchange rate for the relevant time horizon. Given that investors are generally risk averse, the implied RND is, however, only an estimate of the market's "true" perception of the probability distribution.

Chart C: Implied risk-neutral distributions on USD/EUR exchange rates for selected dates



Sources: Citibank and ECB calculations.

Note: The vertical axes show the probabilities, the horizontal axes the one-month forward exchange rates.

not markedly change between the two dates, overall uncertainty, as measured by standard deviation of the RNDs, declined. The function also became slightly more asymmetric in shape, reflecting increased expectations of future euro appreciation.

To summarise, the measures of market expectations of short-term exchange rate developments derived from one-month USD/EUR currency options prices show significant changes between November 2002 and April 2003, when the underlying exchange rate also experienced rather substantial movements. In particular, applying these measures helps to shed further light on exchange rate movements and the distribution of risks around forward exchange rates. However, all caveats need to be kept in mind when drawing specific conclusions about past and expected exchange rate developments.