THE TERM STRUCTURE OF IMPLIED INTEREST RATE VOLATILITIES
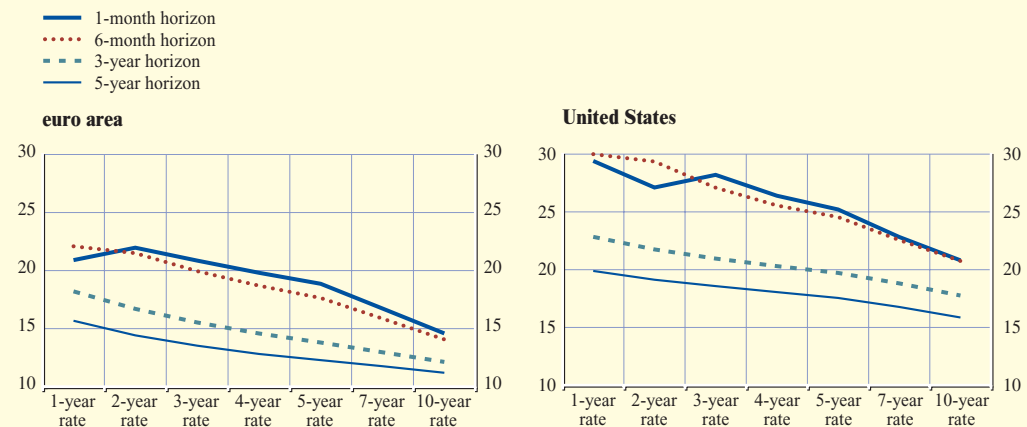
Over the last decade, a number of new interest rate derivatives have been developed. Strong rates of growth in turnover provide evidence that contracts such as interest rate swaptions have become widely used tools to hedge adverse movements in interest rates.[1] Interest rate swaptions are quoted in terms of the implied volatilities of the forward swap or LIBOR rates which are their underlying assets. Implied volatilities express the market's expectations about future volatility in these forward rates over the life of the option and are thus useful indicators to gauge market participants' degree of uncertainty.

This box looks at implied volatilities from swaptions, which are available over a wide range of both interest rate maturities and times to expiration. This feature makes swaptions a particularly interesting analytical tool, because it enables the derivation of a broad family of

1 Swaptions are options on forward swap rates. Hence, for a given swap rate, they can be seen as options on a portfolio of forward (three-month or six-month) LIBOR rates, namely all those LIBOR forward rates included in the interval spanned by the maturity of the swaption plus the life of the swap.

Chart A Term structure of implied forward swap rate volatilities in the euro area and the United States

(percentages per annum; averages of daily data between January 1999 and November 2005)

- 1-month horizon
- 6-month horizon
- 3-year horizon
- 5-year horizon

Sources: Bloomberg and ECB calculations.

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term structures of implied volatilities which provide indications of the market's near- and long-term uncertainty about future short- and long-term interest rates. Specifically, the swaptions employed in this box refer to swap rates denominated in US dollars and in euro with maturities between one and ten years as well as to options on such rates expiring in between one month and ten years,[2] although results are reported for a sub-set of these instruments only.

Chart A shows the average daily term structure of implied interest rate volatilities in the United States and in the euro area between January 1999 (when the euro was introduced) and November 2005. The curves shown in the chart refer to different times to expiration and thus to different expectations horizons, and there are some stylised facts which can be inferred. First, the term structure of implied volatilities has, for each horizon, been higher in the United States than in the euro area. Second, almost all curves, for both economic areas, have typically been downward-sloping, suggesting that uncertainty has decreased with the interest rate maturity. Third, for every swap rate, the whole volatility term structure decreases with the time to expiration of the swaptions; hence uncertainty has been lower the longer the expectations horizon.

Chart B shows the time series of implied volatilities of the one-year and ten-year interest rates over two horizons, three months (left panel) and five years (right panel), for both the euro area and the United States. The time profiles of these implied volatilities suggest again that uncertainty has been nearly always higher in the United States than in the euro area. In addition, they reveal that the differences in average volatilities reported in Chart A derive almost entirely from the period between September 2001 and April 2004. In this sub-sample, near-term implied volatilities of US swap rates surged to extremely high levels. At the peak recorded in August 2002, implied volatility exceeded 70% for the one-year US swap rate over the three-month horizon, and was around 30% for the corresponding euro area rate; the gap was sizeable also over the five-year horizon, with US and euro area implied volatility at roughly 30% and 15%, respectively. From May 2004, the differences in implied volatilities between the two economic areas declined and in 2005 there has been no evidence of sizeable differences in expected interest rate volatilities between the two areas.

2 All swaptions are at-the-money contracts, i.e. their exercise price equals the forward interest rate prevailing at the inception of the contract.

Chart B Implied volatilities of one-year and ten-year forward swap rates at the three-month and five-year horizons in the euro area and the United States

(percentages per annum; end-of-month data up to November 2005)

— euro area, 1-year rate
····· euro area, 10-year rate
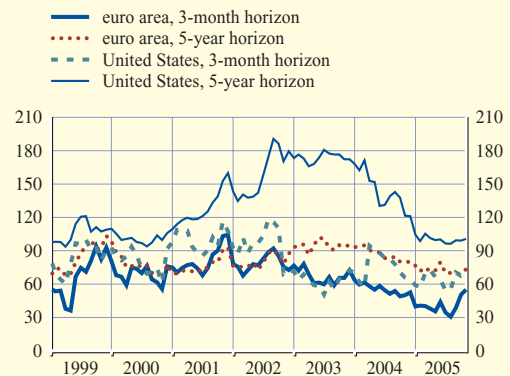- - - United States, 1-year rate
— United States, 10-year rate
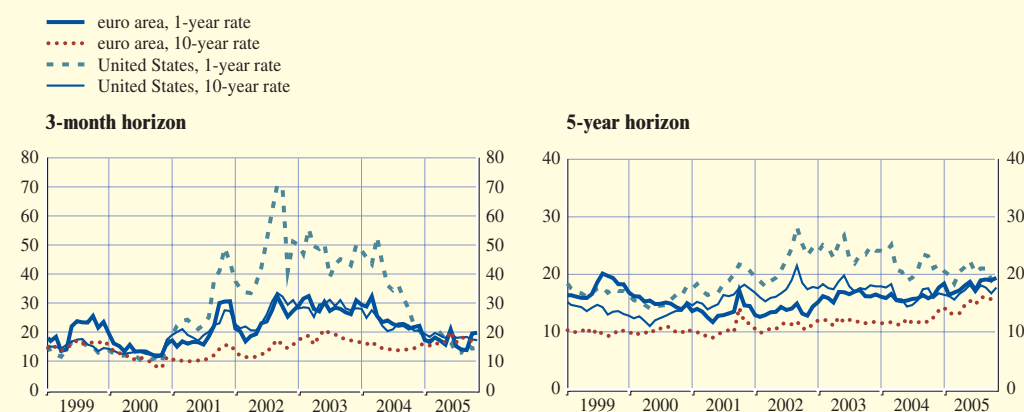
Source: Bloomberg.

Such developments raise the question as to why implied volatility was so high between September 2001 and April 2004. The timing of the rise and subsequent fall in volatilities, which were particularly sharp in the United States, seems to suggest that a number of factors may have played a role. Uncertainty related to the US macroeconomic outlook may have had relatively more influence than in other periods, given the occurrence of mixed signals about the solidity of the business cycle. In addition, in the later part of the sample, monetary policy may have had some influence on volatilities, as economic agents were concerned about the timing and the intensity of the Federal Reserve tightening cycle. This conjecture seems to be reinforced when one observes that, alongside the progressive

Sources: Bloomberg and ECB calculations.

tightening carried out by the Federal Reserve since end-June 2004, implied volatilities have noticeably declined, especially over short horizons. Furthermore, geopolitical tensions in the aftermath of the terrorist attacks in the United States on 11 September 2001 may have raised the global perception of risk. In addition to these factors, the volatility gap between US and euro area yields may have been related, especially in 2003 and in early 2004, to the intense hedging activity in the US mortgage-backed securities market.[3]

While implied interest rate volatilities are typically expressed as a percentage of the level of the underlying forward rates, it might be advantageous to convert them into basis points.[4] This measure can in fact be straightforwardly used to draw a confidence band around a given term structure of forward rates. Chart C displays volatilities, measured in basis points, for the US and the euro area one-year swap rate over the three-month and five-year horizons. The chart first shows that even when measured in basis points, volatilities have been on average higher for US than for euro area rates, although the largest gap occurs for the longer expectations horizon rather than for the shorter one. It also shows that the conversion into basis points has the drawback of making volatilities explicitly dependent on the level of forward rates, and hence on the slope of the yield curve[5] and the size of the associated risk premia.[6] As an example of this, the volatility of the US one-year forward swap rate has been much higher for the longer horizon, while in the euro area the volatilities have been closer to each other. This could be taken as a sign that, between mid-2002 and mid-2004, markets were discounting a much sharper tightening cycle in the United States than in the euro area over the subsequent five years. However, this period was also characterised by an extremely steep yield curve in the United States, which possibly reflected not only expectations of solid growth but also high compensation for risk, which would be inevitably embodied in volatility expressed in basis points.

3 Movements in interest rates often induce significant changes in the average life of a mortgage-backed security (MBS). Investors in such instruments typically hedge interest rate movements and the associated changes in the duration of MBSs through Treasuries, swaps or related derivatives, exacerbating the movements of their prices. See also Bank for International Settlements, Quarterly Review, September 2003.
4 The basis point measure is obtained as the product of implied volatility as a percentage and the corresponding forward swap rate.
5 For example, the one-year rate forward five years can be obtained by combining the six-year and the one-year spot rates.
6 Forward rates not only reflect expectations of future spot rates, but also the presence of time-varying risk premia.