Box 5

VOLATILITY AND RISK AVERSION IN MAJOR CURRENCY MARKETS

The volatility implied in options prices across both major asset classes and economic regions fell significantly after mid-2003, converging in major bond markets from values ranging between 10% and 6% annualised to around 4% in 2006, while falling in major equity markets from values ranging between 50% and 30% annualised in mid-2002 to about 10% by the end of 2006, despite a temporary rise between May and July that year. Implied volatility also fell in major foreign exchange markets after mid-2003, reaching historical lows in 2006. Several factors have been cited as being potential drivers of these patterns. First, as discussed in earlier editions of the FSR, very low risk-free interest rates and an abundance of liquidity in financial markets seemed to set in motion a search for higher yield. Second, the existence of ample market liquidity may have raised the risk appetite of investors, inducing them to take on greater risk. Furthermore, with greater market liquidity, financial transactions tend to have less of an impact on market prices, and some investors may have lowered their expectations of future volatility on account of this. The fall in implied volatility in recent years has often been seen as a manifestation of increasing risk appetite. Although the two quantities are intrinsically linked, financial theory does not however predict that movements in expected volatility, as gauged by implied volatility, are fundamentally proportional to changes in risk appetite or risk aversion. This is because implied volatility is composed of both a premium for volatility risk and expectations of future volatility. What is needed, therefore, to uncover the volatility risk premium – a yardstick of investor risk appetite – is a pure measure of expected volatility. This Box illustrates one way of doing this, and shows why movements in implied volatility should be interpreted with caution.

Volatility risk premiums are proportional to investors' risk appetite and can be inferred by comparing implied volatilities with expectations of future realised volatility. This identification is based on the fact that if investors do not demand compensation for volatility risk, then the

two measures will be, on average, the same. By contrast, if volatility risk is priced, then implied and expected realised volatilities will tend to diverge, and the amount by which they differ represents the compensation for volatility risk. This compensation, usually manifested in higher implied volatilities than expected realised volatility outturns, can be shown under certain assumptions to be inversely related to the coefficient of absolute risk aversion, i.e. the price of risk. Therefore, changes over time in the compensation for volatility risk, i.e. changes in the gap between implied and expected realised volatilities, can be directly interpreted as changes in investor risk aversion.[1] Estimates of the coefficient of risk aversion in foreign exchange markets could be produced by comparing expected future volatilities, based on an assumed empirical model, with implied volatilities. In this empirical illustration, implied volatilities for three major currencies, the US dollar, the euro and the pound sterling, were derived from the prices of interest rate swaptions, while expected volatilities were obtained from simulations of a conditional volatility model fitted to historical changes in swap rates offered on the three currencies.[2]

Chart B5.1 shows the time series of the implied volatility derived from the interest rate swaptions and those of the corresponding compensation for volatility risk for the two-year dollar, euro and pound swap rates. Both the implied volatilities and volatility risk premiums refer to expectations spanning six-month periods. Overall, this yardstick of risk aversion appears to co-move significantly across the main economic areas. Moreover, there is a significant positive relation between the volatility risk premium and implied volatility itself.

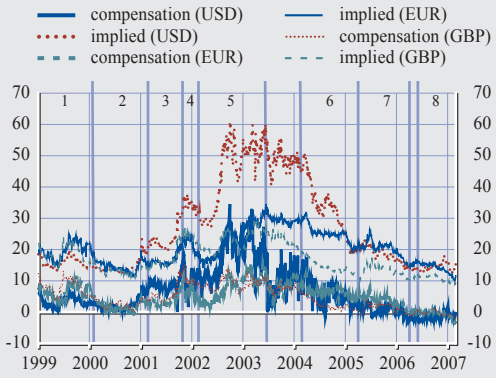
As the estimated time series of risk aversion are dependent on the model chosen to generate volatility forecasts, it is important to cross-check the behaviour of the volatility risk premium against events which are known to have induced distress in financial markets. This measure of risk aversion rose in the aftermath of the Russian debt crisis (August 1998), as well as in anticipation of the bursting of the technology bubble in global equity markets (which started around March 2000). It also increased sharply throughout the US recession (March to November 2001) and especially during the so-called deflation scare period (approximately from November 2002 to August 2003), when it peaked for the dollar. As for the last three events (the Madrid attacks in March 2004, the downgrading of Ford and General Motors' debt in May 2005 and the global stock market turbulence between May and July 2006), the indicator was relatively unperturbed and overall continued its descent from the peaks of June 2003. In this respect it is worth noting that implied volatilities also remained broadly stable around these three events, while the rise in risk aversion at around the time of the Madrid attacks may have been more related to uncertainty about the timing and magnitude of the first official rate increase by the Federal Reserve (which eventually occurred on 30 June 2004), which was a major source of concern for the financial markets at that time. Looking at the patterns of implied volatilities and the volatility risk premiums over the last couple of years shows that lower implied volatilities

1 See, for instance, T. Bollerslev, M. Gibson and H. Zhou (2004), "Dynamic Estimation of Volatility Risk Premia and Investor Risk Aversion from Option Implied and Realized Volatilities", *Board of Governors of the Federal Reserve System Finance and Economics Discussion Series*, 2004-56,. In this study, the coefficient of proportionality between compensation for volatility risk and risk aversion is estimated to equal one, so that minus the compensation for volatility risk can be directly seen as risk aversion. Their study refers to options on the Standard and Poor's 500 Index.

2 The expected realised volatilities of the swap rates to be compared to implied volatilities are calculated on a daily basis, from 15 October 1998 to 1 March 2007, by first estimating and then simulating an asymmetric GARCH (1,1) model on an expanding sample starting on 23 January 1997. The adoption of an expanding sample ensures that expected volatilities derived from the simulation reflect only the information that was available to economic agents when such expectations were formed. Considering a given day in the sample, conditional on the estimated parameters of the model, on the time series of the forecast errors that such a model produces and on the value of the volatility on that day, the model is simulated 5,000 times over a two-year horizon. Daily expected volatilities over a specific horizon are computed by averaging daily volatilities first across this horizon and then across the 5,000 simulations.

Chart B5.1 Implied volatility and estimated volatility risk premium on two-year rates

(six-month options)

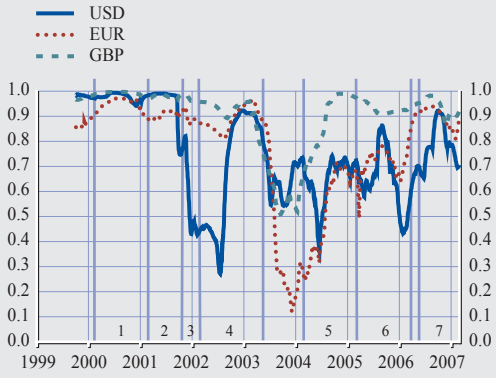


1 Russian debt crisis
2 Nasdaq starts to fall
3 US recession
4 9/11
5 stock markets weak at the beginning of recovery
6 Madrid train bombing
7 Ford and GM downgrades
8 global stock market drop

Sources: Bloomberg and ECB calculations.

Chart B5.2 Rolling correlation between implied volatility and volatility risk premiums on two-year swap rates

(rolling windows of 253 days; six-month options)



1 Nasdaq starts to fall
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5 Madrid train bombing
6 Ford and GM downgrades
7 global stock market drop

Sources: Bloomberg and ECB calculations.

have been coupled with higher risk appetite for the major currencies, but also that movements in this measure of risk appetite have been far less pronounced. Notably, the volatility risk premium has recently reached very low levels, even becoming negative, suggesting that investors were prepared to accept almost no compensation for this type of risk.

Additional evidence on the relationship between implied volatility and risk aversion can be gathered from patterns in time-varying correlations between the two (see Chart B5.2). For all three of the currencies examined, the average correlation was high over the full sample, although there were also a number of large, albeit transitory, declines. In particular, for dollar rates the average correlation fell significantly in the aftermath of the events of 11 September 2001 and after the end of the 2001 recession (from about 1.0 to a low of 0.3), while for the other two currencies it declined only slightly over the same period (from about 1.0 to 0.9 for euro rates, and 0.8 for pound sterling rates). The decline in correlation was also sizeable and rather common across currencies around the end of the so-called deflation scare period, reaching zero for euro rates and about 0.5 for the dollar and the pound sterling. After this, correlations gradually recovered and by the end of February 2007 stood at about 0.7 for the dollar and 0.9 for the other two currencies.

The two main conclusions that emerge from the above are that the measure of risk aversion considered here – which is based on certain assumptions and is restricted to major currency markets – mostly moves significantly less than implied volatilities, and that while the correlation between the two variables is always positive, it can become almost negligible in periods characterised by the presence of sizeable uncertainty. Taken together, the two considerations are rather reassuring from a financial stability standpoint, as they imply that for a given range of changes in implied volatility, risk aversion tends to remain rather stable. Therefore the impact of higher uncertainty, as measured by implied volatility, on financial asset prices is not further amplified by large drops

in risk appetite, as changes in expected volatility lead to changes in risk aversion only to the extent that they exceed a given threshold. Accordingly, the rebound of implied volatilities seen in the first months of 2007 does not seem to have induced higher risk aversion.