BANCA D'ITALIA
EUROSISTEMA

Questioni di economia e finanza
(Occasional papers)

The recent behaviour of financial market volatility

Number 2 - August 2006

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The same version of this paper is published as BIS Paper No. 29, August 2006.

Study group on financial market volatility

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1. Introduction and executive summary

A striking feature of financial market behaviour in recent years has been the low level of price volatility over a wide range of financial assets and markets. The issue has attracted the attention of central bankers and financial regulators due to the potential implications for financial stability. This paper makes an effort to shed light on this phenomenon, drawing on literature surveys, reviews of previous analyses by non-academic commentators and institutions, and some new empirical evidence.

The paper consists of seven sections. Section 2 documents the current low level of volatility, putting it into a historical perspective. Section 3 briefly reviews the theoretical determinants of volatility, with the aim of helping the reader through the subsequent sections of this Report, which are devoted to the explanations of the phenomenon under study. These explanations have been grouped into four categories: real factors; financial factors; shocks; and monetary policy. Thus, Section 4 looks into the relation between volatility and real factors, from both a macro- and a microeconomic perspective. Section 5 considers how the recent developments in financial innovation and improvements in risk management techniques might have contributed to the decline in volatility. Section 6 considers the relation between real and financial shocks and volatility. Finally, Section 7 explores whether more systematic and transparent monetary policies might have led to lower asset price volatility.

Recent patterns in volatility

The evidence presented in this Report shows that over the period from mid-2004 to March 2006 the volatility of short-term and long-term interest rates, stocks, exchange rates and corporate spreads has been generally low relative to the previous five to 10 years in both industrial countries and emerging market economies (EMEs). However, if the sample period is extended back to the last two to three decades, for which daily data are available, other periods in which volatility reached similar low levels can be observed. The exception is represented by the volatility of short-term interest rates, which has reached its lowest level for 20 years in all the main currency areas.

A distinguishing feature of the period analysed is that volatility has been low for a ***prolonged*** period ***simultaneously*** across different assets and markets, in industrial countries and EMEs alike.

The impact of the fall in volatility observed at the individual market/asset level on the variation of returns experienced by investors holding global portfolios may have been mitigated by the apparently increased tendency of domestic bond and stock markets to co-move. In spite of this, the volatility of global portfolios is subdued.

Measures of volatility based on monthly stock and bond prices, available since the second half of the 19th century, reveal that since the 1970s volatility in the major industrialised countries has been on average higher than in the previous 100 years: the current level of volatility is not low in a historical perspective.

Why did volatility decrease?

Several factors may have contributed to the recent decline in asset price volatility. At the ***macroeconomic level***, a number of theoretical and empirical studies suggest that financial volatility is typically countercyclical: the recent fall in asset price variability may thus reflect the ongoing phase of sustained expansion and low inflation experienced by the world economy. Another macroeconomic factor - of a more structural nature - explaining lower volatility may be represented by the so-called "Great Moderation" - the fact that, since the mid-1980s, output growth has become noticeably less volatile, especially in the United States. However, the Great Moderation is an unlikely candidate to explain the recent phase of low volatility, largely because it emerged well before the decline in volatility. Still, there is some preliminary evidence that the volatility of GDP growth and (to a lesser extent) of inflation may have continued to decline over the last 15 years, especially in some countries, and that part of this further decline may have occurred since 2004.

The ***firm-specific components*** of volatility seem to have become more important over time. The theoretical and empirical results surveyed in this Report suggest that volatility is negatively related to firm profitability, and positively related to leverage and to uncertainty about profitability. The graphical analysis presented in Section 4 is thus broadly supportive of the hypothesis that the recent decline in volatility may be related to improvements in the balance sheet conditions of listed companies: around 2003-04 a decline in leverage and an improvement in actual and expected profitability can be observed in most industrialised countries. Furthermore, surveys suggest that over the same period the degree of uncertainty surrounding firms' profitability also decreased.

Developments in financial markets may also have contributed to the decline in volatility. Foremost is the improvement in market liquidity, which has benefited from the growth in transaction volumes in the cash markets (now at the highest levels for the last decade), from the rapid growth of the market for risk transfer instruments (which allow investors to hedge or unwind exposures quickly without having to trade in the cash market) and from the growth of the fraction of assets held by well informed agents managing diversified portfolios, such as institutional investors (eg pension funds, hedge funds). Some of the changes taking place in the US market for mortgage-backed securities (eg greater use of static hedging, growing popularity of adjustable rate mortgages) have contributed, starting in 2004, to reducing hedging-related volatility, with potential spillover effects on long-term debt denominated in other currencies. Finally, according to market commentary, since 2004 there has been a considerable increase in the supply of options (offering protection from financial risks) from investors such as hedge funds, investment banks and pension funds. This has brought downward pressure on option prices, thus reducing implied volatility, with a possible feedback to realised volatility.

The evidence summarised in this Report is not supportive of the so-called "good luck hypothesis" - the possibility that the current phase of low volatility is simply due to the absence of relevant ***shocks***. In fact, since the summer of 2004 the global economy has been affected by a number of adverse shocks, both economic (oil price increases, credit deterioration in the US car industry) and geopolitical (terrorist attacks, natural disasters, war).

Important changes and improvements in the conduct of ***monetary policy*** over the recent past seem to have played a key role in reducing the volatility of at least some interest rates. The Report emphasises a trend among central banks towards increased gradualism in policy action (more frequent policy moves of smaller size), greater transparency, improved communication about policy intentions, and improvements in the operational framework. These translate into more stable money market rates and, to a much lesser extent, long-term rates. Preliminary evidence for the United States and the euro area indicates that over the last two years the transmission of "technical" volatility from the money market to longer-term maturities has been curtailed. While the causes of this change remain to be ascertained, it is plausible that it is related to increased central bank predictability.

Is the reduction in volatility temporary or permanent?

A key issue is whether the current low level of volatility is a permanent new feature of financial markets or only a temporary phenomenon.

The results suggest that important drivers of the volatility reduction seem to be structural, and may therefore have ***a permanent effect on volatility***. These include some of the changes in the financial sector surveyed above (improved market liquidity, greater role of institutional investors, changes in the US market for mortgage-backed securities), as well as the changes in monetary policy mentioned earlier. Moreover, to the extent that the strengthening of the balance sheets of listed firms reflects a cross-country restructuring of the corporate sector independent of the economic cycle (reaping the benefits of the “new economy”, not only in the United States but also in the euro area and Japan), then its effect on volatility may also turn out to be permanent.

However, ***conjunctural factors have also played a role***, suggesting that part of the volatility reduction might be reversed in the future. First of all, to the extent that cyclical factors played a role in containing volatility, some increase should be expected in the event of a slowdown of the world economy. Moreover, if the volatility decline partly reflects an increased supply of options, it could reverse as soon as investors find alternative, more attractive opportunities. Finally, a monetary policy-related factor, which may have contained volatility in the recent past, may contribute to raising it in the future. As policy rates are already near a “neutral level” in the United States, and at the point when they will be so in other countries, the consequent increased uncertainty about future policy moves (a resumed “two-way risk”) may entail higher uncertainty about short-term rates, with possible spillover to longer rates and other asset classes.

Financial markets seem to concur with the view that the reduction in volatility is in part temporary. For example, despite the prolonged period of low volatility, the equity premium implied in stock prices does not seem to have declined. If the reduction in the volatility of stock returns turns out to be of a more permanent nature, sooner or later the equity premium will have to adjust downwards, implying a permanently higher equilibrium level of stock prices.

Implications for financial stability

The level of volatility in financial markets can influence the corporate sector’s investment decisions and bank’s willingness and ability to extend credit facilities. In this context one question that is sometimes raised is what impact changes in the volatility level might have on financial stability. This Report emphasises that the reduction in volatility represents to a considerable extent the consequence of improvements in the functioning and structure of global financial markets: increased market liquidity, the greater role of institutional investors, better communication between central banks and financial markets, and stronger company balance sheets have all contributed to enhancing investors’ ability to avoid shocks or to deal with them, pushing volatility down. In this respect, the current low levels of volatility are associated with improved financial conditions.

An increase in volatility, however, does not necessarily imply that there is deterioration in the financial conditions. Although financial instability is usually followed by heightened volatility, the reverse is not generally true. The effects of an increase in volatility levels on financial conditions will depend on the extent, speed and pervasiveness of the volatility increase. Because risk management practices have improved considerably in recent years, financial institutions are better equipped now to mitigate undesirable effects of large increases in volatility than in the past.

2. Recent patterns in volatility

2.1 Methodology in brief

A large ***set of asset classes*** is considered in the analysis: money market interest rates, long-term government bond indices, corporate yield spreads, stock indices, exchange rates and commodities. The ***number of countries*** considered is limited to France, Germany, Italy, Japan, Switzerland, the United Kingdom and the United States. Whenever appropriate, the euro area is also considered, as are emerging markets and commodities markets.

Volatility is estimated using daily data, following standard practice in financial markets. For data availability reasons, it is measured since 1959 for stock markets, the early 1970s for foreign exchange markets, the late 1970s for money markets and the mid-1980s for bond markets. In Section 2.3, monthly series are used to provide a historical overview of volatility. Finally, July 2004 is chosen as the starting date for the recent period of low volatility, since the latter stabilised at low levels on almost all markets at that time, triggering a debate on its causes and consequences. While this date is somewhat arbitrary, the results presented in what follows are not sensitive to this particular choice.

As to the ***measures of volatility***, realised (ex post) indicators (moving standard deviations) are used because of data availability (implied volatility from option prices would have been preferable, since it is a forward-looking measure).[1] Standard deviations are estimated as exponentially weighted moving averages of squared returns (for details on methodology and data sources, see Appendix 1). For interest rates, there is no agreement on whether volatility should be defined as the standard deviation of absolute rate changes or relative rate changes (normalised by the level of interest rates). This Report focuses on absolute measures.[2]

2.2 The current low level of volatility on a global scale: some empirical evidence

Individual markets

Table 2.1 provides a snapshot of how the current level of volatility compares with past levels. “Current volatility” is computed over the July 2004-March 2006 period, whereas “mean volatility” is the average over the entire available sample. The table also shows the percentage of trading days on which volatility was lower than in the current period (“current quantile”), which is an alternative measure of how low volatility currently is.

Although volatility is currently below the historical average for virtually all assets, clear differences emerge across markets. Three-month ***money market rates*** display both the sharpest drop and the lowest current level of volatility. For instance, in the case of US dollar three-month rates, current volatility is less than one third of its average between September 1977 and July 2004. The “current quantile” of 19% means that past volatility has been lower than it currently is on only 19 out of 100 days. While these measures differ somewhat across countries and assets considered, a substantial drop is clearly detectable everywhere. The reduction in the volatility of short-term interest rates will be further analysed in Section 7 of this Report since it is closely related to monetary policy.

Current bond and stock market volatility is also low, although the decline is less pronounced than for short-term rates. In most countries current volatility in ***bond markets*** is 20-30% lower than past averages. Looking at previous years, in most countries bond volatility was lower than today on 16 to 48 days out of 100. The exception is Switzerland, where no decline is observed in the recent period (indeed, volatility has been lower than today in 62% of the sample). ***Stock market*** volatility declined slightly more than bond market volatility: in Germany, Japan and the United States, volatility levels have been below the current levels over 34% to 57% of the sample; in the other countries the decline is sharper and volatility has been below the current levels over 1% (Italy) to 19% (Switzerland) of the sample.[3] Table 2.1 shows that volatility is also low in markets for ***corporate bonds*** and ***emerging markets***.

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[1] For some markets, for which data on both realised and implied volatility are available, no evidence is found of important differences between the two indicators. ECB (2004a,b) show that implied and realised volatility have co-moved strongly in recent months in the US bond and stock markets and on the eurodollar market.

[2] This choice is warranted by two observations: (a) the risks borne by bond market investors are proportional to the volatility of rate changes (since the return on a portfolio of bonds approximately equals its modified duration times the rate change); (b) within our sample, there are instances of zero rates, in which case relative changes are not defined. Note, however, that while the current level of interest rate volatility is very low if computed as the standard deviation of absolute rate changes, it is above its historical average if computed from relative changes.

Volatility in the ***foreign exchange market*** is only slightly below its historical average, as evidenced by the current quantile. For Japan, Italy and the United Kingdom there is virtually no decline in volatility.

Commodities markets are an exception: since July 2004, volatility has been above its historical average for both ***oil and non-oil commodities***. This phenomenon, not addressed in this Report, may be due to geopolitical shocks (such as the war in Iraq and political uncertainty in many oil-producing countries), the increase in demand due to world economic growth and the related uncertainty about the outlook for prices, and the increase in speculative activity by hedge funds and other market participants. For ***non-oil commodities*** volatility now stands above the 90th percentile of its historical distribution.

Appendix 2 provides charts of historical volatility for individual countries and asset classes which broadly confirm the picture described above.

A global perspective

The previous subsection demonstrated that volatility is low in individual markets in most countries. One interesting issue to explore is whether this is also the case for portfolios of assets. To examine this issue, we look at synthetic indicators of global financial market volatility (Graphs 2.1-2.4).

The first indicator (Graph 2.1), available since 1995, measures the volatility of an equally weighted portfolio including a global bond index (EFFAS G7 Government Bond Index) and a global stock index (FTSE All-World Index), and captures the risks faced by global investors with exposures to most markets (the indicator excludes money market rates, given their close relationship with monetary policy). This indicator shows that global volatility is low, but at a level comparable to that experienced during the mid-1990s. There are two main features of this indicator.

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[3] The fall in stock market volatility may reflect the reduction in the weight attached to high-volatility hi-tech firms after 2001. To address this issue, for the US market we compute an equally weighted index of volatility. This correction does not affect the results. Correcting for compositional effects shows that the recent fall in volatility is even more pronounced.

Table 2.1

Current volatility across asset classes and countries: summary indicators[1]

Daily data; annualised percentages and percentage points

Money market (three-month interest rate)

	USA	Japan	Germany	France	Switzerland	UK	Italy
Start date	02/09/77	02/09/77	02/09/77	02/09/77	02/09/77	02/09/77	02/09/77
Mean volatility	1.38	1.17	0.90	3.33	1.43	1.65	4.00
Current volatility	0.41	0.20	0.21	0.21	0.49	0.43	0.21
Current quantile	19%	11%	3%	2%	9%	14%	1%

Bond market (10-year bond index)

	USA	Japan	Germany	France	Switzerland	UK	Italy
Start date	06/01/86	06/01/86	06/01/86	06/01/86	04/01/96	06/01/86	04/01/88
Mean volatility	4.48	3.14	3.26	3.97	2.94	5.44	3.74
Current volatility	3.88	1.94	2.94	2.96	2.97	4.08	3.41
Current quantile	37%	16%	46%	25%	62%	18%	48%

Stock market

	USA	Japan	Germany	France	Switzerland	UK	Italy
Start date	05/10/59	05/10/59	05/10/59	10/07/87	02/09/87	03/01/85	03/01/75
Mean volatility	13.19	14.13	16.78	19.47	14.88	13.60	18.54
Current volatility	10.07	13.66	12.77	11.52	9.48	8.57	8.47
Current quantile	34%	57%	37%	7%	19%	13%	1%

Nominal exchange rates (vs US dollar)

		Japan	Germany	France	Switzerland	UK	Italy
Start date		05/01/71	05/01/71	05/01/71	05/01/71	05/01/71	05/01/71
Mean volatility		9.39	9.70	9.34	10.96	8.61	8.84
Current volatility		9.20	8.81	8.81	10.06	8.27	8.81
Current quantile		50%	40%	44%	42%	49%	50%

Corporate spreads

	United States		Euro area	
	Non-financial	High-yield	Non-financial	High-yield
Start date	02/01/97	02/01/97	02/01/97	02/01/98
Mean volatility	0.28	1.14	0.35	2.08
Current volatility	0.20	0.85	0.27	1.04
Current quantile	38%	38%	33%	17%

Table 2.1 (cont)

Current volatility across asset classes and countries: summary indicators[1]

Daily data; annualised percentages and percentage points

Other volatility indices

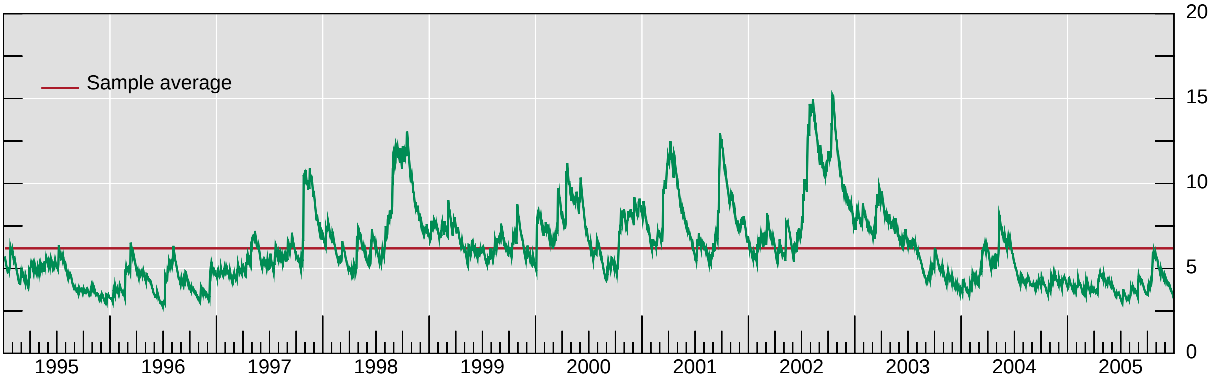
	Emerging markets		Commodity markets	
	Stocks	**Long-term interest rates**	**Oil**	**Non-oil**
Start date	05/07/94	02/04/96	05/04/83	04/01/95
Mean volatility	21.18	4.71	33.76	15.12
Current volatility	13.54	3.46	34.10	19.46
Current quantile	12%	19%	62%	89%

[1] "**Current volatility**" is the average realised volatility observed between 1 July 2004 and 31 March 2006. "**Current quantile**" is the percentage of trading days in the sample on which volatility was lower than the current level of volatility.

Sources: Bloomberg; FTSE; JPMorgan Chase; Merrill Lynch; Standard & Poor's; Thomson Financial; national stock exchanges; BIS. Volatilities are estimated using the RiskMetrics™ EWMA (exponentially weighted moving average) methodology (see Appendix 1 for details).

Graph 2.1

Global volatility indices[1]



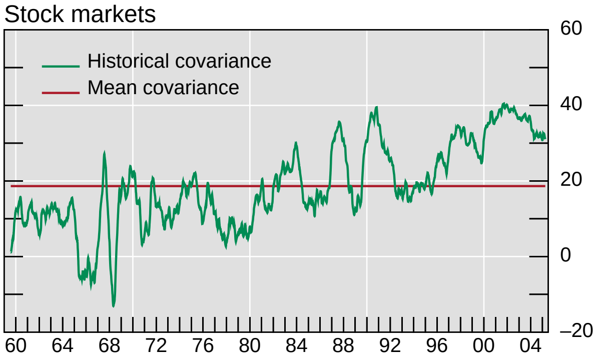
[1] Annualised daily volatility of an equally weighted bond-equity international portfolio including the FTSE global stock index and the EFFAS global bond index; in per cent.

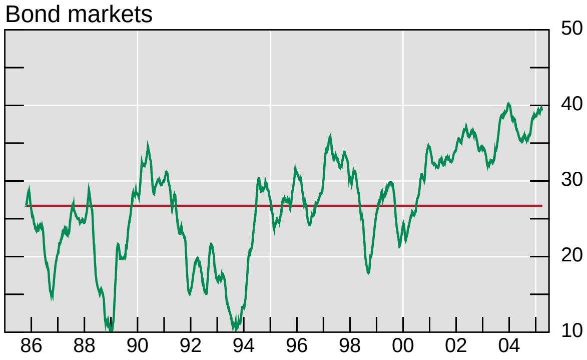
Sources: EFFAS; FTSE.

First, since it is equally weighted, it virtually mirrors volatility in the stock market, which is much higher than in the bond market. Second, the behaviour of the indicator is affected by trends in volatility at the individual market (asset) level, and by covariances among individual markets (assets). To explore this issue, Graph 2.2 displays covariance indices measuring the degree of co-movement of world stock and bond indices (left- and right-hand panel, respectively).[4] Not surprisingly, considering the gradual process of financial integration in the last 20 years, both indicators show that the covariances have increased significantly. Consequently, asset market co-movements have tended to increase global volatility as measured in Graph 2.1.

Graph 2.2

Covariance indices[1]





[1] In per cent. Calculated as the proportion of portfolio variance due to covariances between the domestic markets included in the portfolio. Bond and stock markets are equally weighted portfolios of benchmark indices for the United States, Germany and Japan. For details, see Appendix 1.

Sources: JPMorgan Chase; Standard & Poor's; national data.

We then compute indicators that by construction are not affected by covariances and take care of the scale effect. The first is a simple average of 14 volatility indices for the main bonds, stocks and money markets of the world, all rescaled so as to be equal to 100 at the sample average (Graph 2.3, left-hand panel).[5] This indicator has reached its lowest level since, at least, 1986. The same conclusion emerges from an alternative indicator, based on the location of volatility within its empirical distribution, which is more robust to outliers (Graph 2.3, right-hand panel).[6] This confirms that over the last 20 years closer co-movements among world markets have tended to increase the volatility of portfolios. However, in the most recent period this increase has been more than offset by a marked decline in volatility in individual markets and assets.[7]

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[4] See Appendix 1 for the methodology. The covariance indices avoid the difficulties of interpreting a large number of pairwise correlations and show how much the riskiness of a global portfolio would fall if co-movements between markets were absent.

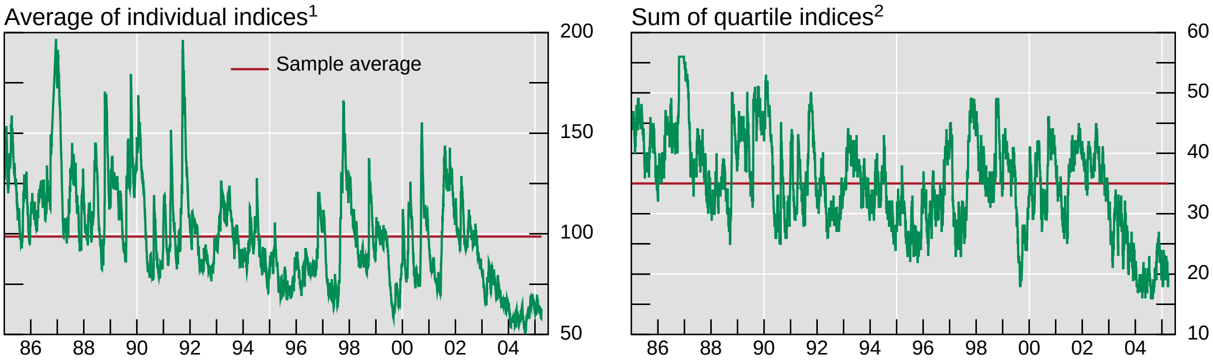
[5] Specifically, the index includes the volatility of stocks, money market rates and bonds for the United States, Germany, Japan, Switzerland and the United Kingdom, excluding only Swiss bonds due to limited data availability.

[6] This is computed as follows. Each of the 14 volatility indices employed in the first indicator is transformed into a quartile index (on any given day, the index can take values from 1 to 4 according to whether it falls in the bottom, intermediate or top quartiles of the empirical distribution of volatility); the quartile indices are then added. Adding quartiles instead of volatility indices provides robustness to outliers and to differences in the amplitude of the oscillations of volatility indices.

[7] Because our conclusions could merely reflect the exceptionally low level of volatility of money market rates, the indices in Graph 2.3 were computed excluding the volatility of three-month interest rates. The previous conclusions remain qualitatively unchanged.

Graph 2.3

Global volatility indices



[1] Simple average of 14 volatility indices; sample period = 100. [2] Sum of quartile indices of 14 domestic volatility indices. For details, see Appendix 1.

Sources: JPMorgan Chase; Standard & Poor's; national data.

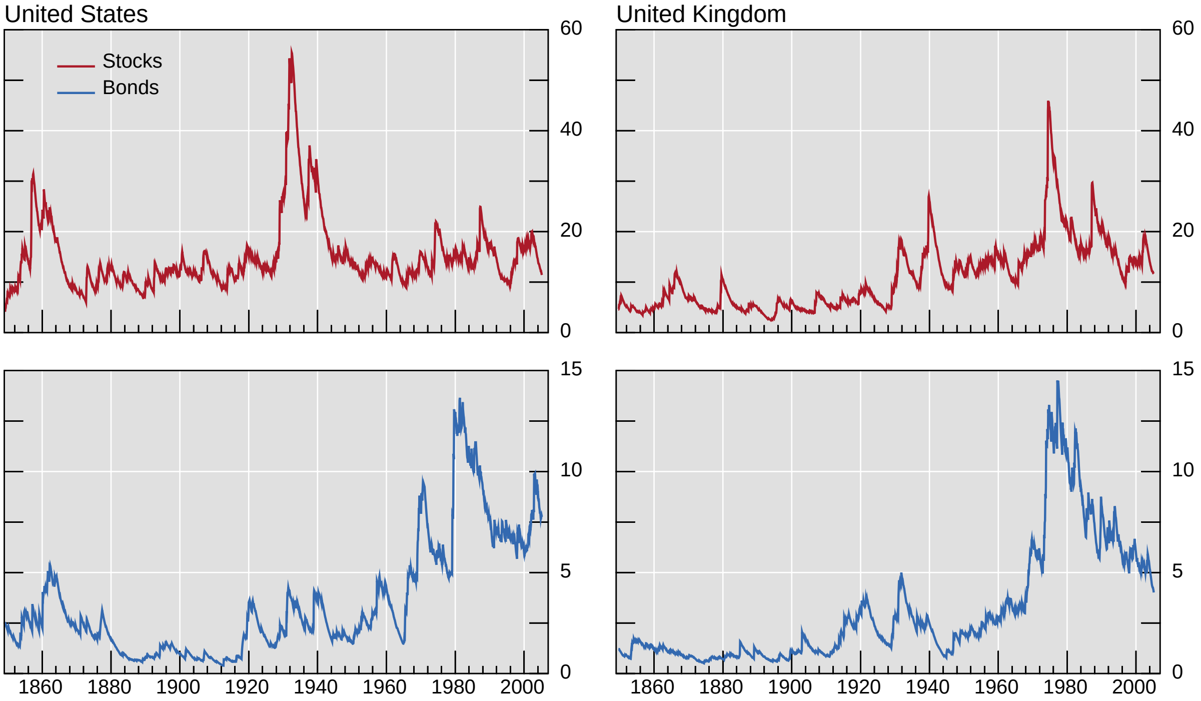
It is worth noting that the mid-2004 to 2006 period was characterised by a modest reduction of co-movements between world stock markets (Graph 2.2), which may have contributed to dampening overall stock market volatility. By contrast, the degree of co-movement in bond markets did not change appreciably.

2.3 Volatility from a longer-term perspective

To put the discussion in perspective, it is helpful to estimate volatility over longer time spans. As mentioned, this can be done at the cost of adopting lower frequency series, since daily

Graph 2.4

Long-term stock and bond return volatilities[1]



[1] Annualised volatilities calculated using monthly data, in per cent.

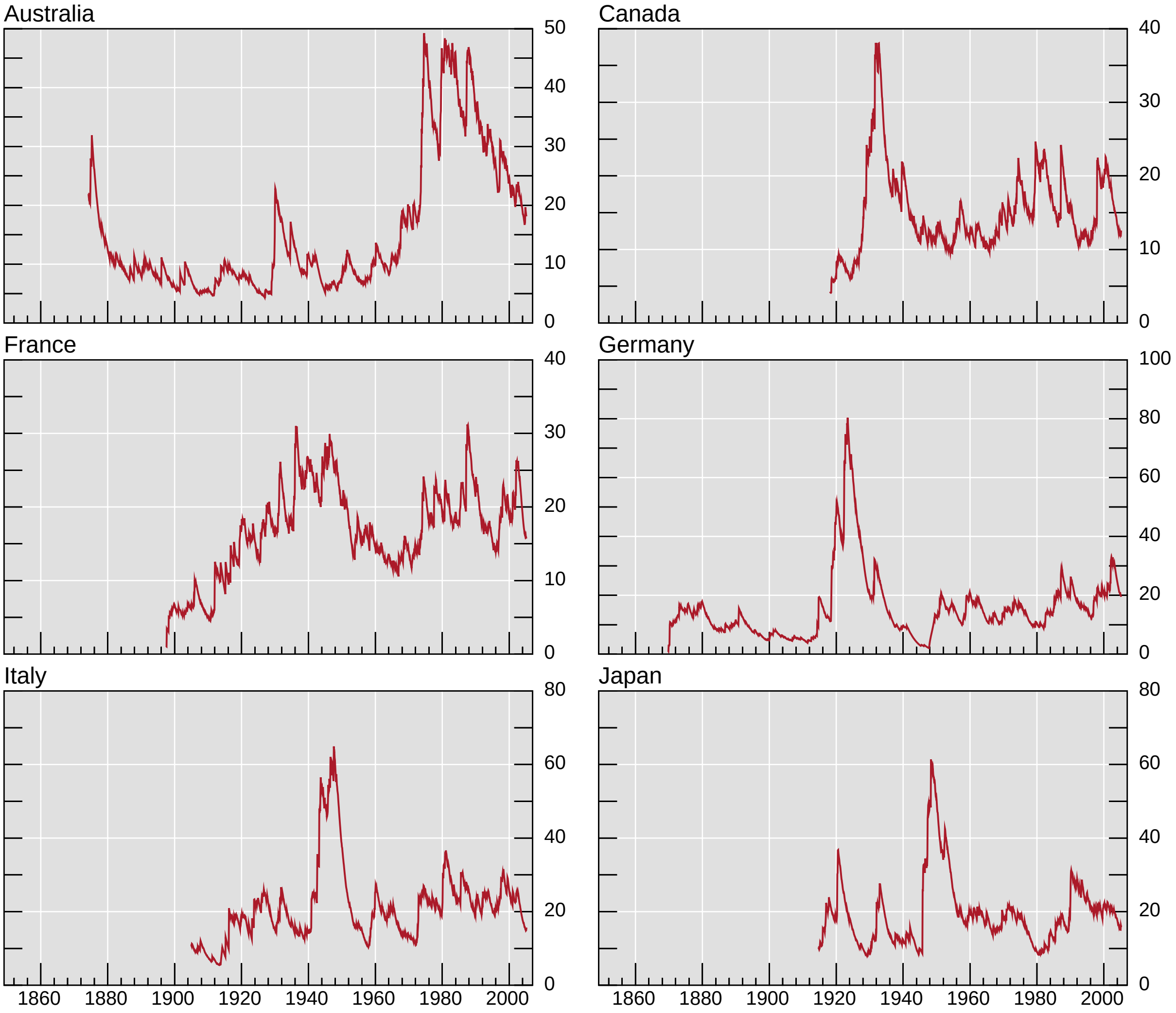
Sources: Global Financial Data; BIS estimates.

data are not available over a long period. Graphs 2.4-2.6 document how stock and bond return volatilities have evolved in a number of countries using monthly data.[8]

Graph 2.5

Long-term stock return volatilities[1]

Monthly data; percentages



[1] Methodology is described in Appendix 1.

Source: Based on Global Financial Data data.

The graphs suggest several conclusions. First, they confirm the previous finding that volatility is currently below its average level in the last 20 years. However, they also reveal that since the 1970s volatility has been generally much higher than in the previous period (at least 100 years for most countries).[9] For bond yields this is true in all countries considered. For stocks the picture is less clear-cut; in general, volatility since the 1970s has been above its historical average over the available sample period, but for several countries the current level does not stand out as an outlier in the long time series. Second, movements of volatility are dominated by a few episodes of sharp increases. The period between the start of the First World War and the end of the Second World War, which includes the tumultuous late 1920s and the depression in the 1930s, stands out in most charts.

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[8] This draws on Gerlach et al (forthcoming), to which the reader is referred for details.

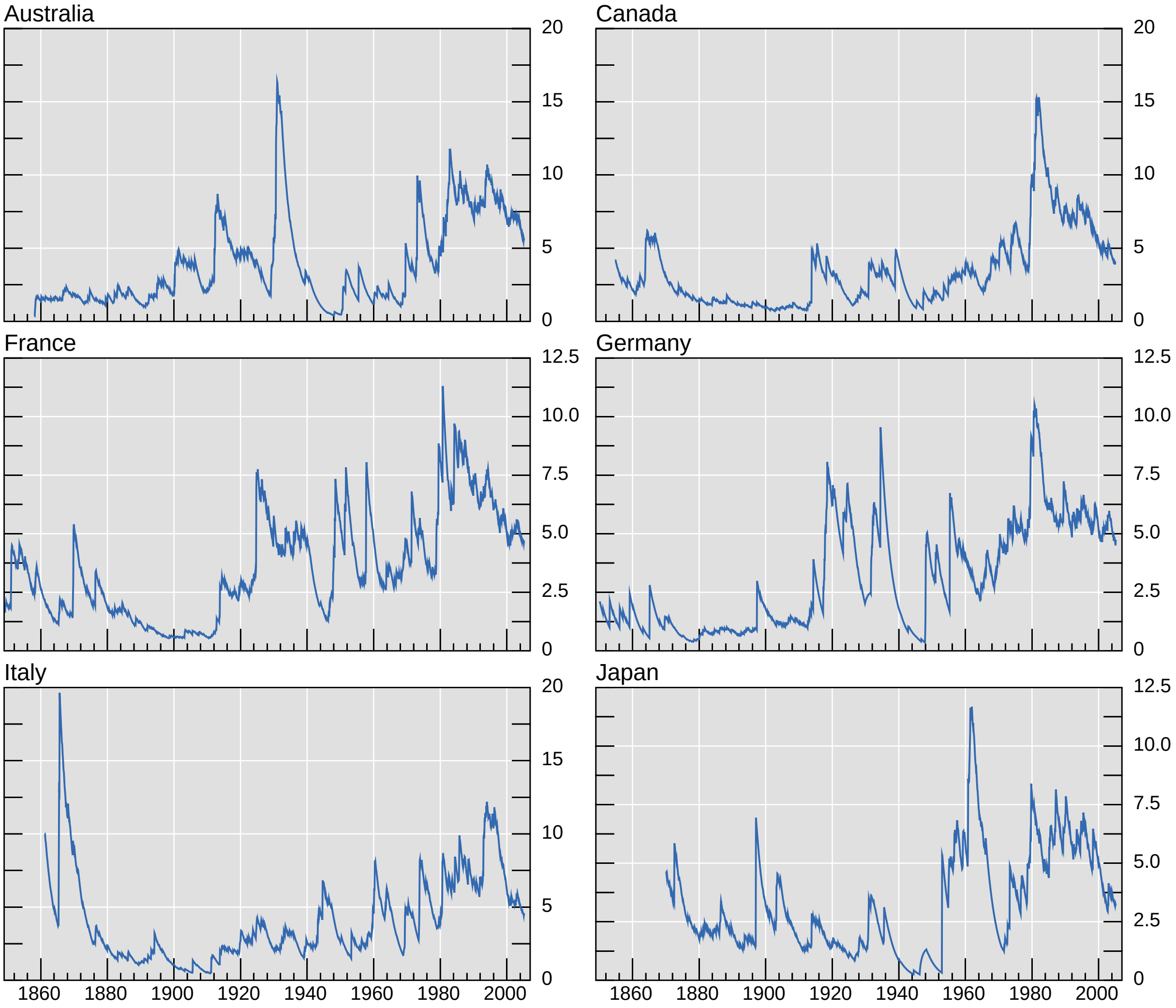
[9] This point is also made indirectly by Houston and Stiroh (2006), who note that over the 1975-2005 period financial volatility steadily increased.

An analysis of the reasons why volatility was low before the 1970s lies beyond the scope of this Report. Contributing factors may have been underdevelopment of market infrastructure and telecommunications, which plausibly slowed down the impact of news arrival, and the different configuration of the world monetary regime. The increase in the 1970s may be related to the sharp increase in worldwide inflation that followed the oil shocks, perhaps coupled with poor monetary and fiscal policy responses, following the end of the Bretton Woods agreements. The high levels of volatility in the 1980s and 1990s might be associated with the global deregulation and liberalisation of financial markets and capital flows, together with the rapid spread of IT technologies.

Graph 2.6

Long-term bond return volatilities[1]

Monthly data; percentages



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[1] Methodology is described in Appendix 1.

Source: Based on Global Financial Data data.

3. Determinants of volatility

This section briefly outlines the main theoretical determinants of asset price volatility and surveys the related literature, as a guide to the overview of the literature and the evidence presented below.

The price p_t of any asset can be expressed as the present value of expected future cash flows, calculated using the appropriate discount factor:

$$p_t = E_t \sum_{i=1}^{T} \frac{d_{t+i}}{\prod_{j=1}^{i} (1 + r_{t+j})(1 + \pi_{t+j}) + \rho_{t+i}} \tag{1}$$

where d_{t+i} is the nominal payoff of the asset at time $t+i$, and r_{t+i}, π_{t+i} and ρ_{t+i} are, respectively, the one-year real interest rate, inflation and the risk premium at $t+i$. T is the maturity date (for stocks T is equal to infinity). Finally, E(.) is the expected value operator.

With appropriate adjustments, this equation applies to all assets,[10] and summarises the variables influencing the price, and therefore the volatility, of the asset. Overall, volatility arises from uncertainty over future cash flows and the discount rate.

At the macro level, cash flows for stocks can be approximated by GDP, so that variations in the volatility of GDP, everything else being equal, translate into changes in stock volatility. Uncertainty over economic conditions also affects the variables in the denominator, that is, real interest rates, expected inflation and the risk premia. Because GDP volatility is relatively high during recessions,[11] high financial volatility tends to be associated with weak economic conditions. Financial volatility is also related to fluctuations in risk aversion;[12] because investors tend to be more risk-averse during recessions,[13] this provides an additional explanation of why financial volatility is countercyclical. Another macro factor is monetary policy, which affects volatility via its impact on inflation, real interest rates and economic activity.

Volatility is also affected by the structure of financial markets. A particularly important factor is market liquidity. Ferguson (2005) argues that financial innovation, the increased willingness of institutional investors to bear risk[14] and the growing role of hedge funds in recent years have raised market liquidity and dampened asset price volatility. Another factor is financial market integration, which completes markets by increasing risk-sharing opportunities, thus reducing the level of risk.[15] Finally, volatility is influenced by the availability of new instruments and improvements in risk management. The development of new instruments for hedging risks, such as CDSs and CDOs,[16] and structural changes in the US mortgage market could also have contributed to reducing volatility.

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[10] Thus, the payoff in the numerator is dividends in the case of stocks, and coupons and the redemption value for bonds.

[11] See, for example, Hamilton and Lin (1996).

[12] See, for example, Cochrane (2005).

[13] For a review of asset pricing models with cyclical variation in the price of risk, see Campbell (2003). Studies finding evidence of a correlation between empirical proxies of the price of risk and the business cycle date back to the end of the 1980s; see Harvey (1989) and Chou et al (1992).

[14] Avramov et al (2006) show that informed trades tend to reduce volatility. Pritsker (2005) shows that in the presence of wide-ranging adverse shocks, trading activity by large investors may exacerbate asset price volatility.

[15] See, for example, JPMorgan (2005).

Finally, firm-specific factors may also affect volatility. In particular, higher profitability and lower leverage reduce the uncertainty on the flow of future payoffs, thus reducing volatility.[17] The effect of leverage and profitability predicts countercyclical variation in volatility, because recessions are associated with higher debt/equity ratios and lower earnings.

4. Impact of real factors on volatility: empirical evidence

4.1 Is the recent reduction in volatility due to the "Great Moderation"?

A potential explanation of the reduction in the volatility of financial assets is greater macroeconomic stability. Several studies have documented that the volatility of a wide range of measures of economic activity, including employment, GDP and its components, declined significantly in the G7 countries.[18] This phenomenon is often referred to as the "Great Moderation".[19]

Explanations of the Great Moderation include lower volatility in durable goods production due to better inventory management (McConnell and Perez-Quiros (2000)); better monetary policy (Bernanke (2004a)); and fewer or less severe negative shocks (Ahmed et al (2002)). Financial innovation, including changes in the market for consumer and business debt, changes to government regulation and shifts in societal attitudes, may also have dampened output volatility by making consumption less sensitive to shocks to income and reducing the sensitivity of residential investment to changes in interest rates (Dynan et al (2006)).

However, the Great Moderation is unlikely to be the cause of the recent decline in asset price volatility. First, there is an issue of timing. In the United States, France and Italy, the moderation occurred already in the 1980s, that is, well before the recent decline in financial market volatility. In Canada, Germany, Japan and the United Kingdom, macroeconomic volatility seems to have shifted twice between high and low levels since the 1970s. Similarly, many emerging markets and developing countries experienced a similar decline in output volatility in the 1980s. Second, the reduction in financial volatility since the early 1980s has been much smaller than the drop in the variability of output and inflation in most countries (Ferguson (2005)). For instance, the annualised standard deviation of equity returns in the United States between 1985 and 2004 was only 0.3 percentage points lower than it was between 1960 and 1984. The difference in the volatility of long-term interest rates between the two time periods was similarly small. This suggests that the relationship between macro volatility and financial market volatility is weak, or that offsetting factors were at work throughout the period.

Why has the long-term decline in macroeconomic volatility not been followed by an appreciable decline in financial volatility? A few hypotheses have been advanced. One is that inflation or output stabilisation may require, at times, forceful policy actions. Those actions could lead to sizeable movements in short-term interest rates that are transmitted to longer maturities and to equities. Thus, the increase in volatility in the denominator of the valuation formula (1) may offset the decrease in volatility in the numerator. Another possible explanation is that investors' risk aversion may remain volatile even if macroeconomic variables are stable and policy adjustments are gradual. This result could arise if investors' perceptions of risk and risk aversion are independent of macroeconomic volatility, or because investors fear that volatility could revert to a higher level in the future (Ferguson (2005)).

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[16] See ECB (2004f), BIS (2004b) and Bank of England (2004b).

[17] As regards the positive relation between leverage and volatility, since stockholders bear the overall risk of the company (provided that the firm is not close to insolvency) any change in the firm's value flows through the stock. Thus, for a given percentage change of the firm's total assets, the lower the price of the stock (and the higher its leverage), the higher the percentage change of the price of the stock which is necessary to compensate for the change in the firm's value (see Black (1976) and Christie (1981)).

[18] See Summers (2005) and Stock and Watson (2002).

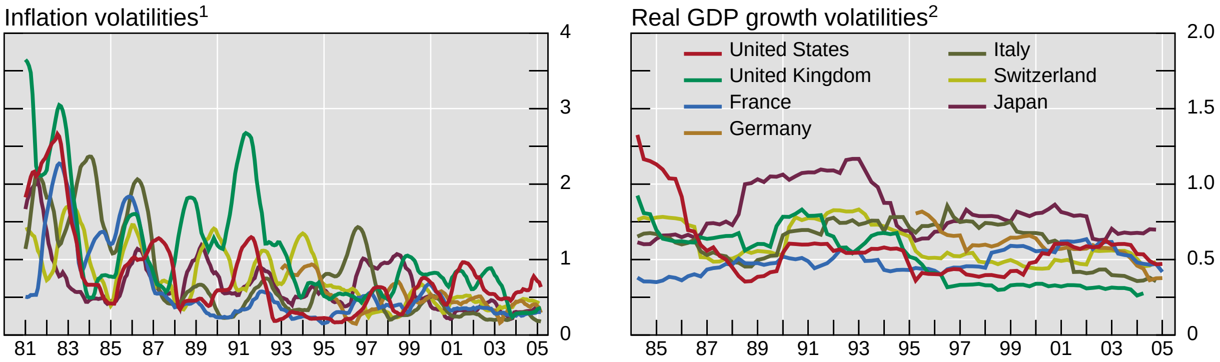
[19] See, for example, McConnell and Perez-Quiros (2000) and Summers (2005).

This issue, which lies outside the scope of this Report, is not pursued further here. By contrast, it is interesting to check whether the recent decline of financial volatility may be associated with a concurrent further reduction of macroeconomic variability by considering two indicators of inflation and output volatility. First, we examine ex post volatility (Graph 4.1). Interestingly, in the last 10 years some measures of the volatility of inflation and, to a lesser extent, of GDP growth, have been generally lower than in the 1990-95 period; moreover, visual inspection of the graph suggests that uncertainty might have declined further, albeit slightly, over the last two years.[20] These conclusions are similar to those based on the indicator of ex ante uncertainty (Graph 4.2), although in this case the reduction in inflation uncertainty is negligible.

Summing up, there is some preliminary evidence that a *further* moderation in macroeconomic volatility - especially inflation volatility - may have occurred over the last 15 years. The possible reduction since 2004, however, appears to be modest, suggesting that its contribution to the recent decline in financial volatility was, at best, limited.

Graph 4.1

Realised volatility of real GDP growth and inflation



[1] Twenty four-month moving standard deviations; in per cent. [2] Twenty-quarter moving standard deviations; in per cent.

Source: IMF.

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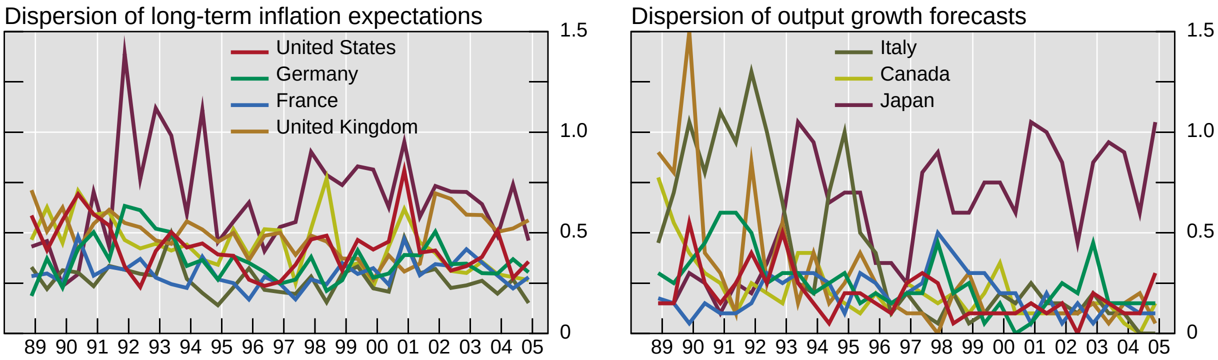
[20] Indeed, the average (across countries) of the standard deviation of inflation (GDP growth) in 2004-05 is equal to 0.36 percentage points (0.38); these values are slightly lower than in the 2000-03 period (0.50 and 0.43, respectively). These results are obtained by using a 20-quarter rolling window; different windows may yield different results. Clearly, more work is needed to ascertain whether there has indeed been a further moderation in output and inflation growth.

Graph 4.2

Dispersion of growth and inflation forecasts[1]



[1] Interquartile range of forecasts formulated by professional forecasters.

Source: Consensus Economics.

4.2 Business cycle

Changes in volatility over the business cycle

Several empirical studies confirm that volatility increases during recessions and decreases in periods of rapid growth, both for stocks and for interest rates in the US market (for other countries the evidence is scant and results are less clear-cut).[21] The recent fall in volatility could therefore be related to the ongoing sustained expansion of the world economy.

The most immediate explanation for why asset price volatility is countercyclical is cyclical variation in the volatility of fundamental variables that in turn affects the variance of asset payoffs, the risk-free rate and the risk premium.[22] Previous research suggests that fluctuations over the business cycle in macroeconomic volatility and in leverage cannot fully explain why stock return volatility also changes over the business cycle. Another potential explanation is cyclical variation in investors' risk aversion, which affects the price of risk.[23] Evidence suggests that some three quarters of the fluctuation in stock returns is accounted for by the conditional variance of fundamentals, while the remaining part is explained by changes in risk aversion.[24] Recent contributions[25] argue that asset price volatility is influenced by variations over time in investors' uncertainty about fundamentals. Since uncertainty is higher when the economy is weak,[26] this approach also predicts countercyclical variation in financial volatility.

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[21] For the United States, the countercyclical behaviour of the volatility of stock returns is documented by Schwert (1989) and Hamilton and Lin (1996). Campbell et al (2001) decompose total volatility into market-level, industry-level and firm-level volatility and find that these volatility measures are all countercyclical. Andreou et al (2000) find that stock return volatility is countercyclical also in the United Kingdom but not in Germany. However, Bittlingmayer (1998) finds that in Germany in the period 1880-1940 stock return volatility was negatively correlated with industrial production growth. The countercyclicality of short- and long-term interest rate volatility in the United States is documented by Bansal and Zhou (2002). Andreou et al (2000) find that in the United Kingdom and Germany volatility is countercyclical only for real interest rates.

[22] See Schwert (1989) and Bansal and Yaron (2004).

[23] The fact that the cyclical pattern in risk may account for countercyclical variation of stock market volatility is documented by Campbell and Cochrane (1999). See also the review in Campbell (2003).

[24] See Bekaert et al (2005).

[25] See David (1997) and Veronesi (1999).

Gerlach et al (2006) provide some new evidence on the cyclical properties of asset price volatility and its relation to macroeconomic variables for eight countries (Australia, Canada, France, Germany, Italy, Japan, the United Kingdom and the United States). To explore how macroeconomic conditions affect the variability of financial asset prices, they run pooled regressions using data spanning more than a century. They find that a fall in output relative to potential (weaker economic conditions) and higher inflation tend to raise bond and stock market volatility but that these relationships are unstable over time. They argue that the lack of robustness may arise from not including factors such as financial crises and episodes of political instability in the analysis.

4.3 Volatility and firm-level characteristics

The firm-specific or idiosyncratic component of volatility plays a major role,[27] suggesting that the recent decline in volatility may be related to fluctuations in firm-level uncertainty. Two characteristics of firms have been found to be related to volatility. First, volatility is positively related to financial leverage, although the effect appears to be weak[28] and results are not always consistent.[29] Second, the volatility of stock returns is negatively related to the profitability of the company and positively related to the uncertainty on firm profitability.[30] Other firm-level variables, including size, book-to-market and age are typically not significant.

Based on this evidence, this section analyses the recent evolution of leverage as well as ex post and expected profitability of listed companies in the United States, the euro area, Japan and the United Kingdom.

Leverage

Since 1995, corporate leverage has declined in Japan and the United States but remained broadly flat in the euro area and the United Kingdom (Graph 4.3, left-hand panel). In the most recent years, leverage has declined sharply in all areas except the United Kingdom. In the case of the United States the decline accelerates in 2003, while in the euro area and Japan the reduction starts in 2004. As for the size of the decline, in the United States and the euro area the reduction is broadly similar.

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[26] Using survey data for the United States, Veronesi (1999) shows that professional forecasters are more uncertain about future growth during recessions.

[27] Campbell et al (2001) find that between 1962 and 1997 in the US stock market there was a noticeable increase in industry-level volatility and, especially, firm-level volatility relative to market volatility. Houston and Stiroh (2006), applying the same methodology to the US financial sector over the 1975-2005 period, find that while idiosyncratic volatility remains dominant, a combination of common shocks, deregulation and diversification has become increasingly important since the mid-1990s. Based on their decomposition, most of the financial volatility decline since 2002 is due to the sectoral component, which has gone back to the levels prevailing before the high-volatility 1998-2003 period.

[28] See Schwert (1989) and Figlewski and Wang (2000) for US firms, and Bekaert and Wu (2000) for Japanese firms.

[29] Wei and Zhang (2006) fail to detect a significant effect; Campbell et al (2001) argue that the leverage effect is not sufficient to explain the rise in stock market volatility observed in the United States in the second half of the 1990s.

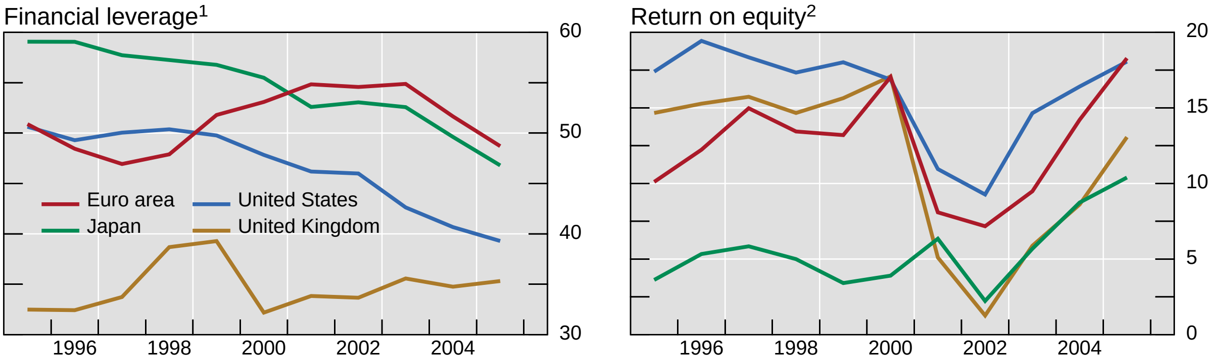
[30] See Wei and Zhang (2006).

Profitability

In all economies considered, ROE declined after 2000, reached a trough in 2002, and then recorded a rapid recovery in all areas, in a range of 8 to 12 percentage points (Graph 4.3, right-hand panel).

Graph 4.3

Financial leverage and return on equity of listed companies



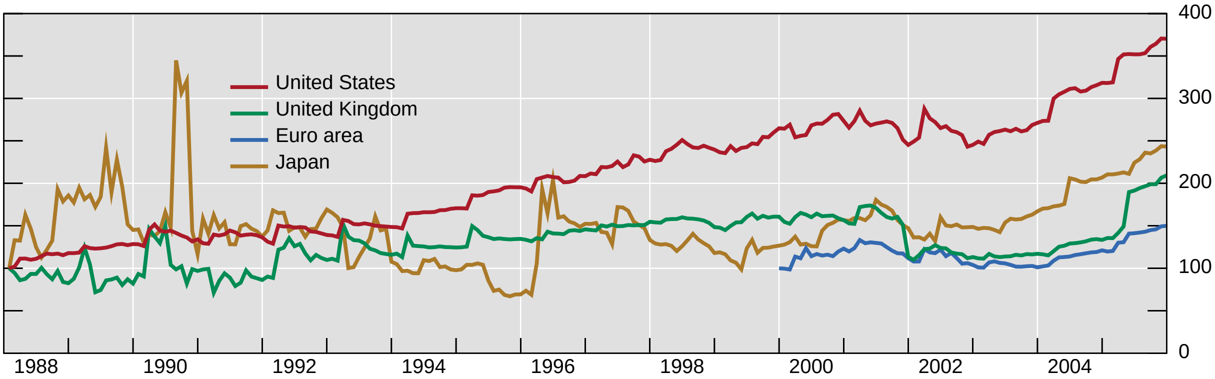
[1] Ratio of financial debt and equity, calculated at book value; sample of non-financial companies that represent approximately 90% of the market capitalisation of their respective markets. Observations with negative equity are excluded. [2] Return on equity is the ratio of net profits to end-of-year equity, calculated at book value. Observations with negative equity are excluded.

Sources: Thomson Financial; Worldscope.

Since ROE is a backward-looking indicator, whereas asset price volatility may be closely tied to expected profitability, Graph 4.4 reports the expected earnings per share over the last decade for the major industrial regions. The data show that expected profitability has increased very rapidly since the beginning of 2004 and that it now stands at its highest level in the period considered.[31]

Graph 4.4

Expected earnings per share of listed companies[1]



[1] January 1988 = 100 (for the euro area, December 1999 = 100). Two-years-ahead expected net income for the companies included in the S&P 500 for the United States and the respective MSCI indices for the other countries.

Source: IBES.

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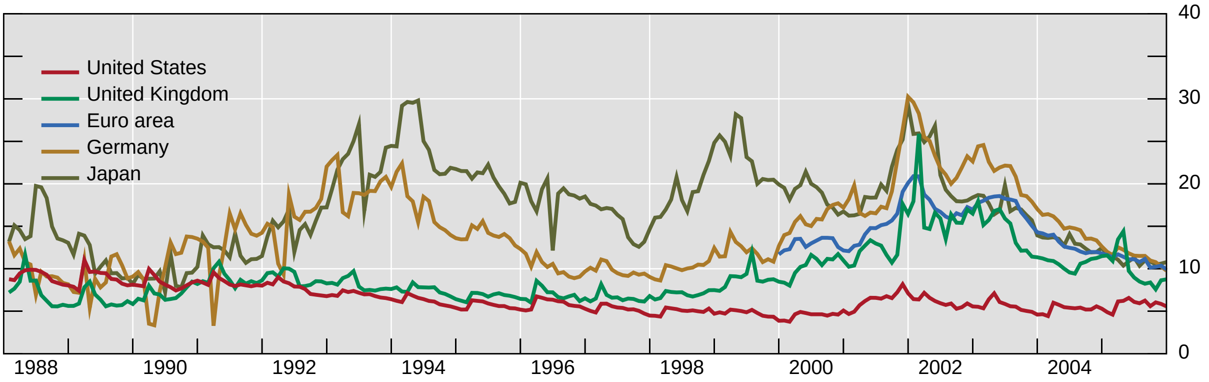
[31] The series refers to ***nominal*** earnings and hence naturally shows an increasing trend. Nonetheless, the strong acceleration of expected profits after 2003 is clearly unrelated to inflation.

Finally, we analyse the uncertainty surrounding firms' profitability. Graph 4.5 shows the standard deviation of analysts' earnings forecasts for listed companies (based on IBES surveys) over the last 20 years.[32] In all economies except the United States, the dispersion of forecasts peaks at the end of 2001 and then declines at a pace which, after a temporary interruption in 2003, becomes rapid. Current levels of dispersion are everywhere close to the lows recorded over the sample.

Graph 4.5

Dispersion of analysts' forecasts on one-year-ahead earnings of listed companies[1]



[1] Cross sectional standard deviation of financial analysts' forecasts as a proportion of the mean forecast for one-year-ahead earnings. Data refer to the S&P 500 index for the United States and to the respective MSCI indices for the other countries.

Source: IBES.

In summary, the graphical analysis is broadly supportive of the hypothesis that the decline of leverage, the improvement in profitability (both actual and expected) and the reduction of the uncertainty regarding the outlook about future earnings seen in most industrialised countries around 2003-04 have contributed to the observed decline in financial volatility.

5. Financial factors

Financial factors may also have contributed to the decline of volatility. This section analyses the role played by investors' risk tolerance; by the increase in liquidity of financial markets; by changes in investors' hedging strategies; and by structural changes in the US mortgage markets.

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[32] Strictly speaking, the graph shows a measure of disagreement among analysts, rather than a measure of uncertainty on the future outlook of corporate profits. An appropriate measure of survey-based uncertainty should be based on the average standard deviation over each survey participant's subjective probability distribution around the expected mean (see Lahiri et al (1988)).

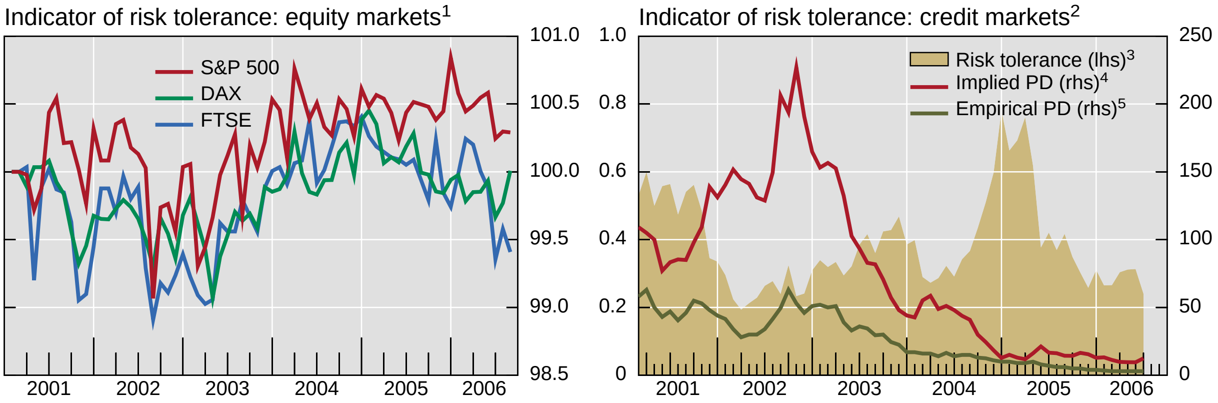
5.1 Increased risk-taking

According to market commentary, since 2004 there has been an upward shift in the supply of options from hedge funds, investment banks and pension funds.[33] This view is supported by the rapid increase in daily open interest registered on the main derivatives exchanges since the end of 2003. For example, open interest on S&P 500 options rose from end-2003 to end-2005 by 78%, whereas those on Euro STOXX 50 rose by 144% over the same period.[34]

Standard market-based measures of risk tolerance are consistent with the view that investors are willing to take more risks. Graph 5.1 shows that on stock markets there has been a considerable rise in risk tolerance since the beginning of 2003; on corporate bond markets, risk tolerance has been fluctuating, with a sharp increase between mid-2004 and mid-2005. A subsequent fall from mid-2005 onwards might be associated with the troubles in the automotive sector.

Graph 5.1

Equity and credit market-based risk tolerance indicators



[1] Derived from the differences between the left tails of two distributions of returns, one implied by option prices, the other based on actual returns estimated from historical data. Indexed to Jan 2001 = 100; an upward movement indicates an increase in risk tolerance. [2] Based on the 125 constituents of the DJ CDX.NA.IG.3 CDS index; monthly averages. [3] Ratio of empirical (ie physical) probabilities of default (PD) to implied (ie risk neutral) PD. [4] PD implied by one-year CDS spreads, assuming a constant recovery rate of 40%. [5] One-year PD estimated by Moody's KMV, based on balance sheet information and asset price volatility.

Sources: Bloomberg; CME; Datastream; Eurex; LIFFE; Markit; Moody's KMV; BIS calculations.

The willingness of investors to take on more risk at favourable points in the business and credit cycle is, however, not surprising. Risk-taking by financial institutions has historically fluctuated with economic and financial conditions and is an integral part of their business.

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[33] This mechanism has been noted by, among others, the Economist (2004), BIS (2004a) and Bank of England (2004a); an endorsement came from the CRMPG II Report, published in July 2005.

[34] Another technical factor that might have helped to stabilise stock prices is the increase in the issuance of reverse convertibles (Barclays Capital (2004)). The buyer of a reverse convertible implicitly sells the issuer a put option, usually written on a stock or an index. If the issuer wants to dynamically hedge the risks embedded in the put option, he has to sell the underlying when its price rises and buy it when the price declines (Hull (2000)). Such a contrarian strategy tends to stabilise the price of the underlying and hence to reduce volatility. According to Dealogic, gross European issues of reverse convertibles rose to €19.1 billion in 2004 and 19.4 billion in 2005, compared with an average of €6 billion in the period 2001-03.

Risk, if not excessive and if properly managed, does not generally represent a threat to the financial system.

According to the risk-taking explanations, financial institutions may have ultimately increased their overall risk exposure, despite the reduction in volatility. Although there is no clear evidence of this, such behaviour would be consistent, for example, with the classical mean variance model of Markowitz (1952), which suggests that a reduction in volatility can indeed induce investors to increase the weight of risky assets and the overall risk of the portfolio.

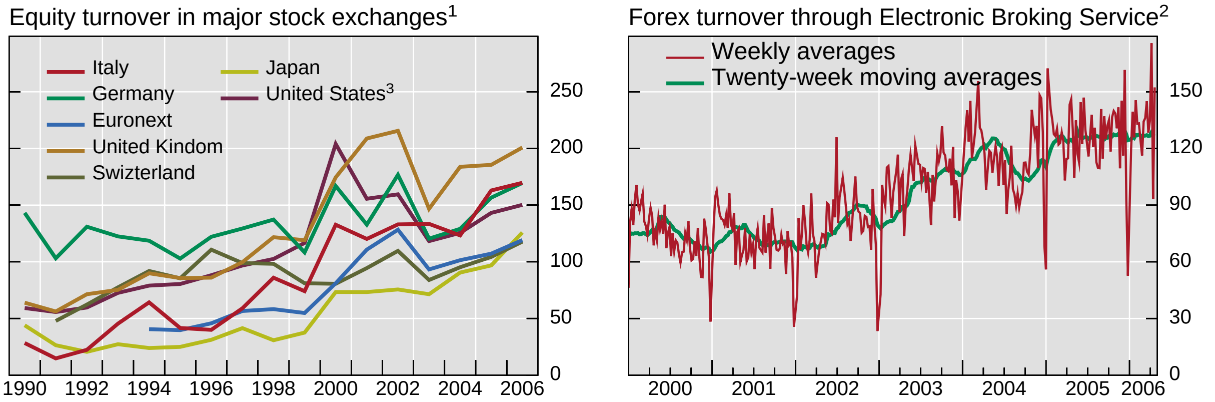
5.2 Improved market liquidity and financial innovation

The sharp decline of financial volatility witnessed over the last few years may have benefited from increased liquidity of financial markets. Since this concept is not easy to operationalise,[35] it is useful to look at several indicators.

Graph 5.2 shows a traditional indicator of liquidity, the turnover on major stock and foreign exchange markets. Throughout the sample the turnover of stock markets has increased considerably, and now stands almost everywhere around the highest levels since 1990. In the foreign exchange markets volumes were virtually flat over the period 2000-02, but since 2003 an upward trend has emerged.

Graph 5.2

Turnover in the stock and forex markets



[1] Ratio of the total value of share trading and the market capitalisation of domestic companies, in US dollar terms; for 2006, 12-month annualised monthly velocity computed in February 2006; in per cent. [2] Daily spot transactions, in billions of US dollars. [3] NYSE and Nasdaq.

Sources: EBS; World Federation of Exchanges data.

In recent years financial innovation and the rise of new classes of financial institutions, combined with a change in the trading behaviour of traditional institutional investors, have contributed to increasing market liquidity.[36] These factors are briefly reviewed below.

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[35] See CGFS (1999).

[36] See Ferguson (2005) and CRMPG II (2005).

Financial innovation and new financial products

Financial derivatives have allowed market participants to price, unbundle and disperse risk throughout the financial system. Until the late 1990s, trading in derivatives on organised exchanges and in OTC markets was limited to products - such as futures, forward contracts, swaps and options - that helped to manage risk related to changes in interest rates, exchange rates and equity prices. In the last few years new products, such as credit default swaps (CDS) and collateralised debt obligations (CDOs), which allow investors to transfer credit risk, have become popular. Table 5.1 shows the notional amounts outstanding of the two major classes of derivatives employed by market participants to transfer market and credit risk, and underscores the exceptionally rapid growth of these instruments.

Table 5.1

OTC and exchange-traded derivatives: notional amounts outstanding

Billions of US dollars, end-of-period data

	1998	2001	2005
Interest rate, currency and equity contracts			
OTC contracts[1]	80,309	111,178	270,100[2]
Exchange-traded contracts	13,975	23,774	57,811
Credit default swaps (CDS)			
Outstanding OTC contracts	na	919	12,430[2]

[1] No data are available before 1998, ie the start date of the OTC Survey. [2] For 2005, end-June.

Sources: ISDA; BIS (2004a).

This significant growth in risk transfer instruments may indirectly enhance market liquidity and hence reduce volatility, in that it allows investors to take on or unwind exposures in a short period of time without having to trade in the cash market. However, the effect may depend on conditions in financial markets (Ferguson (2005); see also the next subsection on mortgage-backed securities). In general, by allowing scope for the transfer and dispersion of market and credit risk, the new instruments create a more resilient financial system, thereby reducing volatility. However, it has been argued that these new instruments may at times increase asset price volatility (Tucker (2005)).[37]

The evolving role of institutional investors

In recent years, the expansion of institutional investors might also have contributed to dampening fluctuations in asset prices. Volatility may be reduced by the rise in the fraction of assets controlled by informed agents holding well diversified portfolios.[38] However, volatility may be exacerbated over the short term by asset managers' investment decisions if these are based either directly or indirectly on the decisions of others (eg positive feedback trading or herding behaviour); these effects may be worsened in bad times by the presence of large players (Pritsker (2005)).

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[37] Laganà et al (2006) discuss several reasons why the development of structured products may have had contrasting effects on overall market liquidity.

[38] CGFS (2003). The role of superior information and rationality (of either individual or institutional investors) in stabilising financial markets is confirmed by recent evidence on daily volatility (Avramov et al (2006)).

Between 1999 and 2005, hedge funds are thought to have more than doubled their size in terms of assets under management.[39] Furthermore, they expanded their activity into areas such as credit risk transfer, reinsurance coverage, foreign exchange markets and private equity (CRMPG II (2005)). Because hedge funds tend to trade more frequently, their presence improves market liquidity and facilitates price discovery, both of which have the effect of reducing volatility. It is quite possible, however, that some of their actions - eg increased selling in falling markets - can also potentially raise the level of volatility (Rajan (2006)).

5.3 Developments in the US residential mortgage market

The US market for residential mortgage-backed securities (MBS) has grown remarkably in recent years and is now the single largest segment of the US fixed income market. A large proportion of US residential mortgages have a fixed interest rate and can be prepaid before maturity without penalty. As mortgage rates decrease, households' incentive to prepay increases, the expected life of outstanding mortgages declines, and their duration shortens. The opposite happens if mortgage rates increase.[40] The swings in MBS duration associated with even moderate changes in interest rates can be large, and market participants thus need to hedge interest rate risk.[41] The increased size of the mortgage market has been accompanied in recent years by correspondingly larger hedging flows.

Some strategies, in particular *dynamic hedging strategies*, used by investors to hedge their mortgage portfolios could significantly amplify interest rate volatility.[42] Dynamic hedging causes investors to sell debt securities when prices are falling (ie when interest rates are rising) and to buy them when prices are rising. If implemented on a large scale, dynamic hedging of MBSs could spark a positive feedback mechanism that would amplify price movements already under way and would thus increase market volatility. This amplification effect is most likely to be important when interest rates are moving rapidly (ie when MBS duration could change fast) and at times of heavy refinancing activity.[43]

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[39] Based on the incomplete data available, assets under management rose from USD 456 billion to 1,100 billion. The total number of funds increased from 3,617 to 8,000.

[40] Since interest rates and MBS duration move in the same direction, MBSs are said to have *negative convexity*. This property implies that the price of MBSs drops at an increasing pace when interest rates rise and increases at a decreasing pace when interest rates fall. Most conventional fixed income securities instead have positive convexity.

[41] Investors that are most likely to hedge their positions include leveraged MBS investors, mortgage originators and mortgage servicers. Non-leveraged investors and leveraged investors whose portfolios are constituted only in small part by mortgages are instead more likely to leave their portfolios unhedged.

[42] The empirical evidence in Perli and Sack (2003) supports this view. As interest rates change, investors using a dynamic hedging strategy would buy or sell certain fixed income securities or derivative contracts to offset changes in the duration of their mortgage portfolios. Because of the negative convexity of MBSs, investors who hedge their mortgage holdings by shorting treasury securities would have to increase those short positions when facing a rise in interest rates if they wish to immunise their portfolio. Conversely, investors would have to reduce their short hedging positions when interest rates decline. Investors who hedge with derivatives would have to enter into positions that would produce analogous results.

[43] Perli and Sack (2003) estimate that in 2002 and 2003, when long-term rates experienced sizeable swings and refinancing peaked, dynamic hedging may have amplified the volatility of long-term US rates by a factor of between 15 and 30%.

Hedging-induced volatility appears to have subsided starting in 2004 as a result of a number of factors, including a diminished incentive to refinance existing mortgages, increased popularity of adjustable rate mortgages, greater use of *static* hedging strategies, and an apparent shift in the type of buyers of MBSs (see below). To the extent that global fixed income markets are correlated, for example because of benchmarking on the part of money managers or cross-border arbitrage by hedge funds and other financial institutions, reduced volatility in the United States may have directly translated into reduced volatility in other countries.

Diminished refinancing activity

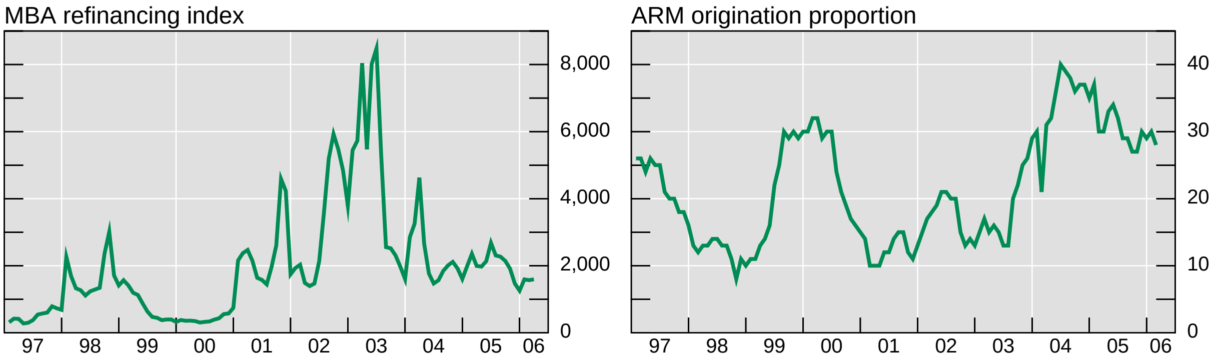
US interest rates reached lows in June 2003, and refinancing activity subsequently peaked in the third quarter of that year. Investors appear to have concluded by mid-June that the cut in the target federal funds rate at the FOMC meeting later that month would conclude the easing cycle, and began forming expectations of tightening. The attendant climb in interest rates drastically cut the value of the prepayment option for the vast majority of households. Consequently, refinancing activity plummeted and has remained low ever since, with the exception of a brief period in early 2004 (Graph 5.3, left-hand panel). The diminished refinancing activity has substantially reduced mortgage originators' need to hedge their positions (Goodman and Ho (2004)).

Increased origination of adjustable rate mortgages

The fraction of new adjustable rate mortgages (ARMs) in the United States increased from 10% in 2003 to 30% in early 2006, with a peak of 40% in mid-2004 (Graph 5.3, right-hand panel).[44] Because the interest rate on ARMs changes periodically in relation to an index (the adjustment period typically varies between one and 12 months), the interest rate risk of most of these products is minimal compared to fixed rate mortgages. ARM investors therefore have little need to dynamically hedge their portfolios. The increased proportion of ARM origination in recent years may therefore have contributed to curbing volatility-inducing hedging flows.

Graph 5.3

US residential mortgage market



Sources: Mortgage Bankers Association and Federal Housing Finance Board.

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[44] Still, despite the recent popularity of ARMs, only about 20% of US borrowers had a primary mortgage with an adjustable rate at the end of 2005.

Increased prominence of static hedging strategies

There is evidence that investors in fixed rate MBSs may have relied increasingly on static approaches to offset interest rate risk. A hedging strategy is dubbed “static” if it does not involve the continuous rebalancing of positions as interest rates change. Effective static strategies include the issuance of callable debt and the purchase of interest rate options.[45] While both callable debt and interest rate options are effective hedging vehicles, they are expensive and have historically been used rather sparingly by investors. The sharp moves in interest rates that took place in 2002 and 2003 and the associated high dynamic hedging costs, however, may have induced some large investors to sacrifice a portion of potential earnings in exchange for better immunisation of their portfolios. The partial substitution of static for dynamic hedging strategies may have reduced interest rate volatility in the last two years.

Shift in the buyers of MBSs

The housing government-sponsored enterprises (GSEs) have been major purchasers of MBSs since the 1990s and have become the largest individual US mortgage investors. The portfolios of the two largest GSEs, Fannie Mae and Freddie Mac, grew by more than $70 billion per year, on average, since 1990, with a peak increase of about $200 billion in 2003. Due, in part, to regulatory concerns, GSE portfolio growth stalled in 2004, when the two agencies added a net amount of mortgages of only about $13 billion, and turned sharply negative in 2005, when the aggregate portfolios of Fannie Mae and Freddie Mac shrank by about $120 billion (see the monthly volume summaries published by both agencies).

Starting in 2004, foreign investors significantly raised their purchases of US MBSs. While in 2003 those investors purchased only about $42 billion of securities, in 2004 and 2005 they acquired $153 billion and $175 billion, respectively (Credit Suisse (2006)). Whereas the GSEs, being highly leveraged, need to hedge their MBS portfolio carefully, foreign investors appear to largely invest their own funds and to target yield levels (Credit Suisse (2006)). As a consequence, in the last two years a large fraction of new mortgages apparently ended up in unhedged portfolios, correspondingly reducing hedging flows.

6. Real and financial shocks: the “good luck” hypothesis

Have real and financial shocks been more benign in recent years? From the end of the 1990s until 2003, several negative shocks hit the international financial system, such as the Russian and Asian crises, international terrorism and geopolitical uncertainty in the Middle East. These shocks would have tended to raise volatility in financial markets.

One explanation for the recent reduction in volatility is that we might have had “good luck” in terms of fewer and less severe negative shocks since mid-2004. Yet, in the last two years the world has been hit by severe shocks, including the earthquake and tsunami in East Asia in December 2004, the hurricanes in the United States in late 2005, ratings downgrades in the automobile sector in May 2005, political unrest in the Philippines and Thailand, and the recent hikes in oil prices. The good luck theory is therefore not plausible. Nonetheless, it can be useful to quantify the sizes of negative shocks and compare the periods before and after mid-2004 to assess their impact on the financial sector. Estimating the size of oil price shocks as in Hamilton (2003), Graph 6.1 (left-hand panel) confirms that the shocks since mid-2004 have been large and clustered in time, and could be expected to have had a considerable impact on the real economy and the financial system.

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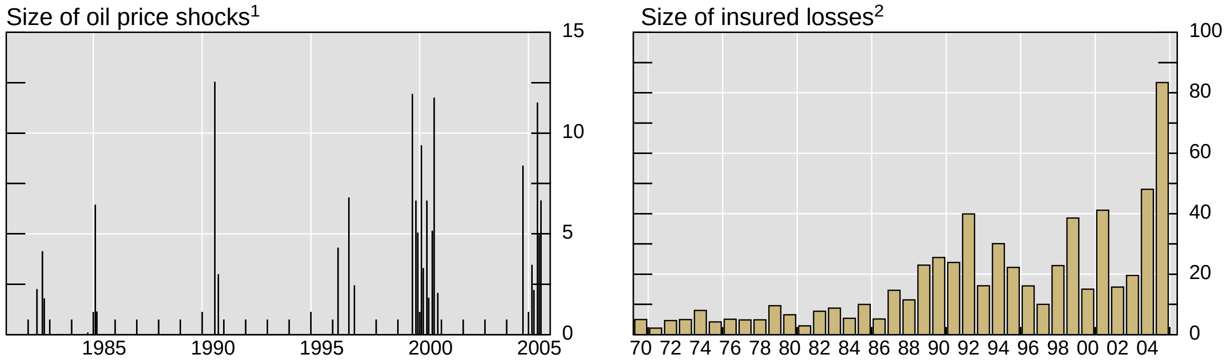
[45] If investors financed all mortgage assets with callable debt (which, like mortgages, also has negative convexity), their balance sheets would be largely immunised against changes in interest rates because the debt could be called in step with mortgage prepayments. While the majority of debt issued by large mortgage investors is non-callable, the fraction of total debt issued by Freddie Mac rose from about 25% in 2002 to 33% in 2004 (Freddie Mac (2004)). Certain interest rate options (such as swaptions) can be used to transform shorter-term non-callable notes into longer-term callable debt, and thus allow the investor to achieve the same result as with the issue of callable debt, but with some added flexibility. Due to their typically high positive convexity, they can also be used to directly offset the negative convexity of the asset portfolio.

Graph 6.1

Oil price shocks and insured losses



[1] Relative increase in the oil price with respect to its maximum in the last three years, in per cent; computed using the method of Hamilton (2003). [2] In billions of US dollars, at 2005 prices.

Sources: HWWA; SwissRe.

Graph 6.1 (right-hand panel) shows that insured losses reached historically high levels in 2004 and 2005. In particular, Hurricane Katrina generated the largest insured single-event loss ever experienced. Since reinsurers are key counterparties to numerous market participants, the global outlook and financial markets can be affected adversely by these losses through failures, ratings downgrades and spillovers. While Graph 6.1 needs to be interpreted with caution (the data also reflect the trend growth of the fairly young reinsurance sector), it indicates that the "good luck" hypothesis is unlikely to be correct.

The financial sector also experienced a number of other shocks, including the downgrading of GM and Ford, and the bankruptcy of Delphi Corporation. Although those events did not seem to have a dramatic impact on financial markets, overall, it seems unlikely that good luck is the reason behind the current low asset price volatility; the other factors considered in this Report are likely to have played a more important role.

7. The role of monetary policy

Another factor that may have accounted for part of the recent decline in volatility is monetary policy. On the one hand, monetary policy directly affects the risk-free nominal rates and the term premia which appear in the denominator of equation (1). Most modern central banks directly target short-term interest rates, whose changes propagate throughout the yield curve. Moreover, the degree of confidence that investors have in their assessment of the future path of policy affects their perceptions of - and their willingness to take - risk. We label this channel the "direct effect" of monetary policy on asset prices. On the other hand, if the evolution of monetary policy has contributed to the Great Moderation, the consequent reduction in output and inflation volatility could have translated into more stable asset prices. We label this effect of policy on asset prices via its effect on economic variables the "indirect effect". Below we discuss the indirect and the direct effects and examine what role they might have played in the recent observed reduction in financial volatility.

7.1 The indirect effect of monetary policy on financial volatility

If monetary policy reduced inflation and output volatility, it may also have lowered financial volatility.[46] However, as discussed in Section 4, the reduction in financial volatility since the early 1980s has been much smaller than the drop in the variability of output and inflation in most countries. This suggests that the indirect effect of monetary policy on financial markets is unlikely to have played a prominent role in the recent reduction in financial volatility. To be sure, there is evidence that output growth volatility may have moderated further since 2004 in some countries (see Section 4). But, as discussed below, it is plausible that the evolution in recent years of monetary policy towards greater consistency, transparency and clearer communication of policy stances may have been much more important.

7.2 The direct effect of monetary policy on financial volatility

Recent changes

Many central banks have strived in recent years to reduce the uncertainty arising from policy decisions. One important element has been the trend towards gradualism in policy action. This is especially clear in the ongoing tightening cycle in the United States, where the target federal funds rate has, as of this writing, been increased 16 times by 25 basis points. In its recent moves the ECB has also adopted a gradualist approach. In general, policy moves in excess of 25 basis points have become increasingly rare in industrialised economies.[47]

Another key factor that has reduced uncertainty about the future direction of policy has been the recent increase in central bank transparency. Probably the most radical innovation in this direction has been introduced by the central banks of New Zealand and Norway, who recently decided to publish expected paths for their own policy rates. More relevant from the perspective of this Report is the inclusion by the FOMC, starting in August 2003, of commentary about the likely future path of policy in its statements released after its meetings.[48] While those forward-looking words were part, at least initially, of the FOMC's set of alternative policies at a time when short-term interest rates were very close to the zero bound (Bernanke and Reinhart (2004)), they have also provided an unprecedented assessment of the Committee's own views about the likely direction and pace of policy rate changes. The ECB has also clearly signalled its policy intentions before its moves, orienting market expectations through a variety of different communication channels, including the introductory statements and the press conferences of the President after each policy setting meeting. The Bank of Japan, with its policy rate virtually at zero from 2001 to July 2006 (when a first hike was announced), committed to keep its policy rate at zero for as long as the economy experienced deflation.

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[46] Many observers suggested that monetary policy in the 1960s and 1970s had a tendency to be destabilising (eg Clarida et al (2000), DeLong (1997), Mayer (1998) and Romer and Romer, (2002)). At that time, policymakers were too confident that activist policies could offset output shocks and keep economies permanently near full employment by trading off output for inflation, even in the long run. In addition, it was widely felt that inflation was a non-monetary phenomenon. Bernanke (2004c) has dubbed these views "output optimism and inflation pessimism" and argued that their combination was a recipe for high volatility in both output and inflation. Once the ineffectiveness of these policies became clear, monetary authorities began abandoning the idea of achieving higher output growth by accepting higher price growth and started recognising inflation as a monetary phenomenon. This policy shift has probably been a key determinant of the Great Moderation.

[47] Bernanke (2004b) notes that uncertainty about the effects of policy moves and the desire not to destabilise financial markets are two of the prominent reasons why gradualism has become so pervasive.

[48] At the August 2003 meeting, the FOMC indicated that the policy accommodation that was in place at the time "could be maintained for a considerable period". At the January 2004 meeting, that language evolved into a statement that "the Committee believes that it can be patient in removing its policy accommodation". Different forward-looking statements were used during the ongoing tightening cycle.

The improved policy communication is likely to have had a number of effects on asset prices. First, to the extent that those views are considered credible by investors and are subsequently borne out, the money market will be stabilised as investors will have little need to adjust their expectations of short-term interest rates in the near future. This effect is apparent from the reduction of short-term rate volatility documented above.

Second, forward-looking communication helps ensure that long-term interest rates and other asset prices do not build in a projected pace of policy action that differs from that anticipated by policymakers (Bernanke (2006)). Because long-term rates are in part determined by future expected short-term rates, the longer the horizon covered by the policy communication, the more long-term interest rates will be stabilised. However, this horizon is necessarily short, since future data may well induce policymakers to revise their views on the course of policy. Hence, the impact of policy communications on longer-term interest rates should be significantly smaller than it is on short-term interest rates. For example, if policy communication managed to fix the path of short-term interest rates for two months, a realistic time horizon, the volatility of 10-year interest rates would be reduced only by a few basis points.

Long-term rates are also influenced by the term premium, that is, the compensation that investors require for the risk that their forecasts of future short-term rates will prove incorrect. Thus, a third potential effect of policy communication on asset prices is to reduce the term premium via the reduction in the uncertainty on the future path of short-term rates. A decomposition of long-term rates into expected future short rates and term premiums along the lines suggested by Kim and Wright (2005) for the United States and Pericoli and Taboga (2006) for the euro area reveals that the volatility of long-term rates is mostly accounted for by the volatility of the term premium. It is possible, then, that some aspects of the recent policy communication strategies, combined with the effects of the other factors discussed in this Report, may have also reduced the volatility of the term premium.

The operational framework of monetary policy is another broad area in which changes with a potential to impact on financial market volatility have been implemented. For example, in March 2004 the Eurosystem implemented several important changes to its operational framework, aimed at reducing uncertainty in the money market and at stabilising market expectations about policy moves (see ECB (2005) for a description of these changes and a broadly positive assessment of their impact).

Empirical evidence

Several papers suggest that policy transparency and consistency have improved the predictability of central bank's policy decisions in recent years.[49] Graph 7.1 provides some evidence that predictability has been especially striking in the United States and the euro area since 2004. The graph shows the average daily absolute variation in one-month rates in the United States and euro area since 1999. It is clear that rates have moved much less since 2004, especially on days when policy meetings were held or when decisions to change policy were made. Clearly, at least one major source of financial market volatility, central bank policy actions, has been muted of late. Interestingly, Graph 7.2 shows that the volatility of longer-term rates has also been reduced at times of policy meetings or actions since 2004, although to a much lesser extent.

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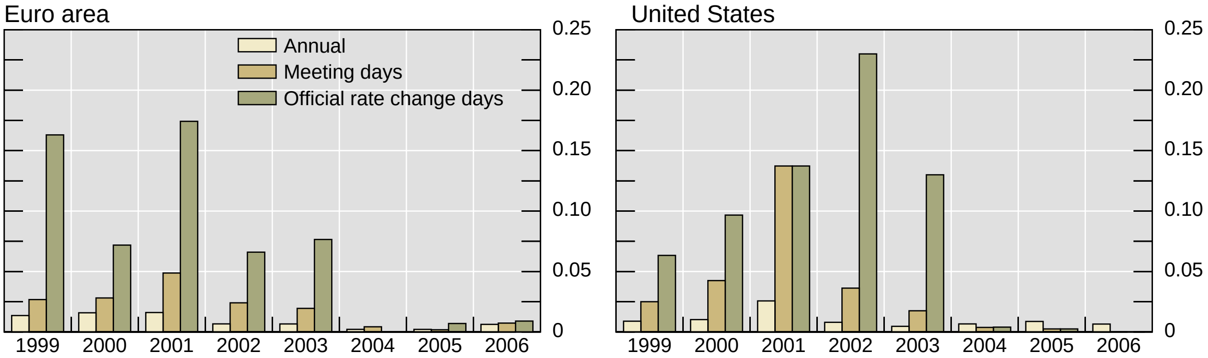
[49] See, among others, Poole et al (2002), Lange et al (2003), Poole (2005) and Swanson (forthcoming).

A different, unrelated strand of the literature has analysed how technical deviations of target rates from their desired levels have propagated along the yield curve. In spite of differences in the methodologies, sample periods and countries analysed, there is a broad consensus that volatility transmission from the short to the long end of the yield curve is limited and quantitatively small.[50]

Graph 7.1

Mean absolute changes in one-month interest rates[1]

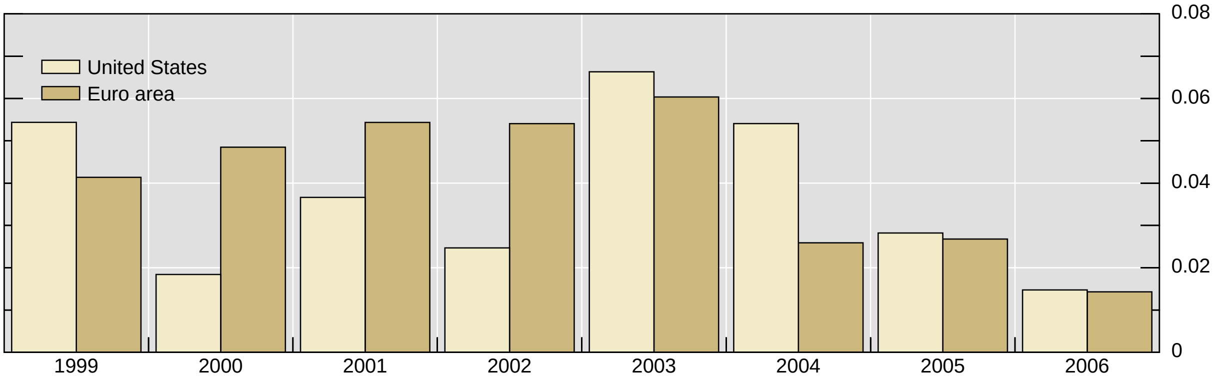


[1] In per cent.

Source: Bank of Italy.

Graph 7.2

Average absolute change of 10-year rates on days of policy meetings[1]



[1] In per cent.

Source: Bloomberg.

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[50] Abad and Novales (2004) find some evidence of contemporaneous transmission of the conditional volatility from one-month rates to longer-term maturities for the United States, Japan and Germany (their analysis stops at the end of 1998, before the start of stage three of European monetary union, so that there is no evidence about the euro area). Their findings confirm the previous results by Ayuso et al (1997), which suggested significant transmission of volatility in Spain, France and the United Kingdom, but not in Germany, between 1988 and 1993 from overnight rates to one-year maturities, even though it was typically quite small. Cassola and Morana (2003) focus on volatility transmission from overnight rates to money market maturities up to 12 months in the euro area, but find little or no evidence of transmission.

Evidence for the most recent years is provided by Colarossi and Zaghini (2006). Using a GARCH model, they analyse volatility spillovers from the overnight rates to longer maturities of up to 10-year rates. The main results can be summarised as follows. First, the estimates conducted over the period from January 1999 to March 2006 confirm the presence of positive spillovers for maturities up to 12 months in the euro area, and up to 10 years in the United States.[51] Second, over the last two years there is a substantial drop in the transmission of volatility. The elasticities become statistically insignificant for all rates, with the exception of the US one-month rate. The causes of this recent change remain to be ascertained. While, in principle, it could be that greater central bank predictability may have contributed to dampening the transmission of money market "technical" volatility to longer-term maturities, other factors are likely to have played a part.

In sum, recent improvements in monetary policymaking - greater gradualism and transparency - may have played a major role in the reduction of money market volatility observed since 2004, and perhaps some role in the reduction of volatility at longer horizons and in other markets. Indeed, it is striking that the drop in financial market volatility took place around the time that forward-looking communication was introduced by policymakers in a number of countries. If these improvements are permanent, so will their effect be on financial market volatility.

There are two additional aspects of the current monetary policy stance that may have dampened volatility. However, these aspects might be reversed in the near future.

The first arises from the very low level of short- and long-term interest rates. First, there is evidence of a positive correlation between level and variability of nominal rates (we run a simple regression of interest rate volatility on interest rate levels: the results show a positive relationship; moreover, a more sophisticated Markov-switching model shows that the higher interest rates are, the more likely it is that there will be a switch from a regime of low volatility to one of high volatility). Therefore, a rise in interest rates might be associated with a volatility increase, particularly for short rates.

Second, since in the recent past policy rates have been at historically low levels, there has been little uncertainty as to the sign of future changes. Once a neutral stance is reached, uncertainty about future policy moves might increase.

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[51] For instance, a 1% increase in the volatility of the EONIA triggers an increase in the volatility of the 12-month rate equal to 0.01% on impact, and to 0.18% in equilibrium (ie if the volatility increase in the EONIA is permanent). The corresponding elasticities for the United States convey a similar message, although a significant volatility transmission is also detected in the case of the 10-year rate.

Appendix 1:
Methodology in detail

Volatility is estimated using the RiskMetrics™ EWMA (exponentially weighted moving average) methodology as discussed below.

1. Starting dates for the sample periods are selected according to the two following criteria:
    - availability of daily data;
    - for each market (eg the stock market), availability of data for all countries.
2. Volatilities refer to:
    - rates of return for stock and bond indices, exchange rates and commodities indices;
    - first differences for interest rates and corporate bond spreads.
3. ***For daily data***, historical volatilities are computed using the RiskMetrics™ EWMA methodology, ie:
    - Variance of return today = λ*(Variance of return yesterday) + (1-λ)*(Rate of return yesterday)^2
    - λ is set equal to 0.94.

    For monthly data, a procedure similar to that proposed by RiskMetrics™ is adopted in order to optimally select the weighting coefficients: λ is chosen so that it provides the best forecast of the future variance of returns. The methodology boils down to finding the λ that produces minimum root mean square error (RMSE) for the forecast. The RMSE is given by

    $$RMSE(\lambda) = \sqrt{\tfrac{1}{T}\sum_{t=1}^{T}\left[r_{t+1}^2 - \hat{\sigma}_{t+1|t}^2(\lambda)\right]^2}$$

    Here, r_{t+1}^2 is the squared return for period $t+1$ and the variance forecast equation is

    $$\hat{\sigma}_{t+1|t}^2 = \lambda\hat{\sigma}_{t|t-1}^2 + (1-\lambda)r_t^2$$

    The average squared returns over the next three months are used. The motivation is that the variance forecast should provide a good proxy for the average variance during the next quarter. In this case, we define

    $$\sigma_{t+1}^2 = \tfrac{1}{3}(r_{t+1}^2 + r_{t+2}^2 + r_{t+3}^2)$$

    Then compute,

    $$RMSE(\lambda) = \sqrt{\tfrac{1}{T}\sum_{t=1}^{T}\left[\sigma_{t+1}^2 - \hat{\sigma}_{t+1|t}^2(\lambda)\right]^2}$$

    We compute RMSE(λ) for λ = 0.93, 0.94, 0.95, 0.96, 0.97 for stocks and bonds, and choose λ = 0.95 since this leads to the smallest mean squared error.
4. Global volatility indices are computed as follows:
    - *Simple average of volatility indices.* Fourteen volatility indices (all rescaled so as to be equal to 100 at the sample average) are averaged. The analysis refers to the volatility of stocks, money market rates and bond yields for the

United States, Germany, Japan, Switzerland and the United Kingdom. The Swiss bond market is excluded due to limited data availability.

Sum of quartile indices. For each of the 14 volatility indices, a quartile index is computed (taking values between 1 and 4), indicating in which quartile of its empirical distribution the volatility index is on any given day. The quartile indices are then added. As a robustness check, we compute the same index, excluding all the money markets (results are qualitatively unchanged).

5. Covariance indices are computed as follows: since, for random variables x_i (the returns of the individual markets) and constants α_i (the weights of the individual markets in the global portfolio), the following equality holds:

$$Var\left(\sum_{i=1}^{n}\alpha_i x_i\right)=\sum_{i=1}^{n}\alpha_i^2 Var(x_i)+2\sum_{i=1}^{n-1}\sum_{j=i+1}^{n}\alpha_i\alpha_j Cov(x_i,x_j)$$

the covariance indices are computed as

$$1-\sum_{i=1}^{n}\alpha_i^2 Var(x_i)\Big/Var\left(\sum_{i=1}^{n}\alpha_i x_i\right),$$

that is, the proportion of the variance of the global portfolio due to covariances between markets. The countries included in the global portfolios are: the United States, Germany and Japan.

6. Data sources:

- Bank for International Settlements (for money market rates and exchange rates);
- JPMorgan Chase (for the 10-year bond indices);
- Bloomberg (for stock indices and global bond and stock indices). The global bond index is provided by the European Federation of Financial Analysts Societies. The global stock index is provided by FTSE;
- Merrill Lynch (for daily data on corporate bond spreads);
- Global Financial Data (for monthly data).

Appendix 2:
Trends in daily volatility across markets and countries

In order to have a better grasp of where market volatility stands now in comparison with previous episodes of market quiet, it is useful to look at its evolution over time, with the help of the graphs below.

In particular, if we look at the variability of ***money market rates*** since the mid-1980s, Graph A2.1 confirms that the current period is truly exceptional: prior to 2003-04, in none of the countries considered was volatility so moderate for so long. Some differences can be found in the pattern of the decline: while in Germany the decline has been gradual, along a downward trend, in the United States, the United Kingdom and, to some extent, Switzerland, a clear break can be found in the mid-1990s. As already mentioned, part of these patterns can be explained by changes in monetary policy strategies and procedures.

For ***long-term government bonds***, Graph A2.2 suggests that the current level of volatility is low but not unprecedented. The volatility of US bond prices has been persistently low, as in the current episode, and also in the years 1997-98. In Germany, volatility was lower than it is now in 1988-89 and in 1992-93. Over the same two periods Japanese bonds displayed as little volatility as they do now. In the other four countries, the pattern is roughly similar, with a current level of volatility that by no means can be considered unprecedented; in contrast, on the Swiss bond market volatility seems to have followed an upward trend since 1996 (the starting date of the sample). It is worth emphasising that towards the end of 2005, bond price volatility picked up in all countries (especially in Japan and Germany).

Stock market volatility (Graph A2.3) is currently low in all countries relative to the level prevailing between 1997 and 2003, but not relative to the levels observed in the less recent past. In particular, the US stock market experienced periods of quiet comparable to the current one throughout the 1960s, in 1976-80 and in 1994-96 (on the eve of the long stock market boom which was interrupted in 2000). Japan and Germany also experienced long periods of market quiet, comparable to the current one, in the mid-1960s and late 1980s. The same applies to the United Kingdom and Switzerland, although the available sample is shorter. In contrast, for France and Italy the recent decline in volatility seems rather an unprecedented event, as far as the available sample is concerned (starting from 1987 and 1975, respectively). In recent months (second half of 2005), volatility has slightly increased, reaching levels close to the historical average.

In most countries, ***exchange rate*** volatility (Graph A2.4) is currently only slightly below or exactly at its long-term average. For the two most traded pairs of currencies (Deutsche mark-dollar and yen-dollar) the current level of volatility is higher than it was in the second half of 1970s, after the demise of Bretton Woods. In addition, in comparison with the 1980s, current variability is not at all low.

For ***corporate bond spreads*** (Graph A2.5), which have been available at a daily frequency only since 1997, current volatility seems to have gone back to the low level prevailing prior to the 2001-02 period, when major shocks (the Argentine crisis, Enron and the 11 September 2001 terrorist attacks) made corporate bond prices very volatile. The 2005 spikes in the investment grade sector resulting from troubles in the automotive industry have been rapidly absorbed.

From a historical perspective, ***emerging markets*** (Graph A2.6) are currently experiencing a phase of extremely low volatility. For example, the volatility of an equally weighted portfolio including a Brazilian and a South Korean stock index (these are two major emerging stock markets) is currently below the first percentile of its historical distribution. Actually, one has to go back to the beginning of 1999 (when the Brazilian government allowed the national currency to float freely) to find the last episode of very high volatility in these markets.

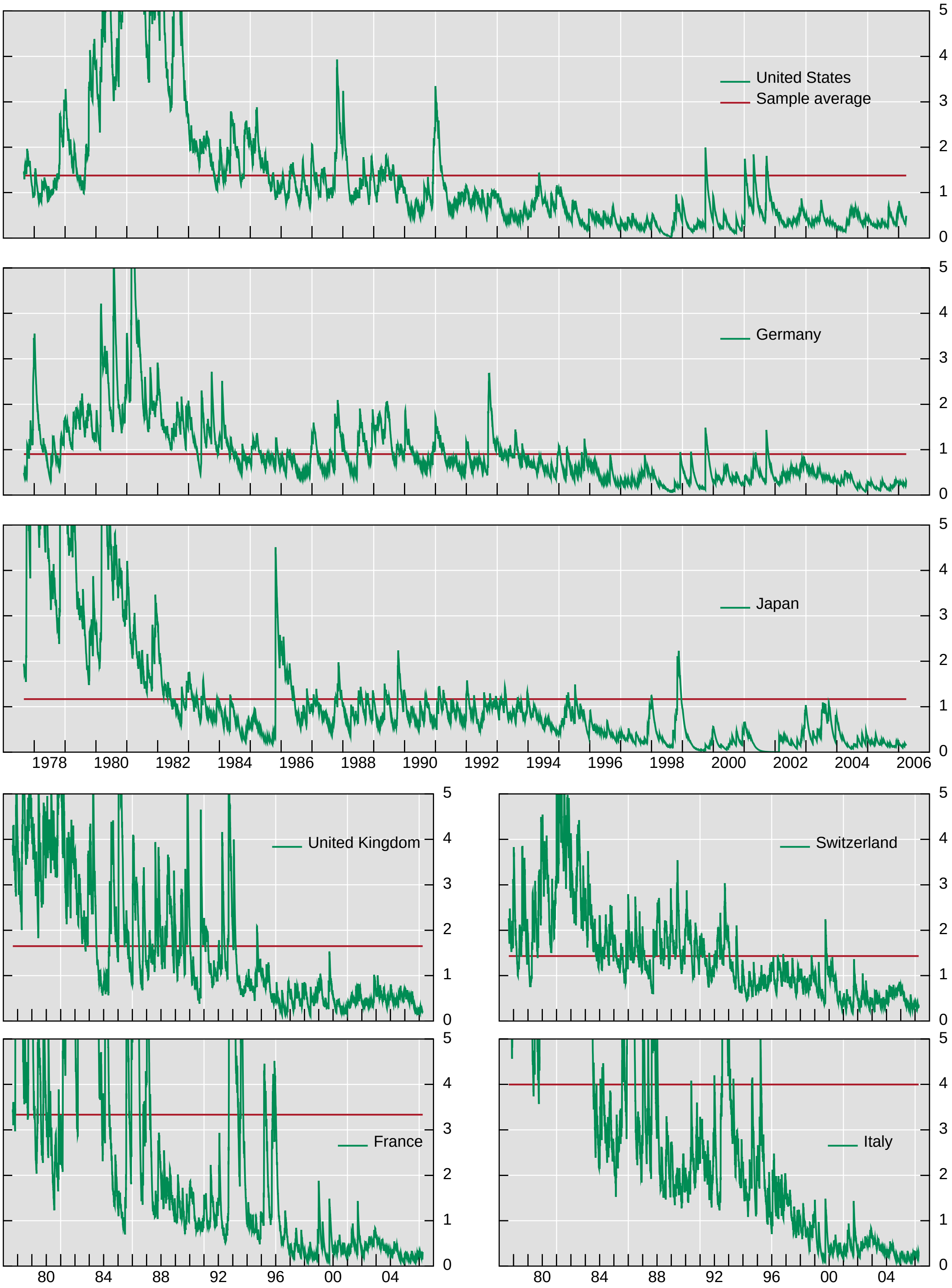
Volatility is also very low in the bond markets of emerging markets countries; an equally weighted index of South African and Indian bonds shows that volatility is currently below the third percentile of its historical distribution.

Since July 2004, volatility in the ***oil market*** (Graph A2.6) has been oscillating around its historical average. The latest episodes of high volatility happened after the terrorist attacks in September 2001 and before the Iraq war in March 2003. The volatility in the ***non-oil commodity markets*** has been higher than its historical average in 2004 and 2005. Volatility in this market now stands above the 90th percentile of its historical distribution.

Graph A2.1

Three-month interest rate volatility

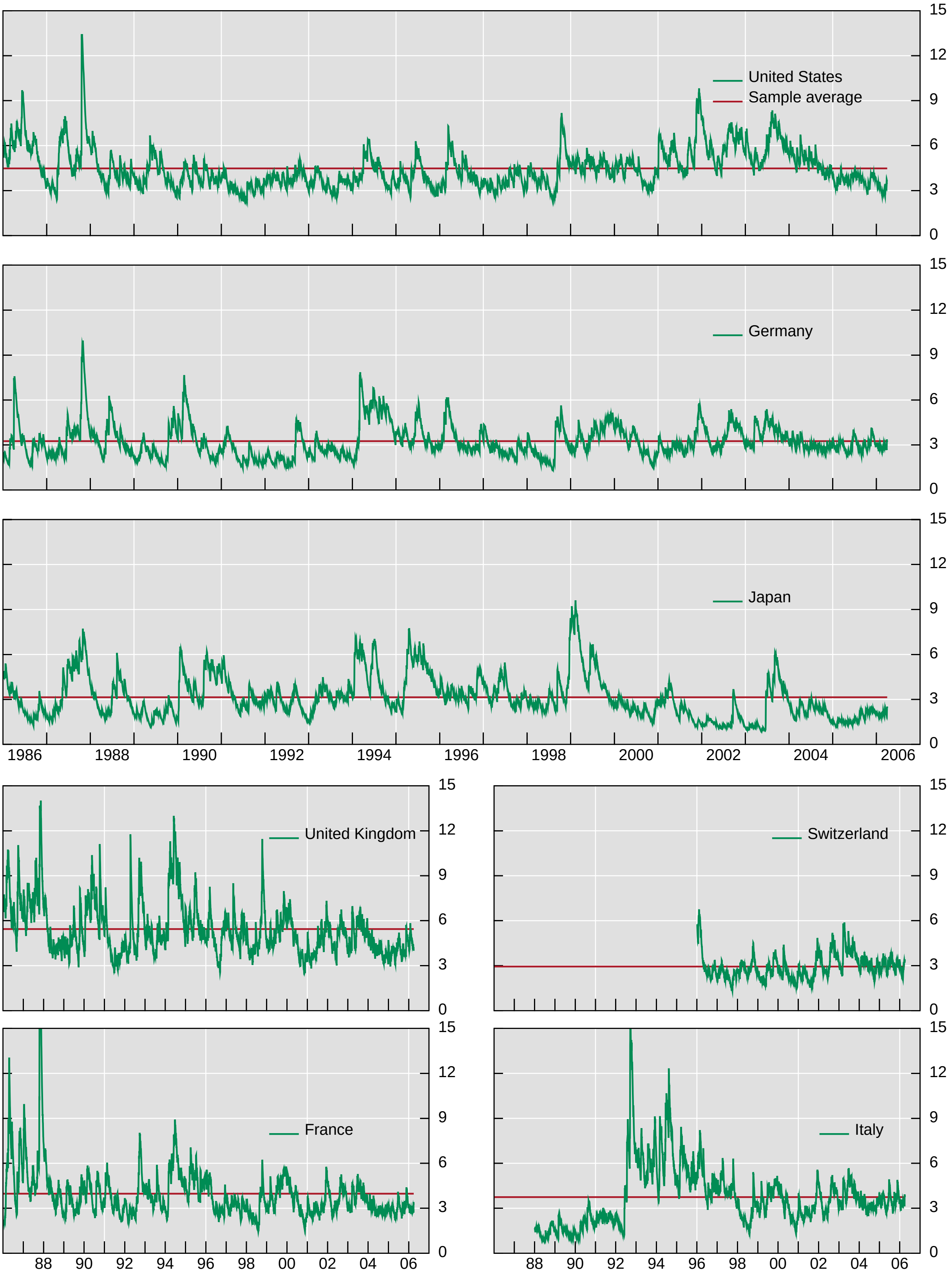
Daily data; percentage points



Graph A2.2

Ten-year bond index volatility

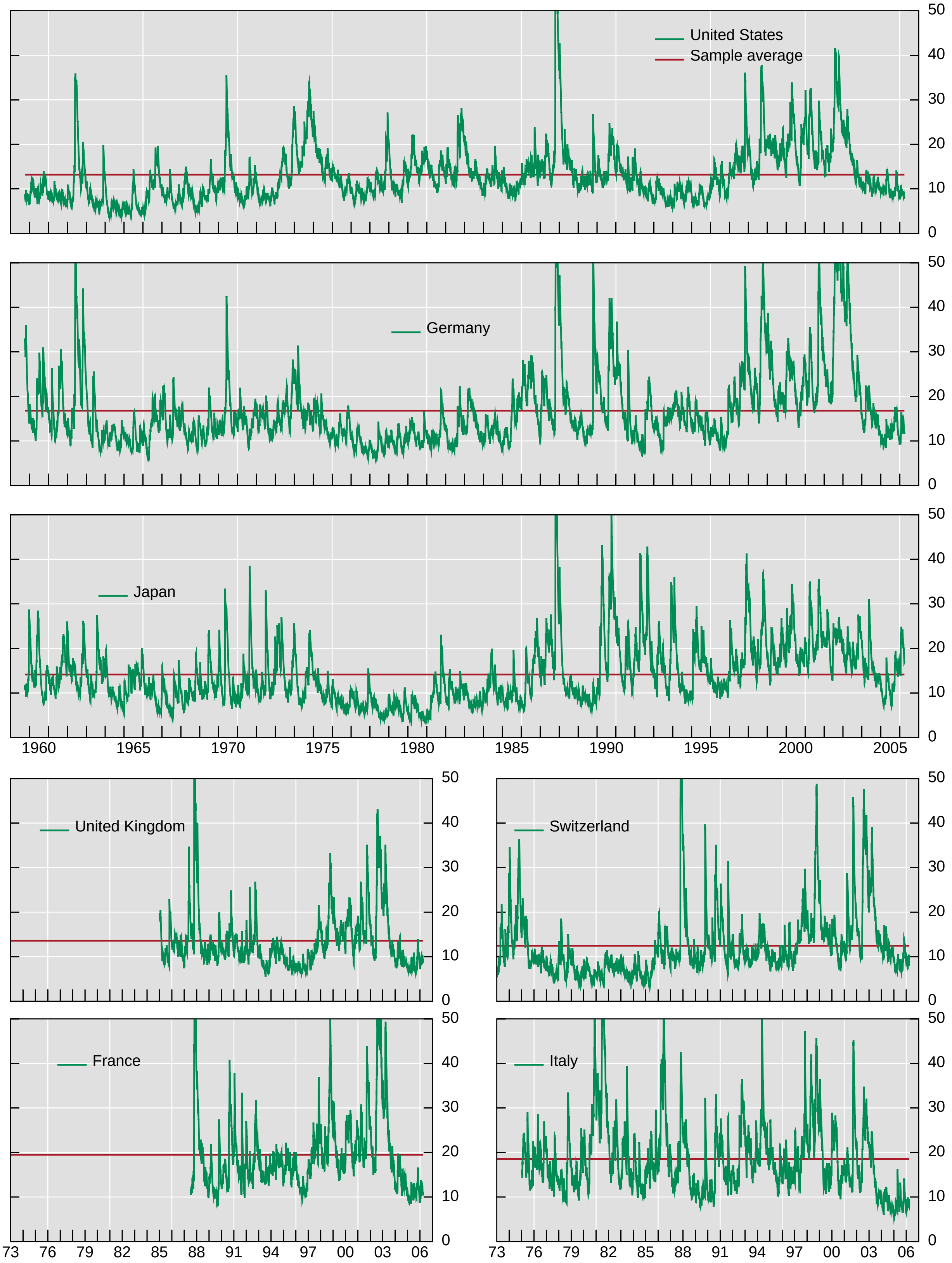
Daily data; per cent



Graph A2.3

Stock market volatility

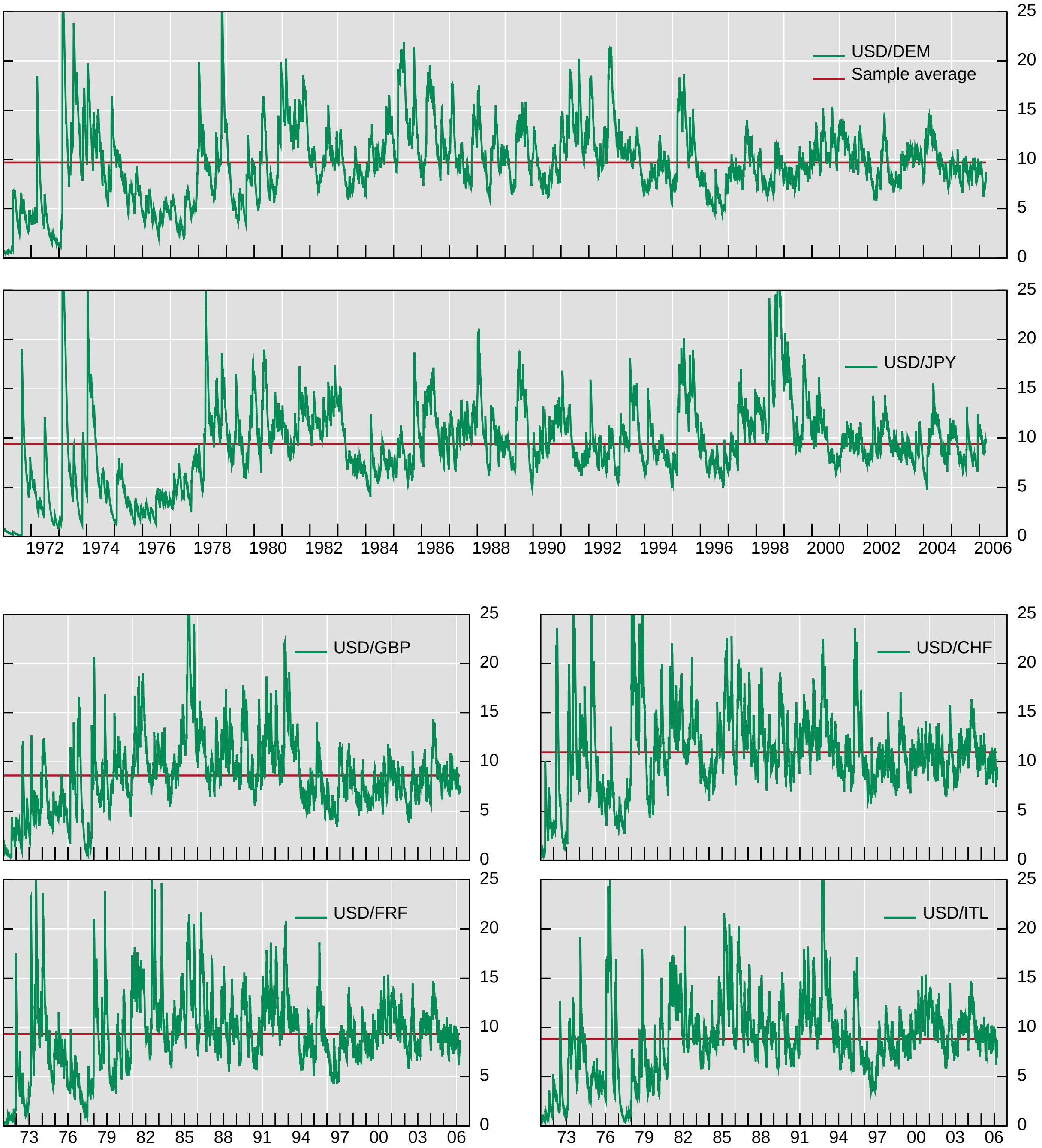
Daily data; per cent



Graph A2.4

Exchange rate volatility

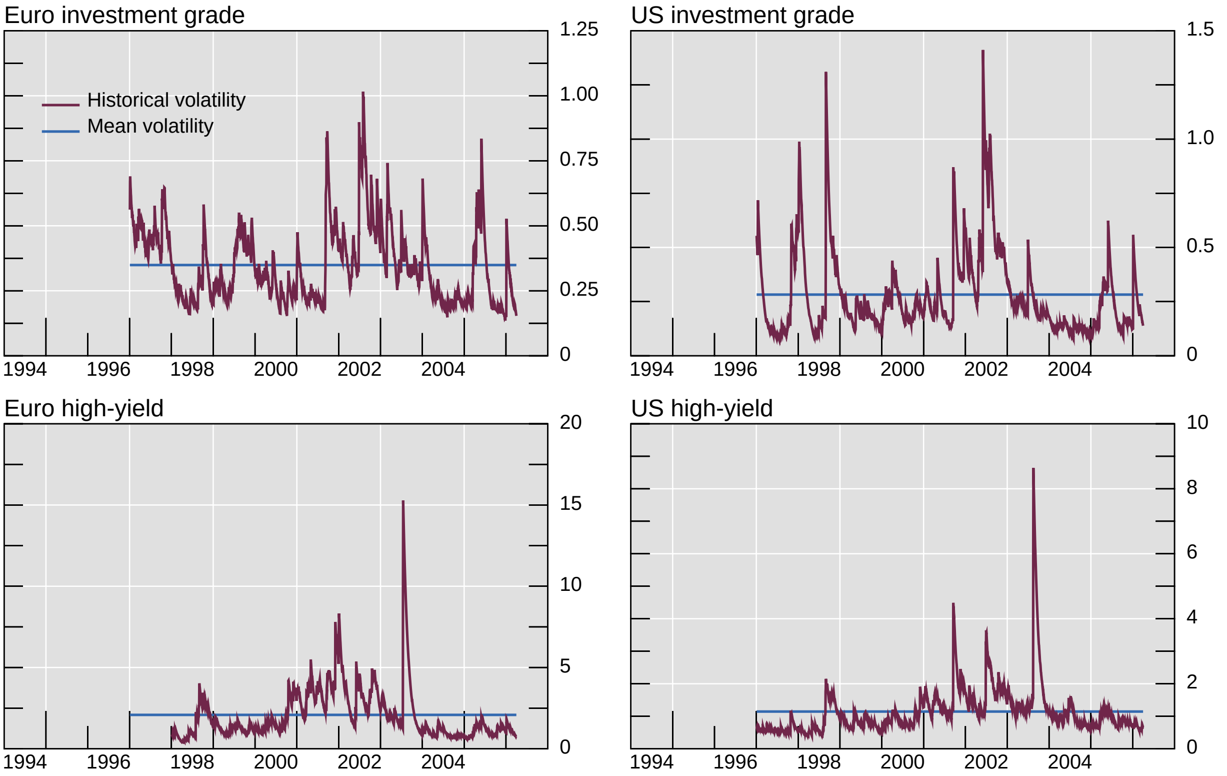
Daily data; per cent



Graph A2.5

Corporate bond spread volatility

Daily data; percentage points

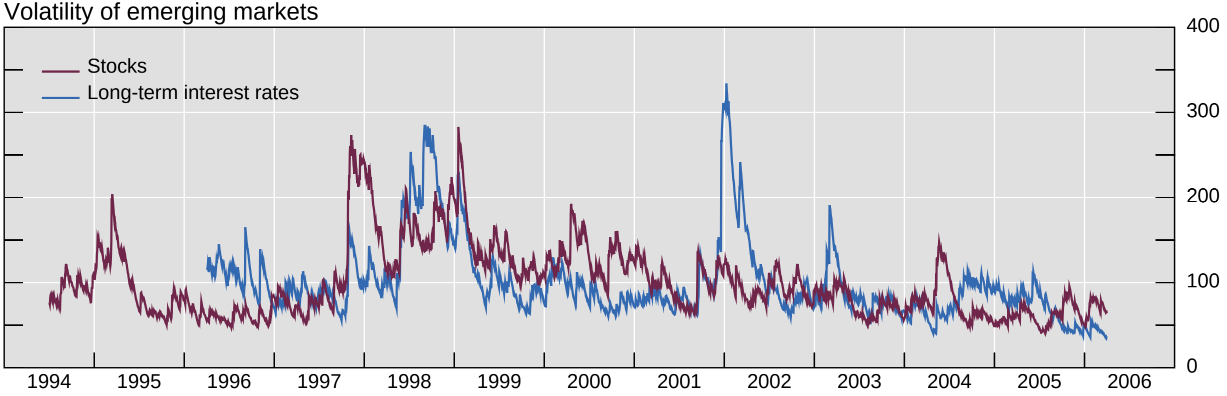


Graph A2.6

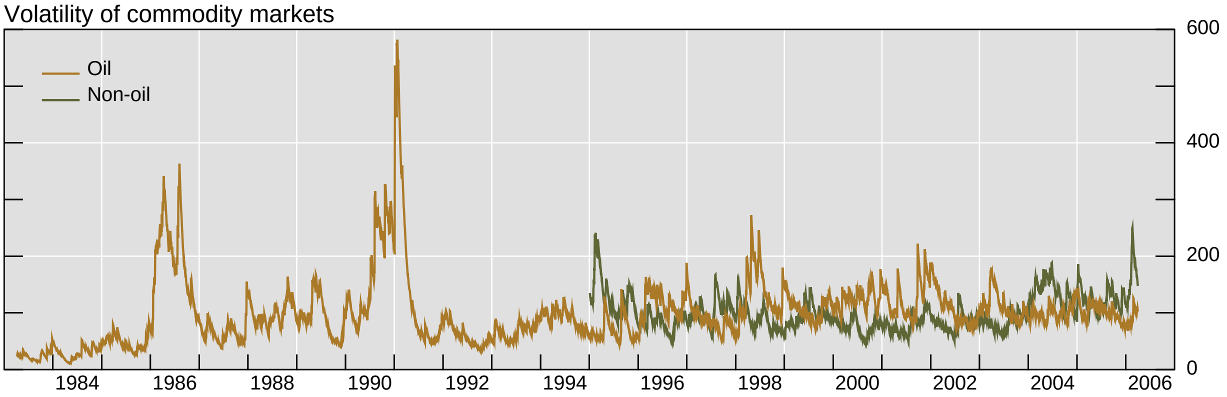
Other volatility indices

Daily data; per cent

Volatility of emerging markets



Volatility of commodity markets



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