The anatomy of the bond market turbulence of 1994

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Introduction

The bond market sell-off of 1994 has begun to show up on lists of market events against which risk management systems are judged. One such list includes the 1987 stock market crash, the 1990 Gulf war, the 1992 European exchange rate mechanism turbulence, the 1994 bond market decline and the 1995 Kobe earthquake (Market Risk Task Force, 1995).

In contrast to the 1987 stock market crash, however, our understanding of the 1994 bond market decline has not benefited from a series of official post-mortems and from subsequent published studies. This paper steps into this lacuna and asks why *volatility* rose across the major bond markets in 1994, with increases ranging from 5 percentage points in the US market to 10 or more elsewhere.[2] The analysis covers thirteen industrialised countries[3] and is largely, though not exclusively, based on OTC data for implied bond yield volatility (see box for more details).

The market's own dynamics seem to provide a stronger answer than variations in market participants' apprehensions about economic fundamentals. We identify three market dynamics: downward markets increase volatility; volatility spills over from certain markets onto others; and it can rise in the wake of substantial withdrawals of foreign investments. We find more limited evidence that monetary or fiscal policies accounted for the rise in volatility in 1994, at least by our measures. Moreover, changing expectations about growth and inflation, while perhaps at work in particular countries, do not offer much of a general explanation.

1. The events

Volatility rose sharply in the world's major bond markets last year, accompanying the early stages of a bear bond market (Graph 1). Volatility generally began to increase in February, soon after the tightening of monetary policy in the United States. The main exception was Japan, where the rise started in January.

The scale and persistence of the increase were not uniform across countries. Measured by the standard deviation of daily percentage changes over a sliding three-month window, the rise was comparatively modest and short-lived in the United States and especially large and persistent in ERM countries. In Europe, volatility generally peaked in mid-year, about one month later than in the United States and a whole quarter behind Japan.

The overall picture is broadly similar when gauged by the movements of the implied volatility of three-month over-the-counter at-the-money option contracts on ten-year benchmark government bonds, the main focus of this paper (same graph, top six panels). The main difference is that the increase in volatility in the US market looks smaller.

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1 We would like to thank Henri Bernard, Angelika Donaubauer and Gert Schnabel for statistical assistance, Wilhelm Fritz for technical help and Stephan Arthur for preparing the graphs.

2 This report is a particular application of the findings presented in our longer paper, "The economics of recent bond yield volatility". The interested reader is referred to that paper for a more detailed treatment of the points distilled here.

3 The United States, Japan, Germany, France, the United Kingdom, Italy, Canada, Australia, Belgium, Denmark, the Netherlands, Spain and Sweden.

Box - the data

Much of the present research draws on a database of weekly yield volatility for three-month at-the-money over-the-counter options on ten-year benchmark government bonds in thirteen major markets as quoted at the market close on Thursdays by a leading market-maker, J.P. Morgan (Watts, 1994 and 1995). Supply and demand in the market for options set the premium price; and this price, together with interest rates, can be used to back out an implied volatility through an option pricing formula. Admittedly, market-makers' methods for mapping premium prices into and out of implied volatilities vary somewhat across firms and over time. However, the difference between these pricing models are subtle enough for market-makers to find it convenient to quote their options in terms of the implied volatilities.

OTC market quotations have a number of advantages over volatilities embodied in the prices of exchange-traded options. They exist for government bonds that are not exchange-traded. And they are quoted for the same maturity at every observation. By contrast, exchange-traded contracts exist only at monthly or longer intervals. Successive quotations on the same contract thus differ if implied volatility varies across contracts with different maturities. While interpolating techniques have been developed to deal with this problem, the constant-maturity aspect of the over-the-counter quotations avoids it altogether.

Relying on over-the-counter quotations for implied volatility from a single market-maker raises questions regarding the reliability (or what might be called the intersubjective truth) of the data. At the outset, recall that financial markets have confronted this problem in the past. The most famous example is the London Interbank Offered Rate (LIBOR) for bank deposits, which, just as an OTC option contract, can expose the buyer to the selling bank's credit risk. Big syndicated loan contracts with interest rates tied to LIBOR will typically specify the five leading banks whose quotations are to be averaged. The difference between an unquestioned acceptance of LIBOR and of our OTC quotations thus reduces from the principle of using over-the-counter prices to the practical question of whether one can rely on one dealer's prices.

Those in charge of monitoring the accuracy of a dealer's valuation of its book typically use quotations of competitors as a benchmark. It is therefore natural to do the same in our case. A comparison of the J.P. Morgan quotations with scattered ones from Hong Kong Banking Corporation's London affiliate (Midland Montague) was reassuring. Given differences in the timing of the quotations and the need to convert price into yield volatility through a standard approximation, the remaining small discrepancies indicated that the J.P. Morgan quotations were a satisfactory basis for the analysis. (See Borio and McCauley, 1995, for details.)

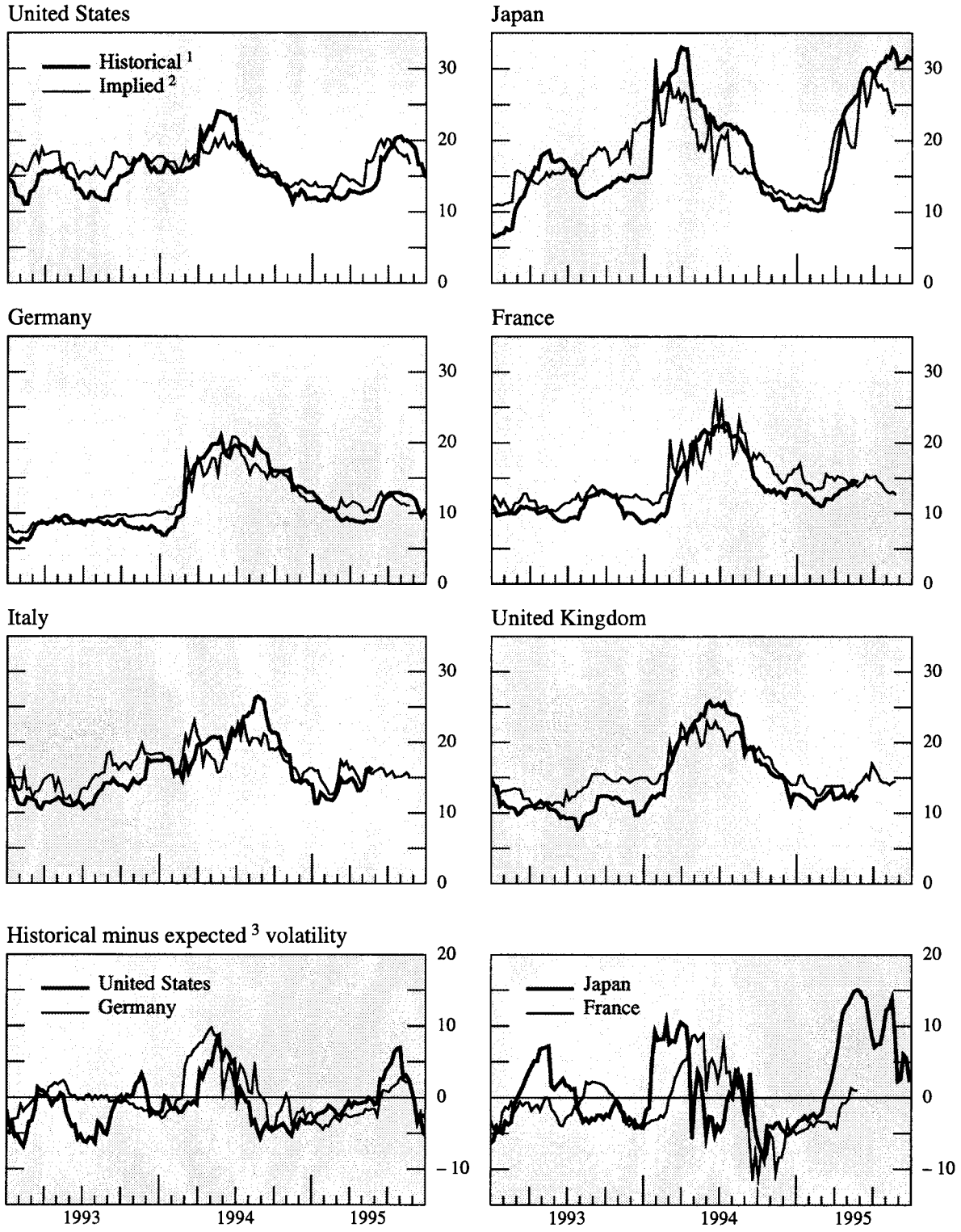
A final issue is the choice between *price* and *yield* volatility. Price volatility is the most useful measure of the variability of holding period returns. It would therefore be the natural choice in the context, say, of "value-at-risk" models. But when it comes to making international comparisons of volatility levels, yield volatility appears to be more appropriate. The reason is that it controls for differences in the duration of the bonds linked to differences in nominal yield levels and cash-flow profiles. This is also useful in longer-term time series when the benchmark bonds change.

As an illustration, consider the comparison between the benchmark US Treasury bond and its Swedish counterpart in mid-September 1995. The US security had a coupon of 6.5%, the Swedish instrument one of 6.0%. Since krona yields exceeded dollar yields by a sizable margin, the Swedish bond sold at a heavy discount; the US security, by contrast, traded close to par. As a result of the deep discount, the Swedish bond approached the long duration of a zero coupon bond. Measured in terms of yield, the implied volatility of the US security was higher, 18.2% against 16.5%. In terms of price volatility, however, the Swedish bond appeared to be considerably more volatile, 10.3% against 8.2%.

Graph 1

Bond yield volatility since 1993

In percentages



[1] Historical volatility is measured as the annualised standard deviation of daily percentage changes in bond yields calculated over the preceding ninety-one calendar days. [2] Yield volatility implied in three-month over-the-counter, at-the-money option contracts on ten-year benchmark government bonds, plotted at the time the contract is struck. [3] Expected volatility is implied volatility plotted at the time the contract expires so as to be aligned with historical volatility (e.g. the point in December is equal to the difference between historical volatility as plotted in December and implied volatility as plotted in September).

Sources: Datastream, J. P. Morgan and national data.

If implied volatility measures market expectations about realised volatility during the life of the option's contract, the evidence indicates two surprises in 1994: participants initially failed to anticipate the turbulence and subsequently overestimated its persistence (same graph, bottom two panels). This pattern, uniform across countries, suggests that implied volatility is firmly anchored to the behaviour of historical volatility in the proximate past.

A look at the rise in volatility from a longer-term perspective highlights both the scale and the unusual international incidence of the increase (Graph 2). Last year's rise appears to be the third such global episode since the beginning of the 1980s. The first two took place, respectively, in the early 1980s and around the stock market crash of 1987. In 1994 volatility reached close to record highs and persistence in some of the countries with the lowest interest rates and better inflation records, such as Germany and the Netherlands. In Europe, it also typically exceeded the levels observed at the time of the ERM turbulence in 1992 and 1993.

2. The possible explanations: market dynamics

2.1 Persistence

The most powerful feature of the dynamics of volatility is its tendency to persist over time, that is, to revert to its mean only gradually. This feature obviously leaves open the question of the force or forces that drive volatility up in the first place and thus cannot *explain* the events of 1994. Nevertheless, since an econometric evaluation of any other factor must take persistence into account, we report in Table 1 the relationship between implied bond volatility in two successive weeks as captured by the autoregressive coefficient. The power of this dynamic factor is evident: it accounts for anything as much as 58 to 93% of the variance of volatility.

Table 1

Persistence of implied bond yield volatility[1]

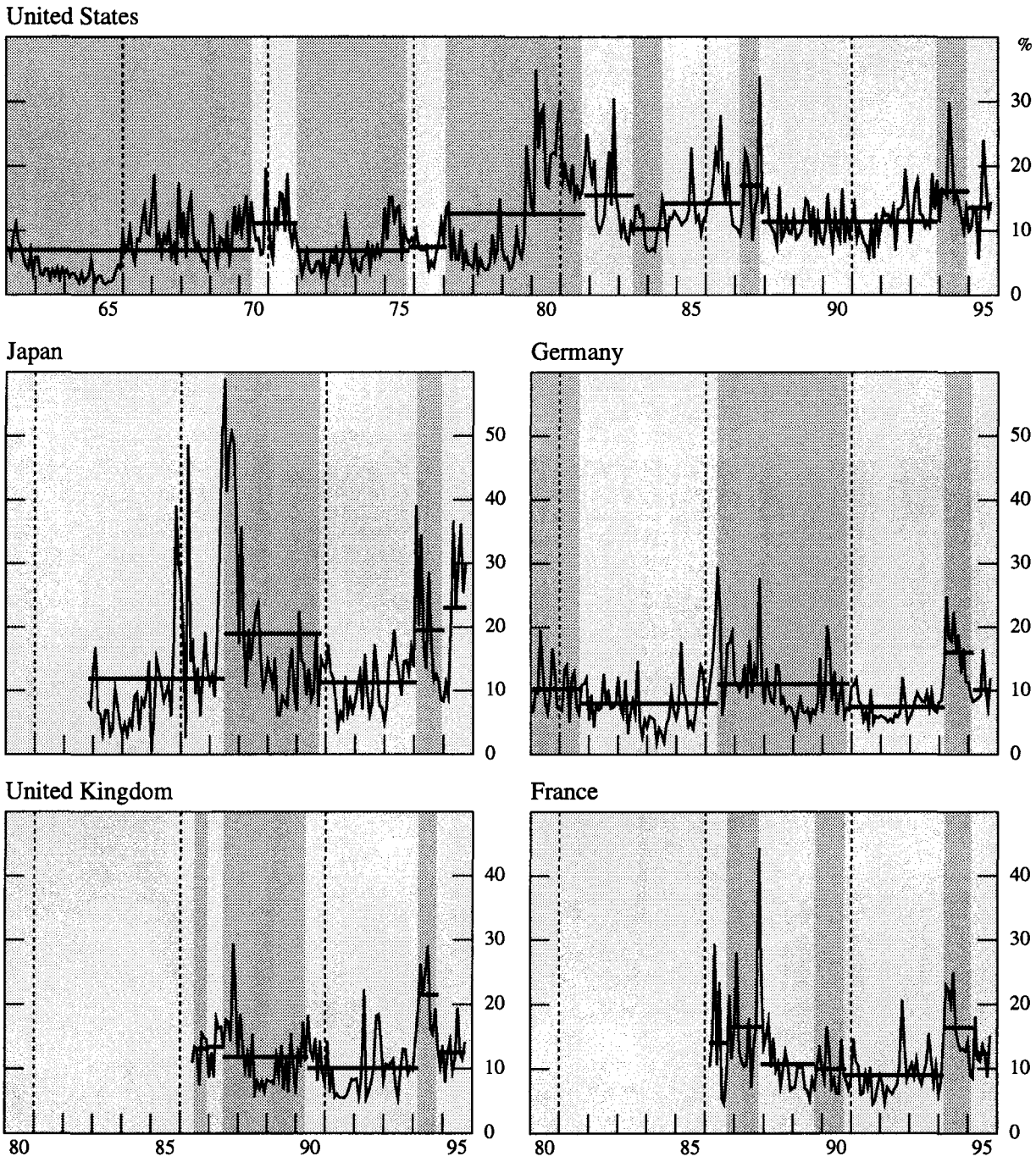
	Persistence parameter[2]	$\overline{R}^2$	**Sample begins on**[3]
United States	0.90***	0.81	31.08.92
Japan	0.93***	0.87	31.08.92
Germany	0.96***	0.93	31.08.92
France	0.90***	0.81	31.08.92
United Kingdom	0.96***	0.92	31.08.92
Italy	0.84***	0.73	31.08.92
Canada	0.95***	0.90	31.08.92
Belgium	0.94***	0.90	31.08.92
Netherlands	0.97***	0.94	31.08.92
Spain	0.77***	0.58	16.11.92
Denmark	0.92***	0.83	14.02.94
Sweden	0.94***	0.89	14.02.94
Australia	0.88***	0.77	21.03.94

Note: In this and subsequent tables and graphs, one, two and three asterisks denote statistical significance at the 10, 5 and 1% level respectively.

[1] Yield volatility implied in three-month over-the-counter at-the-money option contracts on ten-year benchmark government bonds. [2] Autoregressive parameter of AR(1) process estimated by OLS on weekly data. [3] The sample ends on 22.05.95 for all countries.

Graph 2

Bond yield volatility: a longer-term perspective



Note: Volatility is measured as the annualised standard deviation of daily percentage changes during calendar months in the yield on ten-year benchmark government bonds. The shaded (unshaded) areas represent bear (bull) markets and the horizontal lines the average volatility during these periods.

Sources: Datastream and national data.

2.2 Impact of market movements

The twenty-year-old observation (Black, 1976; Hentschel, 1995) that price declines in the stock market are associated with higher volatility applied with particular force to the 1987 crash. For the 1994 bond market decline, we find strong but not ubiquitous evidence that a rise in bond yields over a week pushed implied bond volatility at the end of that week higher (Graph 3). For eight of the thirteen countries, volatility appears directional in our sample period: it rises in response to declines in bond prices but fails to respond significantly to equivalent increases. The data suggest that the United States and Canada are exceptions in that implied volatility does not react at all to proximate market movements. Also, in Japan, Sweden and Spain the response appears to be symmetrical: increases and decreases in yields have a similar effect. The fairly precisely estimated magnitude of the effect of a market move is substantial; its one-third to one-half range suggests that a rise in long rates from 6 to 7% – a 16% increase – might raise volatility by 5 to 8 percentage points.

For Japan we hypothesise that two deflationary developments, the appreciation of the yen in early 1994 and again in early 1995, destabilised the bond market (and the money market, see below). These exchange rate movements would work to change expectations of the price level and set in train market anticipations of changes in short-term interest rates and in fiscal policy.

Our short period analysis of implied volatility finds reinforcement in a longer view of the behaviour of realised volatility (Loeys, 1994). In Graph 2 the shaded bear market periods appear to experience higher volatility as a general rule. Thus, in the German market, for example, recent events echo those during two previous bear markets: at the onset of German reunification and at the wearing-off of the euphoria of the 1986 oil price collapse.

It is difficult to say what lies behind the apparent directionality of volatility. Several potential explanations can be put forward. These include asymmetries in inflation risks (Friedman, 1977), in the ability and willingness of risk-averse market-makers to provide liquidity and in investors' reactions to market movements, especially if they hold leveraged portfolios. Explanations can also relate to option trading strategies and opportunistic issuing patterns by borrowers (Borio and McCauley, 1995). No doubt this is an area that merits further research.

2.3 Foreign disinvestment

Unlike in the 1987 stock market crash (Aderhold, Cumming and Harwood, 1988), international capital flows seem to have played a key role in the 1994 turbulence in the bond market. In particular, volatility rose significantly in continental Europe as foreign investors liquidated their holdings of government bonds.

The association between foreign selling and volatility is quite striking, as can be seen in Graph 4. For example, foreign investors liquidated over DM 13 billion of their holdings of German public debt securities in March 1994, a month in which implied bond volatility leapt by 4 percentage points. Regression analysis suggests that foreign liquidation of bonds of Fr.fr. 187 billion in France, DM 39 billion in Germany and Lit. 27 trillion in Italy in the first half of 1994[4] raised implied bond yield volatility in these markets by 14, 9 and 6 percentage points respectively. These estimated effects are not significantly tainted by any correlation between sales and market movements. Once directionality is allowed for, the estimated coefficients are very similar.[5]

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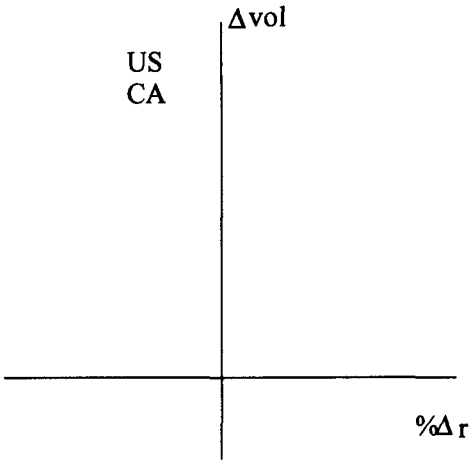
4 February to June for France and Germany; March to July for Italy.

5 In the case of France directionality actually drops out altogether. In those of Germany and Italy, at 7 and 5 percentage points respectively, the estimated influence of foreign rates is only slightly lower.

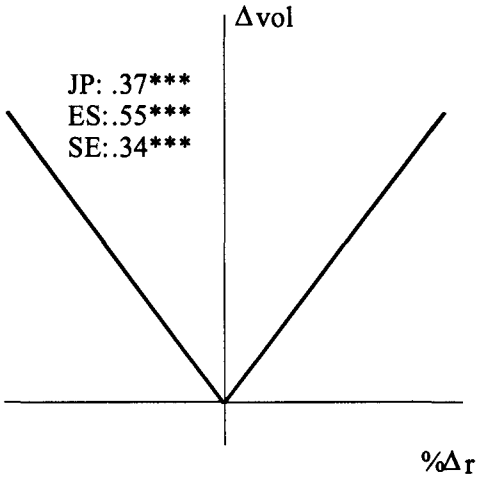
Graph 3

Stylised relationship between implied bond yield volatility and changes in bond yields[1]

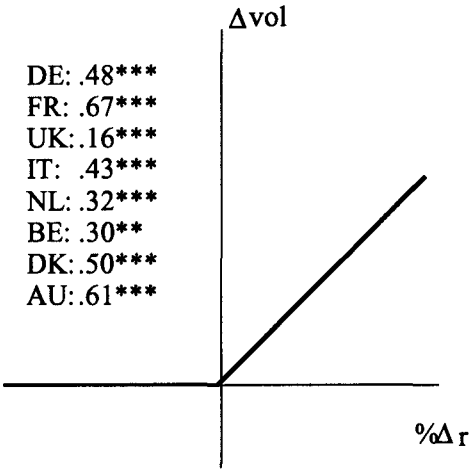
a. No relationship



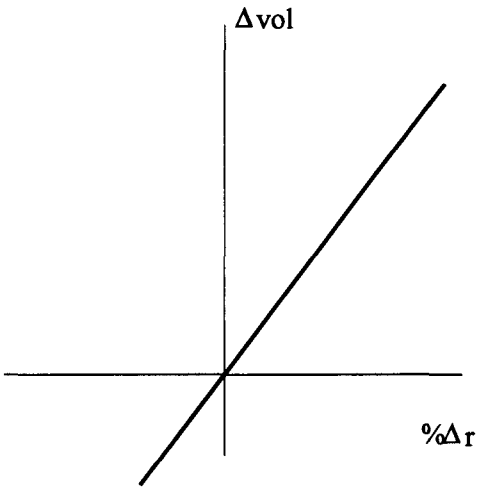
b. Symmetric (adaptive)[2]



c. Semi-directional[3]



d. Directional

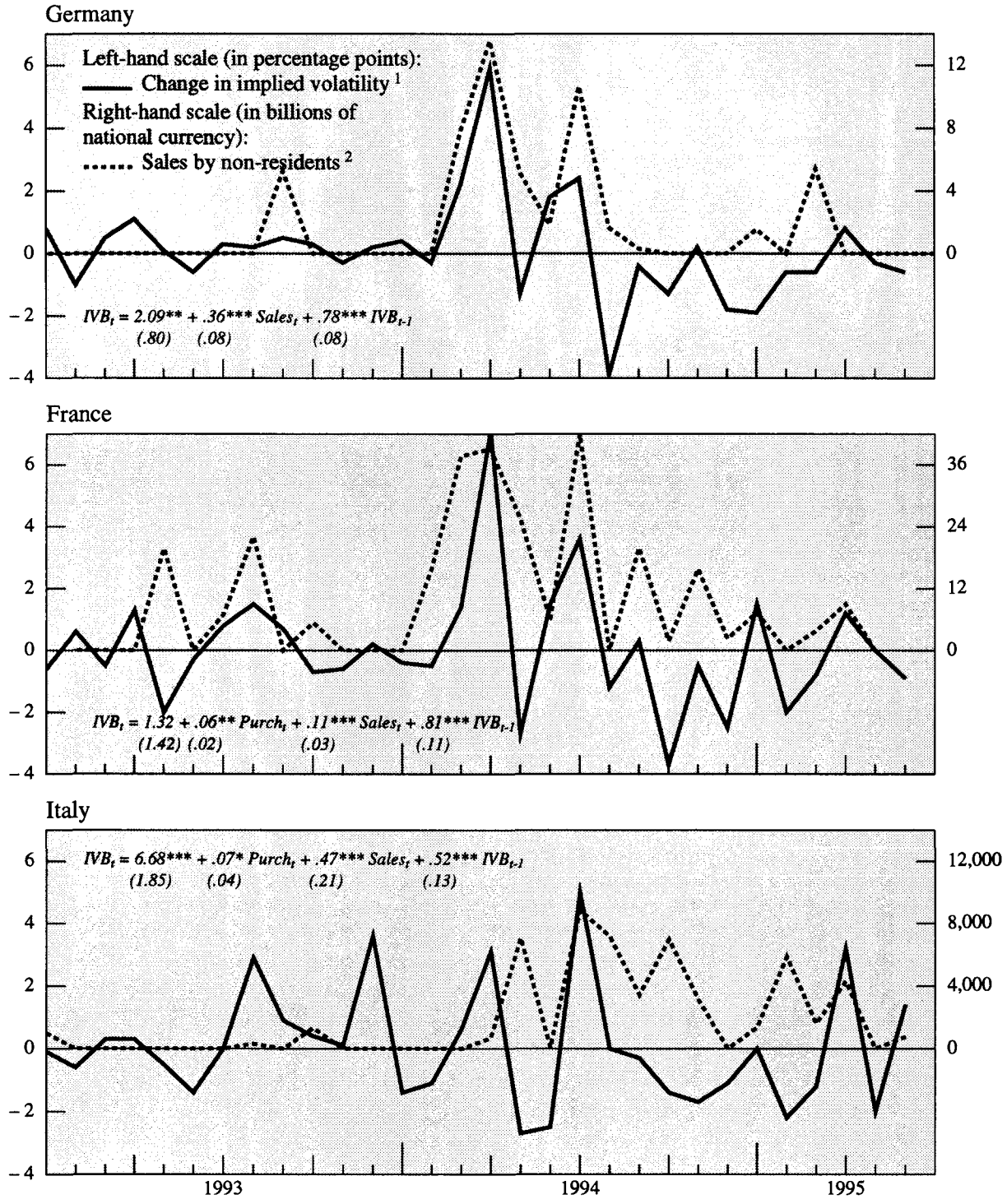


Note: AU: Australia; BE: Belgium; CA: Canada; DK: Denmark; FR: France; DE: Germany; IT: Italy; JP: Japan; NL: Netherlands; ES: Spain; SE: Sweden; UK: United Kingdom; US: United States.

[1] Coefficient estimates of the suitably transformed weekly percentage change in the bond yield (first difference in the logs; Friday to Thursday) in an AR(1) regression for implied bond yield volatility. [2] Coefficients on the absolute value of the change. [3] Coefficients on positive changes only.

Graph 4

Bond yield volatility and bond sales by non-residents in Germany, France and Italy



[1] As defined in Graph 1. [2] Net sales are truncated at zero. For Germany, public sector DM-denominated bonds; for France, OATs and BTNs; for Italy, BTPs.

Sources: J. P. Morgan and central banks.

In our view the relationship between foreign sales and volatility reflects the greater proclivity among foreign investors to leverage their holdings of bonds. As bond prices fell, leveraged investors had to sell, in the same way as shallow-pocketed equity investors receiving margin calls.

Table 2 indicates the large scale of leveraged bond investment leading up to 1994. It is presumed that bond investments by banks and securities firms can be taken as a sign of leverage owing to the predominantly short-term liabilities of these financial firms. The partial evidence suggests that banks' and securities firms' leveraged positions were building up at a rate of $50 billion per quarter in the course of 1993, only to shrink rapidly in the first two quarters of 1994. Note especially the activity of UK-based securities firms, likely buyers and sellers of European bonds.

Table 2

Selected indicators of leverage in international bond markets
(in billions of US dollars)

	1991	1992	1993	1994			
				Q1	Q2	Q3	Q4
United States	131	99	76	9	- 26	- 17	- 22
Commercial banks[1]	111	105	73	17	- 6	- 20	- 18
Securities dealers[1]	20	- 6	3	- 8	- 20	3	- 4
United Kingdom	19	53	136	- 43	- 18	0	..
Banks:[2] gilts	- 2	6	16	2	0	- 1	3
foreign bonds	15	24	52	- 5	- 1	7	19
GEMMs:[3] gilts	..	..	9	- 9	0	1	..
Securities dealers:							
foreign bonds	6	23	59	- 31	- 17	- 5	3
Total	150	152	212	- 34	- 44	- 17	..
Memorandum items:							
Interbank financed[4]	*7*	*54*	*182*	*- 54*	*- 48*	*- 1*	*17*
Repo financed:[5]							
Spain	..	*8*	*24*	*- 8*	*- 8*	*- 4*	*- 2*
Sweden	..	..	*13*	*- 5*	*- 3*	*- 6*	*2*

[1] Treasury and agency securities for banks and corporate and including also foreign bonds for securities dealers. [2] Including building societies. [3] Gilt-edged market-makers. [4] Cross-border interbank domestic currency lending by banks in Europe as an indicator of movements in non-residents' bond purchases hedged against exchange rate risk. [5] Indicators of Treasury bond purchases by non-residents financed through repos.

Sources: National data and BIS.

2.4 Market spillovers

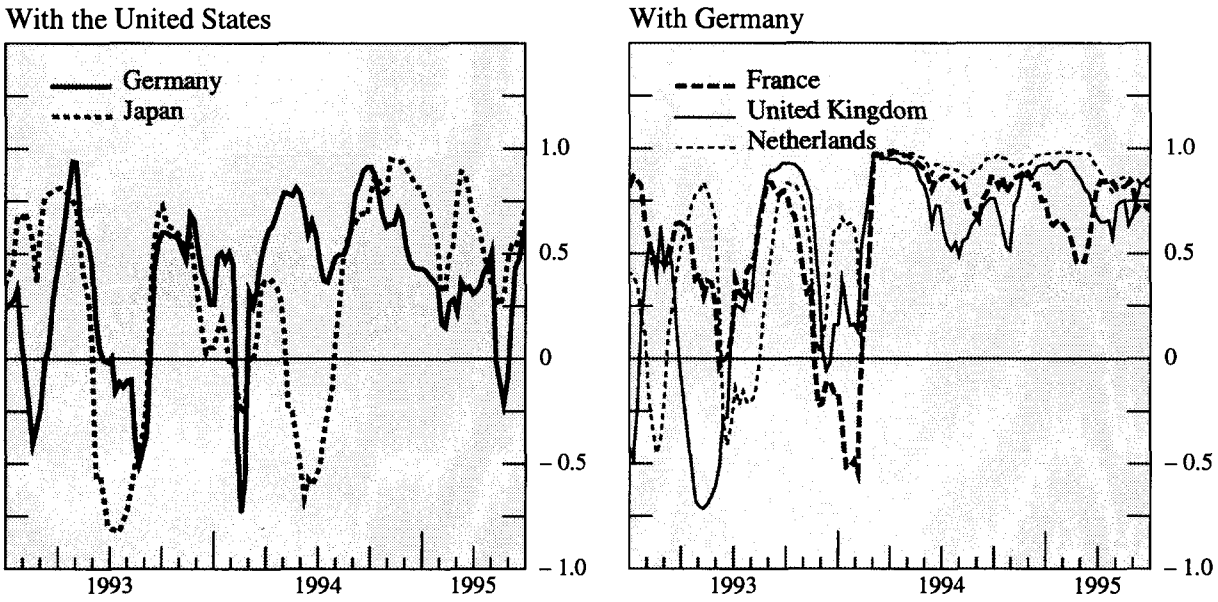
In October 1987 price changes in one market mimicked price changes in others. Studies of the 1987 stock market crash have indeed documented substantial spillovers of volatility across markets (Bennett and Kelleher, 1988; Hamao, Masulis, and Ng, 1990; King and Wadhwani, 1990). Such spillovers seem less a feature of the *usual* interrelations of global bond markets than of global stock markets. Nevertheless, in 1994 spillovers multiplied to create an interesting hierarchy of influence.

In contrast to the two other forms of market dynamics just discussed, spillovers cannot explain the general rise in volatility. That is, the market's decline and foreign disinvestment can be considered as (perhaps unsatisfactory) prime movers. Spillovers represent no more than a force that spreads volatility around.

Simple correlations show that bond yield volatility is more closely related across countries when volatility is high (Singleton, 1994). While 1993 saw quite variable patterns of volatility within the G-3 and across Europe, in 1994's highly volatile markets volatility co-varied considerably across borders; Japan was the exception (Graph 5).

Graph 5

International correlations of implied bond yield volatility *



* The correlation coefficient between weekly implied yield volatilities is calculated over a sixteen-week sliding window and is plotted at the point corresponding to the last observation.

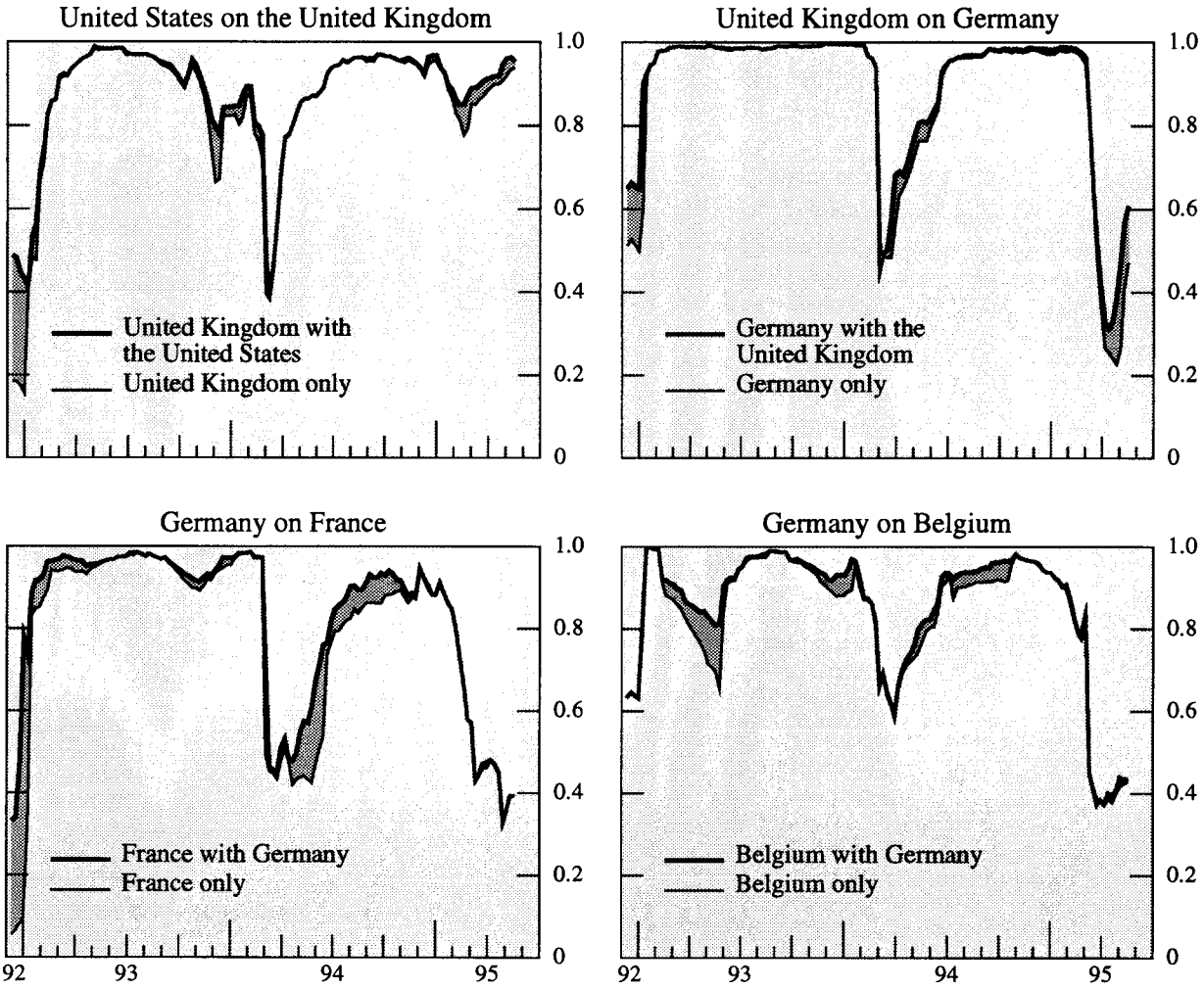
Sources: J. P. Morgan and BIS calculations.

Similarly, lagged volatility in a foreign market adds explanatory power to own lagged volatility when the effect of the latter falters (Graph 6). We find that such spillovers vary in size and direction over time.[6] They were sparse before the US tightening of monetary policy in February 1994, with Frankfurt and London each exerting some influence on other European markets (Graph 7). They became much more pervasive thereafter, when New York broadcast its volatility widely and London appeared to transmit its volatility to continental Europe (Graph 8).

6 The tests were based on AR(1) regressions for market *i* to which the previous week's volatility on market *j* was added. The picture presented here is a simplified one. For a more comprehensive map, see Borio and McCauley (1995).

Graph 6

The explanatory power of persistence and spillovers: rolling regressions *

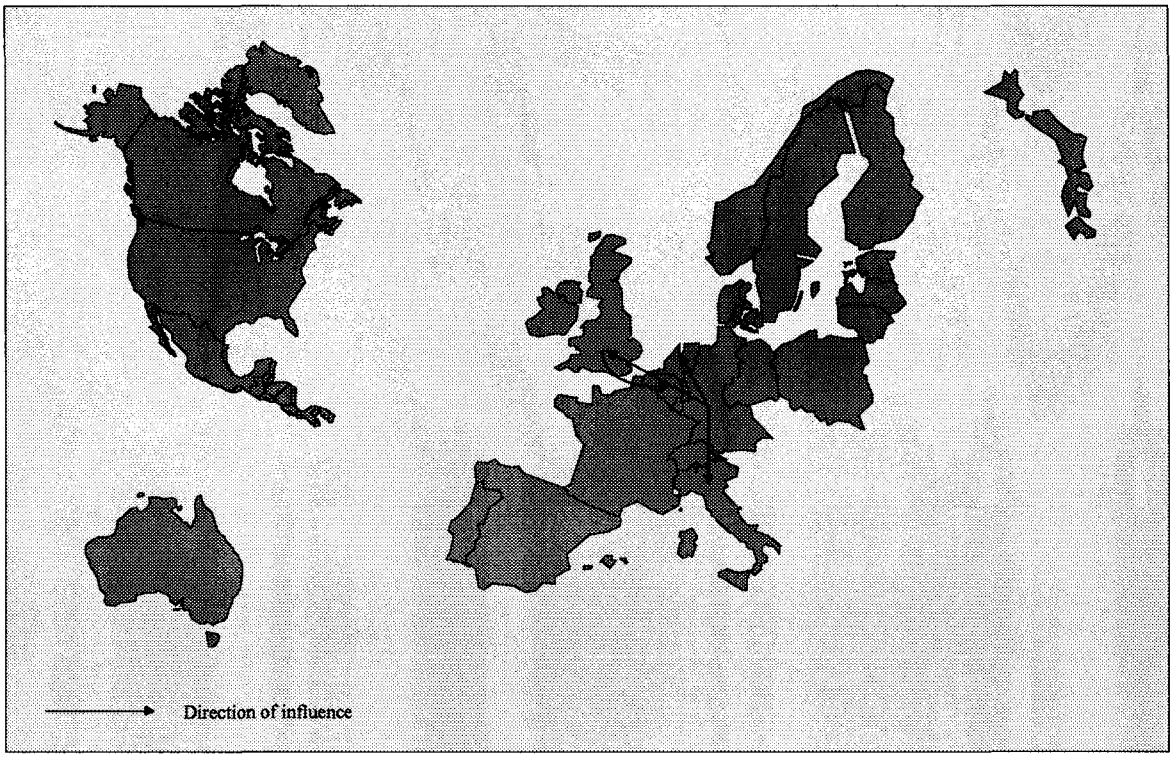


* Uncentred $\bar{R}^2$ from (de-meaned) AR(1) rolling regressions for market i to which the previous week's volatility in market j is added. The regressions are run over a sixteen-week window.

Graph 7

Volatility spillovers

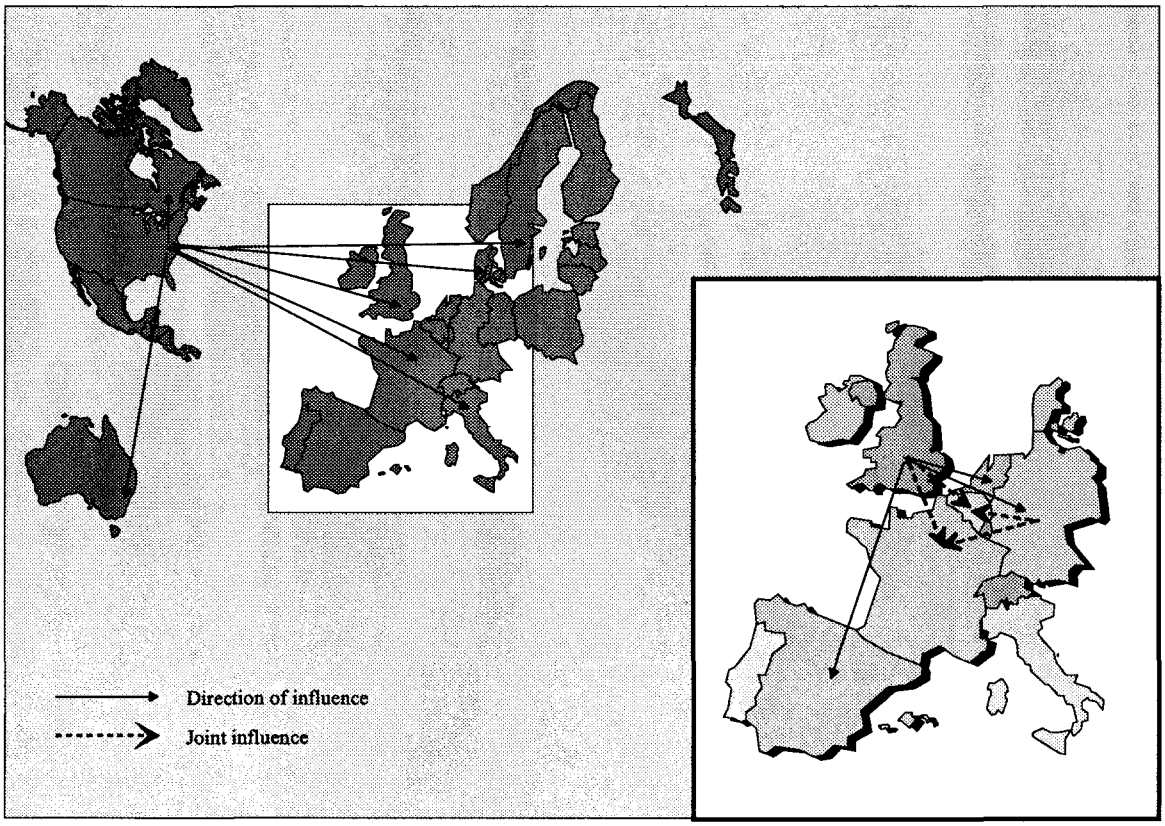
August 1992-January 1994



Graph 8

Volatility spillovers

February 1994-May 1995



3. The possible explanations: domestic economic factors

Domestic economic factors, including the inflation record and money market volatility, help to explain cross-sectional differences in bond volatility. They do not, however, offer much help in explaining the 1994 episode. In particular, changes in expected inflation and growth did not correspond to changes in volatility.

3.1 Inflation performance and expectations

Inflation performance and expectations set the background level of volatility. For evidence, consider the US time series and the cross-section of European countries.

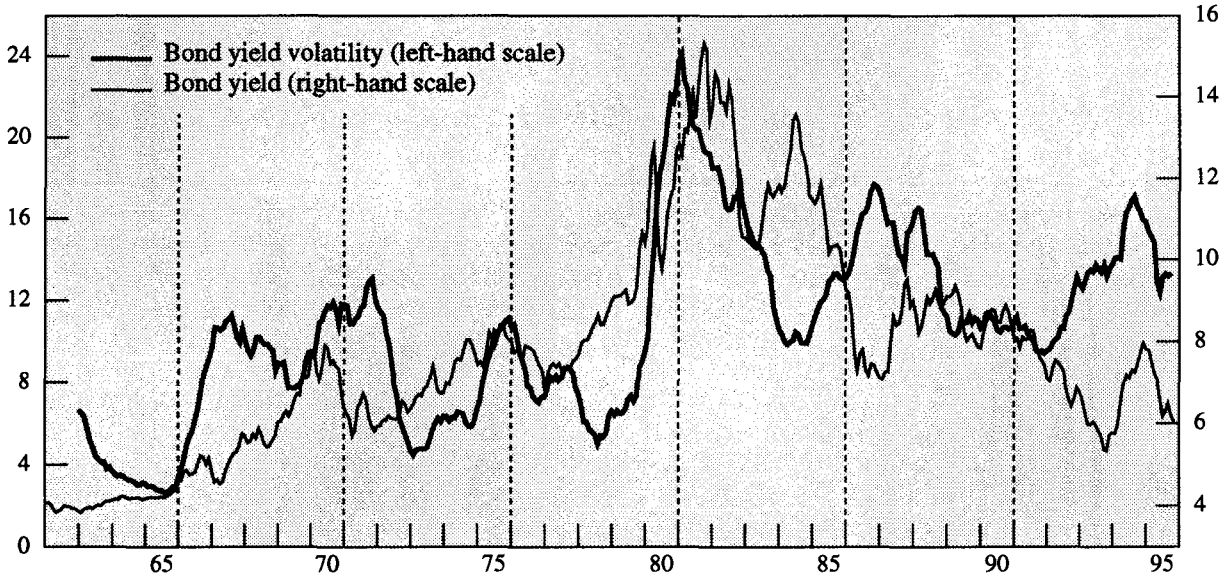
In the 130 years following the Civil War, the most volatile period in US bond markets was the spell of record-high rates fifteen years ago (Wilson, Sylla and Jones, 1990). If inflationary expectations drive yields, then the highest inflation expectations in US history produced the highest yield volatility. A moving average of monthly yield volatility of the ten-year bond peaks in common with yields early in the 1980s (Graph 9).

Within Europe, lower-inflation economies enjoy generally less volatile bond markets. In both 1993 and 1994, the excess of yield volatility of Italian government bonds over that of their German counterparts more or less matched the 4 to 5 percentage point excess of Italian government bond yields over German yields (Graph 10). If international differences in bond yields reflect inflation performance and expectations (as filtered through exchange rate expectations), then higher volatility joins higher yields as the price of inflation.

Graph 9

Volatility and the ten-year Treasury bond yield in the United States *

In percentages

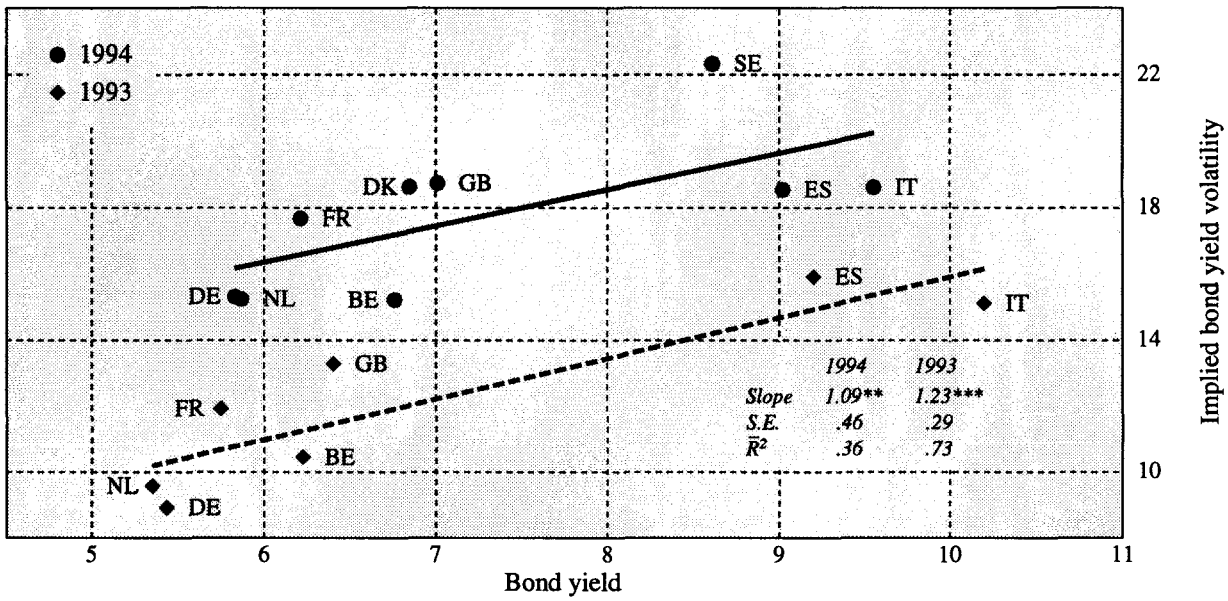


* Volatility is measured as the twelve-month moving average of the annualised standard deviation of daily percentage changes during calendar months.

Graph 10

Implied bond yield volatility and yields in European bond markets

Averages of weekly data, in percentages



Sources: J. P. Morgan, Datastream and national data.

3.2 Revisions of inflation and growth expectations

While volatility reflects long-term inflation performance, changes in volatility in 1994 bore little relation to market participants' revisions of inflation expectations. What is more, the same negative result holds in the case of changes in growth expectations (Table 3). True, some important instances did suggest a relationship; the striking revision of estimates of German growth in the first half of 1994 is one such example. But the relationship does not seem to possess any generality. More formal econometric evidence supports this conclusion (Borio and McCauley, 1995). We have not, however, abandoned this relationship altogether. We are in the process of investigating the explanatory power of changes in the cross-sectional dispersion of opinion (Consensus Economics, 1992-95).

Put differently, our evidence indicates that if expectations about inflation and output growth played a role in the rise of volatility then this role was only indirect, i.e. it operated through their impact on the *level* of yields and hence through one of the identified market dynamics. Whether the sharp increase in bond yields last year was itself fully explicable in terms of fundamentals is a question not addressed here, but one about which some doubts remain (BIS (1995)).

Table 3

Volatility of market participants' growth and inflation forecasts

(in percentage points)

	Growth[1]			Inflation[1]		
	1993[2]	1994[2]	change	1993[2]	1994[2]	change
United States	0.11	0.10	- 0.02	0.08	0.03	- 0.05
Japan	0.25	0.07	- 0.17	0.06	0.06	- 0.01
Germany	0.17	0.17	0.00	0.04	0.05	0.01
France	0.16	0.06	- 0.11	0.10	0.06	- 0.04
Italy	0.09	0.14	0.05	0.10	0.06	- 0.04
United Kingdom	0.06	0.05	- 0.01	0.08	0.15	0.07
Canada	0.06	0.07	0.00	0.06	0.16	0.09
Belgium	0.15	0.07	- 0.08	0.07	0.06	- 0.01
Netherlands	0.12	0.11	0.00	0.07	0.08	0.01
Spain	0.10	0.07	- 0.03	0.12	0.08	- 0.05
Sweden	0.10	0.10	0.00	0.08	0.13	0.05
Australia	0.16	0.12	- 0.04	0.09	0.10	0.01

[1] Standard deviation of the monthly changes in the forecast for average annual GDP growth and consumer price inflation respectively over two years. [2] Year in which forecasts are made.

Sources: © The Economist, London (various issues), and BIS calculations.

3.3 Money market volatility

In the cross-section, money market volatility was associated with bond market volatility across a dozen markets in 1994 (Graph 11). We measure money market volatility as the standard deviation of the daily percentage change in three-month LIBOR three months forward in order to avoid the very close control of the central bank over the shortest rates.

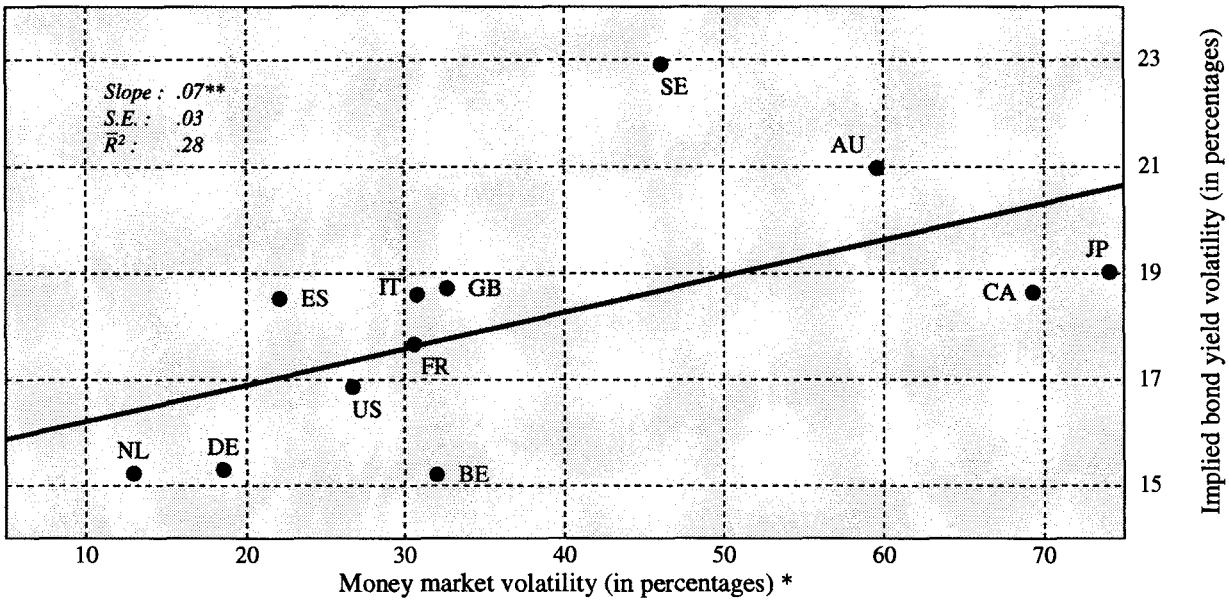
On the basis of the time series, we find evidence of a relationship between *realised* money volatility and *implied* bond volatility in almost all of the markets considered. The relationship in Tokyo is clearly apparent, especially in January 1994, when the rise in bond yield volatility echoed instability in the money market (Graph 12).

For seven of the thirteen markets, money and bond market volatility co-vary significantly at the weekly frequency (Table 4). In the United States, Germany, the United Kingdom, the Netherlands, Spain, Denmark and Sweden, 1 or 2% of (Friday through Thursday's) money market volatility shows up in the respective Thursday close bond volatilities.

More volatile money markets tend to show a significant influence on the respective bond markets only at the monthly frequency (same table). In Japan, France, Belgium and Australia, money market volatility shows a generally stronger effect on bond volatility.

Graph 11

Implied bond yield volatility: relationship with money market volatility



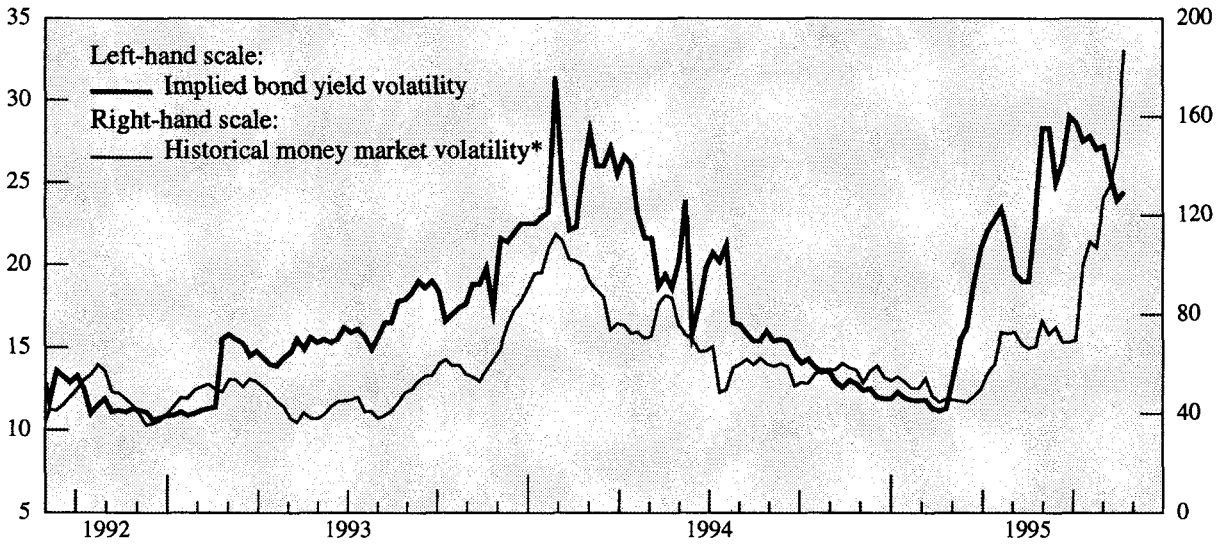
* Annualised standard deviation of the daily percentage change in the yield on three-month LIBOR three months forward; monthly average for 1994. The measure avoids the direct influence of the authorities on spot short-term rates and is therefore a better indicator of market expectations.

Sources: J. P. Morgan, national authorities and BIS.

Graph 12

Implied bond yield volatility and historical money market volatility in Japan

In percentages



* Annualised weekly volatility, calculated over a one-week window, with an imposed zero mean; nine-week moving average.

Sources: J. P. Morgan and national authorities.

Table 4

Implied bond yield volatility and realised money market volatility: regression results[1]

	Weekly			Monthly[2]		
	Whole sample	**Earlier period**	**Later period**	**Whole sample**	**Earlier period**	**Later period**
United States	0.012**	0.005	0.018**	0.006	- 0.027	0.036
	(0.005)	(0.006)	(0.007)	(0.024)	(0.029)	(0.040)
Japan	0.004	0.018	- 0.005	0.066***	0.041***	0.095*
	(0.007)	(0.011)	(0.008)	(0.019)	0.014	(0.053)
Germany	0.025**	0.010	0.032**	0.006	0.032	- 0.046
	(0.010)	(0.008)	(0.015)	(0.059)	(0.062)	(0.107)
France	0.005	0.004	0.010	0.044**	0.030**	0.118**
	(0.005)	(0.005)	(0.012)	(0.017)	(0.012)	(0.052)
Italy	0.011	0.011	0.017*	0.008	0.005	0.030
	(0.010)	(0.015)	(0.009)	(0.011)	(0.014)	(0.052)
United Kingdom	0.009*	0.011*	0.015	0.004	0.006	0.038
	(0.005)	(0.005)	(0.017)	(0.016)	(0.017)	(0.110)
Canada	0.004	0.009*	0.001	0.004	0.023	- 0.008
	(0.003)	(0.005)	(0.002)	(0.010)	(0.014)	(0.012)
Belgium	- 0.003	0.004	- 0.012	0.025[3]	0.008	0.062***
	(0.006)	(0.003)	(0.010)	(0.015)	(0.006)	0.014
Netherlands	0.017***	0.001	0.054***	0.009	- 0.004	0.053
	(0.006)	(0.004)	(0.017)	(0.021)	(0.016)	(0.084)
Spain	0.006		0.003	0.018	0.037	0.017
	(0.006)		(0.010)	(0.016)	(0.026)	(0.025)
Denmark[4]			0.020*			0.063
			(0.011)			(0.057)
Sweden[4]			0.023*			0.070**
			(0.009)			(0.031)
Australia[4]			0.009			0.049
			(0.008)			(0.029)
Japan (period split at end-1993)	0.004	0.004	0.003	0.066***	0.035**	0.090***
	(0.007)	(0.007)	(0.010)	(0.019)	(0.015)	(0.029)

[1] The table shows the coefficient of money market volatility in an AR(1) regression for implied bond yield volatility. The data are weekly. Money market volatility is measured as the standard deviation (around an imposed zero mean) of the implied three-month LIBOR three months forward calculated over non-overlapping one-week horizons (Friday to Thursday). Standard errors are shown in brackets. Blanks indicate missing data. [2] Month-average data. [3] Marginal significance level equal to 10.06%. [4] Data are missing for earlier period. See Table 1.

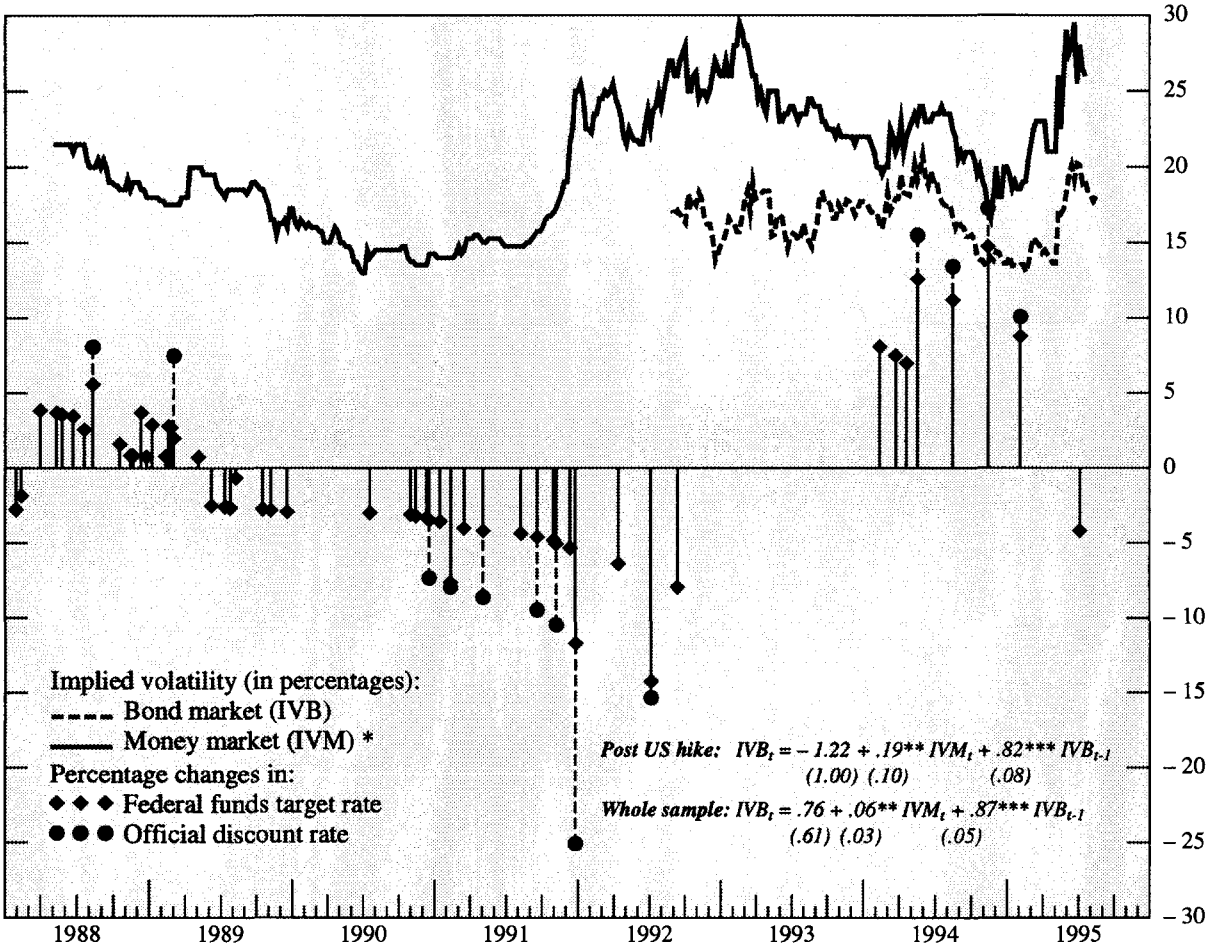
The link between money market and bond market volatility seems to have strengthened in 1994. For instance, in the United States there was no significant transmission of volatility along the yield curve before February 1994, but thereafter 2% of money market volatility appeared in bond volatility.

The tightening of the relationship between money and bond volatility becomes evident when US *implied*, rather than *realised*, money volatility is juxtaposed to implied bond volatility (Graph 13). Moreover, with the benefit of these data, the transmission of volatility gains strength, from 1-2% to some 5% over the whole period and to 20% after February 1994. This result suggests

that our crude measure of realised weekly money volatility may understate volatility transmission by a factor of 4 or 5 over the whole sample.[7]

Graph 13

Implied bond yield and money market volatility and monetary policy in the United States



* Derived from three-year caps on three-month LIBOR.

Sources: Chase Manhattan, J. P. Morgan and the Federal Reserve Board.

On balance, international differences in money market volatility of 40 percentage points or more suggest a fairly weighty role for this factor in the cross-sectional analysis. But even our high estimates of volatility transmission along the yield curve point to only a modest role for money market volatility in making sense of the turbulence of bond markets in 1994.[8] In fact, in a number of countries, money markets were actually more stable in 1994 than in 1993. And for the countries where both money and bond market volatility rose in 1994, the increase in money volatility was too modest to explain much of the rise in bond volatility.

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7 In Borio and McCauley (1995) an additional econometric procedure is used to quantify this bias. The estimates indicate that the adjustment typically varies between 2 and 5 across countries.

3.4 Fiscal policy uncertainty

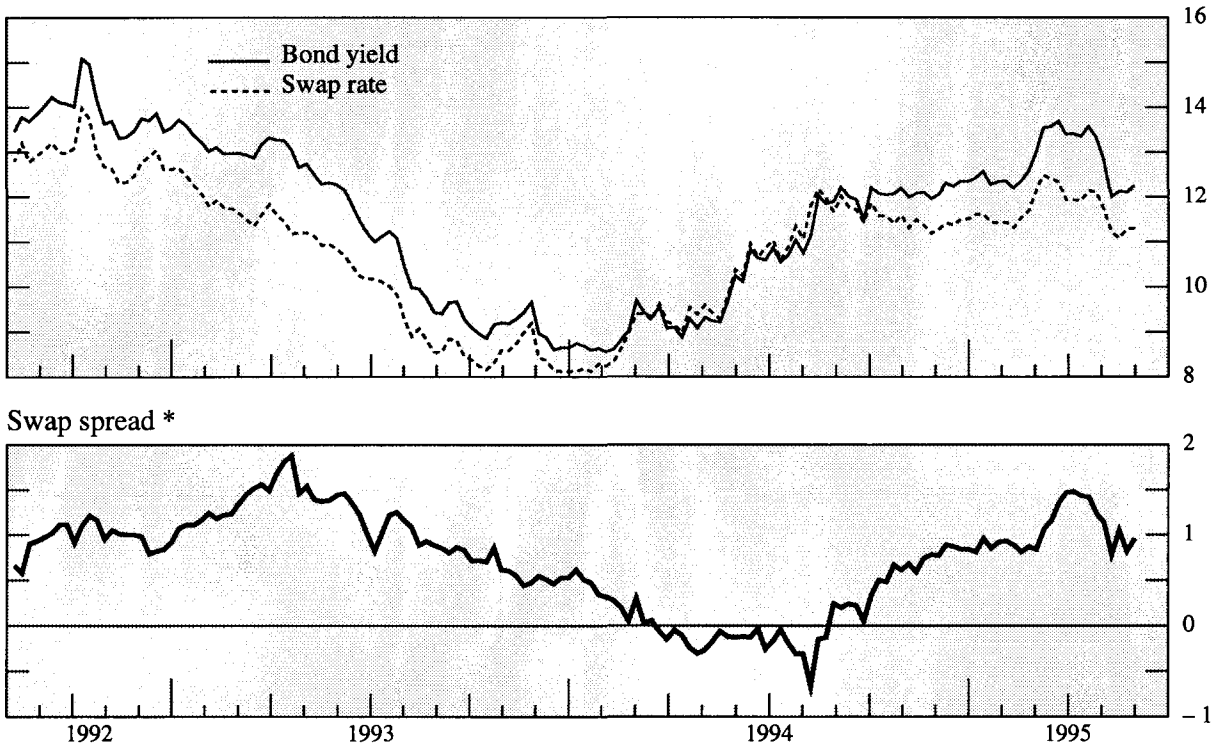
We are able to measure the variation in market participants' views about fiscal policy at a high frequency only for one country. Italy's government debt is so large that movements in the spread between government and private fixed rate borrowing costs largely reflect changing judgements about fiscal policy. In other markets, they mirror primarily movements in private sector default risk, and hence the business cycle, as well as other specific demand and supply factors. In fact, in Italy the configuration of private and public debt rates is unique in favouring private debtors. The best of these can raise long-term funds on better terms than those enjoyed by the Italian Government (Giovannini and Piga, 1992; Banca d'Italia, 1995).

At times the rise in Italian government yields and the associated increase in volatility seem to have reflected the deterioration in the Government's credit standing. Yields on Italian government bonds rose in relation to the cost of private debt in the summer of 1994, when investors' hopes for a businesslike budget process waned, and again in March 1995, when events in Mexico turned investors against financing unsustainable debts, whether domestic or external (Graph 14).

Graph 14

Government bond yield and swap rate in Italy

In percentages



* Difference between the ten-year benchmark government bond yield and the ten-year swap rate.

Sources: Datastream and Reuter.

8 Moreover, the causal link may even have run from bond to money market volatility. As leveraged investors unwound their holdings of bonds, the reduction in their demand for short-term funds may have disturbed money markets.

Regression analysis suggests that in Italy a 10 basis point widening of the spread between public and private debt costs pushes up implied bond yield volatility by a third of a percentage point. Accordingly, the widening of the swap spread in the late summer of 1994 would account for around 2 percentage points of the rise in volatility during that period.[9]

This widely appreciated but hitherto unquantified impulse to Italian bond yield volatility has no obvious parallel in other countries. Until some such evidence is found for the other dozen markets considered, we must provisionally judge the role of fiscal uncertainty in 1994's bond market turbulence to be specific to one market rather than a general factor.

Conclusions

The observation that the highest volatility ever recorded in US bond markets occurred fifteen years ago cautions against many popular conceptions. The highest volatility did not require developed markets for bond futures and options, new forms of leveraged investment or even a substantial presence of foreign investors.

That said, in the bond market turbulence of 1994 we find more evidence of the bond market's own dynamics at work than of measurable uncertainty regarding fundamental macroeconomic and financial factors.

Let us step back and compare the 1994 bond market decline with the 1987 stock market crash. Obviously, the bond market decline was a more diffuse and less global event. The notion that at least some markets were overvalued is probably more widely accepted for the 1987 stock market crash than for the 1994 bond market decline (Hardouvelis, 1988; Bank for International Settlements, 1995).

In terms of the market dynamics which we have emphasised, both incidents reinforce the connection between bear markets and high volatility. An interesting question might be whether the stock market returned to normal volatility faster than did global bond markets in 1994. Both incidents saw an intensification of spillovers and a broadening of their geographical scope. But the importance of foreign disinvestment distinguishes the 1994 bond market decline from the 1987 crash, and this may make it more modern. Similarly, foreign investors' extensive use of leverage sets the 1994 episode apart from the crash of 1987, when leverage remained a domestic phenomenon.

The role of fundamentals in the two cases remains problematic. In 1987 observers vaguely pointed to the effect of interest rate volatility, including that associated with Japanese disinvestment in US bonds, to frictions between the US and German authorities and to other factors. For our part, we have had little success in linking revisions of growth and inflation expectations to the pattern of increases in bond yield volatility last year. And there is just a little weight to be given to the view that increased uncertainty regarding monetary policy drove up bond volatility.

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9 The preferred equation included only positive changes in the swap spread (ΔSP^+) and positive percentage changes in the swap rate (ΔRW^+, approximated by the first difference in the logs) as controlling variable. Asymmetries are again at work:

$$IVB_t = 2.76^{***} + 2.92^{*}\Delta SP^{+} + 0.44^{***}\Delta RW^{+} + 0.80^{***} IVB_{t-1}$$
$$\quad (0.65) \quad (1.54) \qquad (0.11) \qquad (0.04)$$

References

Aderhold, R., C. Cumming and A. Harwood (1988): "International linkages among equities markets and the October 1987 market break". Federal Reserve Bank of New York *Quarterly Review*, 13(2), pp. 34-46.

Banca d'Italia (1995): *Annual Report*, 1994.

Bank for International Settlements (1995): *65th Annual Report,* Basle.

Bennett, P. and J. Kelleher (1988): "The international transmission of stock price disruption in October 1987". Federal Reserve Bank of New York *Quarterly Review*, 13(2), pp. 17-33.

Black, F. (1976): "Studies of stock price volatility changes", in *Proceedings of the Business and Economic Statistics Section.* American Statistical Association, pp. 177-181.

Borio, C.E.V. and R.N. McCauley (1995): *The economics of recent bond yield volatility*, BIS mimeograph.

Consensus Economics (1992 and 1995, various issues): *Consensus forecasts: a digest of international forecasts.*

Friedman, M. (1977): "Nobel lecture: inflation and unemployment". *Journal of Political Economy*, 85, pp. 451-472.

Giovannini, A. and G. Piga (1992): "Understanding the high interest rates on Italian government securities". Centre for Economic Policy Research, 720.

Hamao, Y., R.W. Masulis and V. Ng (1990): "Correlations in price changes and volatility across international stock markets". *The Review of Financial Studies*, 3(2), pp. 281-307.

Hardouvelis, G.A. (1988): "Evidence on stock market speculative bubbles: Japan, the United States, and Great Britain". Federal Reserve Bank of New York *Quarterly Review,* 13(2), pp. 4-16.

Hentschel, L. (1995): "All in the family: nesting symmetric and asymmetric GARCH models". *Journal of Financial Economics*, 39, pp. 71-104.

King, M.A. and S. Wadhwani (1990): "Transmission of volatility between stock markets". *The Review of Financial Studies*, 3(1), pp. 5-33.

Loeys, J. (1994): "Strategies in bear bond markets", in *Volatile markets: risks and opportunities*, J.P. Morgan, pp. 1-15.

Market Risk Task Force, International Swaps and Derivatives Association, Inc. (1995): *Planned supplement to the capital accord to incorporate market risks: comment*, 31st July.

Singleton, K.J. (1994): "Persistence in international interest rate correlations". Prepared for the Berkeley Program in Finance, September.

Watts, M. (1994 and 1995, various issues): "Global options analysis". J.P. Morgan Securities, Ltd., London.

Wilson, J.W., R.E. Sylla and C.P. Jones (1990): "Financial market panics and volatility in the long run, 1830-1988", in E.N. White (ed.), *Crashes and panics: the lessons from history*, Homewood, Il.: Dow Jones-Irwin.