Common movements in volatilities[1]

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Introduction

Observers of markets in 1994 were surprised by the movements in bond volatilities that followed the shift in US monetary policy early in the year. The paper begins by discussing volatility movements in a few equity and bond markets over the past 10-15 years. The paper focuses on volatilities of returns rather than volatilities of prices or yields because return volatility is most directly related to performance of portfolios of assets. The paper investigates whether some of the movements in volatilities observed over the past 15 years can be accounted for by a small set of observable economic variables. The approach is an extension of the GARCH models often employed to describe volatility in international bond and equity returns to include several financial and macro variables in the set of conditioning variables for volatility. Bond and equity returns for Canada, France, Germany, Japan, the Netherlands, Switzerland, the United Kingdom and the United States are modeled.

The paper shows that observable variables can help predict volatility. The paper also provides descriptive evidence that observable variables can be important for explaining movements in volatilities. However, the descriptive evidence suggests that the observable variables considered here are not particularly helpful in predicting situations when volatilities will become very high.

1. Volatility in four national markets

The paper begins by reviewing historical volatility developments in four countries: Germany, Japan, the United Kingdom and the United States. Price volatility for national equity indices and return volatility for ten-year government bonds are discussed. Recent equity volatility in these countries does not seem exceptional by historical standards. While government bond volatility rose in 1994, high values were only observed in the United Kingdom and Germany.

Figure 1 shows monthly standard deviations of daily price movements in equity indices for Germany, Japan, the United Kingdom and the United States. The charts indicate that the major development over the past ten years was the 1987 crash, which was reflected in all four markets. Behavior of volatility in the 1990s has differed across these markets. German volatility was high around the period of unification but has not been extraordinarily high in the past two years. Japanese equity volatility has been quite high in the 1990s relative to most of the 1980s. UK volatility has been moderate lately and US equity volatility has been fairly low in 1994 and 1995.

1 The empirical analysis in this paper draws heavily from my paper "Why do volatilities sometimes move together?", FRBNY, September 1995.

2 Views expressed in this paper are those of the author and do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System.

Figure 1

Historical equity volatility

(monthly standard deviation of daily capital gains)

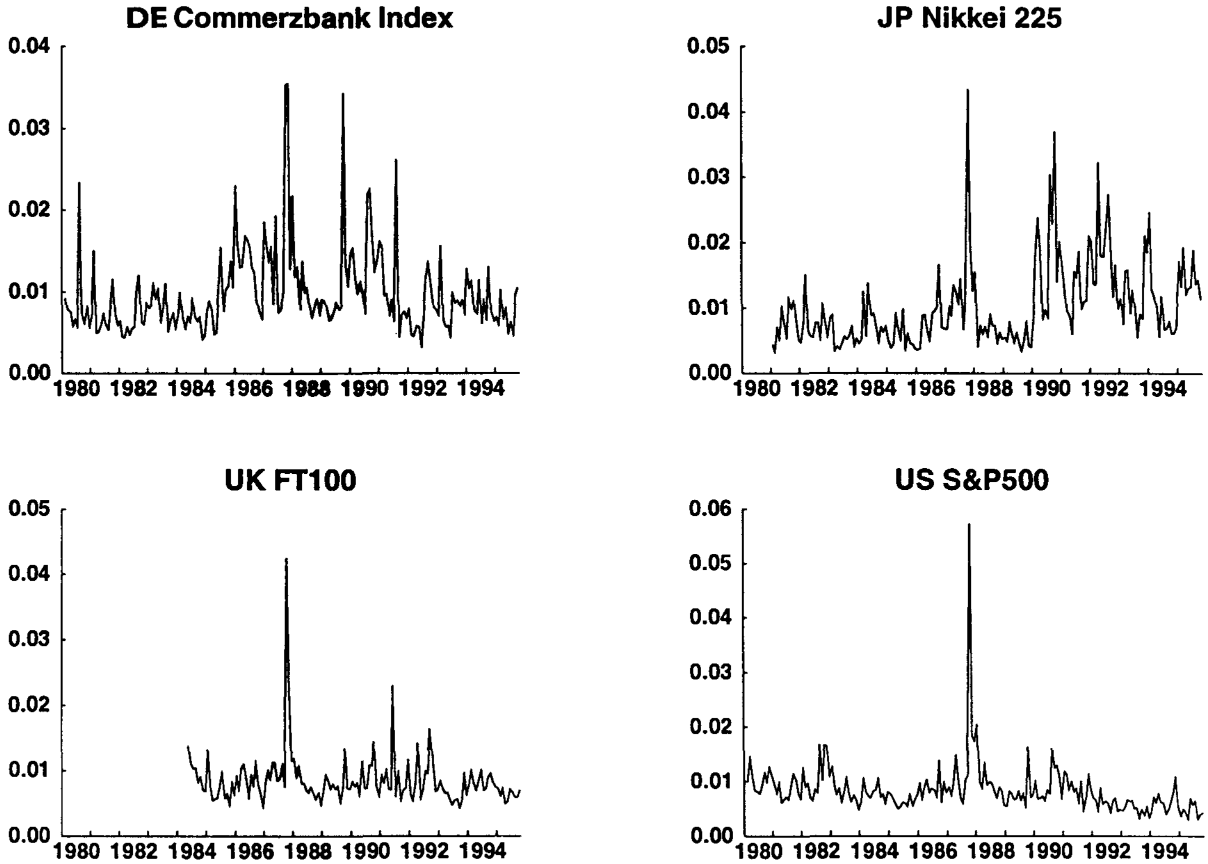

Figure 2 shows monthly standard deviations of daily returns for ten-year government bonds. Returns on the ten-year bonds are approximated from yields using a result in Shiller, Campbell, and Schoenholtz (1983).[3] While high volatilities occurred in all four bond markets in 1987, the experiences since that time are fairly different. Both German and UK bond volatility was quite high in 1994 by the standards of much of the 1980s. In contrast, Japanese and US bond volatility in 1994 and 1995, while higher than 1992 and 1993, did not reach levels reached in the 1980s or early 1990s in the case of Japan.

2. Literature review

A simple but fairly powerful statistical description of returns is the factor model for returns:

$$e_t = E_{t-1}(e_t) + \beta_t \cdot f_t + \varepsilon_t,$$

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3 Specifically, the calculations use the result that the duration of a bond trading at par is:

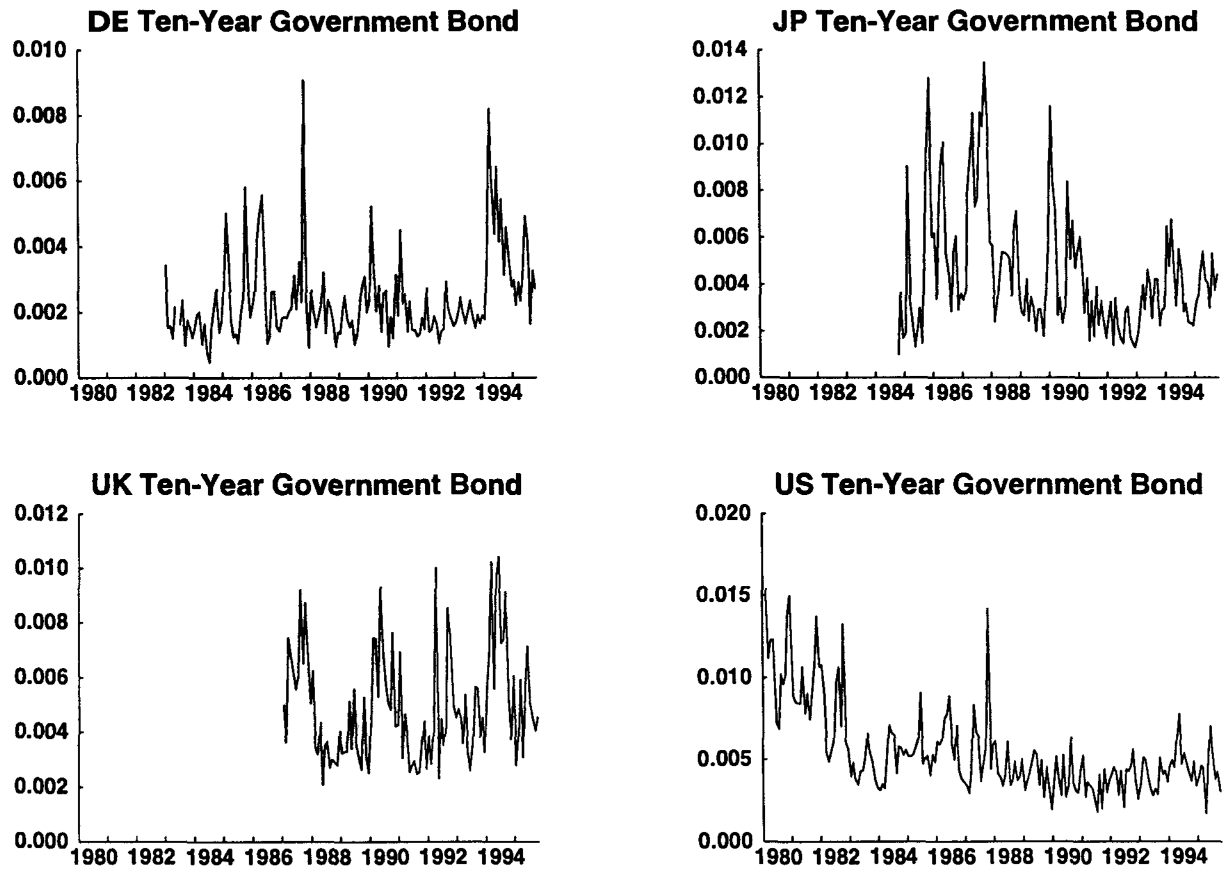
$$D = \left(1-(1+y)^{-n}\right)/\left(1-(1+y)^{-1}\right),$$

where D is the duration, y is the yield and n is maturity in years. Thus, the return on a bond trading near par is approximately $-D \cdot \Delta y/(1+y)$.

Figure 2

Historical bond volatility

(monthly standard deviation of daily returns)



where $e_t = r_t - r_{0,t}$ represents ex post excess returns on assets - the difference between ex post returns r_t and the risk-free rate $r_{0,t}$, $E_{t-1}(e_t)$ is expected excess returns conditional on information available through the previous period, f_t is a set of factors representing non-diversifiable risk, and ε_t is a set of asset-specific shocks. This type of model typically requires restrictions from economic theory to derive expected returns. Although this paper is not concerned with imposing these restrictions, arbitrage pricing theory (APT) provides a set of restrictions on expected returns.[4]

For the purposes of this paper, it is mainly of interest that the factors can include both observable variables and unobservable (latent) variables. Observable variables can include either macroeconomic variables that could affect all returns or fundamental variables that describe characteristics of the country that could be related to returns.[5] This paper focuses on observable macroeconomic variables and financial variables that might be related to returns and to return volatility. This paper extends recent models for the variances of excess equity and bond returns (and by extension the variance of factors) by allowing them to depend on observable macroeconomic factors as well as following GARCH processes.

4 See Ross (1983) for the first exposition. Hodrick (1981), Stulz (1981), Ross and Walsh (1983) and Solnik (1983) provide early development of international versions of the APT. King et al. (1994) is a good recent exposition.

5 Connor (1995) gives an overview of the classes of factor models. Ferson and Harvey (1993) and (1994) provide recent expositions of plausible variables of each type in international APT models.

3. Data description

The main data used in estimation consists of bond returns and equity returns for several major markets (Canada, France, Germany, Japan, the Netherlands, Switzerland, the United Kingdom and the United States) measured monthly from January 1978 to June 1995. The bond return data are derived from monthly total return indices in dollars from Salomon Brothers. The equity return data are derived from total return indices (with gross dividends reinvested) measured in dollars from Morgan Stanley's Capital International Perspective. All return series are converted to excess returns over the one-month Euro-dollar rate. A Lagrange multiplier test for serial correlation in the excess returns suggests that the returns are not serially correlated (see Table 1). Consequently, the remaining analysis does not attempt to model serial correlation in the excess returns.

Table 1

Test for serial correlation in excess returns
(monthly data, 1978:1 to 1995:4)

Country	Equity excess return	Government bond excess return
Canada (CA)	32.0	21.2
France (FR)	34.8	18.9
Germany (DE)	23.1	24.7
Japan (JP)	19.9	32.5
Netherlands (NL)	21.4	22.7
Sweden (SE)	24.5	21.9
United Kingdom (UK)	20.5	30.3
United States (US)	24.5	31.1

Note: LM test statistic distributed χ^2 with 24 degrees of freedom. 5% critical value = 36.4.

The economic variables used in the analysis were selected from variables used in other studies either as variables that could affect returns directly or as variables that might be related to volatility.[6] In several cases, aggregated variables are formed for the United States, Germany and Japan using GDP weights following King et al. (1994). The economic variables include a measure of short-term interest rates (US Treasury bill yield at month-end); the Deutsche Mark/dollar exchange rate (month-end); the yen/dollar exchange rate (month-end); the US trade-weighted dollar (month-end), a weighted average of industrial production growth in the United States, Germany and Japan; a weighted average of money supply growth in the United States, Germany and Japan; a weighted average of consumer price index growth in the United States, Germany and Japan; growth in the real price of oil in dollars; growth in the real price of gold in dollars; the spread between three-month and one-month Euro-dollar yields (called the short-term structure spread below); the spread between the three-month Euro-dollar yield and the three-month Treasury bill yield (called the TED spread[7] below). The data and sources are reported in the data appendix.

For modeling purposes, it is necessary to identify current shocks to the observable economic variables. Although publication lags might in some cases make this problematic, current values of all variables were used in each period to identify the observable macroeconomic factors. Current surprises in these variables are identified, following King et al. (1994), by the residuals of a

6 The economic variables studied in this section are among variables that have been shown to have explanatory power in other studies. See Ferson and Harvey (1994) for a review of these studies. I have also drawn on variables used in King et al. (1994).

7 This differs from standard market terminology where the TED spread refers to the difference between Euro-dollar futures yields and Treasury bill futures yields.

VAR system for the economic variables, including 13 lags of the dependent variable and 3 lags of other economic variables.[8]

4. Model description and results

This section presents two types of descriptive models. The first set of models provides evidence on whether the economic variables contain information about current excess returns on bonds and equity. While unobservable factors can statistically account for return variation, an observable variable is only a plausible factor if shocks in the variable are related to excess returns. If an observable variable is related to excess returns, then variation in the variable can partially account for return volatility. The evidence presented here is based on regressions with constant coefficients. The second descriptive model is a set of GARCH variance models for the individual country returns that allow these observable variables to enter the information set for future volatility. These models provide some evidence on whether the economic variables are informative about future volatility separate from any role as factors that the economic variables might have.

Table 2 presents regressions of excess equity returns on the economic variables in the study. First, note that the observable variables explain between 18% and 30% of variation in excess equity returns.[9] Returns are negatively related to the TED spread for all countries and significantly so for all but Japan. Apparently, rising credit concerns reflected in the TED spread tend to coincide with losses in equity value. Equity returns in the continental European countries (France, Germany, the Netherlands and Switzerland) are all significantly negatively related to dollar appreciation against the Deutsche Mark. Analogously, Japanese equity returns tend to drop when the dollar appreciates against the yen and UK equity returns drop when the trade-weighted dollar appreciates. Shocks to the dollar have no significant effect on either Canadian or US equity returns. The macro variables (CPI inflation, money growth and industrial production growth) and the short-term interest rate are not significantly related to equity returns in any country although money shocks are associated with drops in equity returns except for France. Increases in the short-term structure spread are negatively associated with equity returns and significantly in France, Switzerland and the United States. Real oil and gold price shocks are not significantly related to equity returns for all but France (where equity returns fall with oil price increases) and Canada (where equity returns rise with gold price increases).[10]

The relation of excess bond returns to observable variables is shown in Table 3. The economic variables seem much more closely related to bond returns than to equity returns, explaining between 27% to 70% of total variation. Shocks to the short-term interest rate are negatively related to bond returns for all countries and significantly so for all but Japan and the United Kingdom. Measures of dollar strengthening are significantly negatively related to bond returns for all the countries except the United States and Canada, with dollar appreciation against the Deutsche Mark most important for the continental European countries, shocks in the trade-weighted dollar significant for the United Kingdom and dollar appreciation against the yen significant for Japan (and significantly negative for the United Kingdom, France and Switzerland). TED spread widening is significantly

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8 Q-tests provided no indication of residual serial correlation.

9 Since the regressions provide a best fit over the whole sample, these R^2 are an upper bound on the explanatory power of these economic variables in a model with constant coefficients. A model that allowed the coefficients to change over time might account for more variation.

10 If the economic variables are lagged so that they are likely in agents' information sets at the beginning of the period, the R^2 - which provide a measure of overall predictive power of the measured economic variables - drop to between 0.03 to 0.10. The TED spread is negatively (but not significantly) related to equity returns in all countries but the United Kingdom.

Table 2

Relation of excess equity returns to current economic shocks

(monthly data, 1978:1 to 1995:4)

Coefficients from regressions of excess return on contemporaneous economic variable shocks								
Economic variables	**CA**	**FR**	**DE**	**JP**	**NL**	**SE**	**UK**	**US**
Short-term interest rate	- 0.003 (0.007)	- 0.00003 (0.008)	- 0.0005 (0.0073)	0.008 (0.007)	0.002 (0.006)	- 0.005 (0.006)	0.011 (0.007)	- 0.004 (0.005)
Consumer price index	- 0.0008 (0.0017)	0.003 (0.002)	0.002 (0.002)	- 0.00009 (0.00204)	- 0.0005 (0.0014)	0.0006 (0.0015)	0.0007 (0.0018)	0.0002 (0.0013)
Industrial production	- 0.0001 (0.0005)	0.0005 (0.0006)	- 0.0004 (0.0006)	- 0.0009 (0.0006)	- 0.0003 (0.0005)	- 0.0006 (0.0005)	- 0.0005 (0.0005)	- 0.0001 (0.0004)
Money supply	- 0.0008 (0.0010)	0.0007 (0.001)	- 0.0006 (0.0011)	- 0.0005 (0.0012)	- 0.0001 (0.0009)	- 0.0003 (0.0009)	- 0.0005 (0.0011)	- 0.0004 (0.0008)
Short-term structure spread	- 0.009 (0.013)	- 0.032* (0.016)	- 0.017 (0.015)	- 0.020 (0.016)	- 0.022 (0.012)	- 0.027* (0.012)	- 0.018 (0.014)	- 0.028* (0.010)
TED spread	- 0.052* (0.010)	- 0.050* (0.013)	- 0.043* (0.011)	- 0.011 (0.012)	- 0.044* (0.009)	- 0.041* (0.010)	- 0.048* (0.011)	- 0.042* (0.008)
Real oil price	0.0001 (0.0006)	- 0.0014* (0.0007)	- 0.0010 (0.0006)	- 0.0001 (0.0007)	- 0.0001 (0.0005)	- 0.0005 (0.0005)	- 0.0008 (0.0006)	- 0.0005 (0.0004)
Real gold price	0.003* (0.001)	0.0006 (0.0009)	- 0.0008 (0.0008)	0.0005 (0.0009)	0.0007 (0.0006)	0.0007 (0.0006)	- 0.00003 (0.0008)	0.0002 (0.0006)
Trade-weighted dollar	- 0.45 (0.38)	- 0.17 (0.47)	0.28 (0.41)	- 0.26 (0.45)	- 0.027 (0.33)	- 0.40 (0.35)	- 1.20* (0.40)	- 0.25 (0.29)
Yen/$	0.16 (0.14)	- 0.32 (0.19)	- 0.06 (0.16)	- 1.24* (0.18)	- 0.013 (0.13)	- 0.08 (0.14)	- 0.23 (0.16)	0.09 (0.11)
DM/$	0.29 (0.20)	- 0.58* (0.25)	- 0.94* (0.22)	0.23 (0.25)	- 0.52* (0.18)	- 0.44* (0.19)	0.09 (0.22)	0.15 (0.16)
R^2	0.20	0.24	0.25	0.28	0.25	0.30	0.23	0.18

Notes: Excess returns are gross equity returns (including dividends) in dollars minus the one-month Euro-dollar yield. Economic variables are residuals from a VAR using 13 lags of the variable and 3 lags of all other economic variables. *=significant at 5% level.

associated with lower bond returns in Canada and the United States while widening in the short-term structure spread is related to lower US bond returns. Finally, as in the equity model, oil price inflation is consistently negatively related to bond returns in all countries except Canada but only significantly for France.[11]

11 Using lagged economic variables reduces the R^2 to between 0.04 to 0.11. Positive shocks to the short-term interest rate are negatively related to bond returns in all countries.

Table 3

Relation of excess government bond returns to current economic shocks
(monthly data, 1978:1 to 1995:4)

Coefficients from regressions of excess return on contemporaneous economic variable shocks								
Economic variables	**CA**	**FR**	**DE**	**JP**	**NL**	**SE**	**UK**	**US**
Short-term interest rate	- 0.029* (0.004)	- 0.008* (0.003)	- 0.009* (0.003)	- 0.005 (0.004)	- 0.011* (0.003)	- 0.008* (0.003)	- 0.005 (0.005)	- 0.027* (0.003)
Consumer price index	- 0.0017 (0.0011)	0.0001 (0.0009)	- 0.0007 (0.0008)	- 0.0001 (0.0010)	- 0.0007 (0.0008)	- 0.0005 (0.0009)	0.0006 (0.001)	- 0.0001 (0.0007)
Industrial production	- 0.0001 (0.0003)	0.0002 (0.0003)	- 0.0001 (0.0002)	0.00007 (0.0003)	- 0.0002 (0.0002)	0.00003 (0.0003)	- 0.0005 (0.0004)	- 0.0003 (0.0002)
Money supply	- 0.0005 (0.0006)	0.00002 (0.0005)	0.0002 (0.0005)	0.00003 (0.00059)	- 0.00004 (0.0005)	0.0002 (0.0005)	- 0.00001 (0.0008)	- 0.0006 (0.0004)
Short-term structure spread	- 0.0037 (0.0087)	- 0.0057 (0.0069)	0.0001 (0.0065)	0.0061 (0.0080)	- 0.0051 (0.0065)	- 0.0023 (0.0070)	0.0021 (0.0108)	- 0.0136* (0.0060)
TED spread	- 0.020* (0.007)	0.004 (0.005)	- 0.003 (0.005)	- 0.007 (0.006)	- 0.003 (0.005)	- 0.001 (0.005)	- 0.006 (0.008)	- 0.018* (0.005)
Real oil price	0.0001 (0.0003)	- 0.0006* (0.0003)	- 0.0003 (0.0003)	- 0.0005 (0.0003)	- 0.0002 (0.0003)	- 0.0004 (0.0003)	- 0.0007 (0.0005)	- 0.0004 (0.0002)
Real gold price	0.0001 (0.0005)	- 0.0005 (0.0004)	0.00004 (0.0003)	- 0.0002 (0.0004)	0.00001 (0.0004)	0.0007 (0.0004)	0.0001 (0.0006)	- 0.0004 (0.0003)
Trade-weighted dollar	- 0.33 (0.25)	- 0.17 (0.19)	0.05 (0.18)	0.15 (0.22)	0.065 (0.181)	- 0.24 (0.20)	- 1.32* (0.30)	0.09 (0.17)
Yen/$	- 0.11 (0.10)	- 0.16* (0.08)	- 0.06 (0.07)	- 1.15* (0.09)	- 0.12 (0.07)	- 0.24* (0.08)	- 0.25* (0.12)	- 0.04 (0.06)
DM/$	0.21 (0.13)	- 0.77* (0.11)	- 1.07* (0.10)	- 0.16 (0.12)	- 0.95* (0.10)	- 0.76* (0.11)	0.02 (0.16)	- 0.03 (0.09)
R^2	0.27	0.59	0.70	0.61	0.67	0.64	0.34	0.42

Notes: Excess returns are bond returns (including coupon payments) in dollars minus the one-month Euro-dollar yield. Economic variables are residuals from a VAR using 13 lags of the variable and 3 lags of all other economic variables. *=significant at 5% level.

These results are consistent with earlier literature that suggests that some economic variables are related to returns. Interestingly, bond returns appear to be more tightly linked to these economic variables than are equity returns. Several variables seem individually noteworthy, particularly exchange rates and the TED spread for equity and exchange rates and the Treasury bill rate for bonds. The traditional macro variables (CPI, industrial production and money) do not seem to be significantly related to returns. While oil prices are largely negatively related to bond and equity returns, they only are significant for France.

These economic variables could also be related to future volatility. One method for testing that hypothesis is to add them to GARCH models for the equity and bond returns. The volatility models considered have the form:

$$Var_{t-1}(r_{i,t}) = \alpha_{i,0} + \alpha_{i,1} \cdot r_{i,t-1}^2 + \lambda_{i,1} \cdot I_{t-1} \cdot r_{i,t-1}^2 + \delta_{i,1} \cdot Var_{t-2}(r_{i,t-1}) + \sum_j \beta_{i,j} \cdot x_{j,t-1}$$

where $I_{t-1} = 1$ if $r_{i,t-1} \leq 0$ and 0 otherwise,

and where $r_{i,t}$ is the excess return on either equity or government bonds for country i from t to t+1, $Var_{t-1}(r_{i,t})$ is the variance of the excess return conditional on information available at the beginning of the period, the lagged squared innovation in the excess return is $r^2_{i,t-1}$,[12] and $x_{j,t-1}$ is the shock in economic variable j at time t-1. This model follows the approach of Glosten et al. (1993) by allowing negative shocks to lead to different (and possibly greater) volatility than positive shocks if $\lambda_{i,1}$ is different from zero. Even if the economic variables are not directly related to current returns they could have information for future volatility by signaling conditions when volatility was likely to be unusually high or low.

Models for country equity return volatility are presented in Table 4. Including the economic variables seems to have reduced the size of ARCH effects (α) in volatility since the estimated ARCH parameters are usually larger in GARCH models that exclude the economic variables.[13] Most of the country models display considerable persistence in volatility although the individual coefficients for Switzerland are not statistically different from zero. Several of the volatility models also have fairly large "leverage" effects (measured by λ), indicating that volatility is higher after negative returns than it would be for an equal positive return. Exceptions are Canada, France and the United States, which have fairly small and insignificant asymmetric responses to past shocks; Germany actually has a smaller response to negative shocks than positive shocks. Likelihood ratio tests imply that the economic variables have predictive power in most of the equity models (exceptions are the Netherlands and Switzerland.) Of the economic variables, increases in the short-term interest rate are associated with higher future volatility in all countries, and significantly so in several.

Models for country bond return volatility are presented in Table 5. Persistence is typically smaller in the bond models than in the corresponding equity models. Addition of economic variables tends to reduce the size of ARCH effects and estimated persistence.[14] However, many country models exhibit an asymmetric response of volatility to past bond returns with negative bond returns implying higher future volatility than similar-sized positive returns. These effects are substantial in most countries. Likelihood ratio tests indicate that the group of economic variables have predictive power in all but Canada and France. When significant, increases in the short-term interest rate imply higher future bond volatility. An increase in the short-term structure spread is negatively related to future volatility for most countries and these estimated effects are significantly different from zero for France, Germany, the Netherlands and Switzerland. Surprise appreciation of the trade-weighted dollar is associated with a significant reduction in volatility in Germany and the Netherlands. Dollar appreciation against the yen is associated with lower volatility in Germany and Switzerland. While appreciation of the dollar on a trade-weighted basis is associated with an increase in UK and US bond volatility, appreciation against the Deutsche Mark is associated with lower US volatility.

12 Evidence that there is little serial correlation in the excess returns was presented earlier in the paper. The mean excess return is also typically very small, making the squared excess return quite close to the deviation from the mean. A more precise model would account for predictable variation in expected returns.

13 These results are available from the author.

14 These results are available from the author.

Table 4

Garch models for excess equity returns

(monthly data, 1978:1 to 1995:4)

$$Var_{t-1}(r_{i,t}) = \alpha_{i,0} + \alpha_{i,1} \cdot r_t^2{}_{,t-1} + \lambda_{i,1} \cdot I_{t-1} \cdot r_t^2{}_{,t-1} + \delta_{i,1} . Var_{t-2}(r_{i,t-1}) \sum_j b_{i,j} \cdot x_{j,t-1}$$

and $I_{t-1} = 1$ if $r_{i\,t-1} \leq 0$ and 0 otherwise

Coefficients	CA	FR	DE	JP	NL	SE	UK	US
$\alpha_{i\,1}$	0.04	0.05*	0.15*	0.07	0.00004	0.03	0.004	0.22
	(0.05)	(0.007)	(0.03)	(0.11)	(0.00003)	(0.06)	(0.003)	(0.15)
$\delta_{i\,1}$	0.86*	0.82*	0.79*	0.51*	0.26*	0.30	0.44*	0.85*
	(0.14)	(0.01)	(0.03)	(0.27)	(0.09)	(0.44)	(0.04)	(0.06)
$\lambda_{i\,1}$	0.03	0.01	- 0.15*	0.33*	0.19	0.11	0.20*	0.028
	(0.17)	(0.02)	(0.03)	(0.17)	(0.48)	(0.24)	(0.07)	(2.6)
Short-term interest rate	11.1*	19*	6.6*	1.1	3.2	0.82	19*	3.6
	(3.1)	(3.3)	(1.3)	(21)	(19)	(7.6)	(1.1)	(244)
Consumer price index	- 0.55	- 0.99	- 0.54*	- 0.42	- 0.39	2.3	2.7*	- 0.87
	(0.55)	(0.66)	(0.26)	(31)	(2.6)	(2.1)	(0.6)	(34)
Industrial production	- 0.006	- 0.08	- 0.20	0.11	- 0.59	- 0.98	- 1.1*	0.08
	(0.18)	(0.49)	(0.27)	(4.5)	(4.8)	(1.9)	(0.2)	(4.1)
Money supply	- 8.5	36.6	- 137*	70	4.3	- 448*	161*	0.93
	(31)	(51.3)	(9.6)	(649)	(22.6)	(127)	(15)	(3.9)
Short-term structure spread	- 3.5	- 21.6*	- 5.0	- 14	3.5	- 4.3	15*	2.9
	(6.9)	(8.6)	(3.5)	(15)	(99)	(6.3)	(2.0)	(517)
TED spread	4.6	- 0.53	9.0	44*	5.4	29	4.8*	5.13
	(3.6)	(2.7)	(4.9)	(7.5)	(26)	(22)	(1.5)	(289)
Real oil price	0.27	0.16	1.0*	- 0.13	- 0.61	- 0.41	- 0.42	0.15
	(0.34)	(0.42)	(0.22)	(7.1)	(1.3)	(1.3)	(0.23)	(16)
Real gold price	0.07	0.18	0.90*	0.50	0.22	0.21	- 0.93*	1.1
	(0.20)	(0.96)	(0.14)	(17)	(1.6)	(2.2)	(0.15)	(6.9)
Trade-weighted dollar	170	- 164*	417	272	467	411	521*	- 65
	(305)	(80)	(227)	(1,201)	(629)	(1,006)	(78)	(1,598)
Yen/$	131*	21.9	- 161*	40	84	- 40	77	5.8
	(46)	(120)	(30.3)	(279)	(376)	(77)	(54)	(568)
DM/$	- 231	- 77*	- 207	- 263	291	- 176	- 481*	106
	(178)	(36)	(141.6)	(161)	(1,581)	(554)	(116)	(1,810)
Log likelihood	514.7	461.2	483.1	459.3	517.4	504.0	485.4	533.5

Notes: Excess returns are gross equity returns (including dividends) in dollars minus the one-month Euro-dollar yield. Economic variables are residuals from a VAR using 13 lags of the variable and 3 lags of all other economic variables. Standard errors computed following White (1982) reported in parentheses. *=significant at 5% level.

Table 5

Garch models for excess bond returns

(monthly data, 1978:1 to 1995:4)

$$Var_{t\text{-}1}(r_{i,t}) = \alpha_{i,0} + \alpha_{i,1} \cdot r_t^2,_{t\text{-}1} + \lambda_{i,1} \cdot I_{t\text{-}1} \cdot r_t^2,_{t\text{-}1} + \delta_{i,1}.Var_{t\text{-}2}(r_{i,t\text{-}1}) \sum_j b_{i,j} \cdot x_{j,t\text{-}1}$$

and $I_{t\text{-}1} = 1$ if $r_{i\ t\text{-}1} \leq 0$ and 0 otherwise

Coefficients	CA	FR	DE	JP	NL	SE	UK	US
$\alpha_{i\ 1}$	0.0007 (0.0968)	0.02 (0.09)	0.08* (0.04)	0.06 (0.09)	0.006 (0.007)	0.13* (0.05)	0.05* (0.01)	0.0005 (116)
$\delta_{i\ 1}$	0.82 (0.79)	0.002 (0.016)	0.09* (0.02)	0.12* (0.06)	0.01 (0.02)	0.04* (0.02)	0.31* (0.12)	0.72* (0.03)
$\lambda_{i\ 1}$	0.21* (0.08)	0.309 (0.61)	0.33* (0.07)	0.12 (0.13)	0.377* (0.137)	0.10 (0.08)	0.27* (0.09)	0.28* (0.06)
Short-term interest rate	0.22 (15)	- 2.6 (8.2)	4.6* (0.5)	- 2.1 (1.7)	4.3* (2.1)	8.3* (1.5)	0.53 (3.9)	- 0.19 (0.47)
Consumer price index	- 0.14 (2.5)	- 0.23 (1.4)	0.26 (0.35)	0.92 (0.85)	0.02 (0.36)	0.60* (0.19)	1.3 (1.3)	0.64* (0.08)
Industrial production	- 0.22 (0.09)	0.41 (1.6)	0.17 (0.13)	- 0.64* (0.30)	0.25 (0.30)	0.25 (0.42)	- 1.4* (0.02)	- 0.09 (0.06)
Money supply	- 51 (44)	- 83 (66)	- 102* (8.9)	6.3 (120)	- 85 (198)	- 96* (31)	- 381 (35)	- 41* (14)
Short-term structure spread	- 6.7 (8.9)	- 8.2* (4.2)	- 16.4* (3.6)	- 6.6 (7.5)	- 13* (3.9)	- 5.9* (1.7)	10 (19)	- 3.8 (2.4)
TED spread	0.05 (7.7)	5.9 (3.3)	1.8 (4.8)	10.7* (2.2)	1.8 (4.9)	9.1* (2.1)	5.0 (4.4)	0.62 (2.0)
Real oil price	0.06 (0.64)	- 0.79 (1.6)	- 0.32 (0.18)	- 0.37 (1.06)	- 0.29* (0.09)	- 0.07 (0.18)	- 0.41* (0.14)	- 0.10 (0.06)
Real gold price	0.14 (0.44)	0.23 (1.2)	0.40 (0.15)	- 0.24 (1.1)	0.36 (0.19)	0.05 (0.22)	- 0.71 (0.54)	0.004 (0.082)
Trade-weighted dollar	16 (203)	- 228 (363)	- 220* (88)	- 182 (348)	- 211* (87)	- 210 (109)	288* (46)	175* (62)
Yen/$	3.1 (21)	- 117 (113)	- 124* (24)	69 (203)	- 102 (55)	- 86* (19)	25 (106)	- 16 (18)
DM/$	0.39 (85)	158 (166)	23 (33)	- 100 (176)	7.7 (25)	7.9 (22)	- 151 (148)	- 80* (27)
Log likelihood	587.8	570.5	556.1	540.6	568.3	562.8	517.8	651.7

Notes: Excess returns are bond returns (including coupon payments) in dollars minus the one-month Euro-dollar yield. Economic variables are residuals from a VAR using 13 lags of the variable and 3 lags of all other economic variables. Standard errors computed following White (1982) reported in parentheses. *=significant at 5% level.

Finally, it is possible to evaluate whether these economic variables are practically important by comparing variance predictions from the full variance models to predictions using just the economic variables and lagged variances. Figures 3a and 3b show this comparison for the equity and bond variance models, respectively, for Germany, Japan, the United Kingdom and the United States, while Figures 4a and 4b present the comparison for Canada, France, the Netherlands and Switzerland. Several features stand out across the models. First, the observed economic variables account for part of the variance movements over the whole 1978 to 1995 period. Second, the observed variables typically fail to describe large variance spikes associated with extreme market moves (equity markets in 1987, bond markets in early 1994, for example). Third, except for extreme market moves, economic variables typically do a fairly good job describing developments in equity and bond variance over the past few years.

Figure 3a

Estimated equity return variances

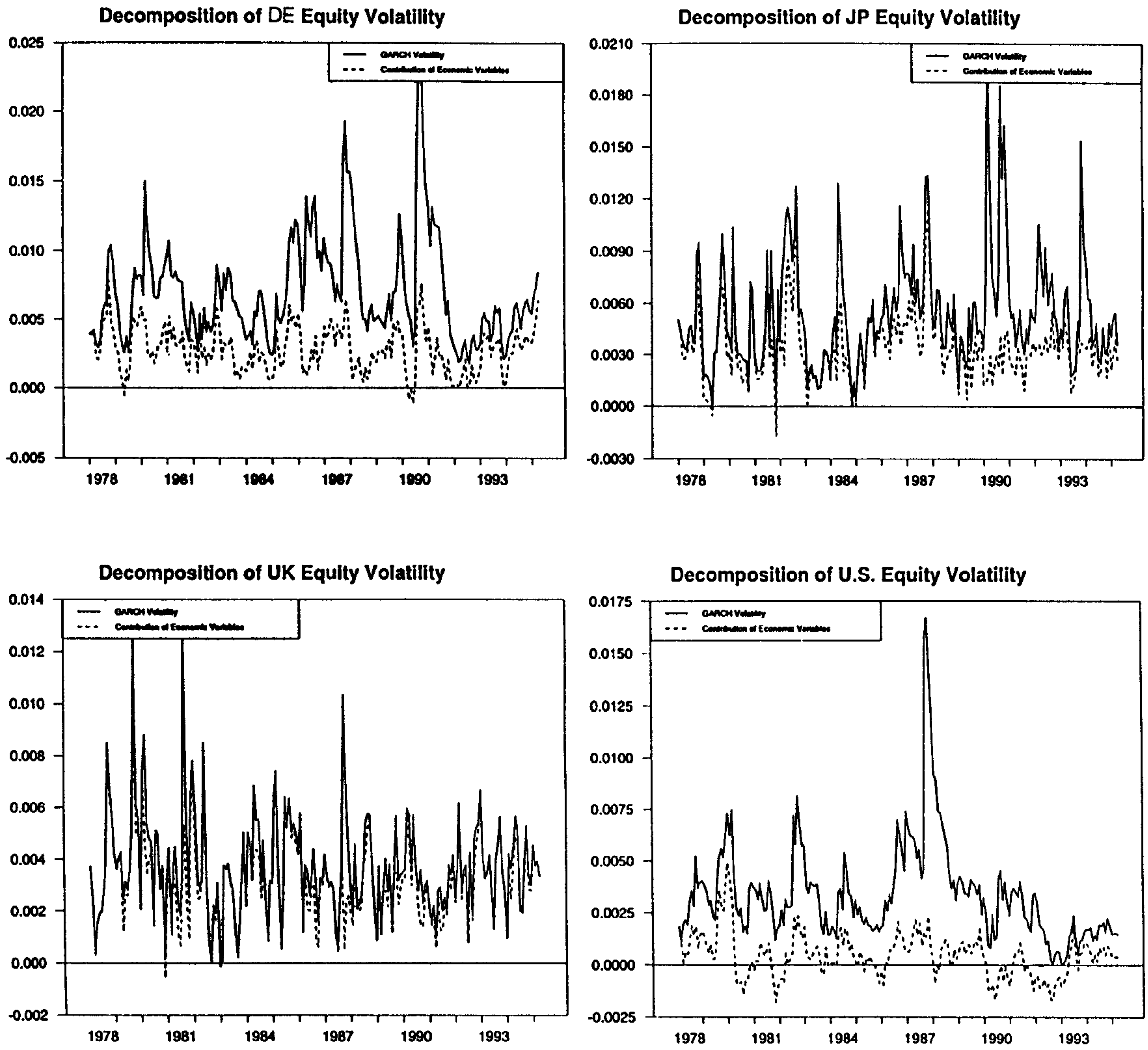


Figure 3b

Estimated bond return variances

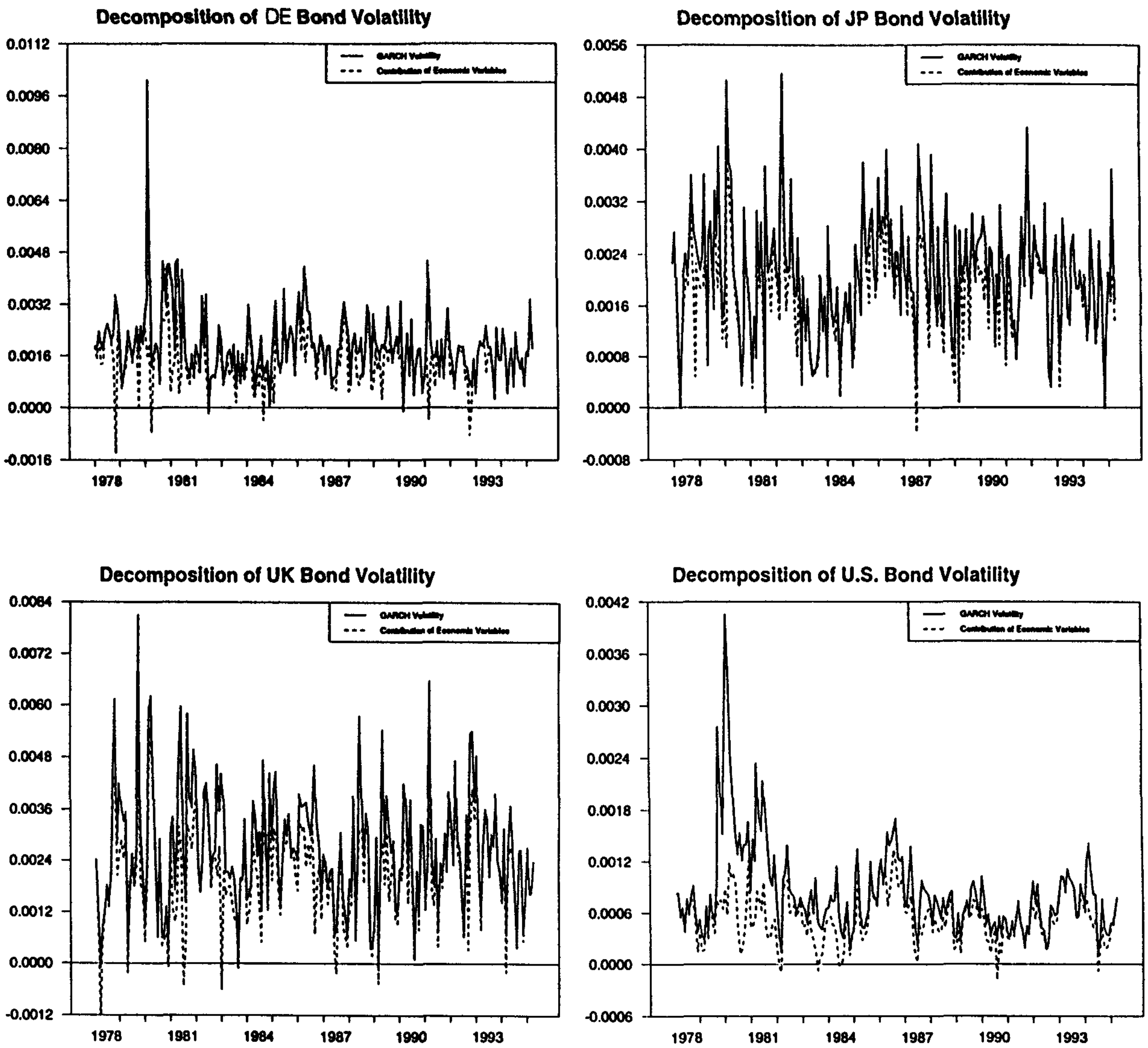


Figure 4a

Estimated equity return variances

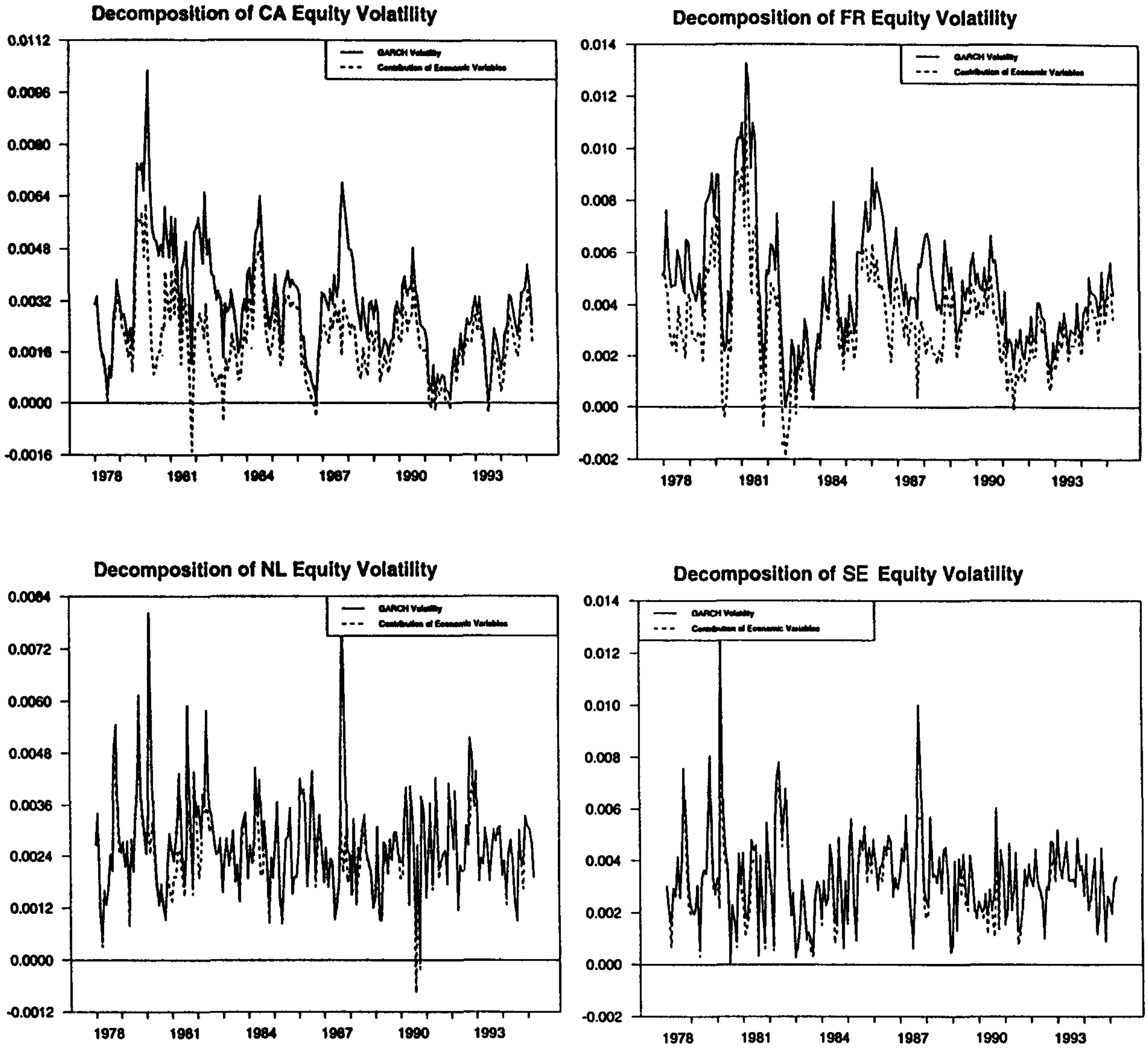
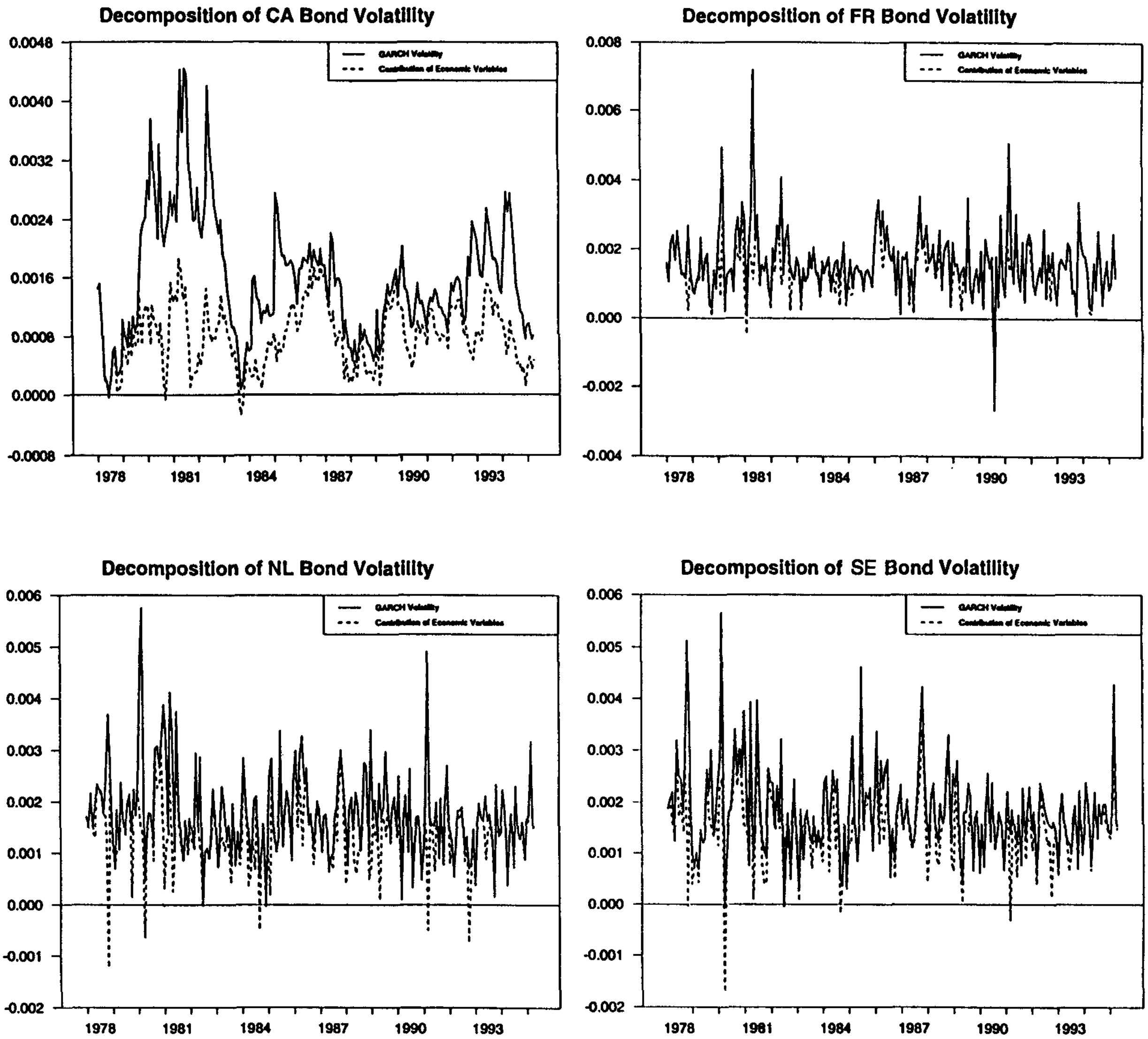


Figure 4b

Estimated bond return variances



Conclusions

The evidence in this paper suggests that one reason for common movements in volatility across markets is that excess returns and the volatility of excess returns are related to measurable economic variables. As other authors have observed, the observable economic variables studied in this paper are associated with current market equity and bond returns in several countries in economically plausible directions.

The paper also presents GARCH models for equity and bond volatility that condition on these economic variables. Several of the economic variables are associated with movements in equity and bond volatility. Conditioning on economic variables tends to reduce the size of ARCH effects in both equity and bond models. The equity volatility models display asymmetric responses to past shocks, a feature often found by other authors. The estimated bond volatility models demonstrate that these asymmetric responses are also important for bond volatility, implying that negative bond returns tend to imply higher future bond volatility. The economic variables provide a practically important source of variation in volatility but they cannot account for occasional volatility spikes associated with large market moves.

DATA APPENDIX

Data series in this paper along with their sources are described below. Series are measured at month-end unless noted.

Daily equity indices - Commerzbank index, Nikkei 225, FT100 (DRI); S&P500 (FRBNY).

Daily bond yields - German, Japanese and UK yield (country sources); US ten-year constant maturity bond yield (FRBNY).

Monthly equity returns - Morgan Stanley Capital International Perspectives return indices (including gross dividend yields) measured in dollars (DRI).

Monthly bond returns - Salomon Brothers indices for government bond returns for bonds with at least one year remaining to maturity and at least US$ 25 million outstanding. Returns are converted to dollars using end-of-month exchange rates. Payments received during the month are assumed to be reinvested at the average one-month local Treasury rate for the month (Datastream).

Libor - average of one month Euro-dollar bid and asked yield (DRI).

Short-term interest rate - yield on three-month Treasury bill (DRI), month average.

Real oil price - US producer price index for crude petroleum products (DRI) deflated by the US CPI.

Real gold price - London afternoon price fixing (dollars) (DRI) deflated by the US CPI.

Consumer price growth - GDP-weighted monthly growth rate in US consumer price index (Haver), German cost-of-living index for all households (country source), Japanese consumer price index, Tokyo (country source).

Industrial production growth - GDP-weighted average monthly growth rate in US industrial production (Haver), German industrial production (Datastream) and Japanese industrial production in mining and manufacturing (country source).

Money supply growth - GDP-weighted monthly growth rate in US M2 (Haver), German M3 (country source) and Japanese M2+CDs (country source).

Short-term spread - spread between three-month Euro-dollar deposit yield (DRI) and one-month Euro-dollar deposit yield (DRI).

TED spread - spread between three-month Euro-dollar deposit yield (DRI) and three-month US Treasury bill yield (DRI).

Exchange rates - yen/dollar (Haver) and DM/dollar (Haver) month average exchange rates; trade-weighted dollar (Haver) month average trade-weighted dollar computed by the Federal Reserve Board of Governors.

GDP weights - previous quarter GDP in dollars (converted using quarter average exchange rates) for the United States (Haver), Germany (country source) and Japan (country source).

US CPI - US consumer price index (Haver) used to deflate the PPI for crude petroleum and the gold price.

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