

[Appeared in *Journal of Fixed Income*, 1996, Vol 6, No 2, 37-48.]

Event Risk and Risk Management of Global Yield Curve Exposure

by

William Fung*
and
David A. Hsieh**

Draft: July 1995

* CEO, Abacus Risk Management.

** Professor of Finance, Fuqua School of Business, Duke University.

Introduction

Empirical evidence to date has largely supported a multifactor approach to modeling bond price behavior. Recent work by Litterman and Scheinkman (1991) indicated that 75% of bond price variations can be explained by parallel shifts in the yield curve. The remaining variations can be attributed to two other factors related to shifts in the shape of the yield curve. To-date, there is still no theoretical consensus on the number of factors that best describe the yield curve dynamics. The need for application tools for managing bond portfolios has motivated empirically driven risk management techniques such as Key Rate Durations, as in Ho (1992). Given the incompleteness of existing yield curve models, the potential for specification error is an area for concern when applying these tools. This is especially the case towards the tail of the bond price distribution corresponding to large changes in interest rate where the current models assumptions are most vulnerable to violation. Ironically, this is also the key scenario of concern from the risk management perspective. We call this *event risk*.

In this paper, we begin by documenting some distribution properties of the global yield curve. [To be added]

Given the lack of linearity in the distribution of key yields, we move on to document the nonlinear behavior of various measures of yield curve shapes globally. The empirical evidence leads us to conclude that linear approximations such as those suggested in Litterman and Scheinkman (1991) and Ho (1992) could be vulnerable to large estimation errors during major yield curve events. The precise level of errors is subject to another source of error. We show that during periods of large interest rate moves, the change in the shape of the yield curve is usually correlated to the level of interest rate itself. This phenomenon is true of all major global yield curves. This poses another problem for applying techniques such as key rate durations where the cross correlations between different key rates are embedded in the initial estimates of the zero coupon curves and are therefore assumed to be constant. No further cross derivatives with respect to the key rates are included in the estimation equation for bond prices. [.....]

Whilst our empirical results are not inconsistent with these linear models being good approximations for managing bond price risks during most normal interest rate moves, one has to be cautious about their applicability during major interest rate events. Given the risk

Risk Management and Term Structure Models

Assume that there are N bonds in a portfolio, denoted by the index $i=1, \dots, N$. For convenience, we will order the bonds so that the first bond ($i=1$) has the shortest maturity, and the last bond ($i=N$) has the longest maturity. Let P_i denote the price of the i -th bond (per dollar of face value). We assume that the price of each bond depends on the yield curve, which is summarized in a vector of interest rates, $y = (y_1, \dots, y_N)$, so that we can write $P_i = P_i(y)$. The value of the bond portfolio is given by:

$$V = \mathbf{E}_i P_i(y) Q_i,$$

where Q_i is the face value of the i -th bond.

If the yield curve changes from y to $y+y$, then the change in the value of the bond portfolio is given by:

$$\Delta V = \mathbf{E}_i Q_i P_i(y+y) - \mathbf{E}_i Q_i P_i(y).$$

This makes clear that the distribution of ΔV depends on that of y .

For a portfolio which contains bonds with short (e.g. one-month) and long (e.g. 30 year) maturities, a large number of points on the yield curve is needed to evaluate V . In principle, one needs the entire continuum of yields, from the instantaneous interest rate to the longest maturity yield. In practice, one can parametrize the yield curve using a term structure model with a small number of parameters.

A tightly parametrized term structure model has the advantage that it

typically has closed-form solutions of bond prices in terms of interest rates and model parameters. This is useful for pricing bonds. But it is potentially flawed for risk management. When pricing a 30-year bond, a bond trader is not interested in how the yield curve will change in the next day, month, or year, but how it behaves, on average, over the next 30 years. A highly parametrized term structure model can serve this purpose well. When measuring the risk of a bond portfolio, a risk manager is interested in how the value of this portfolio will change over the next day, week, or month. The most important part of risk management concerns the tails of the distribution of V . A tightly parametrized term structure model will not allow sufficient degrees of freedom of movement in the yield curve to capture potential tail or extreme events.

This paper takes the approach of Hsieh (1993) in risk management, by examining the statistical properties of daily interest rate changes to determine the type of term structure model needed to describe them.

Nonlinearity in Global Yield Curves

An important characteristic of asset markets is that daily price changes exhibit strong nonlinear dynamics, in the form of conditional heteroskedasticity. This turns out to be true also for interest rates and spreads.

We begin the analysis with the longest time series of daily yield curve data available, based on the Federal Reserve's G13 Selected Interest Rate report. Specifically, we use the 3- and 6-month treasury bill rates from the secondary market, and the 1-, 2-, 3-, 5-, 7-, 10-, and 30-year 'constant maturity' treasury rates. The latter are based on actively traded issues adjusted to constant maturities and are calculated by the U.S. Treasury. The starting point of our analysis is February 14, 1977, when the 30-year bond was first issued. The data end in December 1994.

We divide the data into 4 periods: 1977-79, 1980-84, 1985-89, 1990-94. In addition, we provide information on the forward curve out to 3 years using the 3 month Eurodollar CD futures contracts traded on the Chicago Mercantile Exchange during the 1990-1994 period.

Table 1 provide the autocorrelation in level shifts and yield spreads. We use the change in the 3 month interest rate to measure shifts in the level of interest rates. We use the change in yield spreads between successive points on the yield curve to measure movements in the shape of the yield curve. There is evidence of first degree autocorrelation in the level changes and spread changes, but the Box-Pierce test of autocorrelation for the first 10 lags are typically not statistically significant. Table 2 provides a test of conditional heteroskedasticity, which is a form of nonlinearity. There is strong evidence of conditional heteroskedasticity.

We repeat this exercise for non-US yield curve. Yield curve information is not readily available for non-US countries over the same time period. We obtain interest rates for the last period (1990-94) for Belgium, Canada, Switzerland, Germany, Denmark, France, United Kingdom, Japan, the Netherlands, and Sweden. In each country, the front end of the yield curve consists of the 3-, 6-, and 12-month Eurocurrency deposit rates, and the back end consists of the 2-, 3-, 5-, 7-, and 10-year benchmark bond yields.

The behavior of non-US yield curves are very similar to the U.S. yield curve. Table 3 shows that is evidence of first degrees autocorrelation in level changes and spread changes, but nothing much beyond that. Table 4 shows that there is strong evidence of conditional heteroskedasticity.

There is no surprise that level changes exist nonlinear dynamics. This is consistent with the behavior of other asset and commodity markets. [See Hsieh (1995).] However, it is interesting that spread changes also exhibit strong nonlinear dynamics. Nonlinear dynamics is not only present in parallel shifts of the major global yield curves, but also in the shape of these curves.

Nonlinearity in Factor Models

So far our results have been based on par yields for the major global yield curves. It is possible that there is a different representation of the yield curve which does not possess nonlinear dynamics. First, we show that no linear representation of the yield curve is likely to escape from nonlinear dynamics. To do so, we use factor analysis to extract the principal components of the par yield curve. Litterman and Scheinkman (1991) found that the U.S. yield curve can be described by a three factor model. Tables 2 and 4 report the test for conditional heteroskedasticity for the first three principal components of the global par yield curves. There is still strong evidence of nonlinearity. Since the principal components are themselves conditional heteroskedastic and uncorrelated with each other (by construction), any linear transformation of the yield curve (which can be written as a linear transformation of the principal components) cannot escape nonlinearity.

Next, we argue that there is no other standard representation of the yield curve, such as forward curves and zero curves, which can escape nonlinearity. The reason is actually quite simple. Forward curves and zero curves are cross-sectional nonlinear transformations of par curve curves. The nonlinear dynamics in par yields is a time series property. It is not likely to disappear from the data after any cross-sectional transformation, whether linear or nonlinear. For the U.S., we do have the forward yield curve of 3-month Eurodollar deposit rates up to three years. It has nonlinear dynamics. We are unable to obtain sufficient daily data for longer maturities in forward curves or zero curves.

We believe that the presence of nonlinear dynamics is an important result in the risk management of bond portfolios. Nonlinear dynamics means that the conditional distribution of yield curve changes is different from the unconditional distribution. A properly specified statistical model is needed to generate the distribution of future yield changes, so that the risk manager can obtain a distribution of the changes in the value of a bond portfolio.

Unstable Correlation of Points on Yield Curves

The proper specification of term structure models, from a risk management perspective, must take into account the behavior of the yield curve during extreme moves. Nonlinear dynamics in the yield curve implies that there may be no stable correlation between the front and back end of global yield curves. Here we document evidence of this by examining the extreme tails, or outliers, of the global par yield curves.

Table 5 provides the standard correlation coefficients between level changes and spread changes, and between spread changes in the front and spread changes in the back of the curve. We measure correlation using 5 different windows: 1-, 2-, 3-, 4-, and 5-days. The evidence shows that there is a persistent negative correlation between increases in short term rates and yield spreads. Spreads narrow when the short term rate rises; spreads widen when the short term rate falls. This negative correlation is strongest for spreads at the front end of the curve and weakest at the back end of the curve.

Table 5 also provides information on the correlation between the spread at the front end of the curve (6 month versus 3 month) and the spread at the back end of the curve. There is no strong correlation. Sometimes it is positive, sometimes negative.

Table 6a through 6d provide information on the correlation of extreme moves in the short term rate and spreads. We separate the data between normal and extreme changes. In Table 6a, events are defined to be the 15% upper and lower tails of a distribution. We use 10%, 5%, and 2.5% tails in Tables 6b, 6c, and 6d, respectively.

We shall concentrate our discussion in the most recent period (1990-4) in Table 6c which uses a 5% tail to differentiate between normal changes and extreme changes. The first column of the table provides the percent of the

time when events in a spread and events in the level occur in a 1-day window.

The second column of the table provides the percent of time when events in a spread and events in the 6-3 month spread occur in a 1-day window. For the 30-10 year spread, 21% of the extreme moves occur in the same day as an extreme move in the 3 month rate, and 9% of the events occur in the same day as an event in the 6-3 month spread. If 30-10 year spread is statistically independent of the 3-month rate, extreme moves should coincide about 1% of the time. Thus we conclude that there is strong evidence against statistical independence.

The remaining columns of this table provide the same information while lengthening the event window to 2-, 3-, 4-, and 5-days. The results are similar to those using the 1-day window.

While it is not surprising to find event correlation between levels and spreads, what is interesting is that there is substantial event correlation between the spreads in the back and the front of the curve, even though there is no consistent correlation. For example, in the 1990-4 period, 9% of the events in the 30-10 year spread occur on the same day as an event in the 6-3 month spread. This is nine times more frequent than if the level events and spread events are independent.

Table 7a and 7b provide the normal correlation coefficients for non-US yield curves. There is the same persistent negative correlation between changes in the three month rate and the slope of the yield curve as in the U.S. There is also a lack of strong correlation between the slope at the front and the back of the yield curve.

Table 8a and 8b provide the event correlation for non-US yield curves using a 5% tail cutoff to determine an 'event.' As in the U.S. case, the spread events tend to occur frequently together with level events and with events in the 6-3 month spread.

Conclusion

In this paper, we found that extreme changes in yield spreads are correlated with extreme changes in the short rate and the 6-3 month spread. This occurs in the U.S. yield curve over the 1977-1994 period, as well as in non-US yield curve over the 1990-94 period. This demonstrates the point that large movements in non-parallel shifts of the yield curve are related to large movements of the level of interest rates.

This has important implications for risk management. Consider a zero duration portfolios, which are designed to be insensitive to small parallel shifts of the yield curve. Such a portfolio allows a trader to bet on a spread without being forced to take a directional bet on interest rates. That is why these strategies are 'market neutral.' The fact that level events and spread events are correlated means that zero duration portfolios have directional exposure during extreme moves in interest rates, which raises important risk management issues for market neutral strategies.

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Table 1a. U.S. Yield Curve: Test of Autocorrelation

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)	r(10)	Q(10)
1977-1979 (714 obs):											
GOVT 3M	0.10	0.02	-0.08	-0.02	0.02	-0.14	-0.02	-0.02	0.11	0.01	12.31
GOVT 6M-3M	-0.05	-0.04	-0.15	-0.03	0.10	-0.01	-0.11	-0.09	0.00	0.00	14.40
GOVT 1Y-6M	0.04	-0.07	-0.04	-0.01	0.03	-0.12	-0.06	-0.02	0.07	0.05	12.55
GOVT 2Y-1Y	-0.14	-0.01	0.00	-0.04	0.02	-0.06	0.06	-0.08	-0.03	-0.10	19.94
GOVT 3Y-2Y	-0.27	-0.01	0.04	-0.08	-0.06	0.05	-0.02	-0.03	0.01	0.01	15.68
GOVT 5Y-3Y	-0.13	0.01	0.03	-0.07	-0.08	0.06	-0.10	-0.01	0.02	-0.06	11.75
GOVT 7Y-5Y	-0.11	-0.02	-0.05	-0.04	-0.03	-0.03	0.03	-0.02	0.05	0.07	9.66
GOVT 10Y-7Y	-0.13	-0.02	-0.13	-0.02	0.00	-0.01	-0.05	0.01	0.04	-0.04	16.20
GOVT 30Y-10Y	-0.09	0.03	-0.07	-0.02	-0.02	0.02	0.10	0.08	0.05	-0.04	10.24
1980-1984 (1247 obs):											
GOVT 3M	0.13	0.04	-0.01	0.05	0.05	0.04	0.00	0.03	0.04	0.04	20.33
GOVT 6M-3M	0.02	0.07	-0.05	-0.05	-0.04	-0.06	-0.05	-0.02	-0.01	0.04	13.85
GOVT 1Y-6M	-0.03	0.01	-0.01	-0.02	0.07	-0.05	-0.10	0.00	-0.04	0.04	13.84
GOVT 2Y-1Y	-0.25	-0.03	0.00	0.05	0.01	-0.02	-0.04	0.04	0.06	-0.02	48.18*
GOVT 3Y-2Y	-0.20	-0.03	-0.01	0.00	0.00	-0.03	0.02	0.06	-0.06	0.04	44.76*
GOVT 5Y-3Y	-0.16	0.00	-0.03	-0.02	0.03	-0.01	-0.02	0.03	0.00	0.04	18.58
GOVT 7Y-5Y	-0.21	-0.02	0.00	-0.02	0.02	0.00	-0.03	0.05	-0.02	0.05	32.21*
GOVT 10Y-7Y	-0.30	-0.01	0.05	-0.04	0.00	-0.03	0.09	-0.01	-0.02	-0.03	35.98*
GOVT 30Y-10Y	-0.14	0.00	-0.01	-0.06	0.12	-0.02	0.03	-0.03	-0.04	0.03	25.52*
1985-1989 (1248 obs):											
GOVT 3M	0.13	0.02	-0.08	0.01	-0.07	-0.06	0.02	-0.04	-0.04	-0.02	16.35
GOVT 6M-3M	-0.07	0.02	-0.12	0.02	-0.13	-0.08	-0.04	0.01	0.04	0.07	30.99*
GOVT 1Y-6M	-0.05	-0.09	-0.10	0.00	0.02	-0.05	-0.02	-0.01	0.02	-0.04	14.00
GOVT 2Y-1Y	-0.16	-0.07	-0.07	0.04	0.00	-0.02	0.05	-0.01	0.00	-0.02	24.80*
GOVT 3Y-2Y	-0.22	-0.03	-0.03	-0.03	0.03	-0.01	0.01	-0.05	0.00	-0.06	41.07*
GOVT 5Y-3Y	-0.17	0.00	0.00	-0.02	0.00	-0.04	0.02	0.00	-0.04	-0.10	41.31*
GOVT 7Y-5Y	-0.19	0.02	-0.07	0.02	-0.03	-0.02	-0.04	-0.04	-0.02	0.02	34.21*
GOVT 10Y-7Y	-0.17	0.05	-0.12	0.02	-0.02	0.04	-0.03	0.02	-0.05	-0.01	47.99*
GOVT 30Y-10Y	-0.12	0.03	0.06	-0.02	0.03	-0.01	-0.03	0.02	-0.04	0.03	13.71
1990-1994 (1249 obs):											
GOVT 3M	0.13	-0.04	-0.01	0.00	0.02	-0.02	-0.02	-0.02	0.11	0.08	39.50*
GOVT 6M-3M	-0.01	-0.06	-0.03	-0.09	0.00	-0.06	-0.03	-0.01	-0.02	-0.04	14.26
GOVT 1Y-6M	-0.05	-0.11	-0.07	-0.07	0.06	-0.05	-0.01	-0.01	0.00	0.07	36.79*
GOVT 2Y-1Y	-0.09	-0.02	-0.01	-0.02	-0.06	0.00	0.00	0.00	0.01	-0.01	15.42
GOVT 3Y-2Y	-0.25	0.04	-0.05	-0.01	0.00	-0.03	0.03	-0.04	0.03	-0.03	55.54*
GOVT 5Y-3Y	-0.13	0.01	0.02	-0.03	0.00	0.02	0.02	-0.03	-0.03	-0.03	23.95*
GOVT 7Y-5Y	-0.11	-0.04	-0.03	0.00	-0.03	-0.01	-0.04	0.02	-0.04	0.02	23.54*
GOVT 10Y-7Y	-0.14	0.02	0.01	-0.04	0.01	-0.02	0.06	0.02	0.00	-0.02	29.32*
GOVT 30Y-10Y	-0.01	-0.03	-0.07	-0.04	0.00	-0.02	-0.02	0.09	0.03	0.01	14.54
Eurodollar futures 1990-1994 (1265 obs):											
EDF 3M	0.09	0.01	0.02	0.00	0.01	0.01	0.00	-0.02	0.01	0.02	11.34
EDF 6M	0.07	0.01	-0.01	-0.05	-0.02	-0.02	0.01	0.02	0.01	0.04	8.43
EDF 9M	0.09	-0.01	-0.02	-0.03	0.02	-0.01	0.01	0.01	0.01	0.05	16.05
EDF 12M	0.11	0.00	-0.01	-0.03	0.01	-0.01	0.01	0.01	0.01	0.05	19.70
EDF 15M	0.13	0.00	0.00	-0.03	0.00	-0.01	0.02	0.02	0.01	0.05	23.94*
EDF 18M	0.13	0.00	0.01	-0.04	0.00	-0.01	0.02	0.02	0.01	0.05	23.49*
EDF 21M	0.12	0.00	0.01	-0.05	-0.02	-0.02	0.01	0.02	0.01	0.04	21.60
EDF 24M	0.07	0.01	-0.01	-0.05	-0.02	-0.02	0.01	0.02	0.01	0.04	8.43
EDF 27M	0.11	0.00	0.00	-0.06	-0.02	-0.03	0.01	0.01	0.02	0.04	19.83
EDF 30M	0.11	0.00	0.00	-0.06	-0.02	-0.03	0.02	0.00	0.02	0.05	19.76
EDF 33M	0.09	0.00	0.00	-0.07	-0.02	-0.04	0.01	0.00	0.02	0.04	17.74
EDF 36M	0.10	0.00	0.00	-0.06	-0.04	-0.03	0.00	0.00	0.01	0.05	16.75

Table 1b. U.S. Yield Curve: Test of Autocorrelation

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)	r(10)	Q(10)
1977-1979:											
Factor 1	0.07	0.01	-0.09	-0.01	0.04	-0.13	-0.05	-0.05	0.09	0.00	11.11
Factor 2	-0.05	-0.02	-0.07	-0.05	0.02	-0.02	0.02	-0.07	0.04	-0.01	7.30
Factor 3	0.00	-0.08	-0.08	-0.05	-0.02	-0.07	0.03	0.06	0.01	0.01	6.86
1980-1984:											
Factor 1	0.13	0.04	-0.01	0.05	0.05	0.03	0.00	0.03	0.05	0.04	19.07
Factor 2	-0.02	0.06	-0.03	-0.01	-0.05	-0.06	-0.03	-0.02	0.01	-0.01	8.36
Factor 3	-0.25	0.03	-0.05	-0.05	0.03	-0.03	-0.12	0.04	0.01	0.03	57.97*
1985-1989:											
Factor 1	0.10	0.02	-0.09	0.00	-0.09	-0.06	0.02	-0.02	-0.02	-0.01	15.34
Factor 2	-0.01	-0.01	-0.16	0.03	-0.06	-0.07	-0.08	-0.03	0.01	0.02	24.78*
Factor 3	-0.06	-0.10	0.02	0.01	0.02	-0.04	0.03	-0.02	0.00	0.02	13.67
1990-1994:											
Factor 1	0.14	-0.04	-0.01	-0.01	0.01	-0.01	-0.01	-0.01	0.11	0.07	38.23*
Factor 2	0.04	-0.04	-0.04	-0.05	0.03	-0.05	-0.03	0.02	0.01	0.01	14.05
Factor 3	-0.18	-0.04	-0.05	-0.03	-0.02	-0.01	-0.02	-0.03	-0.02	0.02	46.73*

Notes:

Q(10) distribution: 18.3 (5%), 20.5 (2.5%), 23.2 (1%).

* = statistically significant at the 1%.

Table 2a. U.S. Yield Curve Test of Conditional Heteroskedasticity

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)	r(10)	Q(10)
1977-79:											
GOVT 3M	0.31	0.32	0.30	0.36	0.29	0.27	0.30	0.31	0.32	0.21	639.52*
GOVT 6M-3M	0.39	0.30	0.32	0.34	0.38	0.31	0.28	0.25	0.26	0.28	695.70*
GOVT 1Y-6M	0.32	0.20	0.23	0.17	0.18	0.16	0.15	0.24	0.21	0.15	305.20*
GOVT 2Y-1Y	0.21	0.19	0.16	0.17	0.23	0.21	0.22	0.11	0.12	0.17	236.47*
GOVT 3Y-2Y	0.39	0.24	0.24	0.20	0.20	0.17	0.11	0.10	0.17	0.24	337.83*
GOVT 5Y-3Y	0.38	0.28	0.22	0.28	0.30	0.21	0.20	0.23	0.24	0.21	476.83*
GOVT 7Y-5Y	0.26	0.18	0.17	0.08	0.15	0.12	0.01	0.08	0.06	0.11	137.44*
GOVT 10Y-7Y	0.18	0.10	0.15	0.03	0.08	-0.01	0.04	0.08	0.02	0.09	61.77*
GOVT 30Y-10Y	0.23	0.18	0.29	0.25	0.18	0.15	0.20	0.13	0.21	0.18	302.06*
1980-1984:											
GOVT 3M	0.24	0.24	0.23	0.24	0.30	0.21	0.20	0.24	0.29	0.27	757.47*
GOVT 6M-3M	0.28	0.24	0.26	0.28	0.21	0.18	0.20	0.23	0.23	0.31	747.57*
GOVT 1Y-6M	0.23	0.17	0.13	0.14	0.23	0.13	0.19	0.13	0.18	0.15	362.09*
GOVT 2Y-1Y	0.30	0.22	0.20	0.22	0.21	0.19	0.15	0.22	0.24	0.16	572.74*
GOVT 3Y-2Y	0.19	0.23	0.16	0.15	0.13	0.22	0.15	0.14	0.18	0.08	344.99*
GOVT 5Y-3Y	0.28	0.20	0.16	0.16	0.18	0.18	0.21	0.21	0.19	0.20	486.41*
GOVT 7Y-5Y	0.23	0.20	0.16	0.14	0.11	0.11	0.12	0.11	0.11	0.11	266.75*
GOVT 10Y-7Y	0.36	0.24	0.26	0.23	0.23	0.17	0.22	0.17	0.14	0.21	650.96*
GOVT 30Y-10Y	0.25	0.24	0.23	0.21	0.15	0.19	0.13	0.16	0.12	0.12	424.96*
1985-1989:											
GOVT 3M	0.22	0.15	0.19	0.17	0.16	0.08	0.12	0.08	0.13	0.08	257.95*
GOVT 6M-3M	0.20	0.19	0.23	0.17	0.22	0.13	0.12	0.15	0.13	0.14	367.52*
GOVT 1Y-6M	0.19	0.17	0.22	0.15	0.20	0.08	0.11	0.11	0.13	0.14	296.44*
GOVT 2Y-1Y	0.13	0.09	0.04	0.12	0.08	0.04	0.08	0.05	0.07	0.02	76.51*
GOVT 3Y-2Y	0.18	0.11	0.07	0.01	0.03	0.04	0.04	0.06	0.08	0.00	80.78*
GOVT 5Y-3Y	0.11	0.05	0.07	0.07	0.09	0.05	0.02	0.08	0.06	0.07	63.09*
GOVT 7Y-5Y	0.15	0.11	0.11	0.08	0.08	0.08	0.08	0.12	0.09	0.04	122.66*
GOVT 10Y-7Y	0.12	0.09	0.11	0.07	0.04	0.11	0.04	0.03	0.08	0.02	79.14*
GOVT 30Y-10Y	0.27	0.23	0.19	0.21	0.20	0.15	0.07	0.11	0.14	0.15	414.28*
1990-1994:											
GOVT 3M	0.08	0.10	0.11	0.09	0.07	0.06	0.08	0.03	0.11	0.05	84.60*
GOVT 6M-3M	0.11	0.15	0.13	0.14	0.16	0.06	0.10	0.06	0.09	0.09	159.07*
GOVT 1Y-6M	0.12	0.07	0.01	0.00	0.07	0.01	0.05	0.06	0.02	0.07	45.38*
GOVT 2Y-1Y	0.06	0.06	0.04	0.04	0.03	0.10	0.00	0.01	0.01	-0.01	26.53*
GOVT 3Y-2Y	0.11	0.06	-0.03	0.04	0.05	0.06	0.01	0.05	0.08	0.01	42.06*
GOVT 5Y-3Y	0.02	0.09	-0.03	-0.01	0.04	-0.01	0.01	0.02	-0.01	0.09	23.49*
GOVT 7Y-5Y	0.06	0.06	0.01	0.03	0.06	0.09	0.02	0.00	0.04	0.02	27.82*
GOVT 10Y-7Y	0.07	0.02	0.03	0.04	0.02	0.01	0.02	-0.01	0.03	-0.02	12.30
GOVT 30Y-10Y	0.19	0.14	0.12	0.17	0.08	0.10	0.10	0.11	0.12	0.11	204.94*
Eurodollar futures 1990-1994:											
EDF 3M	0.09	0.09	0.09	0.09	0.13	0.06	0.06	0.11	0.11	0.05	102.58*
EDF 6M	0.10	0.04	0.02	0.05	0.05	0.05	0.04	0.02	0.03	0.07	33.32*
EDF 9M	0.04	0.03	0.03	0.06	0.09	0.04	0.03	0.07	0.06	0.02	33.31*
EDF 12M	0.04	0.03	0.03	0.04	0.09	0.06	0.04	0.06	0.06	0.03	32.62*
EDF 15M	0.03	0.02	0.03	0.04	0.07	0.07	0.04	0.05	0.05	0.04	27.19*
EDF 18M	0.04	0.03	0.03	0.05	0.06	0.07	0.05	0.04	0.05	0.06	31.17*
EDF 21M	0.04	0.03	0.03	0.05	0.05	0.08	0.05	0.04	0.05	0.07	33.81*
EDF 24M	0.10	0.04	0.02	0.05	0.05	0.05	0.04	0.02	0.03	0.07	33.32*
EDF 27M	0.06	0.04	0.03	0.08	0.07	0.08	0.06	0.05	0.06	0.07	49.79*
EDF 30M	0.06	0.05	0.02	0.07	0.08	0.09	0.06	0.05	0.07	0.07	51.76*
EDF 33M	0.08	0.05	0.03	0.07	0.08	0.09	0.06	0.06	0.07	0.07	55.78*
EDF 36M	0.09	0.05	0.03	0.07	0.09	0.09	0.05	0.06	0.08	0.07	65.41*

Table 2b. U.S. Yield Curve Test of Conditional Heteroskedasticity

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)	r(10)	Q(10)
1977-1979:											
Factor 1	0.33	0.33	0.32	0.37	0.29	0.28	0.31	0.31	0.32	0.23	298.53*
Factor 2	0.33	0.26	0.22	0.21	0.20	0.18	0.19	0.15	0.14	0.09	141.10*
Factor 3	0.30	0.34	0.28	0.30	0.28	0.24	0.27	0.24	0.22	0.19	200.75*
1980-1984:											
Factor 1	0.24	0.24	0.23	0.24	0.30	0.22	0.21	0.24	0.29	0.26	489.35*
Factor 2	0.25	0.19	0.21	0.21	0.15	0.20	0.17	0.17	0.19	0.20	298.72*
Factor 3	0.25	0.16	0.17	0.14	0.13	0.19	0.19	0.15	0.13	0.13	237.44*
1985-1989:											
Factor 1	0.23	0.17	0.22	0.18	0.19	0.09	0.11	0.10	0.14	0.11	102.00*
Factor 2	0.17	0.16	0.23	0.15	0.20	0.06	0.13	0.10	0.11	0.14	132.37*
Factor 3	0.08	0.14	0.10	0.11	0.13	0.03	0.06	0.08	0.07	0.08	72.47*
1990-1994:											
Factor 1	0.08	0.11	0.10	0.09	0.07	0.05	0.10	0.03	0.10	0.04	66.32*
Factor 2	0.13	0.05	0.07	0.05	0.06	0.10	0.04	0.06	0.06	0.08	55.96*
Factor 3	0.05	0.00	0.07	-0.03	0.04	0.01	-0.01	0.05	0.04	-0.01	13.75

Table 3a. Non-US Yield Curve Test of Autocorrelation (1990-94)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)	r(10)	Q(10)
Belgium											
3M	-0.01	0.13	-0.06	0.06	-0.13	-0.05	-0.05	-0.09	-0.09	0.02	11.10
6M- 3M	-0.19	-0.05	-0.12	-0.03	-0.01	0.07	0.00	-0.07	-0.02	0.03	14.33
1Y- 6M	-0.14	-0.14	-0.11	-0.05	-0.03	0.02	-0.08	-0.01	0.05	0.03	16.18
2Y- 1Y	-0.22	-0.11	0.01	0.06	-0.13	0.02	0.07	-0.06	-0.08	0.02	31.91
3Y- 2Y	-0.05	-0.04	-0.15	0.02	-0.01	0.00	0.01	0.00	0.02	-0.02	12.58
5Y- 3Y	-0.14	-0.08	-0.13	0.01	0.04	-0.04	0.03	-0.05	0.00	0.02	28.23
7Y- 5Y	-0.19	-0.11	-0.03	0.01	0.01	-0.07	0.04	-0.02	0.04	-0.03	31.14
10- 7Y	-0.11	-0.12	-0.03	-0.03	0.03	-0.11	0.02	-0.02	-0.03	-0.02	21.35
Canada:											
3M	0.03	-0.02	0.01	0.09	0.11	-0.02	-0.05	0.01	-0.05	0.05	11.31
6M- 3M	-0.21	-0.10	0.01	-0.07	0.03	-0.03	0.00	-0.01	-0.02	-0.02	13.16
1Y- 6M	-0.35	0.01	-0.02	-0.02	0.00	0.04	-0.05	-0.05	0.05	0.03	10.02
2Y- 1Y	-0.25	-0.08	-0.03	0.00	0.00	-0.06	0.03	0.04	-0.10	0.07	51.14
3Y- 2Y	-0.06	-0.02	-0.04	-0.04	0.03	0.03	0.00	-0.02	0.02	0.05	9.24
5Y- 3Y	-0.11	-0.07	-0.02	0.06	-0.02	0.02	-0.05	-0.02	-0.01	0.00	20.16
7Y- 5Y	-0.19	-0.04	-0.02	-0.03	0.03	-0.08	0.05	0.01	-0.03	0.05	31.64
10- 7Y	-0.09	0.01	-0.03	0.07	-0.07	0.04	0.00	0.00	-0.01	0.02	17.95
Switzerland:											
3M	-0.05	-0.04	-0.10	0.01	0.03	0.06	0.01	0.00	-0.02	0.04	17.18
6M- 3M	-0.25	-0.14	-0.03	-0.02	0.01	0.00	0.00	0.05	-0.05	-0.04	53.93
1Y- 6M	-0.36	-0.08	0.00	0.01	-0.02	-0.02	0.03	-0.02	0.01	0.02	49.66
2Y- 1Y	-0.13	-0.07	0.00	-0.03	-0.05	-0.02	-0.02	-0.04	0.01	-0.02	21.56
3Y- 2Y	-0.10	-0.09	-0.04	-0.05	-0.06	-0.02	-0.01	-0.01	0.00	-0.04	26.10
5Y- 3Y	-0.10	-0.12	-0.04	-0.10	-0.09	-0.03	0.01	0.01	0.08	0.00	41.44
7Y- 5Y	-0.05	-0.06	-0.11	-0.05	-0.05	-0.01	-0.06	0.00	-0.04	-0.01	30.20
10- 7Y	-0.09	-0.05	-0.10	-0.04	-0.04	-0.02	-0.02	-0.02	-0.06	0.01	28.83
Germany:											
3M	-0.14	0.05	-0.06	0.03	0.01	-0.07	0.04	-0.07	0.05	-0.02	16.10
6M- 3M	-0.39	-0.02	-0.03	-0.01	-0.03	0.06	-0.03	-0.04	0.03	0.00	36.73
1Y- 6M	-0.43	0.10	-0.14	0.05	-0.05	0.02	0.03	0.00	0.00	-0.03	53.37
2Y- 1Y	-0.23	-0.04	-0.06	0.02	-0.01	-0.04	-0.05	0.04	-0.07	0.04	47.03
3Y- 2Y	-0.08	-0.04	-0.12	-0.02	-0.03	-0.04	0.02	-0.05	0.00	0.00	23.75
5Y- 3Y	-0.01	-0.03	-0.09	-0.01	-0.04	-0.01	-0.06	0.00	-0.01	-0.01	12.25
7Y- 5Y	-0.04	-0.03	-0.02	0.01	-0.04	-0.06	-0.03	0.00	-0.01	0.00	7.87
10- 7Y	-0.01	-0.01	-0.05	-0.03	0.00	-0.09	-0.03	-0.02	0.04	0.00	14.24
Denmark:											
3M	0.02	-0.04	-0.11	0.03	0.12	-0.05	-0.06	-0.01	0.02	-0.15	7.11
6M- 3M	-0.02	-0.08	-0.07	-0.05	0.09	-0.09	-0.01	0.02	-0.04	-0.15	7.52
1Y- 6M	-0.06	-0.05	-0.19	-0.03	0.07	-0.03	-0.10	-0.02	0.06	-0.11	19.17
2Y- 1Y	-0.14	-0.04	-0.16	0.01	0.04	-0.03	-0.03	-0.08	0.07	0.02	20.81
3Y- 2Y	-0.23	-0.17	0.00	-0.01	0.06	0.02	-0.12	0.05	0.07	-0.07	21.74
5Y- 3Y	-0.26	-0.15	0.05	-0.03	0.02	0.05	-0.13	0.04	0.03	-0.10	17.61
7Y- 5Y	-0.21	0.03	-0.09	-0.02	-0.02	0.02	-0.04	0.00	0.01	-0.04	21.57
10- 7Y	-0.17	-0.04	0.00	0.02	-0.09	0.08	0.01	-0.07	-0.01	0.10	21.85
France:											
3M	-0.01	-0.26	-0.06	0.23	0.06	-0.15	0.00	0.02	-0.06	0.01	13.57
6M- 3M	-0.32	-0.07	0.12	-0.08	0.03	0.00	-0.01	0.01	-0.07	0.03	15.18
1Y- 6M	-0.29	-0.20	-0.08	0.22	-0.04	-0.09	-0.05	0.11	-0.03	-0.04	25.79
2Y- 1Y	-0.38	-0.03	-0.04	0.01	-0.01	-0.02	0.04	-0.05	0.02	0.02	9.08
3Y- 2Y	-0.18	-0.02	-0.04	0.05	-0.07	0.01	0.04	-0.03	-0.04	-0.06	22.79
5Y- 3Y	-0.31	0.03	-0.07	0.03	-0.04	0.05	-0.10	0.05	-0.03	-0.02	28.05
7Y- 5Y	-0.38	0.00	0.02	0.02	-0.04	0.02	0.04	-0.07	0.05	-0.04	85.34

10- 7Y	-0.43	-0.01	-0.01	-0.04	0.04	0.01	-0.01	-0.02	0.02	-0.06	68.86
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United Kingdom:

3M	-0.04	0.05	-0.05	0.07	0.01	0.02	-0.05	0.02	-0.07	0.02	17.02
6M- 3M	-0.39	-0.18	0.07	0.03	0.00	-0.03	0.02	-0.01	-0.01	0.02	15.80
1Y- 6M	-0.37	-0.12	0.00	0.01	-0.01	0.01	0.03	0.05	-0.15	0.10	8.55
2Y- 1Y	-0.26	-0.03	-0.01	0.02	-0.04	-0.01	-0.01	-0.03	0.07	-0.01	15.22
3Y- 2Y	-0.10	0.00	-0.02	-0.02	-0.05	-0.04	0.01	-0.03	0.05	-0.04	29.40
5Y- 3Y	-0.13	-0.05	-0.02	0.01	0.01	0.00	-0.02	0.00	0.01	-0.04	10.38
7Y- 5Y	-0.13	-0.02	0.01	0.00	-0.03	-0.01	-0.08	0.01	-0.02	-0.01	15.15
10- 7Y	-0.19	-0.03	0.01	0.01	-0.02	0.02	-0.01	0.01	-0.01	0.02	25.42

Table 3b. Non-US Yield Curve Test of Autocorrelation (1990-94)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)	r(10)	Q(10)
Japan:											
3M	-0.13	-0.04	0.00	-0.01	0.08	-0.01	-0.01	0.01	-0.02	-0.01	13.89
6M- 3M	-0.29	-0.12	-0.01	-0.06	0.05	0.03	-0.07	0.04	0.03	0.00	32.19
1Y- 6M	-0.26	-0.20	0.04	0.00	0.01	-0.02	-0.03	0.01	-0.01	0.00	27.73
2Y- 1Y	-0.19	-0.11	0.00	0.01	-0.01	-0.05	-0.03	-0.01	0.01	-0.02	21.33
3Y- 2Y	-0.04	0.03	-0.01	-0.02	-0.05	-0.04	-0.04	0.02	0.02	0.08	12.71
5Y- 3Y	0.07	0.07	-0.02	-0.03	0.04	-0.05	-0.04	-0.01	0.00	-0.02	15.93
7Y- 5Y	-0.07	0.02	-0.01	-0.04	0.00	-0.03	0.00	-0.07	-0.02	0.03	7.21
10- 7Y	-0.18	-0.04	0.10	-0.07	-0.06	-0.09	0.10	-0.03	0.00	0.04	18.27
The Netherlands:											
3M	-0.04	0.04	0.05	-0.02	0.02	-0.04	0.01	-0.02	0.01	0.00	8.09
6M- 3M	-0.19	-0.11	-0.02	-0.06	-0.04	-0.02	0.01	0.00	0.02	-0.06	37.20
1Y- 6M	-0.22	-0.07	0.01	-0.10	0.01	-0.02	0.03	-0.03	0.00	-0.03	32.66
2Y- 1Y	-0.11	-0.11	-0.08	0.01	0.05	-0.07	-0.03	-0.03	0.00	-0.04	36.97
3Y- 2Y	-0.18	-0.03	0.01	-0.06	0.01	-0.04	-0.05	-0.02	-0.01	-0.02	34.35
5Y- 3Y	-0.12	0.02	-0.07	0.00	0.01	-0.05	-0.01	0.00	-0.03	-0.03	16.69
7Y- 5Y	-0.08	-0.07	-0.04	-0.02	-0.01	0.00	0.03	0.02	-0.04	-0.03	14.06
10- 7Y	-0.15	-0.02	-0.03	-0.05	-0.04	-0.06	0.05	0.00	-0.03	-0.02	33.48
Sweden:											
3M	-0.37	-0.08	0.01	-0.20	0.11	0.14	-0.09	0.00	0.05	-0.07	9.81
6M- 3M	-0.18	-0.16	-0.13	-0.08	-0.10	0.18	0.07	-0.07	0.02	-0.02	15.05
1Y- 6M	-0.52	0.00	0.22	-0.35	0.22	-0.06	-0.06	0.07	-0.03	0.04	18.69
2Y- 1Y	-0.40	-0.02	-0.04	-0.03	0.16	-0.13	-0.06	0.05	0.00	0.04	12.15
3Y- 2Y	-0.15	-0.01	-0.02	0.00	-0.07	0.00	0.06	-0.07	-0.05	0.04	20.41
5Y- 3Y	-0.16	-0.08	0.07	-0.02	-0.05	0.00	-0.04	-0.07	0.04	0.01	19.54
7Y- 5Y	0.05	-0.02	-0.14	0.08	-0.03	-0.06	-0.11	0.03	0.01	0.04	18.41
10- 7Y	-0.17	-0.02	-0.03	-0.03	-0.04	-0.04	0.04	-0.03	0.00	0.05	16.34
Belgium:											
Factor1	-0.06	0.11	-0.06	0.06	-0.15	-0.05	-0.03	-0.08	-0.10	0.00	11.85
Factor2	-0.12	-0.18	-0.01	-0.02	-0.02	0.02	-0.02	-0.05	0.00	0.09	16.82
Factor3	-0.19	-0.05	-0.15	0.02	-0.05	0.08	0.00	-0.06	0.00	0.01	20.83
Canada:											
Factor1	-0.05	-0.01	-0.03	0.10	0.02	-0.04	-0.03	0.05	-0.05	0.03	11.45
Factor2	-0.14	-0.06	-0.04	0.00	-0.04	-0.04	0.05	-0.01	-0.07	0.06	35.10
Factor3	-0.30	-0.05	0.00	-0.06	0.01	0.00	-0.02	-0.03	0.01	0.01	7.17
Switzerland:											
Factor1	-0.36	0.01	-0.07	0.08	-0.07	0.00	0.02	0.00	0.00	0.00	9.65
Factor2	-0.11	-0.08	-0.03	-0.04	-0.06	-0.03	-0.01	-0.01	0.01	-0.04	26.41
Factor3	-0.12	-0.11	-0.03	-0.08	-0.09	-0.01	-0.01	-0.02	0.06	0.01	39.23
Germany:											
Factor1	-0.38	0.14	-0.20	0.04	0.02	-0.02	0.01	-0.01	0.00	0.01	13.98
Factor2	-0.28	0.02	-0.04	0.03	-0.05	0.00	-0.02	0.00	0.01	0.01	36.89
Factor3	-0.36	0.11	-0.16	0.05	-0.02	-0.02	0.05	-0.04	0.03	-0.05	50.34
Denmark:											
Factor1	-0.02	-0.04	-0.10	0.03	0.11	-0.06	-0.05	-0.01	0.02	-0.14	7.40
Factor2	-0.31	0.03	-0.13	-0.02	0.03	-0.05	0.02	-0.01	-0.01	-0.03	10.97
Factor3	-0.17	-0.01	-0.20	-0.01	0.05	-0.02	0.00	-0.08	0.05	0.00	24.08
France:											
Factor1	-0.17	-0.09	-0.04	0.06	0.05	-0.09	0.01	0.02	-0.03	0.01	12.45
Factor2	-0.16	-0.13	-0.04	0.10	0.03	-0.09	0.01	0.01	-0.05	0.00	12.76

Factor3	-0.41	-0.02	-0.02	-0.01	-0.02	0.00	0.03	-0.03	0.00	0.01	5.92
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United Kingdom:

Factor1	-0.37	0.08	-0.08	-0.02	0.03	-0.03	0.00	0.01	-0.01	0.01	12.44
Factor2	-0.39	-0.17	0.05	0.02	0.00	-0.02	0.03	0.00	-0.04	0.04	15.12
Factor3	-0.11	0.08	-0.08	0.08	-0.01	0.01	-0.01	0.02	-0.05	0.04	27.21

Japan:

Factor1	-0.30	0.07	-0.12	0.04	-0.03	-0.02	0.01	0.00	0.00	0.00	8.71
Factor2	-0.28	-0.04	-0.07	0.02	-0.02	-0.03	0.00	0.01	0.00	-0.01	7.97
Factor3	-0.28	-0.13	-0.01	-0.03	0.04	0.00	-0.05	0.03	0.01	-0.01	25.22

Table 3c. Non-US Yield Curve Test of Autocorrelation (1990-94)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)	r(10)	Q(10)
The Netherlands:											
Factor1	-0.45	0.05	-0.06	0.01	0.02	-0.06	0.03	-0.01	0.00	0.00	11.04
Factor2	-0.10	-0.05	-0.03	0.00	0.03	-0.08	-0.01	-0.02	0.02	-0.03	22.40
Factor3	-0.11	-0.07	-0.01	-0.05	0.01	-0.01	-0.03	-0.01	0.00	-0.03	20.46
Sweden											
Factor1	-0.39	-0.07	0.02	-0.21	0.14	0.12	-0.09	0.00	0.03	-0.06	9.74
Factor2	-0.34	-0.08	0.07	-0.22	0.02	0.00	0.06	0.02	-0.02	0.06	11.82
Factor3	-0.38	-0.09	-0.02	0.03	0.02	-0.04	0.01	-0.03	0.03	0.01	11.13

Table 4a. Non-US Yield Curve Test of Conditional Heteroskedasticity (1990-94)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)	r(10)	Q(10)
Belgium											
3M	0.40	0.29	0.32	0.32	0.39	0.36	0.32	0.16	0.20	0.26	1258.63
6M- 3M	0.29	0.17	0.27	0.10	0.14	0.12	0.10	0.08	0.08	0.10	346.53
1Y- 6M	0.19	0.19	0.15	0.11	0.05	0.06	0.10	0.08	0.10	0.01	182.78
2Y- 1Y	0.30	0.28	0.19	0.14	0.12	0.10	0.09	0.04	0.11	0.11	360.58
3Y- 2Y	0.18	0.08	0.13	0.08	0.07	0.07	0.08	0.03	0.04	0.06	111.11
5Y- 3Y	0.22	0.11	0.19	0.09	0.07	0.04	0.08	0.09	0.10	0.13	195.63
7Y- 5Y	0.27	0.15	0.17	0.19	0.20	0.17	0.13	0.14	0.14	0.13	379.26
10- 7Y	0.30	0.21	0.25	0.24	0.23	0.23	0.17	0.19	0.24	0.18	655.52
Canada:											
3M	0.14	0.06	0.06	0.12	0.10	0.02	0.08	0.03	0.07	0.09	94.03
6M- 3M	0.22	0.08	0.06	0.09	0.09	0.02	0.00	0.00	-0.01	0.01	93.66
1Y- 6M	0.29	0.13	0.02	0.05	0.05	0.03	0.05	0.02	0.02	0.02	145.98
2Y- 1Y	0.22	0.21	0.15	0.13	0.13	0.09	0.14	0.13	0.20	0.17	344.04
3Y- 2Y	0.14	0.17	0.16	0.12	0.10	0.08	0.07	0.07	0.09	0.14	183.96
5Y- 3Y	0.13	0.09	0.04	0.06	0.04	0.03	0.09	0.01	0.03	0.07	57.98
7Y- 5Y	0.21	0.10	0.04	0.06	0.03	0.05	0.05	0.04	0.04	0.05	94.77
10- 7Y	0.25	0.13	0.05	0.05	0.06	0.04	0.07	0.05	0.09	0.08	144.28
Switzerland:											
3M	0.13	0.13	0.12	0.09	0.13	0.12	0.14	0.19	0.12	0.13	228.20
6M- 3M	0.15	0.11	0.04	0.03	0.07	0.03	0.07	0.08	0.05	0.01	73.38
1Y- 6M	0.24	0.05	0.02	-0.01	0.04	0.01	0.02	0.08	0.12	0.06	115.16
2Y- 1Y	0.10	0.05	0.06	0.03	0.06	0.01	0.03	0.05	0.06	0.07	42.65
3Y- 2Y	0.03	0.06	0.03	0.02	0.05	0.01	-0.01	0.02	0.00	0.06	16.83
5Y- 3Y	0.06	0.09	-0.02	0.08	0.09	0.03	0.01	-0.01	0.04	0.04	40.83
7Y- 5Y	0.02	0.03	0.05	0.08	0.08	0.07	0.01	0.00	0.02	-0.01	28.00
10- 7Y	0.02	0.06	0.11	0.07	0.03	0.06	0.05	-0.03	0.05	-0.02	41.97
Germany:											
3M	0.20	0.20	0.13	0.16	0.19	0.11	0.08	0.10	0.10	0.11	270.18
6M- 3M	0.33	0.14	0.12	0.08	0.04	0.02	0.01	0.03	0.04	0.10	213.44
1Y- 6M	0.40	0.16	0.13	0.06	0.06	0.07	0.03	0.04	0.05	0.04	287.19
2Y- 1Y	0.18	0.03	0.02	0.07	0.07	0.08	0.03	0.03	0.08	0.04	77.80
3Y- 2Y	0.08	0.05	0.05	0.07	0.03	0.02	0.00	0.01	0.00	0.04	26.54
5Y- 3Y	0.15	0.16	0.10	0.09	0.06	0.09	0.10	0.04	0.11	0.08	142.83
7Y- 5Y	0.13	0.16	0.14	0.13	0.10	0.13	0.10	0.08	0.11	0.10	184.74
10- 7Y	0.12	0.06	0.10	0.04	0.02	0.07	0.06	0.10	0.10	0.03	74.98
Denmark:											
3M	0.36	0.23	0.36	0.26	0.30	0.16	0.18	0.23	0.21	0.22	869.36
6M- 3M	0.34	0.23	0.33	0.22	0.31	0.20	0.23	0.28	0.22	0.22	894.51
1Y- 6M	0.37	0.16	0.23	0.29	0.19	0.13	0.17	0.12	0.09	0.14	550.08
2Y- 1Y	0.21	0.16	0.24	0.24	0.20	0.21	0.18	0.18	0.23	0.19	550.66
3Y- 2Y	0.33	0.36	0.25	0.28	0.25	0.22	0.30	0.21	0.24	0.20	918.64
5Y- 3Y	0.41	0.33	0.31	0.23	0.25	0.26	0.29	0.24	0.28	0.23	1069.11
7Y- 5Y	0.32	0.20	0.17	0.14	0.12	0.18	0.13	0.12	0.12	0.08	379.50
10- 7Y	0.28	0.21	0.13	0.27	0.15	0.17	0.10	0.15	0.14	0.25	489.35
France:											
3M	0.50	0.53	0.40	0.49	0.36	0.39	0.31	0.37	0.33	0.33	2159.81
6M- 3M	0.48	0.35	0.39	0.32	0.23	0.23	0.23	0.23	0.20	0.22	1167.77
1Y- 6M	0.43	0.26	0.17	0.31	0.20	0.22	0.17	0.21	0.14	0.12	743.06
2Y- 1Y	0.47	0.08	0.06	0.06	0.03	0.06	0.07	0.08	0.10	0.09	349.57
3Y- 2Y	0.20	0.05	0.06	0.05	0.12	0.08	0.03	0.06	0.05	0.03	100.06
5Y- 3Y	0.30	0.11	0.04	0.04	0.10	0.10	0.10	0.08	0.08	0.05	196.53
7Y- 5Y	0.34	0.18	0.20	0.15	0.15	0.15	0.10	0.13	0.13	0.14	413.26

10- 7Y	0.46	0.32	0.29	0.22	0.31	0.27	0.24	0.26	0.21	0.26	1110.43
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United Kingdom:

3M	0.23	0.13	0.13	0.15	0.10	0.07	0.11	0.07	0.07	0.05	189.18
6M- 3M	0.57	0.17	0.09	0.02	0.01	0.01	0.00	-0.01	0.01	0.02	470.74
1Y- 6M	0.49	0.09	0.01	0.05	0.03	0.01	0.01	0.08	0.20	0.12	403.89
2Y- 1Y	0.31	0.13	0.10	0.08	0.08	0.08	0.07	0.16	0.17	0.11	282.70
3Y- 2Y	0.05	0.04	0.08	0.05	0.03	0.04	0.02	-0.01	0.00	0.01	21.34
5Y- 3Y	0.15	0.17	0.06	0.07	0.04	0.04	0.04	0.05	0.07	0.10	107.02
7Y- 5Y	0.19	0.14	0.10	0.08	0.06	0.02	0.07	0.04	0.06	0.08	120.24
10- 7Y	0.24	0.17	0.12	0.13	0.11	0.07	0.09	0.12	0.15	0.11	249.63

Table 4b. Non-US Yield Curve Test of Conditional Heteroskedasticity (1990-94)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)	r(10)	Q(10)
Japan:											
3M	0.09	0.05	0.03	0.03	0.03	0.00	0.07	0.04	0.03	0.02	29.09
6M- 3M	0.24	0.08	0.05	0.03	0.02	0.03	0.00	-0.01	0.02	0.02	90.97
1Y- 6M	0.23	0.12	0.04	0.06	0.01	0.01	0.00	0.00	0.05	0.03	97.71
2Y- 1Y	0.21	0.12	0.06	0.06	0.03	-0.01	-0.01	-0.01	-0.02	0.00	90.51
3Y- 2Y	0.16	0.02	0.10	0.02	0.09	0.07	0.03	0.01	0.00	0.10	77.46
5Y- 3Y	0.15	0.04	0.05	0.05	0.05	0.06	0.00	0.02	0.04	0.01	48.34
7Y- 5Y	0.23	0.21	0.16	0.19	0.12	0.19	0.17	0.23	0.20	0.14	451.63
10- 7Y	0.40	0.21	0.22	0.22	0.18	0.25	0.28	0.19	0.20	0.18	754.80
The Netherlands:											
3M	0.00	0.00	0.02	0.02	0.07	0.03	0.00	-0.05	0.02	0.03	12.66
6M- 3M	0.10	0.04	-0.01	0.07	0.08	0.01	-0.02	-0.03	0.00	0.03	31.89
1Y- 6M	0.16	0.00	-0.01	0.05	0.03	0.00	-0.04	-0.06	-0.01	0.00	43.89
2Y- 1Y	0.12	0.08	0.05	0.09	0.11	0.08	0.02	0.01	0.03	0.02	68.92
3Y- 2Y	0.19	0.13	0.11	0.16	0.12	0.13	0.09	0.10	0.11	0.06	208.00
5Y- 3Y	0.25	0.15	0.12	0.15	0.18	0.12	0.13	0.13	0.12	0.14	308.91
7Y- 5Y	0.17	0.07	0.10	0.06	0.06	0.08	0.08	0.06	0.08	0.05	99.51
10- 7Y	0.15	0.15	0.09	0.14	0.09	0.07	0.09	0.02	0.08	0.10	143.13
Sweden:											
3M	0.53	0.22	0.11	0.26	0.30	0.27	0.13	0.06	0.10	0.13	808.13
6M- 3M	0.51	0.24	0.16	0.12	0.20	0.22	0.18	0.12	0.07	0.08	658.92
1Y- 6M	0.51	0.08	0.23	0.38	0.25	0.10	0.09	0.09	0.05	0.05	718.16
2Y- 1Y	0.45	0.10	0.08	0.10	0.24	0.25	0.19	0.09	0.04	0.07	507.76
3Y- 2Y	0.19	0.13	0.10	0.10	0.08	0.08	0.17	0.05	0.07	0.04	162.44
5Y- 3Y	0.27	0.13	0.15	0.10	0.13	0.11	0.08	0.06	0.07	0.04	216.05
7Y- 5Y	0.33	0.12	0.21	0.17	0.15	0.13	0.15	0.11	0.13	0.15	399.51
10- 7Y	0.23	0.06	0.17	0.12	0.08	0.08	0.04	0.06	0.08	0.09	173.09
Belgium:											
Factor1	0.40	0.28	0.31	0.30	0.37	0.33	0.30	0.14	0.20	0.26	122.61
Factor2	0.20	0.24	0.16	0.15	0.09	0.11	0.08	0.08	0.11	0.08	88.14
Factor3	0.23	0.12	0.24	0.09	0.08	0.09	0.08	0.07	0.08	0.07	88.19
Canada:											
Factor1	0.12	0.07	0.09	0.14	0.12	0.03	0.06	0.06	0.09	0.09	56.59
Factor2	0.13	0.17	0.13	0.20	0.15	0.10	0.15	0.14	0.14	0.11	159.06
Factor3	0.30	0.12	0.05	0.09	0.08	0.02	0.01	0.02	0.01	0.02	18.55
Switzerland:											
Factor1	0.37	0.02	0.07	0.08	0.08	0.06	0.03	0.01	0.00	0.01	33.05
Factor2	0.04	0.04	0.04	0.03	0.06	0.01	0.01	0.02	0.01	0.07	17.17
Factor3	0.10	0.11	0.01	0.08	0.13	0.03	0.02	0.01	0.05	0.09	50.55
Germany:											
Factor1	0.38	0.15	0.21	0.08	0.02	0.02	0.01	0.01	0.01	0.01	41.56
Factor2	0.25	0.09	0.12	0.15	0.13	0.12	0.06	0.06	0.08	0.08	91.14
Factor3	0.38	0.23	0.23	0.14	0.14	0.12	0.07	0.08	0.10	0.10	115.86
Denmark:											
Factor1	0.37	0.23	0.34	0.24	0.28	0.16	0.17	0.22	0.20	0.20	111.82
Factor2	0.39	0.12	0.18	0.10	0.07	0.09	0.09	0.07	0.07	0.05	86.60
Factor3	0.29	0.16	0.26	0.20	0.13	0.15	0.14	0.12	0.18	0.14	161.47
France:											
Factor1	0.39	0.25	0.17	0.23	0.16	0.18	0.13	0.15	0.13	0.13	209.01
Factor2	0.42	0.29	0.25	0.27	0.21	0.20	0.15	0.19	0.17	0.17	210.07

Factor3	0.47	0.06	0.04	0.04	0.02	0.04	0.06	0.09	0.08	0.08	51.07
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United Kingdom:

Factor1	0.40	0.09	0.08	0.07	0.03	0.03	0.02	0.00	0.01	0.00	19.39
Factor2	0.58	0.16	0.08	0.02	0.00	0.00	0.01	0.02	0.04	0.03	12.30
Factor3	0.21	0.11	0.12	0.14	0.11	0.05	0.10	0.09	0.07	0.04	94.46

Japan:

Factor1	0.35	0.09	0.13	0.05	0.03	0.04	0.01	0.00	0.00	0.00	12.08
Factor2	0.32	0.09	0.09	0.03	0.02	0.01	-0.01	-0.01	-0.01	-0.01	18.67
Factor3	0.24	0.09	0.04	0.03	0.02	0.02	-0.02	0.00	0.00	0.01	13.95

Table 4c. Non-US Yield Curve Test of Conditional Heteroskedasticity (1990-94)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)	r(10)	Q(10)
The Netherlands:											
Factor1	0.46	0.05	0.06	0.02	0.02	0.06	0.03	0.00	0.00	0.00	12.25
Factor2	0.08	0.03	0.04	0.08	0.09	0.06	0.03	-0.01	0.02	0.02	29.31
Factor3	0.07	0.07	0.04	0.10	0.08	0.05	0.02	0.03	0.04	0.09	35.68

Sweden:

Factor1	0.53	0.19	0.09	0.27	0.33	0.28	0.13	0.06	0.10	0.13	39.69
Factor2	0.40	0.08	0.24	0.23	0.07	0.13	0.18	0.10	0.07	0.10	36.27
Factor3	0.48	0.14	0.15	0.10	0.11	0.14	0.09	0.05	0.06	0.03	81.21

Table 5. Correlation Coefficients for U.S. Yield Spreads and Levels

	1-day		2-day		3-day		4-day		5-day	
	3M	6-3M	3M	6-3M	3M	6-3M	3M	6-3M	3M	6-3M
Period: 1977-79 (714 observations)										
3M	1.00	-0.63	1.00	-0.60	1.00	-0.59	1.00	-0.58	1.00	-0.58
6M- 3M	-0.63	1.00	-0.60	1.00	-0.59	1.00	-0.58	1.00	-0.58	1.00
1Y- 6M	-0.07	0.02	-0.05	0.05	-0.01	0.06	0.00	0.08	-0.02	0.11
2Y- 1Y	-0.45	0.16	-0.44	0.17	-0.45	0.15	-0.45	0.16	-0.46	0.17
3Y- 2Y	-0.19	0.05	-0.27	0.01	-0.34	0.05	-0.36	0.08	-0.39	0.09
5Y- 3Y	-0.21	-0.01	-0.31	0.02	-0.42	0.09	-0.45	0.11	-0.49	0.17
7Y- 5Y	-0.32	0.06	-0.39	0.11	-0.41	0.10	-0.42	0.07	-0.40	0.04
10- 7Y	-0.16	-0.01	-0.28	0.01	-0.26	-0.02	-0.24	-0.04	-0.23	-0.07
30-10Y	-0.39	-0.02	-0.50	0.01	-0.53	0.02	-0.56	0.01	-0.56	0.01
Period: 1980-84 (1247 observations)										
3M	1.00	-0.46	1.00	-0.50	1.00	-0.51	1.00	-0.51	1.00	-0.52
6M- 3M	-0.46	1.00	-0.50	1.00	-0.51	1.00	-0.51	1.00	-0.52	1.00
1Y- 6M	-0.13	0.14	-0.18	0.31	-0.20	0.37	-0.22	0.41	-0.21	0.43
2Y- 1Y	-0.50	0.08	-0.54	0.13	-0.56	0.14	-0.58	0.14	-0.60	0.14
3Y- 2Y	-0.27	0.03	-0.33	0.05	-0.40	0.05	-0.44	0.09	-0.47	0.12
5Y- 3Y	-0.27	0.03	-0.32	0.03	-0.36	0.06	-0.38	0.07	-0.41	0.08
7Y- 5Y	-0.22	0.03	-0.27	0.02	-0.33	0.04	-0.36	0.04	-0.39	0.04
10- 7Y	-0.20	-0.01	-0.26	-0.01	-0.26	-0.04	-0.26	-0.04	-0.26	-0.05
30-10Y	-0.16	-0.07	-0.24	-0.06	-0.27	-0.08	-0.27	-0.10	-0.28	-0.11
Period: 1985-89 (1248 observations)										
3M	1.00	-0.33	1.00	-0.29	1.00	-0.28	1.00	-0.26	1.00	-0.25
6M- 3M	-0.33	1.00	-0.29	1.00	-0.28	1.00	-0.26	1.00	-0.25	1.00
1Y- 6M	-0.07	-0.24	-0.08	-0.25	-0.06	-0.27	-0.05	-0.25	-0.05	-0.23
2Y- 1Y	-0.19	0.09	-0.20	0.15	-0.20	0.19	-0.17	0.20	-0.16	0.19
3Y- 2Y	-0.06	0.01	-0.12	0.03	-0.13	0.05	-0.12	0.07	-0.13	0.08
5Y- 3Y	-0.15	0.01	-0.21	0.04	-0.22	0.05	-0.21	0.04	-0.19	0.03
7Y- 5Y	-0.15	0.02	-0.21	0.01	-0.23	0.01	-0.25	0.02	-0.26	0.00
10- 7Y	-0.15	-0.07	-0.21	-0.06	-0.23	-0.06	-0.24	-0.06	-0.25	-0.07
30-10Y	-0.31	-0.03	-0.35	-0.07	-0.37	-0.07	-0.38	-0.07	-0.38	-0.08
Period: 1990-94 (1249 observations)										
3M	1.00	-0.24	1.00	-0.24	1.00	-0.24	1.00	-0.22	1.00	-0.20
6M- 3M	-0.24	1.00	-0.24	1.00	-0.24	1.00	-0.22	1.00	-0.20	1.00
1Y- 6M	0.07	0.08	0.08	0.09	0.12	0.11	0.15	0.13	0.17	0.15
2Y- 1Y	-0.03	0.14	-0.05	0.20	-0.06	0.24	-0.09	0.27	-0.11	0.30
3Y- 2Y	-0.13	0.06	-0.16	0.12	-0.14	0.13	-0.12	0.16	-0.11	0.15
5Y- 3Y	-0.17	0.02	-0.22	0.02	-0.28	0.02	-0.31	-0.01	-0.34	-0.03
7Y- 5Y	-0.28	-0.06	-0.32	-0.01	-0.32	-0.01	-0.32	-0.03	-0.33	-0.04
10- 7Y	-0.21	-0.09	-0.25	-0.11	-0.26	-0.10	-0.27	-0.11	-0.28	-0.12
30-10Y	-0.32	-0.13	-0.36	-0.15	-0.38	-0.17	-0.40	-0.19	-0.42	-0.21

Table 6a. U.S. Yield Curve Event Correlations at 15% Tail Probabilities

	1- day		2- day		3- day		4- day		5- day	
	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M
Period: 1977- 79 (714 observations)										
3M	100%	66%	100%	61%	100%	58%	100%	53%	100%	55%
6M- 3M	63%	100%	60%	100%	57%	100%	53%	100%	57%	100%
1Y- 6M	44%	44%	47%	43%	48%	45%	41%	43%	40%	40%
2Y- 1Y	48%	40%	42%	40%	47%	42%	46%	41%	50%	43%
3Y- 2Y	35%	35%	37%	37%	46%	41%	47%	41%	49%	39%
5Y- 3Y	43%	42%	44%	38%	43%	36%	44%	36%	46%	38%
7Y- 5Y	37%	32%	40%	36%	37%	36%	39%	32%	40%	31%
10- 7Y	33%	32%	39%	38%	37%	36%	38%	31%	40%	35%
30- 10Y	42%	42%	42%	36%	43%	36%	40%	32%	43%	32%
Avg.	46%	46%	51%	42%	52%	47%	51%	45%	53%	45%
Period: 1980- 84 (1247 observations)										
3M	100%	54%	100%	51%	100%	50%	100%	52%	100%	54%
6M- 3M	54%	100%	52%	100%	52%	100%	52%	100%	54%	100%
1Y- 6M	50%	46%	48%	49%	49%	47%	49%	46%	51%	51%
2Y- 1Y	53%	44%	57%	42%	56%	40%	57%	47%	58%	48%
3Y- 2Y	45%	42%	51%	42%	49%	43%	48%	43%	52%	42%
5Y- 3Y	44%	43%	50%	41%	49%	37%	49%	40%	51%	43%
7Y- 5Y	41%	37%	42%	37%	44%	41%	45%	38%	50%	44%
10- 7Y	44%	41%	43%	43%	46%	38%	43%	39%	42%	34%
30- 10Y	43%	42%	46%	43%	48%	42%	49%	46%	47%	45%
Avg.	50%	49%	57%	44%	57%	49%	57%	50%	59%	51%
Period: 1985- 89 (1248 observations)										
3M	100%	42%	100%	40%	100%	39%	100%	36%	100%	37%
6M- 3M	40%	100%	41%	100%	38%	100%	39%	100%	36%	100%
1Y- 6M	39%	46%	35%	45%	35%	42%	35%	40%	31%	41%
2Y- 1Y	38%	37%	36%	37%	31%	31%	33%	30%	34%	31%
3Y- 2Y	29%	30%	29%	29%	30%	26%	31%	23%	31%	25%
5Y- 3Y	32%	30%	35%	25%	32%	23%	36%	22%	30%	23%
7Y- 5Y	34%	31%	34%	33%	34%	28%	35%	32%	34%	26%
10- 7Y	36%	28%	38%	26%	34%	27%	37%	28%	34%	30%
30- 10Y	36%	33%	40%	28%	35%	29%	38%	30%	36%	29%
Avg.	39%	42%	46%	34%	43%	38%	45%	38%	43%	38%
Period: 1990- 94 (1249 observations)										
3M	100%	40%	100%	40%	100%	38%	100%	37%	100%	38%
6M- 3M	45%	100%	41%	100%	41%	100%	39%	100%	38%	100%
1Y- 6M	38%	33%	33%	33%	32%	34%	34%	35%	32%	36%
2Y- 1Y	32%	28%	33%	32%	33%	30%	28%	33%	30%	33%
3Y- 2Y	28%	25%	32%	33%	33%	28%	31%	32%	31%	33%
5Y- 3Y	34%	27%	33%	29%	33%	26%	33%	25%	33%	27%
7Y- 5Y	36%	25%	37%	29%	34%	25%	32%	23%	32%	23%
10- 7Y	36%	29%	34%	28%	33%	26%	34%	24%	33%	28%
30- 10Y	34%	25%	37%	27%	34%	26%	37%	27%	36%	29%
Avg.	39%	37%	45%	32%	44%	37%	44%	37%	43%	39%

Table 6b. U. S. Yield Curve Event Correlations at 10% Tail Probabilities

	1- day		2- day		3- day		4- day		5- day	
	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M
Period: 1977- 79 (714 observations)										
3M	100%	62%	100%	52%	100%	54%	100%	51%	100%	51%
6M- 3M	61%	100%	55%	100%	51%	100%	51%	100%	50%	100%
1Y- 6M	40%	32%	38%	33%	40%	33%	35%	34%	28%	31%
2Y- 1Y	43%	37%	43%	34%	44%	39%	44%	34%	48%	32%
3Y- 2Y	37%	33%	31%	28%	37%	34%	44%	32%	36%	31%
5Y- 3Y	41%	33%	42%	35%	40%	33%	40%	25%	47%	32%
7Y- 5Y	32%	22%	34%	29%	34%	31%	34%	24%	35%	27%
10- 7Y	25%	21%	34%	28%	28%	28%	31%	25%	30%	25%
30- 10Y	37%	35%	40%	27%	35%	28%	39%	27%	39%	22%
Avg.	42%	40%	48%	34%	48%	42%	48%	38%	48%	38%
Period: 1980- 84 (1247 observations)										
3M	100%	47%	100%	43%	100%	45%	100%	47%	100%	44%
6M- 3M	49%	100%	43%	100%	45%	100%	47%	100%	46%	100%
1Y- 6M	41%	38%	37%	45%	42%	38%	44%	43%	45%	42%
2Y- 1Y	47%	33%	52%	30%	48%	36%	52%	38%	55%	40%
3Y- 2Y	38%	31%	39%	29%	43%	33%	44%	33%	43%	29%
5Y- 3Y	40%	35%	39%	32%	42%	31%	41%	33%	45%	30%
7Y- 5Y	33%	31%	34%	29%	39%	30%	38%	32%	40%	29%
10- 7Y	35%	34%	36%	32%	35%	32%	33%	29%	35%	27%
30- 10Y	37%	35%	36%	35%	38%	36%	40%	34%	40%	35%
Avg.	44%	41%	50%	34%	51%	42%	52%	43%	53%	42%
Period: 1985- 89 (1248 observations)										
3M	100%	36%	100%	35%	100%	30%	100%	33%	100%	29%
6M- 3M	35%	100%	36%	100%	30%	100%	33%	100%	30%	100%
1Y- 6M	30%	43%	26%	36%	27%	40%	27%	34%	25%	37%
2Y- 1Y	30%	29%	24%	25%	27%	20%	25%	23%	24%	21%
3Y- 2Y	19%	20%	20%	17%	22%	18%	24%	16%	22%	16%
5Y- 3Y	23%	20%	28%	18%	24%	12%	26%	13%	23%	11%
7Y- 5Y	26%	21%	24%	27%	28%	22%	25%	21%	29%	20%
10- 7Y	24%	18%	23%	15%	29%	14%	29%	17%	27%	21%
30- 10Y	34%	25%	32%	17%	30%	20%	31%	21%	30%	19%
Avg.	32%	35%	37%	25%	38%	31%	38%	31%	37%	31%
Period: 1990- 94 (1249 observations)										
3M	100%	40%	100%	34%	100%	32%	100%	31%	100%	32%
6M- 3M	31%	100%	37%	100%	33%	100%	33%	100%	33%	100%
1Y- 6M	24%	30%	22%	23%	20%	24%	26%	23%	24%	27%
2Y- 1Y	21%	21%	24%	21%	24%	25%	21%	25%	23%	28%
3Y- 2Y	15%	19%	21%	20%	23%	21%	27%	21%	24%	25%
5Y- 3Y	21%	24%	21%	14%	24%	19%	24%	18%	24%	21%
7Y- 5Y	25%	20%	26%	15%	25%	14%	23%	16%	22%	14%
10- 7Y	25%	23%	22%	17%	24%	16%	24%	18%	27%	17%
30- 10Y	24%	22%	22%	16%	28%	16%	26%	22%	29%	19%
Avg.	27%	33%	36%	21%	37%	30%	38%	30%	38%	32%

Table 6c. U. S. Yield Curve Event Correlations at 5% Tail Probabilities

	1- day		2- day		3- day		4- day		5- day	
	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M
Period: 1977- 79 (714 observations)										
3M	100%	50%	100%	52%	100%	44%	100%	40%	100%	40%
6M- 3M	48%	100%	54%	100%	43%	100%	40%	100%	41%	100%
1Y- 6M	33%	31%	29%	26%	36%	25%	29%	20%	25%	17%
2Y- 1Y	38%	29%	45%	28%	40%	31%	47%	24%	49%	24%
3Y- 2Y	27%	30%	34%	25%	32%	19%	29%	19%	35%	17%
5Y- 3Y	41%	22%	32%	22%	38%	28%	42%	18%	50%	27%
7Y- 5Y	28%	14%	40%	26%	45%	25%	29%	15%	32%	19%
10- 7Y	21%	14%	19%	16%	17%	22%	20%	20%	15%	10%
30- 10Y	38%	26%	41%	22%	34%	20%	34%	14%	41%	12%
Avg.	38%	33%	45%	27%	46%	34%	44%	29%	46%	29%
Period: 1980- 84 (1247 observations)										
3M	100%	33%	100%	35%	100%	39%	100%	40%	100%	36%
6M- 3M	33%	100%	36%	100%	40%	100%	40%	100%	38%	100%
1Y- 6M	30%	24%	28%	29%	31%	31%	37%	29%	40%	31%
2Y- 1Y	44%	22%	42%	16%	45%	22%	38%	28%	43%	27%
3Y- 2Y	24%	16%	33%	18%	28%	24%	26%	23%	32%	24%
5Y- 3Y	28%	21%	27%	22%	27%	19%	34%	20%	34%	21%
7Y- 5Y	25%	18%	21%	15%	28%	18%	31%	21%	31%	18%
10- 7Y	25%	20%	24%	18%	20%	23%	21%	18%	28%	22%
30- 10Y	16%	30%	20%	25%	25%	24%	24%	27%	24%	24%
Avg.	33%	31%	41%	23%	41%	33%	42%	34%	44%	33%
Period: 1985- 89 (1248 observations)										
3M	100%	28%	100%	30%	100%	24%	100%	25%	100%	21%
6M- 3M	29%	100%	30%	100%	24%	100%	25%	100%	22%	100%
1Y- 6M	23%	35%	18%	32%	18%	35%	17%	33%	13%	29%
2Y- 1Y	20%	22%	20%	19%	18%	16%	20%	22%	17%	14%
3Y- 2Y	13%	12%	14%	8%	13%	9%	14%	9%	15%	11%
5Y- 3Y	16%	11%	20%	9%	16%	6%	12%	6%	17%	4%
7Y- 5Y	17%	12%	15%	11%	18%	12%	14%	11%	13%	5%
10- 7Y	15%	8%	16%	5%	18%	4%	16%	8%	16%	5%
30- 10Y	24%	13%	22%	8%	25%	9%	22%	7%	17%	6%
Avg.	24%	27%	31%	16%	30%	24%	29%	25%	28%	22%
Period: 1990- 94 (1249 observations)										
3M	100%	27%	100%	32%	100%	20%	100%	25%	100%	24%
6M- 3M	32%	100%	33%	100%	23%	100%	25%	100%	27%	100%
1Y- 6M	20%	17%	10%	10%	13%	13%	14%	14%	11%	15%
2Y- 1Y	19%	10%	15%	11%	12%	13%	19%	15%	17%	18%
3Y- 2Y	16%	17%	13%	14%	11%	13%	17%	15%	17%	12%
5Y- 3Y	17%	10%	10%	9%	16%	10%	15%	11%	16%	7%
7Y- 5Y	19%	6%	17%	11%	15%	7%	16%	9%	11%	7%
10- 7Y	17%	6%	17%	9%	12%	4%	18%	7%	20%	6%
30- 10Y	21%	9%	16%	7%	14%	10%	17%	13%	18%	11%
Avg.	25%	22%	29%	14%	29%	21%	31%	23%	30%	22%

Table 6d. U.S. Yield Curve Event Correlations at 2.5% Tail Probabilities

	1- day		2- day		3- day		4- day		5- day	
	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M
Period: 1977- 79 (714 observations)										
3M	100%	36%	100%	51%	100%	51%	100%	37%	100%	31%
6M- 3M	37%	100%	56%	100%	54%	100%	37%	100%	31%	100%
1Y- 6M	14%	11%	23%	11%	30%	18%	31%	18%	35%	8%
2Y- 1Y	24%	18%	35%	23%	51%	27%	50%	26%	51%	17%
3Y- 2Y	21%	18%	40%	17%	34%	21%	31%	12%	34%	5%
5Y- 3Y	40%	16%	36%	18%	40%	20%	47%	17%	48%	12%
7Y- 5Y	22%	2%	40%	18%	47%	23%	43%	13%	47%	14%
10- 7Y	25%	8%	17%	11%	17%	2%	19%	9%	33%	10%
30- 10Y	41%	10%	46%	15%	51%	19%	59%	18%	62%	13%
Avg.	31%	22%	45%	20%	48%	30%	49%	27%	52%	23%
Period: 1980- 84 (1247 observations)										
3M	100%	29%	100%	42%	100%	36%	100%	37%	100%	39%
6M- 3M	30%	100%	40%	100%	37%	100%	36%	100%	41%	100%
1Y- 6M	20%	22%	20%	25%	27%	27%	38%	25%	36%	23%
2Y- 1Y	34%	12%	30%	11%	31%	15%	27%	13%	26%	18%
3Y- 2Y	20%	6%	21%	13%	10%	13%	15%	11%	25%	15%
5Y- 3Y	20%	12%	26%	19%	24%	12%	25%	11%	28%	6%
7Y- 5Y	14%	8%	12%	8%	18%	8%	25%	13%	26%	9%
10- 7Y	20%	8%	21%	15%	19%	12%	15%	6%	15%	6%
30- 10Y	10%	17%	15%	11%	14%	18%	14%	14%	12%	15%
Avg.	26%	22%	34%	19%	35%	27%	37%	26%	37%	25%
Period: 1985- 89 (1248 observations)										
3M	100%	19%	100%	20%	100%	22%	100%	17%	100%	20%
6M- 3M	19%	100%	22%	100%	22%	100%	18%	100%	20%	100%
1Y- 6M	15%	33%	11%	27%	11%	24%	10%	25%	7%	19%
2Y- 1Y	17%	9%	15%	7%	16%	13%	20%	14%	13%	16%
3Y- 2Y	11%	6%	11%	6%	12%	6%	15%	7%	13%	10%
5Y- 3Y	12%	3%	15%	3%	6%	1%	7%	0%	10%	0%
7Y- 5Y	11%	3%	8%	3%	8%	4%	8%	5%	9%	3%
10- 7Y	10%	6%	8%	3%	6%	1%	7%	0%	9%	0%
30- 10Y	17%	8%	20%	5%	17%	3%	11%	5%	12%	4%
Avg.	18%	21%	27%	11%	25%	19%	24%	20%	24%	19%
Period: 1990- 94 (1249 observations)										
3M	100%	20%	100%	18%	100%	19%	100%	18%	100%	17%
6M- 3M	21%	100%	18%	100%	20%	100%	17%	100%	17%	100%
1Y- 6M	8%	12%	10%	8%	5%	6%	5%	6%	11%	7%
2Y- 1Y	11%	5%	15%	5%	11%	6%	12%	14%	19%	13%
3Y- 2Y	15%	8%	7%	6%	13%	7%	12%	7%	8%	5%
5Y- 3Y	9%	2%	10%	7%	8%	3%	13%	6%	10%	3%
7Y- 5Y	17%	5%	14%	5%	9%	9%	6%	4%	7%	5%
10- 7Y	8%	6%	4%	4%	9%	1%	10%	0%	6%	1%
30- 10Y	13%	5%	13%	3%	12%	4%	17%	5%	12%	6%
Avg.	18%	18%	27%	8%	25%	17%	25%	17%	25%	17%

Table 7a. Non-US Yield Curve Correlations (1990-94)

		1-day		2-day		3-day		4-day		5-day	
		3M	6-3M	3M	6-3M	3M	6-3M	3M	6-3M	3M	6-3M
Belgium											
3M		1.00	-0.38	1.00	-0.39	1.00	-0.39	1.00	-0.43	1.00	-0.46
6M	3M	-0.38	1.00	-0.39	1.00	-0.39	1.00	-0.43	1.00	-0.46	1.00
1Y	6M	-0.27	-0.37	-0.32	-0.33	-0.40	-0.29	-0.43	-0.22	-0.45	-0.15
2Y	1Y	-0.45	0.01	-0.40	0.05	-0.42	0.06	-0.43	0.07	-0.44	0.07
3Y	2Y	0.09	-0.07	0.05	-0.04	0.06	-0.04	0.05	-0.04	0.03	0.00
5Y	3Y	-0.12	-0.01	-0.17	0.00	-0.23	0.04	-0.24	0.06	-0.26	0.06
7Y	5Y	-0.03	-0.02	-0.13	-0.02	-0.14	-0.02	-0.16	-0.01	-0.17	0.03
10-	7Y	-0.09	0.06	-0.10	0.07	-0.15	0.06	-0.18	0.08	-0.19	0.07
Canada											
3M		1.00	-0.19	1.00	-0.21	1.00	-0.20	1.00	-0.19	1.00	-0.17
6M	3M	-0.19	1.00	-0.21	1.00	-0.20	1.00	-0.19	1.00	-0.17	1.00
1Y	6M	-0.16	-0.39	-0.19	-0.21	-0.20	-0.12	-0.22	-0.06	-0.25	0.00
2Y	1Y	-0.47	-0.19	-0.40	-0.18	-0.38	-0.16	-0.37	-0.14	-0.40	-0.11
3Y	2Y	-0.08	0.01	-0.15	0.00	-0.21	0.00	-0.23	0.02	-0.23	0.01
5Y	3Y	-0.07	-0.04	-0.17	-0.06	-0.21	-0.08	-0.24	-0.10	-0.27	-0.12
7Y	5Y	-0.07	0.00	-0.13	-0.02	-0.16	-0.05	-0.17	-0.06	-0.20	-0.09
10-	7Y	-0.11	-0.04	-0.19	-0.09	-0.25	-0.10	-0.28	-0.17	-0.30	-0.16
Switzerland											
3M		1.00	-0.39	1.00	-0.38	1.00	-0.39	1.00	-0.39	1.00	-0.38
6M	3M	-0.39	1.00	-0.38	1.00	-0.39	1.00	-0.39	1.00	-0.38	1.00
1Y	6M	-0.24	-0.27	-0.25	-0.27	-0.28	-0.25	-0.29	-0.20	-0.31	-0.17
2Y	1Y	-0.27	-0.01	-0.27	-0.01	-0.29	0.04	-0.31	0.04	-0.32	0.04
3Y	2Y	-0.01	-0.03	-0.03	-0.03	-0.02	-0.05	-0.01	-0.04	0.02	-0.05
5Y	3Y	0.00	0.02	0.01	0.03	0.03	0.04	0.02	0.04	0.00	0.06
7Y	5Y	0.01	0.03	0.01	0.02	0.00	0.00	0.02	-0.02	0.05	-0.05
10-	7Y	0.00	-0.05	0.01	-0.03	0.03	-0.03	0.02	0.00	0.01	0.01
Germany											
3M		1.00	-0.35	1.00	-0.33	1.00	-0.28	1.00	-0.29	1.00	-0.31
6M	3M	-0.35	1.00	-0.33	1.00	-0.28	1.00	-0.29	1.00	-0.31	1.00
1Y	6M	-0.22	-0.43	-0.22	-0.30	-0.24	-0.26	-0.21	-0.20	-0.19	-0.14
2Y	1Y	-0.29	-0.07	-0.26	-0.08	-0.27	-0.06	-0.26	-0.04	-0.25	-0.01
3Y	2Y	-0.02	0.02	-0.06	-0.02	-0.06	0.00	-0.10	0.00	-0.12	0.01
5Y	3Y	-0.09	-0.03	-0.17	-0.01	-0.22	0.00	-0.26	0.03	-0.29	0.04
7Y	5Y	-0.08	0.00	-0.11	0.00	-0.14	0.01	-0.16	0.01	-0.18	0.00
10-	7Y	0.07	-0.01	0.01	-0.01	0.00	-0.03	-0.04	-0.06	-0.04	-0.08
Denmark											
3M		1.00	-0.83	1.00	-0.85	1.00	-0.85	1.00	-0.87	1.00	-0.88
6M	3M	-0.83	1.00	-0.85	1.00	-0.85	1.00	-0.87	1.00	-0.88	1.00
1Y	6M	-0.59	0.26	-0.64	0.32	-0.68	0.39	-0.71	0.46	-0.73	0.53
2Y	1Y	-0.37	0.04	-0.38	0.05	-0.35	0.02	-0.31	0.01	-0.33	0.05
3Y	2Y	-0.10	0.06	-0.08	0.06	-0.10	0.08	-0.11	0.08	-0.12	0.09
5Y	3Y	-0.09	0.13	-0.12	0.15	-0.17	0.18	-0.19	0.19	-0.22	0.20
7Y	5Y	-0.20	0.14	-0.25	0.17	-0.31	0.21	-0.34	0.24	-0.35	0.27
10-	7Y	-0.15	0.14	-0.18	0.19	-0.20	0.20	-0.21	0.20	-0.22	0.19

Table 7b. Non-US Yield Curve Correlations (1990-94)

		1-day		2-day		3-day		4-day		5-day	
		3M	6-3M	3M	6-3M	3M	6-3M	3M	6-3M	3M	6-3M
France											
3M		1.00	-0.57	1.00	-0.62	1.00	-0.65	1.00	-0.66	1.00	-0.68
6M	3M	-0.57	1.00	-0.62	1.00	-0.65	1.00	-0.66	1.00	-0.68	1.00
1Y	6M	-0.48	0.03	-0.56	0.11	-0.51	0.14	-0.49	0.18	-0.53	0.22
2Y	1Y	-0.28	-0.19	-0.36	-0.02	-0.38	0.05	-0.35	0.00	-0.40	0.08
3Y	2Y	-0.08	0.04	-0.13	0.03	-0.20	0.07	-0.23	0.07	-0.22	0.06
5Y	3Y	-0.14	0.06	-0.24	0.12	-0.27	0.12	-0.31	0.13	-0.33	0.16
7Y	5Y	-0.07	0.04	-0.09	0.02	-0.15	0.02	-0.19	0.04	-0.20	0.03
10-	7Y	-0.03	-0.03	-0.09	0.02	-0.11	0.01	-0.07	-0.04	-0.06	-0.05
United Kingdom											
3M		1.00	-0.11	1.00	0.02	1.00	0.09	1.00	0.14	1.00	0.14
6M	3M	-0.11	1.00	0.02	1.00	0.09	1.00	0.14	1.00	0.14	1.00
1Y	6M	-0.08	-0.78	-0.17	-0.74	-0.17	-0.69	-0.18	-0.63	-0.13	-0.59
2Y	1Y	-0.11	-0.38	-0.14	-0.34	-0.19	-0.26	-0.19	-0.23	-0.21	-0.21
3Y	2Y	-0.15	-0.15	-0.18	-0.13	-0.18	-0.13	-0.21	-0.14	-0.21	-0.13
5Y	3Y	-0.17	-0.30	-0.23	-0.31	-0.25	-0.30	-0.29	-0.30	-0.29	-0.28
7Y	5Y	-0.13	-0.23	-0.24	-0.28	-0.29	-0.28	-0.32	-0.28	-0.35	-0.30
10-	7Y	-0.12	-0.05	-0.24	-0.06	-0.31	-0.11	-0.34	-0.15	-0.36	-0.15
Japan											
3M		1.00	-0.37	1.00	-0.30	1.00	-0.28	1.00	-0.25	1.00	-0.21
6M	3M	-0.37	1.00	-0.30	1.00	-0.28	1.00	-0.25	1.00	-0.21	1.00
1Y	6M	-0.14	-0.34	-0.14	-0.33	-0.14	-0.26	-0.14	-0.20	-0.16	-0.13
2Y	1Y	-0.39	-0.12	-0.41	-0.09	-0.41	-0.09	-0.39	-0.08	-0.37	-0.09
3Y	2Y	-0.04	-0.03	-0.04	-0.01	-0.03	-0.01	-0.03	-0.02	-0.02	-0.03
5Y	3Y	0.01	0.06	0.01	0.02	0.00	0.02	-0.01	-0.01	-0.03	0.01
7Y	5Y	0.03	0.02	0.01	0.03	0.00	0.03	-0.03	0.03	-0.05	0.02
10-	7Y	0.02	-0.04	-0.03	-0.03	-0.07	-0.04	-0.08	-0.04	-0.08	-0.08
The Netherlands											
3M		1.00	-0.35	1.00	-0.33	1.00	-0.33	1.00	-0.34	1.00	-0.34
6M	3M	-0.35	1.00	-0.33	1.00	-0.33	1.00	-0.34	1.00	-0.34	1.00
1Y	6M	-0.17	-0.28	-0.17	-0.22	-0.18	-0.17	-0.19	-0.16	-0.20	-0.11
2Y	1Y	-0.47	-0.15	-0.43	-0.16	-0.42	-0.13	-0.41	-0.08	-0.40	-0.05
3Y	2Y	-0.05	0.02	-0.05	0.02	-0.04	0.00	-0.03	-0.01	-0.02	-0.02
5Y	3Y	-0.09	-0.04	-0.15	-0.01	-0.20	0.00	-0.23	-0.01	-0.24	-0.03
7Y	5Y	-0.03	0.06	-0.04	0.04	-0.07	0.04	-0.10	0.06	-0.14	0.06
10-	7Y	-0.02	-0.04	-0.05	-0.10	-0.05	-0.15	-0.07	-0.17	-0.10	-0.17
Sweden											
3M		1.00	-0.73	1.00	-0.80	1.00	-0.84	1.00	-0.77	1.00	-0.79
6M	3M	-0.73	1.00	-0.80	1.00	-0.84	1.00	-0.77	1.00	-0.79	1.00
1Y	6M	-0.46	-0.22	-0.23	-0.34	-0.10	-0.39	-0.20	-0.41	0.00	-0.53
2Y	1Y	0.31	0.06	0.17	0.12	0.14	0.15	0.21	0.19	0.12	0.22
3Y	2Y	0.00	-0.04	0.12	-0.15	0.04	-0.11	0.07	-0.14	0.02	-0.13
5Y	3Y	-0.05	0.03	-0.07	0.06	-0.08	0.03	-0.13	0.07	-0.19	0.10
7Y	5Y	0.01	-0.01	-0.08	0.01	-0.11	0.01	-0.19	0.06	-0.27	0.09
10-	7Y	0.03	0.01	-0.03	0.01	-0.09	0.04	-0.14	0.08	-0.19	0.07

Table 8a. Non-US Yield Curve Event Correlations (5% Tail Probability)

	1- day		2- day		3- day		4- day		5- day	
	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M
Belgium										
3M	100%	44%	100%	33%	100%	37%	100%	32%	100%	33%
6M- 3M	35%	100%	49%	100%	44%	100%	46%	100%	48%	100%
1Y- 6M	39%	42%	46%	39%	44%	49%	46%	47%	39%	37%
2Y- 1Y	44%	29%	41%	20%	40%	26%	37%	22%	36%	24%
3Y- 2Y	26%	23%	22%	20%	21%	22%	28%	18%	29%	16%
5Y- 3Y	11%	16%	9%	6%	12%	9%	11%	8%	12%	10%
7Y- 5Y	16%	13%	19%	13%	16%	16%	15%	14%	17%	11%
10- 7Y	14%	15%	16%	9%	16%	13%	12%	13%	9%	10%
Canada										
3M	100%	26%	100%	37%	100%	26%	100%	29%	100%	24%
6M- 3M	40%	100%	36%	100%	45%	100%	39%	100%	32%	100%
1Y- 6M	18%	20%	16%	33%	13%	15%	17%	20%	18%	17%
2Y- 1Y	30%	14%	29%	22%	26%	12%	21%	16%	24%	14%
3Y- 2Y	7%	4%	15%	17%	10%	9%	16%	13%	15%	13%
5Y- 3Y	13%	5%	14%	12%	10%	5%	11%	3%	13%	6%
7Y- 5Y	12%	10%	12%	9%	16%	9%	15%	10%	11%	7%
10- 7Y	10%	6%	16%	13%	16%	8%	19%	18%	17%	10%
Switzerland										
3M	100%	35%	100%	18%	100%	23%	100%	27%	100%	25%
6M- 3M	32%	100%	40%	100%	36%	100%	39%	100%	31%	100%
1Y- 6M	21%	27%	14%	37%	16%	26%	22%	30%	19%	23%
2Y- 1Y	8%	8%	14%	4%	9%	6%	12%	6%	14%	5%
3Y- 2Y	9%	9%	12%	4%	9%	4%	12%	6%	10%	3%
5Y- 3Y	10%	8%	11%	3%	14%	4%	16%	6%	10%	6%
7Y- 5Y	9%	11%	12%	3%	11%	3%	13%	9%	14%	7%
10- 7Y	8%	11%	10%	3%	4%	3%	6%	6%	6%	7%
Germany										
3M	100%	42%	100%	40%	100%	24%	100%	28%	100%	17%
6M- 3M	48%	100%	32%	100%	27%	100%	27%	100%	29%	100%
1Y- 6M	19%	32%	18%	31%	25%	55%	31%	37%	22%	27%
2Y- 1Y	20%	8%	19%	16%	16%	11%	14%	9%	14%	7%
3Y- 2Y	9%	9%	14%	12%	9%	11%	6%	10%	9%	3%
5Y- 3Y	6%	6%	12%	14%	13%	10%	12%	8%	14%	4%
7Y- 5Y	17%	12%	13%	17%	16%	16%	16%	12%	13%	7%
10- 7Y	11%	9%	11%	14%	12%	10%	12%	10%	13%	9%
Denmark										
3M	100%	70%	100%	71%	100%	69%	100%	73%	100%	71%
6M- 3M	71%	100%	65%	100%	68%	100%	71%	100%	71%	100%
1Y- 6M	68%	71%	61%	60%	68%	64%	63%	60%	64%	62%
2Y- 1Y	46%	41%	49%	50%	45%	46%	50%	49%	40%	44%
3Y- 2Y	18%	16%	14%	14%	19%	12%	19%	15%	17%	16%
5Y- 3Y	15%	12%	17%	17%	22%	17%	25%	24%	24%	23%
7Y- 5Y	18%	18%	22%	20%	23%	17%	24%	21%	27%	25%
10- 7Y	13%	10%	17%	18%	23%	24%	18%	24%	20%	22%

Table 8b. Non-US Yield Curve Event Correlations (5% Tail Probability)

	1- day		2- day		3- day		4- day		5- day	
	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M
France										
3M	100%	47%	100%	55%	100%	57%	100%	61%	100%	62%
6M- 3M	72%	100%	64%	100%	64%	100%	61%	100%	61%	100%
1Y- 6M	54%	43%	54%	43%	56%	49%	56%	51%	55%	51%
2Y- 1Y	35%	20%	27%	19%	38%	27%	33%	27%	32%	30%
3Y- 2Y	26%	13%	24%	13%	24%	16%	22%	16%	28%	25%
5Y- 3Y	22%	9%	23%	16%	31%	20%	26%	20%	31%	24%
7Y- 5Y	16%	8%	18%	11%	17%	16%	21%	19%	23%	20%
10- 7Y	12%	4%	18%	13%	13%	13%	14%	12%	17%	17%
United Kingdom										
3M	100%	31%	100%	28%	100%	22%	100%	26%	100%	29%
6M- 3M	31%	100%	26%	100%	36%	100%	26%	100%	31%	100%
1Y- 6M	19%	26%	16%	29%	25%	30%	27%	31%	29%	33%
2Y- 1Y	24%	14%	21%	16%	24%	16%	22%	17%	17%	18%
3Y- 2Y	15%	13%	13%	14%	20%	11%	19%	10%	18%	13%
5Y- 3Y	21%	15%	18%	17%	26%	16%	21%	16%	25%	19%
7Y- 5Y	23%	16%	19%	20%	21%	16%	20%	20%	23%	20%
10- 7Y	17%	10%	17%	18%	17%	13%	16%	15%	17%	15%
Japan										
3M	100%	24%	100%	24%	100%	32%	100%	31%	100%	29%
6M- 3M	42%	100%	30%	100%	26%	100%	22%	100%	26%	100%
1Y- 6M	30%	26%	20%	25%	18%	23%	19%	22%	20%	21%
2Y- 1Y	30%	12%	29%	14%	24%	17%	19%	16%	24%	17%
3Y- 2Y	3%	0%	6%	3%	3%	6%	5%	11%	7%	9%
5Y- 3Y	10%	3%	4%	3%	5%	4%	6%	10%	6%	10%
7Y- 5Y	4%	3%	9%	8%	6%	7%	11%	13%	14%	13%
10- 7Y	8%	3%	11%	6%	3%	6%	4%	8%	7%	11%
The Netherlands										
3M	100%	30%	100%	37%	100%	33%	100%	16%	100%	16%
6M- 3M	41%	100%	36%	100%	27%	100%	28%	100%	28%	100%
1Y- 6M	25%	39%	25%	37%	23%	32%	22%	17%	25%	24%
2Y- 1Y	30%	14%	32%	14%	24%	13%	29%	3%	24%	4%
3Y- 2Y	8%	10%	8%	9%	9%	7%	6%	3%	11%	4%
5Y- 3Y	6%	4%	8%	9%	10%	13%	13%	3%	14%	3%
7Y- 5Y	4%	3%	9%	10%	10%	10%	16%	3%	16%	3%
10- 7Y	9%	5%	12%	15%	15%	16%	12%	4%	16%	4%
Sweden										
3M	100%	67%	100%	64%	100%	67%	100%	67%	100%	67%
6M- 3M	67%	100%	64%	100%	67%	100%	67%	100%	67%	100%
1Y- 6M	36%	48%	31%	52%	32%	50%	33%	48%	31%	48%
2Y- 1Y	29%	31%	32%	36%	32%	37%	34%	37%	34%	37%
3Y- 2Y	19%	19%	25%	22%	25%	22%	25%	23%	27%	25%
5Y- 3Y	16%	16%	26%	20%	25%	19%	27%	22%	26%	17%
7Y- 5Y	28%	22%	33%	30%	30%	33%	30%	30%	33%	29%
10- 7Y	20%	15%	22%	15%	29%	21%	27%	20%	30%	20%

Table 9. 1995 Global Yield Curve Event Correlations at 5% Tail Probabilities

	1- day		2- day		3- day		4- day		5- day	
	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M	3M	6- 3M
U. S. :										
3M	100%	55%	100%	33%	100%	38%	100%	42%	100%	31%
6M- 3M	55%	100%	42%	100%	43%	100%	42%	100%	46%	100%
1Y- 6M	31%	43%	31%	15%	31%	21%	42%	10%	52%	0%
2Y- 1Y	21%	15%	12%	12%	25%	18%	16%	22%	21%	21%
3Y- 2Y	5%	11%	14%	7%	23%	7%	13%	6%	6%	13%
5Y- 3Y	25%	18%	7%	15%	18%	18%	12%	18%	5%	5%
7Y- 5Y	18%	0%	12%	6%	27%	5%	15%	15%	28%	7%
10- 7Y	16%	16%	22%	16%	13%	13%	11%	16%	16%	16%
30- 10Y	37%	25%	12%	12%	23%	29%	17%	29%	13%	13%
Germany:										
3M	100%	18%	100%	0%	100%	9%	100%	21%	100%	23%
6M- 3M	33%	100%	0%	100%	12%	100%	44%	100%	36%	100%
1Y- 6M	20%	20%	25%	0%	26%	0%	30%	10%	30%	20%
2Y- 1Y	21%	0%	10%	0%	10%	5%	0%	5%	5%	5%
3Y- 2Y	10%	10%	0%	10%	5%	5%	15%	0%	11%	0%
5Y- 3Y	10%	10%	0%	5%	5%	0%	5%	0%	10%	0%
7Y- 5Y	10%	0%	5%	0%	10%	0%	10%	0%	5%	0%
10- 7Y	10%	0%	10%	0%	5%	0%	10%	5%	10%	5%
Japan:										
3M	100%	16%	100%	17%	100%	26%	100%	33%	100%	22%
6M- 3M	13%	100%	17%	100%	27%	100%	33%	100%	22%	100%
1Y- 6M	21%	21%	33%	16%	7%	7%	12%	18%	13%	0%
2Y- 1Y	31%	15%	26%	15%	36%	21%	26%	15%	26%	15%
3Y- 2Y	10%	10%	15%	5%	21%	0%	26%	0%	10%	0%
5Y- 3Y	16%	0%	21%	5%	21%	10%	36%	15%	21%	10%
7Y- 5Y	5%	16%	0%	16%	10%	15%	15%	10%	15%	10%
10- 7Y	10%	5%	22%	16%	10%	21%	5%	15%	5%	15%

Risk Management and Term Structure Models

Assume that there are N bonds in a portfolio, denoted by the index $i=1, \dots, N$. For convenience, we will order the bonds so that the first bond ($i=1$) has the shortest maturity, and the last bond ($i=N$) has the longest maturity. Let P_i denote the price of the i -th bond (per dollar of face value) and y_i its yield to maturity. The (modified) duration of this bond, D_i , is given by:

$$D_i = - (1/P_i) (dP_i/dy_i).$$

Its convexity, C_i , is given by:

$$C_i = (1/P_i) (d^2P_i/dy_i^2).$$

The value of the bond portfolio is given by:

$$V = \sum_i P_i Q_i,$$

where Q_i is the face value of the i -th bond. The duration of the portfolio is the weighted average of the duration of the individual bonds:

$$D = \sum_i w_i D_i,$$

where $w_i = (P_i Q_i)/V$ is the share of the i -th bond's market value in the portfolio.

Similarly, the convexity of the portfolio is given by:

$$C = \sum_i w_i C_i.$$

For small changes in interest rates, the change in the value of the bond portfolio can be approximated by a second order Taylor series expansion around the initial yields:

$$\Delta V \approx - \sum_i w_i D_i \Delta y_i + \frac{1}{2} \sum_i w_i C_i (\Delta y_i)^2.$$

The probability distribution of ΔV is generated from a term structure model, i.e., the joint distribution of the vector of yield changes, $(\Delta y_1, \dots, \Delta y_N)$.

This paper points out that extreme movements in the levels occurs frequently with extreme moves in spreads. When this is not particularly interesting from a valuation or trading perspective, it is very significant from a risk management perspective.

Look at longer intervals:

In 1994, the U.S. bond market has witnessed the sharpest decline in 50 years, and in 1995, it has seen the sharpest rally since the October 1987 stock market crash. The amount of volatility has dramatically increased the risk of interest rate positions, particularly for fixed income arbitrageurs who exploit historically relation of spreads across various markets.

This paper concentrates on the relation between short term rates and the slope of the yield curve. This is important from a risk management perspective. Consider a portfolio of bonds with various maturities. The changes in the value of the portfolio is due to changes in the short term interest rate and changes in the slope of the yield curve. The risk manager must assess the probability of an unacceptably large decline in the value of the portfolio, as discussed in Hsieh (1993). Typically, this is done by simulating the movement of the entire yield curve using a term structure model.

One-factor models of the term structure of interest rate, such as Vasicek (1977) or Cox, Ingersoll, and Ross (1985), do not generate sufficient movement of the short rate and the yield curve slope to reflect real world conditions. At a minimum, a two-factor model is needed. For example, Brennan and Schwartz (1979) use two interest rates: a short rate and a long rate. Shafer and Schwartz (1984) use the level of interest rates and the spread between the short and long rate.

An important consideration is the degree of correlation between changes in levels and changes in spreads, *particularly* for extreme changes. It is generally known that there is a small negative correlation between changes in the level of interest rates and the steepness of the yield curve. An increase (decrease) in rates is typically associated with a flattening (steepening) of the yield curve.

What is less well known, which is established in this paper, is that extreme changes in levels occur frequently with extreme changes in spreads. If the simulation model does not take this into account, the risk manager may come to an incorrect assessment of the probability of an unacceptably large decline in the value of the bond portfolio.

In order to investigate this issue, this paper considers two types of interest rate risks --- level risk and spread risk. Level risk refers to the risk from changes in the level of interest rates, which is measured as changes in the 3 month interest rate. Spread risk refers to the risk stemming from changes in the spread between two points on the yield curve.

Within each type of interest rate risk, we further distinguish between event risk and normal risk. Event risk refers to rare large changes while normal risk refers to typical changes. Operationally, we define the upper and lower tails of a distribution to be 'events', and the remainder of the distribution to be 'normal outcomes.'

The key question of this paper is: are extreme changes in the level of interest rates correlated with extreme changes in yield spreads? If the answer is affirmative, this has important implications for risk management.

I

Before proceeding to the data, we perform a change in variables. It is well known that interest rates in the yield curve vector y are highly correlated with each other, but spreads of interest rates are much less correlated with the levels. Thus, empirical term structure models typically employ a change in variables, using a single interest rate and spreads. We define the spread variables:

$$s_i = y_i - y_{i-1}, \text{ for } i=2, \dots, N.$$

Now the term structure model consists of the variables $(y_1 \text{ and } s_2, \dots, s_N)$. We refer to y_1 as the change in the interest rate level, and s_i as the change

in the slope of the yield curve. We now examine the tail events in y_1 and the spreads, s_i .

Let y_n denote the par yield bond maturing in the n -th period.
Let f_n denote the n -period ahead 1-period forward interest rate.
Let z_n denote the n -period zero coupon interest rate.

Define:

$D_n = 1/(1+z_n)^n$ to be the price of a zero coupon bond paying \$1 in n periods.

Then:

$$Y_n = (1-D_n)/(D_1+\dots+D_n).$$

Thus, par yield is a nonlinear function of zero coupon yields.

Now:

$$(1+z_{n+1})^{n+1} = (1+z_n)^n (1+f_{n+1}).$$

So there is also a nonlinear relation between y_n and f_n .