Identifying the Factors that Affect Interest-Rate Swap Spreads: Some Evidence from the United States and the United Kingdom

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We assess the ability of the factors proposed in previous research to account for the stochastic evolution of the term structure of the U.S. and U.K. swap spreads. Using as factor proxies the level, volatility, and slope of the zero-coupon government yield curve as well as the Treasury-bill–London Interbank Offer Rate (LIBOR) spread and the corporate bond spread, we identify a procyclical behavior for the short-maturity U.S. swap spreads and a countercyclical behavior for longer maturity U.S. swap spreads. Liquidity and corporate bond spreads are also significant, but their importance varies with maturity. The liquidity premium is more important for short-maturity

The authors thank Robert Bliss, Abhay Abhyankar, Nicola Anderson, and an anonymous referee of this journal for their very useful comments and suggestions. Any remaining errors, however, are the authors' responsibility.
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Received July 2000; Accepted October 2000

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The Journal of Futures Markets, Vol. 21, No. 8, 737–768 (2001)

swap spreads, although the corporate bond spread affects long-maturity swap spreads. For the United Kingdom, swap spreads are countercyclical across maturities. In addition, we find that shocks to the liquidity premium are more significant for long-maturity swaps and that the links between corporate bond markets and swap markets are much stronger than in the United States. When we look at the links between U.S. and U.K. swap markets, we identify a significant influence of the U.S. factors on the U.K. swap spreads across maturities. Jrl Fut Mark 21: 737–768, 2001

INTRODUCTION

Given the widespread success of interest-rate swap contracts over the past decade, a variety of models have been developed to explain the pricing and determinants of interest-rate swaps. What has now become a textbook treatment of swap pricing is the decomposition of the swap agreement into a portfolio consisting of a fixed-rate and a floating-rate bond, suggested by Smith, Smithson, and Wakeman (1988). According to this model, the rate of a generic interest-rate swap should equal the redemption yield on a government bond with identical maturity trading at par.

Although very useful for providing an insight into the fundamental relationships behind swap valuation, this model does not allow for the spread between swap rates and government bond yields we observe in practice. Empirical observation further implies that these spreads not only can be significant in size but also can exhibit rich variation over time and across maturities (e.g., Sun, Sundaresan, & Wang, 1993). In the literature, swap spreads have been attributed mainly to the presence of two factors not taken into account in the framework of the standard model, that is, liquidity and default premia. The focus of this article is to assess the relevant impact of each of these factors in describing the observed variation in swap spreads across maturity and over time.

A general framework for examining the factors driving swap spreads is provided by Duffie and Singleton (1999, 1997). They demonstrated that the assumptions of no-default and liquidity risk made by Smith et al. (1988) and Sun et al. (1993), to express the fixed leg of the swap as the yield on a coupon-paying government bond, are unnecessarily strong. They showed that these assumptions can be relaxed if the short-term discount rate used to price the swap is adjusted to reflect the additional risk of default and lack of liquidity. The result is a spread that relies on current and expected future differences between the short-term discount rates used to value payments from the swap and those on a coupon-bearing, risk-free bond.

A large body of literature on swap pricing, although predating this work, can be viewed as helping to identify the factors able to explain this spread. With the focus first on *default premia,* this term is normally used in the literature to refer to compensation required to account for default risk relating to the counterparties in the swap. A theoretical model of default risk was developed by Sorensen and Bollier (1994), who suggested that the price of default depends on the value of two options, which in turn depend on the slope of the term structure and the volatility of the short rate of interest. Other studies take a more ad hoc approach, suggesting the use of information from the corporate bond market to represent default risk.

Grinblatt (1995), however, introduced the view that generic swaps are virtually default-free. He attributed the spread between discount rates used to value swaps and government bonds to liquidity differences between government securities and short-term Eurodollar borrowing. The higher liquidity of the government securities generates a convenience yield, or liquidity premium, which is lost to an investor wishing to receive fixed payments, who—instead of purchasing a Treasury note—enters into a swap agreement. In this framework, the swap spread is determined entirely by the present value of current and future convenience yields, which Grinblatt proxied with the current spread between London Interbank Offer Rate (LIBOR) and the Treasury-bill (T-bill) rate. He found that this model can generate a wide variety of swap-spread curves and explained about 35 to 40% of the variation in U.S. swap spreads across time.

More generally, empirical evidence as to which of these factors are most influential in determining swap spreads is mixed. One of the first empirical studies of swap rates was by Sun et al. (1993). They found that although swap spreads generally increase with maturity, the amount by which they do so is much smaller when the term structure is inverted. Extending this research, Minton (1997) concluded that synthetic swaps of futures contracts and portfolios of corporate bonds can track interest-rate swaps, although the relationship is not perfect. Thus, she found that although swap rates appear to be related to both the level and slope of the term structure, other factors such as credit risk and liquidity also appear to play a role.

In the empirical part of their research, Duffie and Singleton (1997) examined the importance of factors such as the level of the term structure, a proxy for default risk, and a proxy for liquidity for the 10-year U.S. swap spread. Using a vector autoregressive (VAR) framework, they provided evidence that the largest part of the swap spread variation is due to its own shocks. Liquidity shocks have a small impact on the short term, whereas credit shocks have no impact over the first couple of months but gain importance over the long run. Finally, Brown, Harlow, and Smith (1994) expressed swap spreads as functions of proxies for expected future levels of LIBOR over Treasury spreads and various measures for credit risk and hedging costs of the swap dealers. They found that all these variables are related to swap spreads, although their relative importance varies with swap maturity.

In this article, we focus our research on the factors that give rise to the interest-rate swap spread. In the second section, we describe the basic interest-rate swap pricing model and discuss the reasons that cause swap zero-coupon rates to differ from government zero-coupon rates. On the basis of the existing literature, the third section proposes a set of variables that can be used as proxies for the unobserved factors that drive swap spreads. The fourth section describes the data, and the fifth section discusses a series of methodological issues relevant to our empirical work. The empirical results are presented in the sixth section. We analyze swap spreads of various maturities for both the U.S. and U.K. swap markets. In that way, not only do we identify cross-sectional differences in the factor structure of swap spreads across maturities, but we also examine the differences in the way U.S. and U.K. swap markets operate. The links between the U.S. and U.K. swap markets are further explored in the seventh section. Finally, the last section concludes the article.

SWAP PRICING MODEL

We focus our attention on the standard interest-rate swap contract traded in the generic swap markets. The most common type of interest-rate swap is the fixed-for-floating par swap. This is a contract between two counterparties to exchange future cash flows or equivalently to exchange interest-rate risk positions. One party of the swap agreement, namely, the fixed payer, agrees to pay—on each payment date until the maturity of the swap—an amount equal to a fixed interest rate applied on a notional principal. In return, the fixed payer receives from the other counterparty, the floating payer, cash flows based on the same notional principal but calculated with respect to a floating interest rate (e.g., the LIBOR rate).[1]

Because the swap is essentially the difference between a fixed-rate bond and a floating-rate bond, the valuation of a swap is closely related

[1]The most common interest-rate swap is a swap where LIBOR at the beginning of each reset period is used to calculate the payments at the end of the period.

to the pricing of fixed-rate instruments. The price of a swap refers to the fixed rate of interest that makes the value of the swap equal to zero at the contract date. Duffie and Singleton (1997) showed that the fixed rate of an n-period fixed–floating swap contract that values it at par is given by

$$s_{n,t} = \frac{1 - B_{n,t}}{\sum_{j=1} B_{j,t}} \tag{1}$$

where $B_{j,t}$ ($i = 0.5, 1, 1.5, \ldots, 10$) is the term structure of stochastic discount factors, the price of a zero-coupon bond at each maturity j. These are defined as:

$$B_{j,t} = E\left[\exp\left(-\int_t^{t+j} R_s\, ds\right)\middle| F_t\right] \tag{2}$$

where the expectation is under the equivalent martingale measure for the information set F_t typically available to investors and R_s is the instantaneous zero-coupon swap rate.

This procedure can also be reversed, so that given a set of swap rates, $s_{i,t}$, $i = 1, \ldots, 10$, Equation 1 can be employed sequentially to infer the term structure of discount rates. These are then compared to the zero-coupon yields derived from Treasury bonds to estimate the spread between the two classes of assets. Equation 2 further implies that the spread is related to the difference in the instantaneous interest rates used to price the two assets. The investigation of those factors causing the difference in discount rates and how they influence the swap spread is the focus of the remaining sections.

SWAP-SPREAD DECOMPOSITION

In the previous section, we described how spreads are driven by differences in the floating rate in the swap and the corresponding discount rate in government securities. In the literature, the difference between the two rates has been attributed to two factors, a default premium and a liquidity premium. In what follows, we discuss each of these premia in turn, focusing on the factors that have been mentioned in the literature as either determining them or acting as suitable proxies.

Default Premium

A number of proxies for the default premium have been mentioned in the literature, ranging from those developed in a theoretical model to those chosen on a more ad hoc basis. An example of the former case is the model of swap risk developed by Sorensen and Bollier (1994). This model evaluates jointly the probability of swap counterparty default and the economic cost of default for the solvent counterparty. According to their model, the price of default equals the value of two options; one representing the probability of default of the counterparty and the other the probability of its own default. The value of both these options, in turn, depends on the slope of the term structure and the volatility of the short rate. Therefore, we use both of these variables in our empirical work.

A more ad hoc approach is to assume that the default risk in swaps can be accurately proxied with information from the corporate bond market. Any such proxy is clearly imperfect because the characteristics of the two securities are not totally comparable and corporate bond spreads will reflect additional premia relevant to the bond markets. Nevertheless, given that swap default spreads are unobservable, we followed many studies, for example, Minton (1997), Brown et al. (1994), and Duffie and Singleton (1997), in using the difference between the yield on a portfolio of medium-maturity AAA bonds and the yield on an equivalent government bond as a proxy for the default premium.

Combining elements of the two approaches, we further note the results of Longstaff and Schwartz (1995). They developed a two-factor model for corporate bond spreads, finding that these are negatively correlated with the slope of the term structure. Hence, any significant influence of the slope on the swap spread may be interpreted either in the option pricing approach of Sorensen and Bollier (1994) or in providing support for the use of information from the corporate bond market as a general proxy for default premia.

Liquidity Premium

The rationale behind liquidity premia as a determinant of swap spreads is described by Grinblatt (1995). The idea is that these premia directly influence the short-term interest rates from which swaps and government bonds are priced and, therefore, determine the swap spread. Assuming the relevant variables are the LIBOR and T-bill rate, he argued that default risk alone cannot explain the size of the spread between them. Instead, he suggested a more realistic explanation for the LIBOR–T-bill spread is that of a convenience yield investors are willing to pay for the greater liquidity of the Treasury market. Following Grinblatt, we employ the spread between the 3-month LIBOR and 3-month T-bill rates to approximate the liquidity premium. In this case, we would expect swap spreads to rise as LIBOR becomes relatively higher than the T-bill rate.

For the United Kingdom, however, whether or not this is likely to hold is questionable. The T-bill market in the United Kingdom is, in fact, relatively illiquid, suggesting that the spread between the two may not be particularly indicative of a convenience yield as Grinblatt (1995) suggested. However, we can still include the spread in our empirical work if we are a little more careful about its interpretation. If liquidity is an issue, we might expect the spread to actually narrow as the T-bill rises. Hence, we may see swap spreads increase as the LIBOR–T-bill spread narrows. At the same time, this is not inconsistent with the LIBOR rate tightening relative to the true short-term, risk-free rate of interest.

DATA

We investigated the importance of these factors in U.S. and U.K. interest-rate swap spreads with weekly data from May 1991 to February 1999. The data were sampled every Wednesday.[2] All the data were provided by BLOOMBERG with the exception of the U.S. and U.K. government yield curves. The U.S. and U.K. government yield curves were estimated with the Svensson (1994, 1995) methodology.[3] The appendix provides details of how the zero-coupon swap rates were derived from the generic swap rates provided by BLOOMBERG.

The 3-month T-bill interest rate is used as a proxy for the short rate, with the squared first difference denoting its volatility. For the slope of the zero-coupon term structure, we use the difference between the 10-year rate and the 2-year rate. In addition, the spread between the 3-month LIBOR and T-bill rates, known as *TED*, provides a proxy for the liquidity premium,[4] and the spread between corporate bond yields and corresponding maturity government bond yields acts as a proxy for default risk. For the United States, this is estimated by BLOOMBERG as the difference between the yield of a portfolio of AAA corporate bonds with a maturity of 10 years and the yield of a corresponding-maturity U.S. Treasury bond. For the United Kingdom, no such estimate is available because of the much lower issuance of corporate bonds. Therefore, we form our own portfolio of corporate bonds that includes bonds rated A or higher with maturities of 5 to 10 years.

[2]When data were unavailable, Thursday's rates were used. Such substitutions represent less that 2% of the sample size.

[3]For a detailed description of the Svensson methodology, see Anderson, Breedon, Deacon, Derry, and Murphy (1996) and Bianchi (1997).

[4]Because of differences between LIBOR and T-bill day-count conventions, LIBOR was multiplied by $\frac{365}{360}$ before TED was estimated.

TABLE I
U.S. Descriptive Statistics

Rates	*M*	*SD*	*Minimum*	*Maximum*
U.S. zero swap rates				
3-year	5.96	0.86	4.26	8.07
7-year	6.63	0.83	5.07	8.80
10-year	6.89	0.83	5.18	8.92
U.S. zero treasury rates				
3-year	5.69	0.84	4.13	7.72
7-year	6.30	0.83	4.35	8.24
10-year	6.57	0.85	4.55	8.55
U.S. swap spreads				
3-year	0.27	0.12	0.01	0.61
7-year	0.34	0.12	0.09	0.78
10-year	0.33	0.12	0.09	0.76
U.S. proxy variables				
3-month T-bill	4.62	0.93	2.73	5.93
Term structure slope	1.13	0.82	0.06	2.97
Volatility	0.01	0.02	0.00	0.24
Liquidity	0.42	0.18	0.01	1.35
AAA corporate spread	0.38	0.09	0.16	0.76

Note: The statistics are based on 396 weekly observations from May 1991 to February 1999. The U.S. zero-swap and zero-treasury term structures are estimated from swap rates and Treasury bond yields as described in the Appendix. All rates are percentages.

The statistical properties of the U.S. and U.K. swap and government yield curves as well as the proxy variables used in our model are reported in Tables I and II and Figures 1 to 3 and 4 to 6, respectively. According to Tables I and II, the average swap and government yield curves in both countries are upward sloping. In the United Kingdom, swap spreads are also on average increasing with maturity, whereas in the U.S. swap spreads increase up to 5 years and subsequently level off. Figure 1 shows the slopes of the U.S. government and swap curves as well as the corporate bond spreads. The slopes of the zero-coupon and corporate bond term structures are always positive in our sample period, although swap spreads are often decreasing with maturity. Figures 2 and 3 plot the term structures of zero-coupon bonds and zero swaps, respectively. A comparison of the evolution of the two term structures shows that movements of the term structure of government bonds are closely reflected on the term structure of zero-swap rates.

Figures 4 to 6 provide information for the U.K. data. In Figure 4 we see that the slope of the U.K. yield curve exhibits great variation over time, especially around the exit of sterling from the European Exchange Mechanism in 1992 and the Asian and Russian crises of 1997 and 1998,

TABLE II
U.K. Descriptive Statistics

Rates	*M*	*SD*	*Minimum*	*Maximum*
U.K. zero swap rates				
3-year	7.39	1.24	5.00	10.45
7-year	7.79	1.22	4.98	10.72
10-year	7.94	1.24	4.98	10.75
U.K. zero treasury rates				
3-year	7.14	1.30	4.44	10.33
7-year	7.49	1.31	4.12	10.36
10-year	7.61	1.32	4.17	10.36
U.K. swap spreads				
3-year	0.25	0.17	0.003	1.01
7-year	0.29	0.20	0.002	1.20
10-year	0.32	0.18	0.003	1.08
U.K. proxy variables				
3-month T-bill	6.73	1.57	4.69	10.72
Term structure slope	0.65	0.93	−1.27	2.74
Volatility	0.02	0.12	0.00	1.72
Liquidity	0.35	0.19	−0.28	1.03
AAA corporate spread	0.38	0.09	0.16	0.76

Note: The statistics are based on 396 weekly observations from May 1991 to February 1999. The U.K. zero-swap and zero-treasury term structures are estimated from swap rates and Treasury bond yields as described in the Appendix. All rates are percentages.

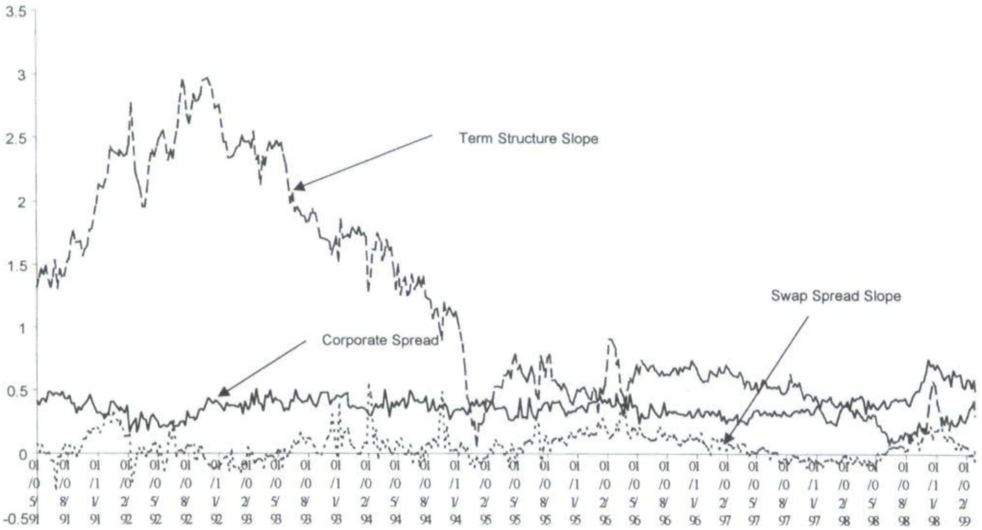

FIGURE 1
U.S. swap-spread slope and zero-coupon slope.

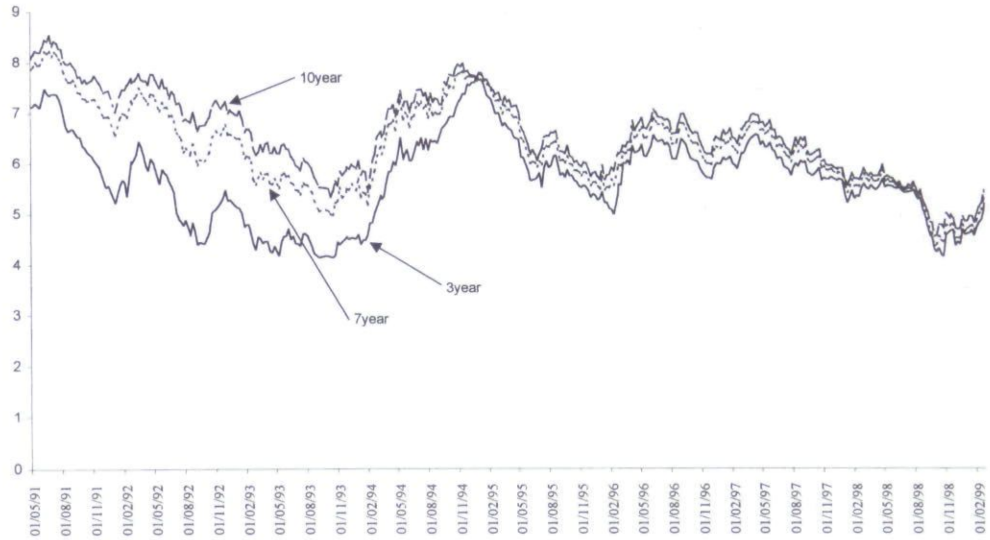

FIGURE 2
Term structure of U.S. zero-coupon bonds.

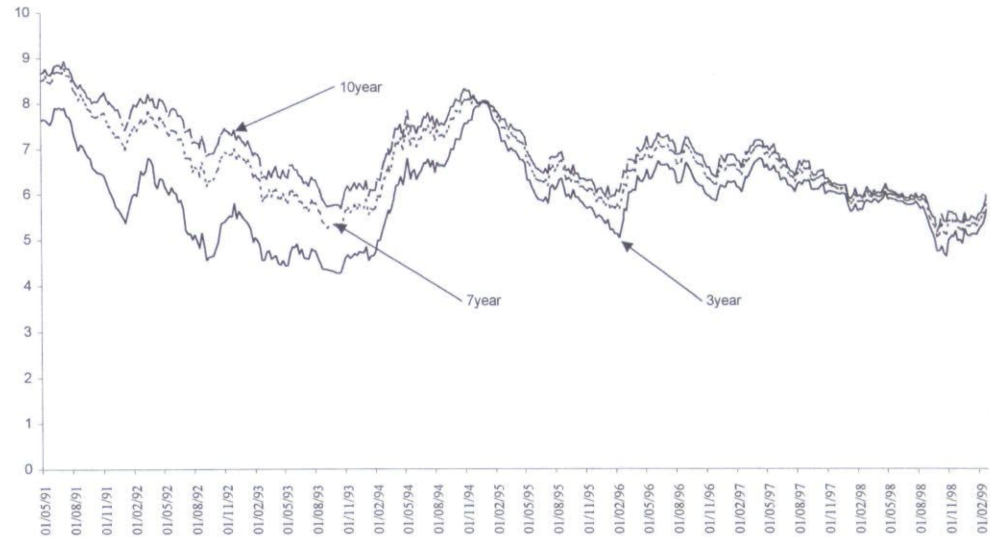

FIGURE 3
Term structure of U.S. zero-swap rates.

respectively. In addition, the corporate bond spread widens significantly during the time of the Russian crises. A comparison of Figures 5 and 6 shows that although the term structures of government bond and swap rates are closely related, swap spreads do vary over time.

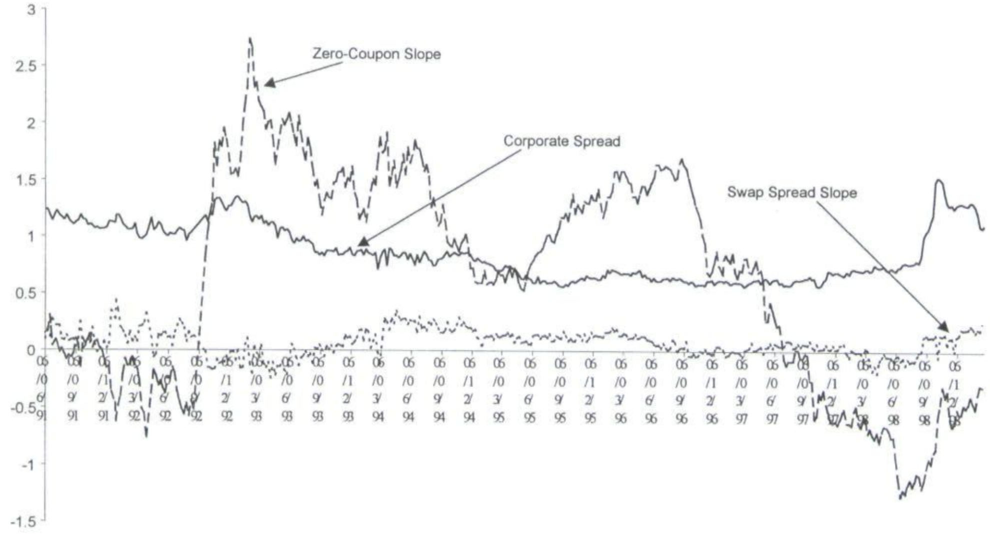

FIGURE 4
U.S. swap-spread slope and zero-coupon slope.

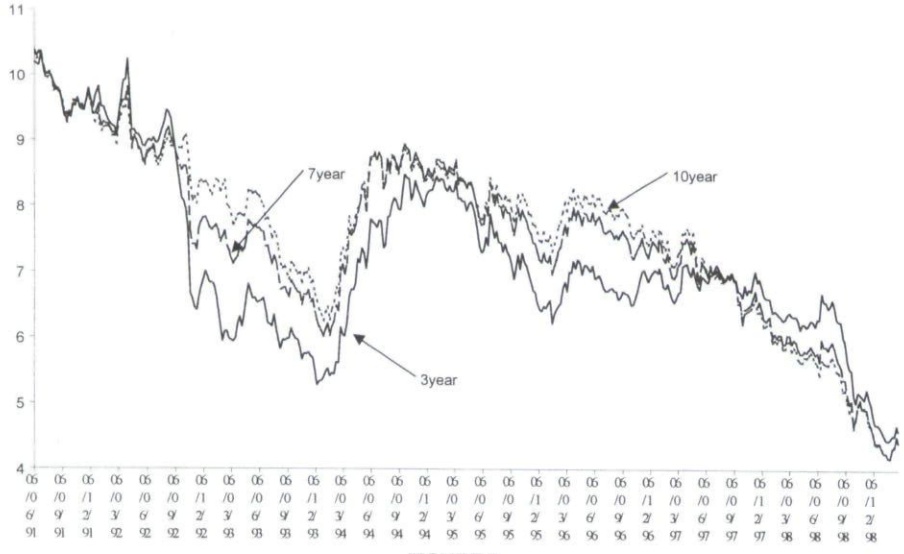

FIGURE 5
Term structure of U.K. zero-coupon interest rates.

ECONOMETRIC SPECIFICATION

In the previous sections, we defined a set of factors that have been identified in the literature as affecting the stochastic evolution of swap spreads. Furthermore, we identified a set of variables that can act as proxies for these factors. One problem when these proxies are used for

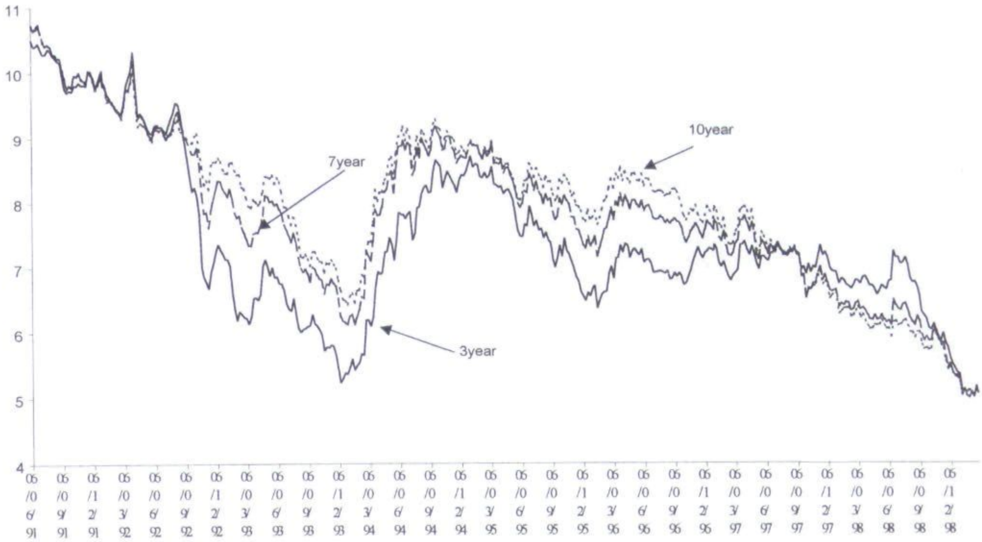

FIGURE 6
Term structure of U.K. zero-swap rates.

econometric work, however, is that they are closely interrelated. For instance, the slope of the term structure has a direct impact on the default premium and an indirect one through the corporate bond spread. To assess the relative impact of these factors on swap spreads, we employ the vector autoregression (VAR) methodology, which applies multivariate ordinary least squares (OLS) estimation within a system where not only the swap spread but all factor proxies are treated as endogenous variables. The VAR approach is preferred to single OLS regressions because of its ability to capture not only the direct (i.e., instantaneous) impact of each of the proxies on the spread but also the indirect (i.e., lagged) effect of each variable on the spread through its interaction with the remaining variables in the system. An additional advantage of the VAR methodology is that it allows us to test the possibility of feedback effects from the term structure variables to liquidity and default spreads.

Our VAR analysis reports the decomposition of the 3-year, 7-year, and 10-year spreads between zero swap rates and zero-coupon Treasury bond yields, respectively, based on a vector of six endogenous variables:

$$x_t = [\text{3-Month T-Bill, Slope, Volatility, Liquidity,}\\ \text{Corporate Spread, Swap Spread}_i]'$$

where $i = 3$, 7, and 10 years, respectively; all other variables are defined in the fourth section. For each country, we estimate three different VAR systems (thereafter, VARs), one for each of the 3-, 7-, and 10-year swap spreads, while keeping the rest of the information set unaltered. This allows an investigation of the relative importance of each factor across maturity.[5] Before interpreting the VAR results, we need to ensure that the errors in each equation of the VARs are approximately white noise. Each of the VAR systems is estimated with a lag length of 10 (except for the U.S. 3-year swap spread, where we use a lag length of 11), which ensures that the residuals are serially uncorrelated (up to about 10), homoscedastic, and free of Autoregressive Conditional Heteroscedasticity (ARCH) effects (up to about 7).[6] Based on the estimated VARs, impulse response functions were estimated for the U.S. and U.K. spreads. These functions trace the dynamic response of one variable to an impulse in another variable in the system. With 1,000 replications, a 2-*SD* confidence interval is also computed for the impulse response functions via Monte Carlo simulation. The impact of the proxies on the swap spreads needed to be interpreted with caution when the estimated confidence intervals include zero.[7]

To account for the possibility of correlation of the errors across different equations, the impulse response functions are orthogonalized. More specifically, the equation errors of each VAR are orthogonalized by a Choleski decomposition so that the covariance matrix of the resulting errors is diagonal (e.g., Lutkepohl, 1993). One disadvantage of the impulse response analysis is that it is sensitive to the ordering of the variables in the VAR, meaning that different ordering of the variables may lead to different results. To reduce this problem, the ordering needs to be chosen such that the first variable is the only one with a potential contemporaneous impact on the other variables in the system. Then, the second variable has to be chosen such that it may have a direct impact on all other variables but not on the first one, and so on. The vector of the endogenous variables (x_t) defined previously represents the way in which we choose to order the variables in each VAR. The 3-month rate is the first variable in the VARs. We see this as the most fundamental variable, in the sense that shocks to the 3-month rate may have a contemporaneous effect on all remaining variables, whereas shocks to all other variables may only have lagged effects on the short rate. Spread$_i$ enters

[5]VAR results for both countries, involving the remaining maturities, are available from the authors on request.

[6]Normality failure and ARCH effects are reported for both the U.S. and U.K. volatility equations; however, this result is somewhat expected as our main focus is on the modeling of interest-rate swaps, rather than the modeling of volatility. A full set of diagnostic tests is available from the authors.

[7]However, this is not always the case. On the basis of Monte Carlo simulations, Fachin and Bravetti (1996) showed that in most cases the confidence intervals are wide enough to include zero even when the true response is statistically different from zero.

last in the VARs, therefore allowing for potential contemporaneous and lagged effects from all other variables on the swap spread. In that sense, the ordering of the variables in the VARs is in line with our discussion in the third section.[8]

EMPIRICAL RESULTS

Figures 7 to 9 and 10 to 12 report the impulse response functions estimated for the U.S. and U.K. spreads, respectively. In addition to Figures 7 to 12, Tables III and IV report the decomposition of the variance of the forecast errors of U.S. and U.K. swap spreads 1 to 104 weeks ahead. For ease of comparison, the periods of variance decomposition are similar to the ones reported in Duffie and Singleton (1997). Each row of the tables reports the proportion of variance attributed to its own shocks as well as shocks to the remaining variables; hence, each row sums to 100%. The variance decomposition results help in assessing the relative importance of the components of the swap spreads.

A final issue that has to be addressed before a discussion of our results is that of the stability of the estimated VARs over time. Their stability is analyzed with recursive OLS estimates. The plots (in Figure 13 for the U.S. spreads and in Figure 14 for the U.K. spreads) of the 1-step Chow tests together with their 1% critical values suggest reasonable parameter constancy for the estimated equations.[9] Just a few exceptions occur in March 1996 and September and December 1998 for the U.S. spreads and in late June 1995, August and October 1998, and the beginning of January 1999 for the U.K. spreads. The instability observed between August and December 1998 could be related to the Russian crisis and the subsequent collapse of the Long Term Capital Management hedge fund. For the U.K., June 1995 and the beginning of January 1999 could be related to the change in the taxation of the U.K. government bonds and the introduction of the Euro, respectively.

U.S. Swap-Spread Results

The results in Table III reveal that the slope of the term structure plays an important role in determining the swap spreads. The significance of the

[8]The only variables whose ordering in the VAR is not clear are the slope and volatility of the short rate. Swapping the ordering of the two variables and reestimating the VARs do not affect the results. As discussed later, this is due to the weak effect of the volatility on the swap spreads.

[9]For a detailed discussion of these tests, see Doornik and Hendry (1997). We report the Chow tests only for the swap-spread equations. Graphs for the rest of the endogenous equations in the VARs are available on request.

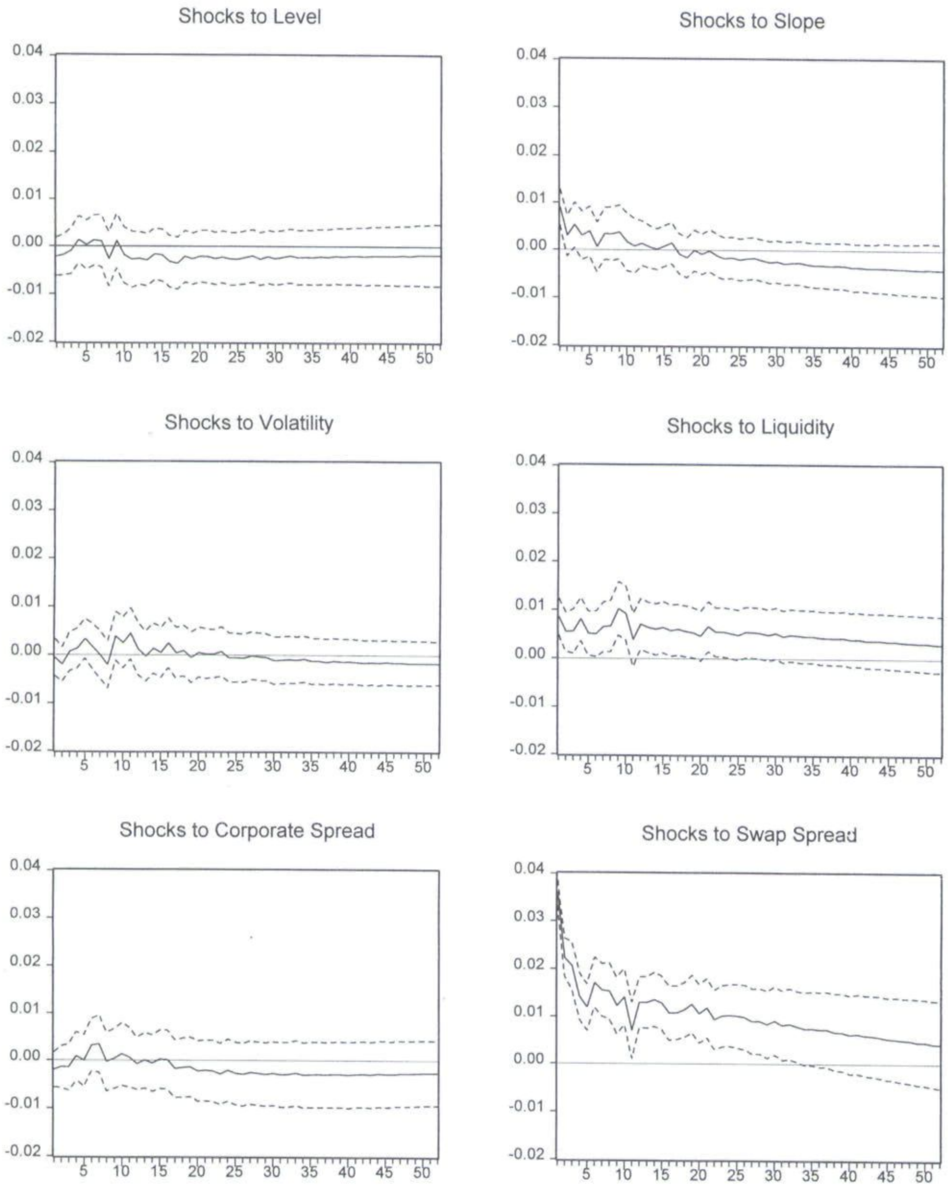

FIGURE 7
Impluse responses for the 3-year U.S. swap spread.

slope indicates that considerations about the future path of interest rates and the state of the economy in the business cycle have a considerable impact on swap spreads. Nevertheless, the impact of changes in the slope of the term structure on swap spreads is not uniform across maturities.

The impulse responses show that a steepening of the risk-free term structure will cause the short-term swap spreads to increase, at least in the short run, and the long-term spreads to decrease. The countercyclical

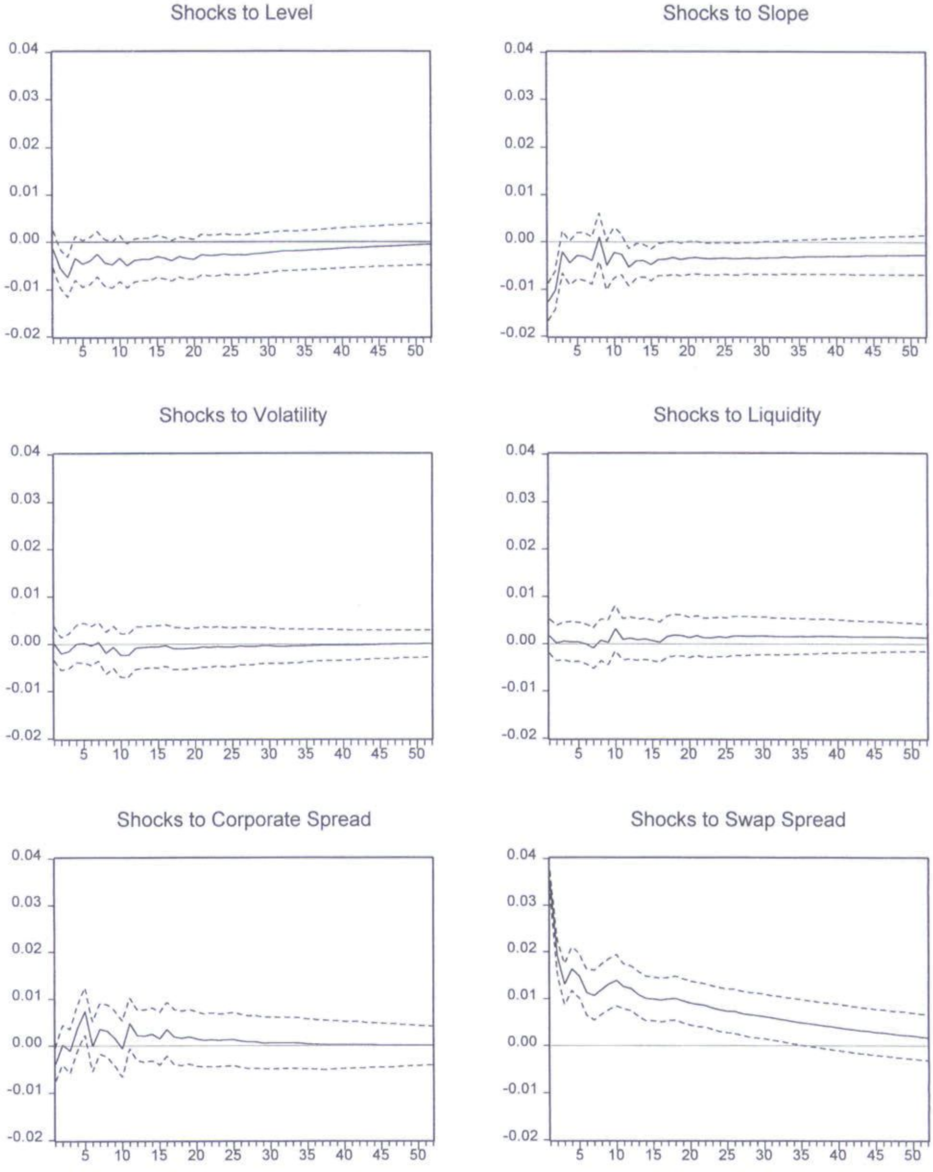

FIGURE 8
Impluse responses for the 7-year U.S. swap spread.

behavior of the long-term spreads is easy to explain. Increases in the slope of the yield curve are associated with an expanding economy and an improvement of business conditions. This in turn should alleviate any default considerations and cause swap spreads to decline. In the short term, however, it means that the floating-rate payers will be faced with higher interest rates without being able to fully benefit from the

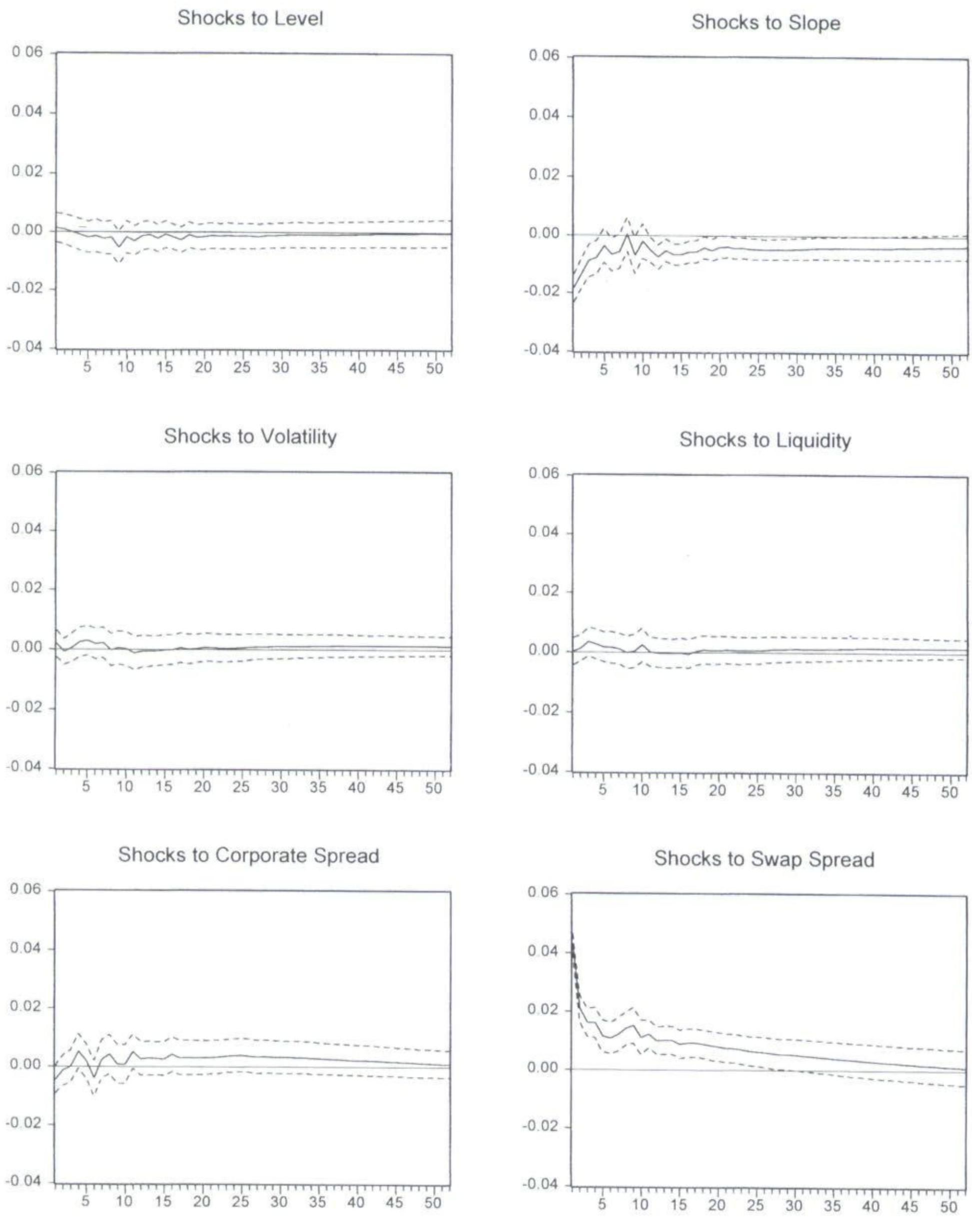

FIGURE 9
Impluse responses for the 10-year U.S. swap spread.

expanding economy because the actual improvement in business conditions usually occurs with a considerable lag. This explains the procyclical behavior of the short-term swap spreads. These findings are also in agreement with the results of Fama (1986) and Van Horn (1979), who reported that long-term credit spreads move in the opposite direction of short-term spreads.

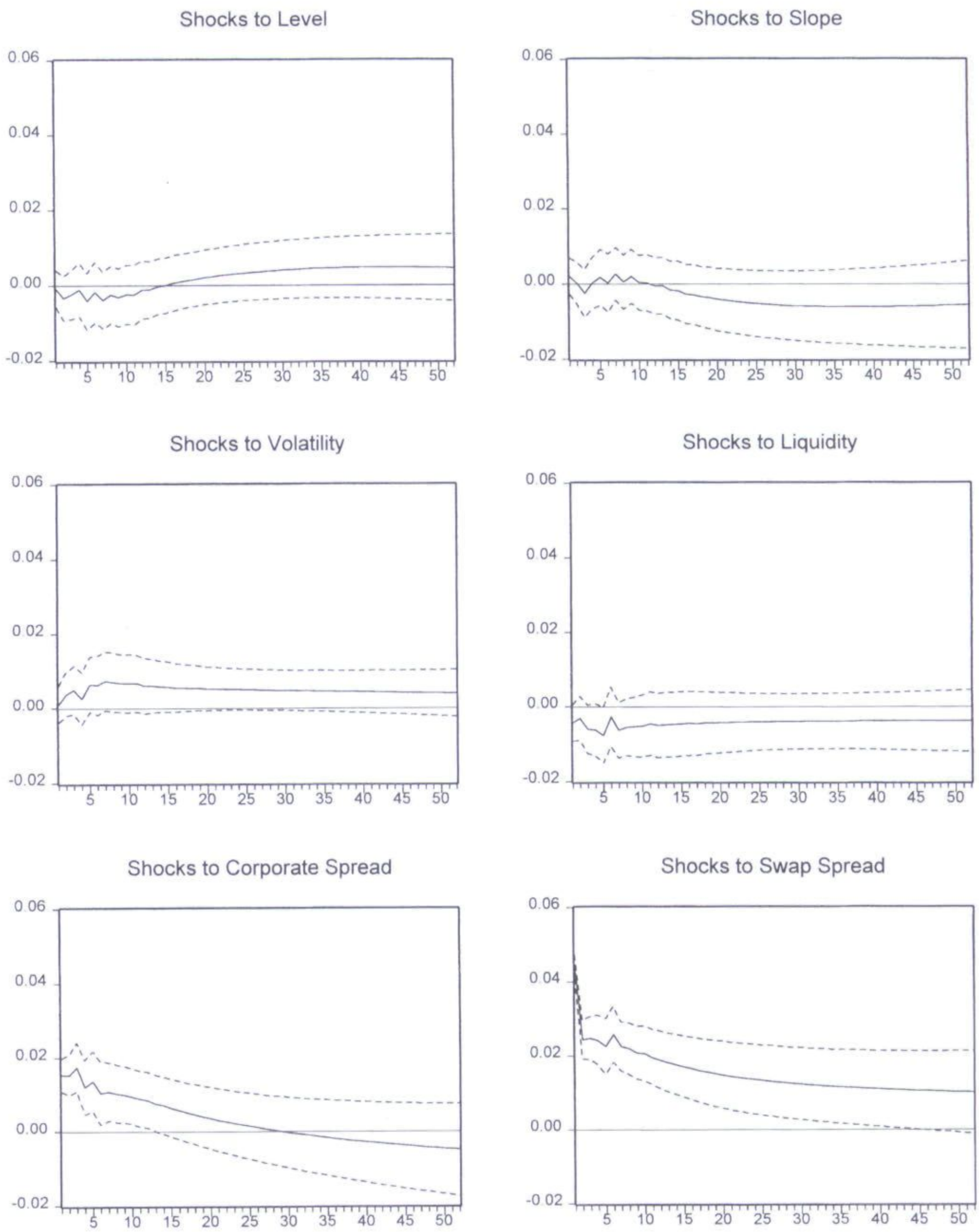

FIGURE 10
Impluse responses for the 3-year U.K. swap spread.

An additional feature of the impulse response functions is the negative but small effect of the level of the term structure on the swap spread. The intuition behind this result is that periods of unfavorable expectations coincide with falling interest rates and a deterioration of default and liquidity conditions. A negative relationship between rates and credit

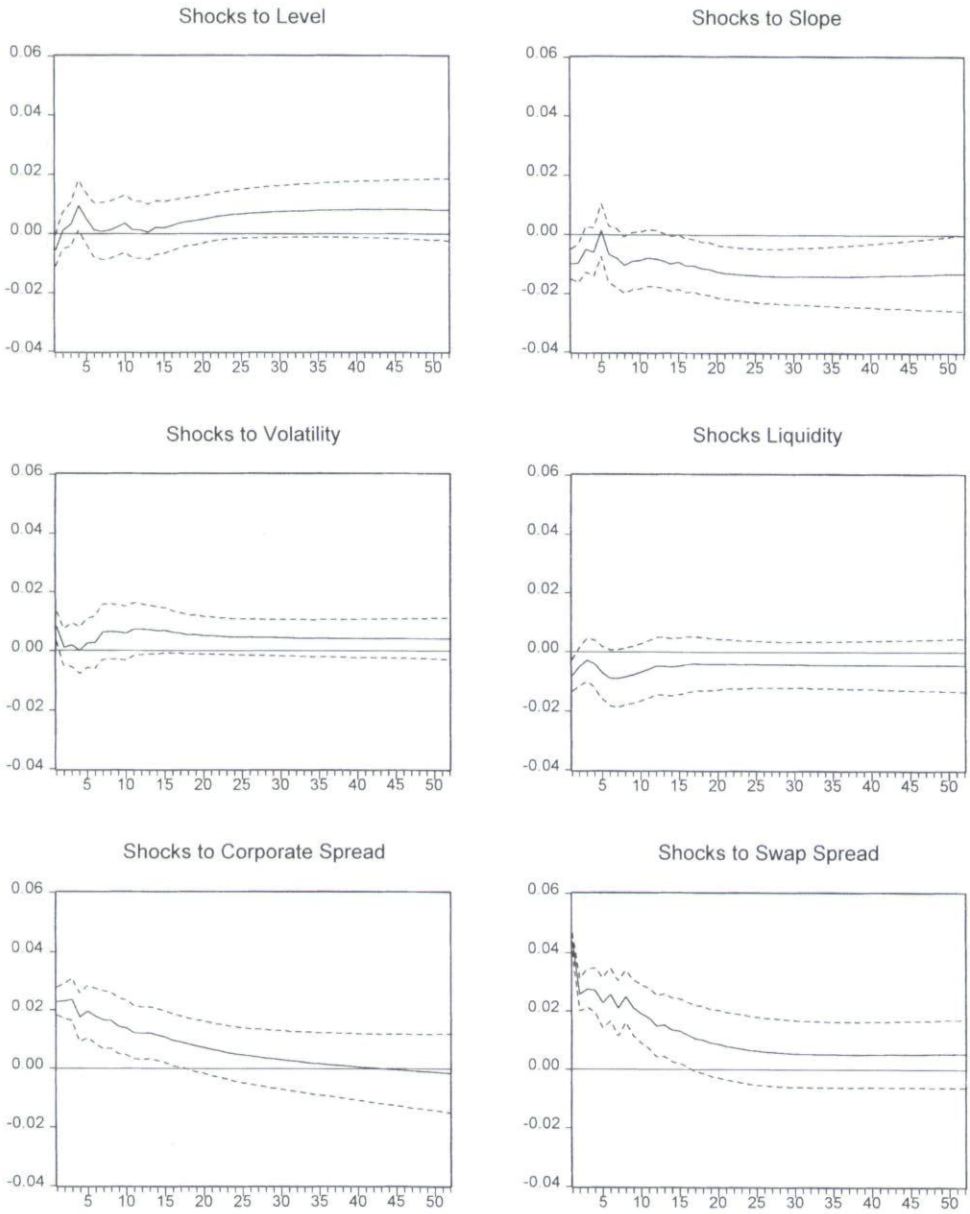

FIGURE 11
Implluse responses for the 7-year U.K. swap spread.

spreads is also estimated for corporate bond yields (see Duffee, 1998; Longstaff & Schwartz, 1995).

The TED and corporate bond spreads also have a significant effect on the determination of the swap spreads, but their importance varies across maturities. Liquidity premia are more important at short maturities, and they account for 15.5% of the 3-year spread variance 52 weeks ahead.

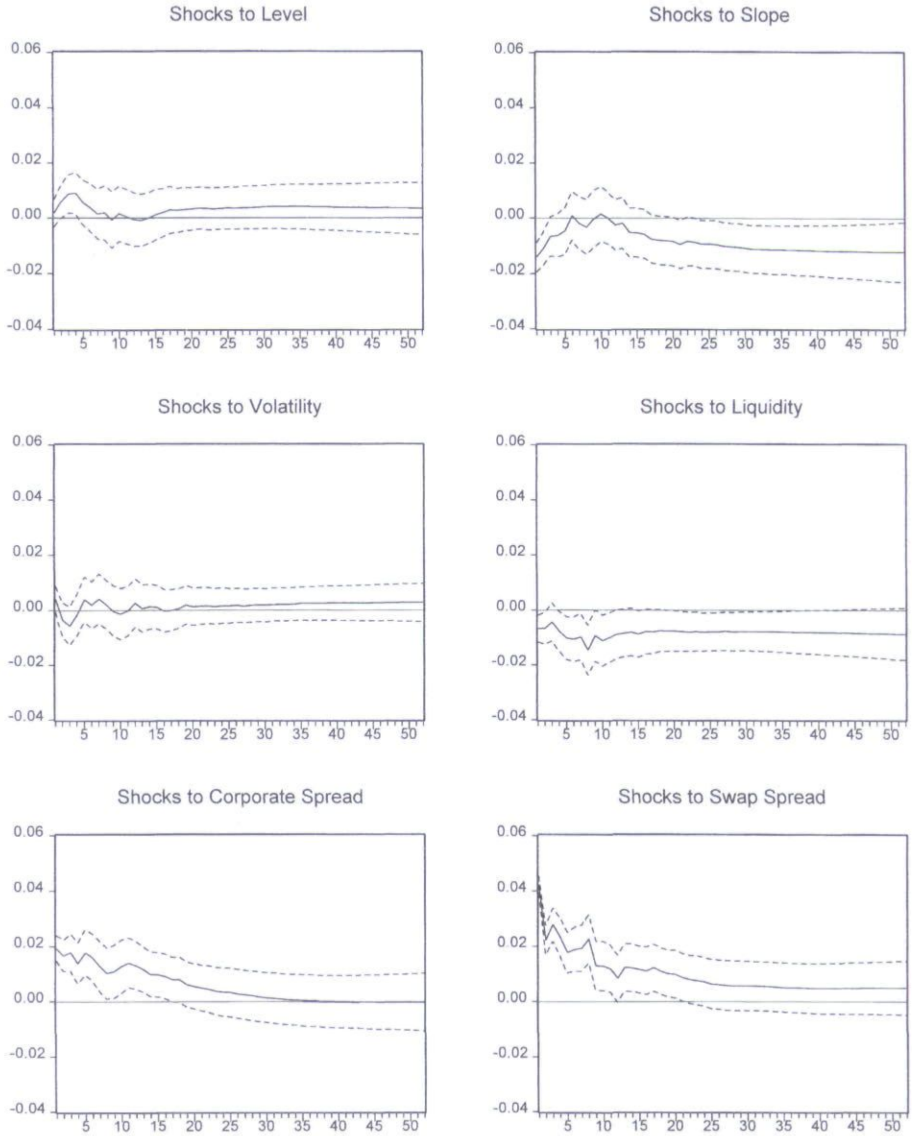

FIGURE 12
Impluse responses for the 10-year U.K. swap spread.

However, their importance diminishes when we examine longer maturity swaps, probably because of the higher liquidity of the swap markets in these maturities. One explanation for the lack of liquidity for shorter maturities is the abundance of short-term instruments, such as interest-rate futures and forwards, available to investors. Conversely, default considerations are much more important at the long end of the swap markets, as the contribution of the default premium to the variance of swap

TABLE III

Variance Decomposition of U.S. Swap Spreads

Week	*Level*	*Slope*	*Volatility*	*Liquidity*	*Corporate Spread*	*Spread*
			3-Year Spread			
1	0.33%	5.52%	0.03%	4.93%	0.28%	88.92%
4	0.39%	4.53%	0.24%	7.06%	0.32%	87.46%
8	0.38%	4.22%	0.56%	7.98%	0.87%	85.99%
26	1.78%	2.83%	1.07%	14.25%	1.19%	78.88%
52	2.56%	5.32%	1.30%	15.45%	3.18%	72.19%
78	2.86%	9.38%	1.81%	15.05%	3.86%	67.03%
104	2.92%	12.25%	2.04%	14.56%	3.88%	64.35%
			7-Year Spread			
1	0.14%	11.50%	0.00%	0.20%	1.25%	87.04%
4	4.08%	11.91%	0.27%	0.13%	1.27%	82.34%
8	5.02%	10.11%	0.33%	0.15%	3.33%	81.07%
26	6.74%	10.33%	0.54%	0.76%	3.21%	78.42%
52	6.80%	12.87%	0.51%	1.58%	2.82%	75.42%
78	6.60%	14.96%	0.55%	2.04%	2.73%	73.13%
104	6.46%	16.30%	0.70%	2.22%	2.65%	71.67%
			10-Year Spread			
1	0.09%	15.25%	0.14%	0.00%	0.93%	83.59%
4	0.11%	18.63%	0.26%	0.54%	1.39%	79.07%
8	0.39%	17.43%	0.57%	0.58%	2.16%	78.86%
26	1.43%	18.96%	0.45%	0.54%	4.22%	74.40%
52	1.49%	22.51%	0.75%	0.99%	6.62%	67.63%
78	1.45%	24.76%	0.99%	1.41%	6.43%	64.97%
104	1.40%	25.54%	1.14%	1.57%	6.24%	64.10%

Note: Each row reports the proportion of variance of the forecast error of swap spreads 1 to 104 weeks ahead that can be attributed to its own shocks versus shocks to the remaining variables in the VARs.

spreads 52 weeks ahead increases from 3.18% in the 3-year swap spread to 6.6% in the 10-year swap. The only proxy meanwhile that does not have a significant impact on the swap spreads is the volatility of the short-term interest-rate changes. This finding is similar to the results of Sundaresan (1991).

Finally, by treating all variables in the system as endogenous, the VAR approach allows us to assess the dynamic impact of the term structure on the liquidity and default proxies. The variance decomposition of the liquidity premium (reported in Table V) reveals that the main factors determining the TED spread are the level of the 3-month T-bill rate and the slope of the term structure. In addition, the default premium has a very strong impact on liquidity conditions across maturities. The results for the default premium are even more revealing. The swap spread in

TABLE IV
Variance Decomposition of U.K. Swap Spreads

Week	*Level*	*Slope*	*Volatility*	*Liquidity*	*Corporate Spread*	*Spread*
			3-Year Spread			
1	0.02%	0.19%	0.05%	0.86%	10.65%	88.22%
4	0.39%	0.22%	0.65%	2.21%	19.01%	77.20%
8	0.77%	0.26%	2.85%	3.13%	18.28%	74.70%
26	1.03%	1.61%	5.35%	4.27%	14.15%	73.58%
52	3.36%	5.52%	6.25%	4.98%	11.27%	68.60%
78	4.27%	6.56%	6.33%	5.44%	13.06%	64.33%
104	4.14%	6.40%	6.23%	5.81%	15.68%	61.75%
			7-Year Spread			
1	1.20%	3.69%	2.50%	2.46%	19.56%	70.59%
4	2.00%	3.93%	1.10%	1.83%	29.21%	61.93%
8	1.50%	4.48%	1.58%	3.83%	29.54%	59.07%
26	2.64%	14.99%	4.18%	4.66%	25.39%	48.14%
52	7.78%	28.88%	4.56%	5.22%	17.81%	35.74%
78	10.28%	33.55%	4.80%	5.67%	15.00%	30.68%
104	10.78%	34.70%	5.03%	6.07%	14.62%	28.81%
			10-Year Spread			
1	0.13%	8.38%	0.64%	1.89%	15.20%	73.75%
4	3.47%	7.39%	1.17%	3.09%	20.49%	64.38%
8	2.82%	5.25%	1.19%	8.21%	22.82%	59.71%
26	2.49%	9.63%	0.93%	14.29%	23.18%	49.47%
52	3.48%	24.12%	1.30%	18.35%	15.90%	36.84%
78	3.14%	32.93%	1.70%	21.81%	11.47%	28.95%
104	2.44%	38.61%	2.03%	24.95%	8.51%	23.44%

Note: Each row reports the proportion of variance of the forecast error of swap spreads 1 to 104 weeks ahead that can be attributed to its own shocks versus shocks to the remaining variables in the VARs.

conjunction with the slope and level of the term structure are the main factors determining the corporate bond spread. These results imply that a model of corporate bond spreads as a function of the term structure of risk-free interest rates and the swap spreads might yield significant results.

U.K. Swap-Spread Results

The variance decomposition results for the U.K. swap spreads, reported in Table IV, indicate a factor structure different from the one reported previously for the U.S. market. This difference in the factor structure is more pronounced in longer maturities where an idiosyncratic

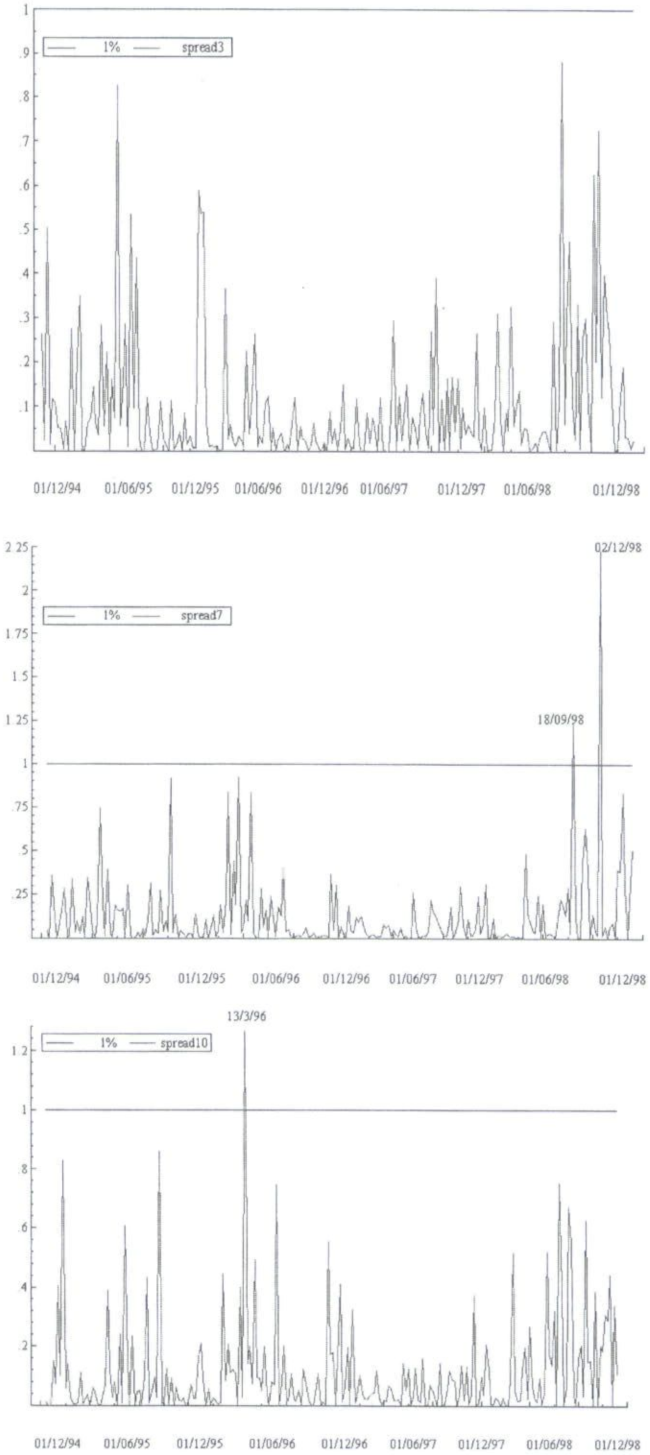

FIGURE 13
Recursive tests for the U.S. spreads.

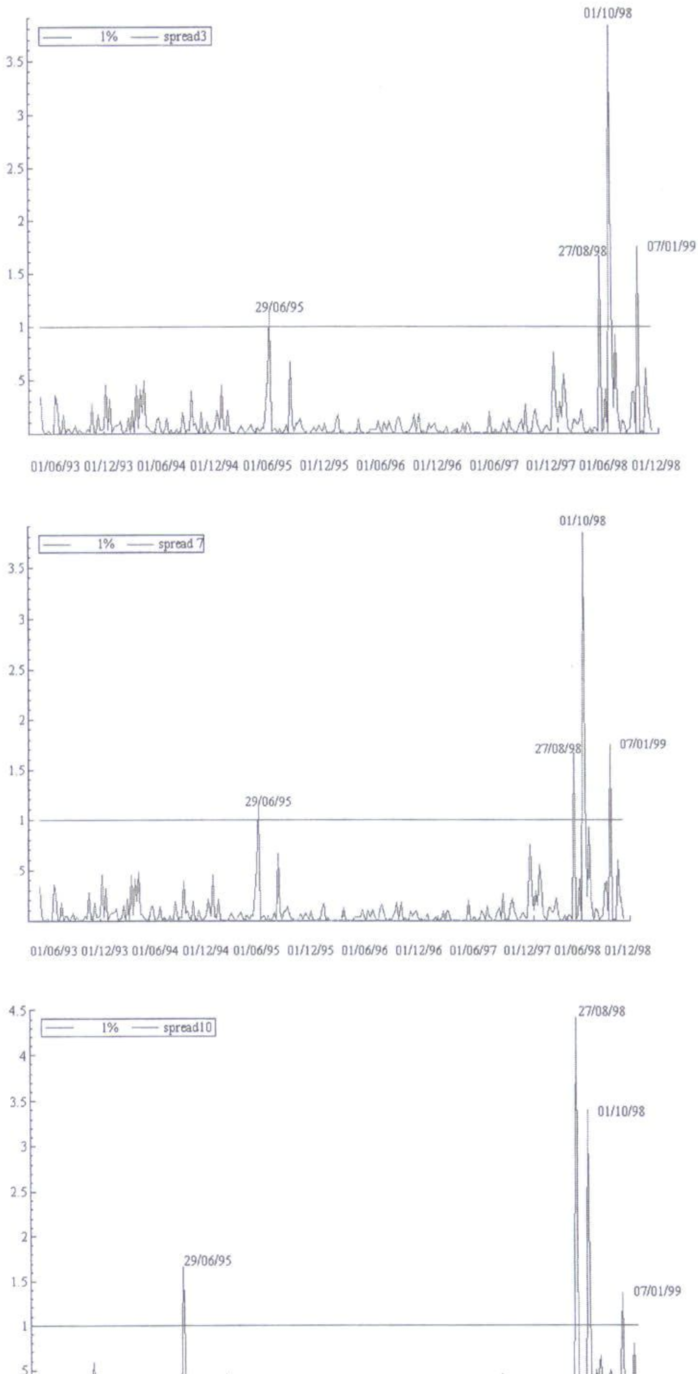

FIGURE 14
Recursive tests for the U.K. spreads.

TABLE V

Variance Decomposition of U.S. Liquidity and Corporate Spread

Maturity	*Level*	*Slope*	*Volatility*	*Liquidity*	*Corporate Spread*	*Spread*
			Liquidity			
3-year	18.21%	10.72%	2.93%	40.24%	17.03%	10.80%
7-year	15.98%	17.61%	2.69%	40.23%	15.52%	8.96%
10-year	15.95%	15.27%	2.70%	40.71%	15.88%	9.48%
			Default			
3-year	17.55%	7.80%	2.82%	2.49%	55.46%	13.71%
7-year	13.39%	15.92%	1.64%	1.66%	58.17%	9.23%
10-year	12.67%	16.36%	2.35%	1.63%	61.55%	5.43%

Note: Each row reports the proportion of variance of the forecast error of liquidity and default premia 52 weeks ahead that can be attributed to its own shocks versus shocks to the remaining variables in the 3-year, 7-year, and 10-year VARs estimated.

variation of 7- and 10-year swap spreads accounts for 28 and 23% of their total variation compared with 72 and 64% for the U.S. swap spreads.

One difference between results obtained for U.S. and U.K. swap markets is the more significant impact of corporate bond risk on the U.K. swap spreads. A possible explanation for this result is that hedging activities of corporations attempting to minimize their interest-rate exposure, caused by the issuance of corporate debt, through swaps create strong links between the corporate bond and swap markets. Volatility is also significant, albeit with declining importance, across maturities. This can be attributed to the huge surge of volatility at the time of the United Kingdom's exit from the European Exchange Rate mechanism, around September 1992. Liquidity is also more significant for the U.K. swap spreads than the U.S. swap spreads, and contrary to what is observed in the United States, its impact on swap spreads increases with maturity. Finally, the slope of the term structure has a major impact on swap spreads, especially for longer maturities.

The impulse responses reported in Figures 10 to 12 complement the variance decomposition results by tracing the dynamic effects of shocks to endogenous variables on the swap spread. As expected, shocks to default and volatility proxies have a positive impact on the swap spreads across maturities. What is more difficult to rationalize is the negative impact of liquidity shocks on the swap spreads. As briefly mentioned in the third section, this counterintuitive finding can be attributed to the way the T-bill market operates in the United Kingdom. Grinblatt (1995) rationalized the use of the LIBOR minus T-bill spread as a proxy for liquidity under the assumption that T-bill rates reflect expectations about short-term interest rates and that investors require a mark-up spread to participate in the less liquid LIBOR market. In this model, a widening of the LIBOR–T-bill spread is a result of increased illiquidity in the money markets. Nevertheless, these conditions do not apply in the U.K. market. Contrary to the United States, where the T-bill market is extremely liquid, the issuance of U.K. T-bills is limited. The T-bills are used by commercial banks as collateral for their dealings with the Bank of England during open market operations.[10] The lack of issuance combined with high demand for T-bills by banks means that a widening of the LIBOR–T-bill spread is often caused by squeezes in the T-bill market rather than a lack of liquidity in the money markets. The fact that the liquidity proxy is affected by a lack of liquidity in the T-bill rather than the LIBOR market is the reason for the negative impact of the liquidity proxy on swap spreads.

Figures 10 to 12 also show that shocks to the slope of the term structure have a negative effect on the swap spreads across all maturities. This implies that the negative relationship between short-term and long-term credit spreads does not carry over to the U.K. data and that the whole term structure of swap spreads exhibits a countercyclical behavior.

Finally, Table VI reports the variance decomposition for the U.K. liquidity and default variables. Similar to what was reported for the

TABLE VI

Variance Decomposition of U.K. Liquidity and Corporate Spread

Maturity	*Level*	*Slope*	*Volatility*	*Liquidity*	*Corporate Spread*	*Spread*
			Liquidity			
3-year	18.54%	8.83%	2.50%	62.03%	3.25%	4.85%
7-year	17.33%	10.01%	3.50%	58.98%	3.17%	7.00%
10-year	20.34%	10.29%	2.79%	52.76%	2.50%	11.33%
			Default			
3-year	7.39%	11.36%	1.32%	0.54%	76.24%	3.15%
7-year	6.59%	21.15%	0.94%	1.45%	66.81%	3.06%
10-year	9.83%	16.66%	1.26%	6.07%	63.22%	2.60%

Note: Each row reports the proportion of variance of the forecast error of liquidity and default premia 52 weeks ahead that can be attributed to its own shocks versus shocks to the remaining variables in the 3-year, 7-year, and 10-year VARs estimated.

[10]At the time of writing, conditions in the U.K. market are changing as responsibility for T-bill issuance passes over to the Debt Management Office. However, it will presumably be some time before a more liquid market can be developed.

United States, interest-rate variables such as the level and slope of the term structure are the main factors in influencing the liquidity and default proxies. What we do not observe in the U.K. results, however, is the effect of the swap spreads on the corporate bond spread observed in the U.S. data.

INTERNATIONAL LINKAGES IN SWAP MARKETS[11]

In this section, we investigate the links between U.S. and U.K. swap spreads in more detail. Given the degree of integration between the U.S. and U.K. capital markets and the ability of major swap dealers to participate in both markets, it is reasonable to expect that developments in one market will affect the other. Ideally, we would like to examine the relationship between the two markets in a system that includes all the U.S. and U.K. factors we identified in the previous sections. This would mean estimating a VAR with 12 endogenous variables. The large number of variables, in conjunction with the number of lags in the VAR, would result in the loss of a large number of degrees of freedom and a possible overfitting of the system. These statistical issues would critically affect the credibility of our results. To maintain the dimensions of the VAR to a manageable level and still be able to address the issue of linkages between U.S. and U.K. swap markets, we estimate a VAR that includes only the levels, slopes, and swap spreads of the two countries. By formulating the problem in such a way, we can examine the degree to which the fundamentals (expressed by the level and slope of the term structure) and credit conditions of one country (expressed by the swap spreads) affect the credit conditions of the other.

The results are given in Table VII.[12,13] The first panel of Table VII reports the variance decompositions of the U.S. swap spreads. These results indicate that although the U.K. variables exert some influence on the U.S. swaps, the main factors driving the U.S. swap spreads are domestic U.S. factors. The results for the U.K. spreads are reported in the second panel of Table VII. The effect of the variations of the U.K.

[11]We thank an anonymous referee for suggesting this line of research.

[12]As discussed in the fifth section, the variance decomposition results depend on the ordering of the variables in the VAR. The ordering we employ in this section is the following: U.S. level, U.K. level, U.S. slope, U.K. slope, U.S. swap spread, and U.K. swap spread. The decision for the U.S. variables to precede the corresponding U.K. ones is justified on the basis of the relative size and liquidity of the two markets.

[13]Parameter stability tests did not provide any indication of significant parameter instability and are not reported.

TABLE VII
Variance Decomposition of U.S. and U.K. Swap Spreads in an International Framework

Maturity	*U.S. Level*	*U.K. Level*	*U.S. Slope*	*U.K. Slope*	*U.S. Spread*	*U.K. Spread*
			U.S. Swap Spreads			
3-year	7.61%	4.75%	22.92%	9.67%	43.22%	11.81%
7-year	6.89%	2.85%	21.74%	10.48%	52.76%	5.28%
10-year	5.55%	0.77%	26.47%	7.09%	55.69%	4.42%
			U.K. Swap Spreads			
3-year	1.12%	3.94%	17.00%	9.10%	3.95%	64.88%
7-year	2.62%	12.47%	20.77%	18.60%	9.14%	36.39%
10-year	0.98%	6.54%	25.45%	14.35%	16.03%	36.66%

Note: Each row reports the proportion of variance of the forecast error of U.S. and U.K. swap spreads 52 weeks ahead that can be attributed to its own shocks versus shocks to the remaining variables in the 3-year, 7-year, and 10-year VARs estimated.

slope on the U.K. swap spreads is evident across maturities.[14] The U.S. slope is the second most important factor in explaining the variability of the U.K. swap spreads after the U.K. spreads' own variation. Its significance rises from 17% on the 3-year spread to 25.5% on the 10-year U.K. swap spread. The significance of the U.S. swap spread in accounting for the variation in U.K. spreads also increases across maturities from 4% on the 3-year U.K. spread to 16% on the 10-year U.K. spread. One explanation for the greater integration of the swap spreads at longer maturities is related to the greater liquidity of the 10-year swaps and their increased significance as hedging instruments due to a lack of alternative, competitive instruments, such as interest-rate futures, that could perform a similar role.

CONCLUSIONS

According to previous research on interest-rate swaps, considerations about the probability of counterparty default and the lack of liquidity in the interbank markets are the two factors that create a discrepancy between swap and government bond rates of equal maturity. In this article, we suggested a set of variables that can act as proxies for the two unobserved factors across maturities and across countries. The

[14]These reports are similar to the results of Eom, Subrahmanyam, and Uno (2000) for the Japanese swap market and Fehle (2000).

difference between LIBOR and T-bill rates is employed as a proxy for liquidity, whereas the level, slope, and volatility of the term structure and the difference between the yield on a portfolio of corporate bonds and a corresponding Treasury bond acts as a proxy for default risk.

By examining U.S. and U.K. swap spreads of different maturities, we were able to provide a more complete picture of the significance and direction of the impact of the various factors on swap spreads. The results from U.S. swaps indicate that the slope and level of the risk-free term structure are significant determinants of swap spreads across maturities. We find that the slope of the term structure, similar to empirical results on corporate credit spreads, has a positive effect on the short-term swap spreads and a negative effect on long-term swap spreads. Also, changes in the level of the term structure have a negative impact on the spreads. The liquidity and corporate bond spreads are also important in determining the swap spreads, but their importance varies across maturities. Liquidity effects are more important in short-maturity swaps, where a variety of interest-rate instruments are available to investors. On the contrary, default-risk considerations are the major determinants of swap spreads in longer maturities.

By comparing these findings to the results from the U.K. swap market, we were able to identify a number of differences in the ways that the two markets operate. In the United Kingdom, the links between the corporate bond market and the interest-rate swap market are more pronounced. In addition, our results indicate that liquidity considerations in U.K. swap markets are more important than in the United States, although the interpretation of the U.K. results is complicated by the incomplete development of the U.K. T-bill market. Furthermore, the slope of the U.K. term structure has a negative impact across the term structure of swap spreads, indicating a countercyclical behavior for the U.K. swap spreads.

The links between the U.S. and U.K. swap markets were further examined within a framework that includes both U.S. and U.K. factors. Our main finding is that to a great extent the relationship between the two markets is one-way. Variation in U.S. term structure variables and swap spreads affect the developments in the U.K. swap market. We find little evidence for a U.K. influence on U.S. markets.

Finally, there are a number of issues that our research does not address, mainly because of a lack of appropriate data. The first issue relates to the effects of excess demand from investors for one side of the swap contracts. If investors believe that interest rates are going to fall in the future, they will ask to pay floating and receive fixed. The excess demand for the one side of the swap will make it difficult for swap dealers to hedge their outstanding positions and can lead to an increase in the swap bid–ask spreads. Finally, we were unable to explore the effects of asymmetric credit risk of the swap counterparties. The impact of asymmetric credit risk can be assessed only if the credit quality of the counterparties is known. This information is not publicly available in the generic swap markets. The effects of credit ratings can be studied only if confidential bank data are available, as in the study by Cossin and Pirotte (1997). Our intention is to investigate these issues further in future research.

APPENDIX: CONSTRUCTION OF A ZERO-SWAP TERM STRUCTURE

This appendix describes the methodology used to estimate zero-coupon term structures of interest rates from U.S. and U.K. interest-rate swap data.

The estimation of the term structure of interest rates for maturities longer than a year is based on swap rates. The most common type of interest-rate swap is the fixed-to-floating par swap. This is a contract between two counterparties to exchange future cash flows or equivalently to exchange interest-rate risk positions. One party of the swap, namely, the fixed payer, agrees to pay on each payment day until the maturity of the swap and an amount equal to a fixed interest rate applied on a notional principal. In return, the fixed payer receives from the other counterparty, the floating payer, cash flows based on the same notional principal but calculated with respect to a floating interest rate (e.g. the LIBOR rate). The payments of these cash flows usually occur either annually or semiannually.

The technique used to infer the prices of zero-coupon bonds from swap rates is called *bootstrapping* and is based on the fact that interest-rate swaps are par instruments with zero-net present value. For U.S. interest-rate swaps, where the swap cash flows occur annually, the prices of discount bonds, $B_{0,t}$, implied by the swap market are given by

$$B_{0,t} = \frac{1 - s_t(\sum_{i=1}^{i=t-1} a_{i-1,i} B_{0,i})}{1 + s_t a_{t-1,t}} \tag{A1}$$

where s_t is the swap rate, $i = 1, 2, \ldots, t$, and the accrual factor is $a_{i-1,i}$.[15]

[15]For United States Dollar (USD) interest-rate swaps, the accrual factor is defined as $a_{i-1,i} = \dfrac{t_i - t_{i-1}}{360}$.

For U.K. swaps, where the swap cash flows occur semiannually, the calculations are slightly more complicated.[16] If the swaps make semiannual payments, we have to use swap rates every half-year to calculate the zero bond prices for each half-year. Again, a linear interpolation needs to be used to get an estimate of the missing swap rates. The only swap rate we are not able to calculate using linear interpolation is the $s_{1.5}$ swap rate because the s_1 rate is not available. The way to calculate s_1 is to use $B_{1.5}$ and B_1 estimated from the money market rates as follows:[17]

$$s_1 = \frac{1 - B_{0,1}}{a_{0,0.5}B_{0,\frac{1}{2}} + a_{0.5,1}B_{0,1}} \tag{A2}$$

$s_{1.5}$ can be calculated by interpolation between s_1 and s_2.

Finally, the zero bond prices can be calculated with the bootstrap method as in Equation A1, but now the index i in the summation is being done semiannually such that $i = 1, 1.5, 2, 2.5, \ldots, t$.

On the basis of those zero-coupon bond prices, we can estimate the implied annualized yields as[18]

$$r_{0,t} = \left(\frac{1}{B_{0,t}}\right)^{\frac{1}{a_{0,t}}} - 1 \tag{A3}$$

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[16]In the U.K. swap markets, the swap day-count convention is 365 days per year. Thus, the accrual factor is $a_{i-1,i} = \frac{t_i - t_{i-1}}{365}$.

[17]When swaps are settled semiannually, we also need to estimate $B_{0,0.5}$. According to money market conventions, $B_{0,0.5} = \frac{1}{1 + r_t a_{0,0.5}}$, where r_t is the 6-month LIBOR.

[18]The accrual factors now refer to bonds, and as a result they are $a_{i-1,t_i} = \frac{t_i - t_{i-1}}{365}$.

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