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DYNAMICS OF SWAP SPREADS: A CROSS-COUNTRY STUDY

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Summary

We examine the empirical behaviour of swap spreads in Germany, Britain and the US over the last five years. Swap spreads of three maturities (2-, 5- and 10-year) are considered. The movements of swap spreads are explained using the movements in credit spreads, Libor-gc spreads, the shape of the government curve and returns on equity market indices. We document evidence for a regime shift in the dynamics of swap spreads over the last 12-15 months. The level and persistence of spreads and the volatility of changes in spreads are markedly higher now.

Moreover, their sensitivity to credit spreads and the cross-country correlation in spread changes have increased significantly. An increase in investor and dealer risk aversion, the reduction in leverage of risk capital employed by relative-value hedge funds (which were typical receivers on swaps), a perception of increased risk in asset markets and increases in spread volatility induced by lower liquidity could be cited as factors that have contributed to the recent spread widening.

Euro-area swap spreads continue to remain at half the levels of their British and US counterparts. Lower credit spreads in Europe and lower Libor-gc spreads may partly explain this feature. The level of issuance of credit bonds in Europe, the risk appetite of dealers and hedge funds, the shrinking supply of Treasury securities in the US, the performance of global (especially US) equity markets and cyclical movements in the US economy relative to the European economy are likely to be the key drivers of swap spreads in the near-to-intermediate term.

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I Introduction

Few sectors of the financial market have undergone a faster rate of growth and change over the last 15 years than the interest rate swap market. Swaps were first used in the mid-1980s as straightforward liability management tools, with market participants swapping fixed for floating rate interest streams. By 1990 the notional outstanding amount of swaps had grown to $2.3 trillion, but their range of application was limited.

In this decade developments include the creation of a new asset class, asset swaps (fixed rate bonds swapped to floating rate for bank and other Libor-based investors) and swaptions (options on forward swaps). These instruments allow investors to take a view on future interest rate and yield curve movements.

The use of swaps has also expanded. Hedge funds use swaps both to take views on credit spread direction and to profit from price movements in the repo market. Bond dealers are increasingly using swaps to hedge cash positions. The notional amount of swaps outstanding is now over $50 trillion. The rate of growth has far outstripped that of any other financial market. Daily turnover in the swap market, estimated at about $5bn in 1990 is now close to $150bn.

Financial markets are interrelated, and swaps lie at the centre of many market relationships. Swap markets link government, corporate debt and money markets across currencies (via basis swaps) and maturities. So, the variables that drive the underlying term structure of the government and credit curves should explain swap spread movements. At the same time, the dynamics of swap spreads should be helpful in understanding bond markets. These considerations underline that a range of factors needs to be analysed in order to understand movements in swap spreads. Moreover, the importance of each factor, along with their interrelationships, most likely changes over time.

This study documents empirically the linkages between swap, government credit and volatility markets. We construct a model to enable us to assess quantitatively whether movements in swap spreads are warranted by price changes in these markets. This model can help investors determine the appropriate time to go long or short swap spreads. It could also be used by corporations, agencies and sovereigns in timing debt issuance and in deciding whether or not to swap a particular issue.

This study also highlights international differences in the behaviour of swap spreads. We consider three countries — the US, Germany and the UK. Within each, we examine three maturities (2-, 5-year and 10-year). Our results can provide useful inputs into decisions about international swap arbitrages and cross-border issuance.

Our key findings on the drivers of swap spreads are as follows:

- Among the factors that help explain movements in swap spreads, the most important are: credit spreads, the level of interest rates and the slope of the yield curve, and volatility and risk aversion in asset markets.
- There is evidence of a regime shift in the distribution of swap spreads since the financial crisis of autumn 1998. Swap spreads are now fluctuating around a higher mean and the volatility of spread movements is also higher. The sensitivity of swap spreads to credit spreads has also increased significantly.

- The reduction in risk capital devoted to relative-value trades that involved shorting Treasuries against (receiver) swaps, the increasing specialness of on-the-run Treasuries in the US market and perceptions of increased risk have all contributed to spread widening. In the near-to-intermediate term, many of these factors are likely to persist and swap spreads could well remain wider than their historical means.
- Euro swap spreads remain at half the level of their US and UK counterparts. Lower credit and Libor-gc spreads (which in turn could be the result of bank deposits being the dominant avenue for short-term investing in Europe, the somewhat higher credit quality of European banks and a dearth of European credit bonds) may partly explain this feature.
- Swap spreads show a mean-reversion tendency. This is stronger in the US and Germany than in the UK. The relative illiquidity of the UK market is a reason for this feature.
- The correlation of swap spreads among countries has increased. In common with many financial markets, it is especially high during volatile periods.

This article has six sections. The next part provides a basic introduction to swap cash flows and the valuation of swaps. Section III presents salient features of the observed dynamics of swap spreads. A detailed description of the factors that drive swap spreads over time and across currencies is provided in section IV while section V presents an econometric model that seeks to explain changes in swap spreads for the period 1994-99. The final section summarises our conclusions.

II Interest Rate Swaps: Description and Pricing

Before proceeding with an economic and econometric analysis of the dynamics of swap spreads, we first show how the cash flows on an interest rate swap are defined and discuss some basic swap pricing relations.

A swap contract is a contract between two counterparties to exchange one stream of cash flows for another. The most common interest rate swap is a fixed for floating swap. The cash flows on this swap can be understood by the following example.

Example 1

Consider a 4-year interest rate swap where a counterparty pays 5% and receives the one-year Euribor.[1] The notional is 100 million euros. The Euribor fixing at swap inception is 4%. Euribor at the end of years 1, 2 and 3 turn out to be 3.5%, 3% and 6% respectively. The net cash flows to the counterparty are:

Year 0	Year 1	Year 2	Year 3	Year 4
0	(1m)	(1.5m)	(2m)	1m

[1] In reality swap cash flows are typically indexed to the 6-month Libor or 3-month Libor. We are using the 1-year Libor in this example. For simplicity, all rates follow the actual/actual convention.

The fixed rate on the above swap, 5%, would be the 4-year swap rate prevailing at the time of the inception of the swap.[2] If the yield to maturity on a 4-year par Treasury bond at this time is 4.5%, then one measure of the 4-year swap spread would be the difference between the 4-year swap rate and the 4-year Treasury yield (50bp in this example).

Swap spread as a weighted average of forward TED spreads

How are swap rates and swap spreads determined? This is a complex question. In the following sections, we discuss a number of economic drivers of swap spreads. However, a useful starting point for thinking about swaps is a simple and important relation between swap spreads and (forward) spreads between the interest rates for short-term unsecured and secured lending. This relationship is based on the fact that a portfolio of forward rate agreements, or FRAs, can replicate the cash flows on a swap. A FRA is a forward contract where the parties agree that a certain interest rate will apply to a certain principal during a specified future period of time. For example, a FRA initiated in year zero, maturing in year two, written on the 1-year Libor and with a notional amount of 100, is a claim to the following cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4
0	0	$[f_{1,2}(0) - l(1)]$	0	0

where $f_{1,2}(0)$ is a rate fixed at date 0. This fixed rate is the forward Libor for lending and borrowing between years one and two (locked in at year zero). Consider a trading strategy in which one receives fixed on a swap (and pays Libor) and takes an offsetting position in a series of FRAs (one for each year). The cash flows on this strategy are (for a 4-year swap):

Receiver swap (with notional of 100)

Year 0	Year 1	Year 2	Year 3	Year 4
0	$[c - l(0)]$	$[c - l(1)]$	$[c - l(2)]$	$[c - l(3)]$

2 Using symbols in an interest rate swap contract, one of the counter-parties promises to pay cash flows equal to interest at a predetermined fixed rate, *c*, on a notional principal, *F*, for a number of years, *N*. In return, this counterparty will receive cash flows equal to coupon at a floating rate on the same notional amount for the same period of time. The floating rate applied to the cash flow in year t is determined by the (1-year) Libor rate in year $t-1$. No cash flows are exchanged at the inception of the swap. The swap has a zero net present value when initiated. Thus net contracted cash flows to the party receiving fixed in a 4-year swap are

Year 0	Year 1	Year 2	Year 3	Year 4
0	$[c - l(0)]F$	$[c - l(1)]F$	$[c - l(2)]F$	$[c - l(3)]F$

where payments are made at the beginning of each year and where $l(t)$ denotes the 1-year Libor at the beginning of year t.The N -year swap yield at date t, $c(t, N)$, is defined to be the fixed rate c in an N -year swap initiated at that date. The N -year swap spread at date t is defined as the difference between the swap yield $c(t, N)$ and the Treasury yield for the same date and maturity.

Offsetting FRAs (each with notional of 100)

Year 0	Year 1	Year 2	Year 3	Year 4
0	$[l(0) - f_{0,1}(0)]$	0	0	0
0	0	$[l(1) - f_{1,2}(0)]$	0	0
0	0	0	$[l(2) - f_{2,3}(0)]$	0
0	0	0	0	$[l(3) - f_{3,4}(0)]$

The net cash flows on the above strategy are riskless (as both c and $f_{n,n+1}(0)$ are known as of time 0). Moreover, the strategy does not cost any money up front (its present value is zero). Therefore, the present value of the net cash flow from the strategy should also be zero, otherwise a risk-less arbitrage would exist between FRAs and swaps. This implies that the swap rate should equal

$$c(t,N) = \frac{\sum_{n=1}^{N} Z(t,T_n)\, f_{T_{n-1},T_n}(t)}{\sum_{n=1}^{N} Z(t,T_n)}$$

where $T_0 = t$ (the date of the initiation of the strategy), T_1 is date of the first cash flow on the swap, T_N is the date of the last cash flow on the swap, $Z(t,T_n)$ is the discount factor prevailing at t for maturity T_n and $f_{T_{n-1},T_n}(t)$ is the forward Libor, determined in year t for lending and borrowing between years T_{n-1} and T_n.

Example 2

The 1-year Libors one year and two years forward are 5% and 5.5% respectively. The 1-year and 2-year discount factors are 0.95 and 0.895 respectively. The 2-year swap rate is therefore:

$$\frac{(0.95\times 5\%) + (0.895\times 5.5\%)}{0.95 + 0.895} = 5.2\%$$

A similar equation holds for par Treasury yields, except the forward Libor is replaced by the forward 1-year Treasury rate. Consequently, the swap spread is a weighted average of the difference between forward Libor and forward Treasury rates for various maturities[3] (the forward TED spreads). Any deviations between swap spreads and (forward) TED spreads would be arbitraged away by market participants.

This definitional exercise serves to underline the interrelationships between swap spreads and other financial markets and instruments.

[3] We are assuming that the swap is fully collateralised so that default risk can be ignored. Hence, the discount factors for swap and Treasury yields are the same.

III A First Look at the Dynamics of Swap Spreads

Having defined swap spreads, we can now begin to examine the observed cross-country behaviour of swap spreads. In this section we first discuss how swap spreads are measured in our study. Next we discuss the important features of the observed data on swap spreads in our sample period.

Measurement of swap spreads

Swap spreads are typically measured as the difference between the swap yield and the yield to maturity on the benchmark Treasury bond with equivalent maturity. Two points should be noted about this convention. First, benchmark Treasury bonds are generally more liquid than other bonds and often trade special in the repo market[4]. Therefore, they typically display a benchmark premium. Thus, one component of the swap spreads computed relative to benchmarks is this specialness premium which on occasions can be quite large.

Second, the benchmark bond of which the yield is used to calculate swap spreads may not have the same maturity as the swap. Therefore, swap spreads as computed relative to benchmark yields also contain a component related to the slope of the Treasury yield curve between the swap maturity and the maturity of the benchmarks.

Although these components are present in conventional measures of swap spreads, they are not directly related to the credit aspect of swap spreads which is the focus or our study. Consequently, we are measuring swap spreads as the difference between the swap yield for a given maturity less the fitted par Treasury yield for that maturity. Fitted Treasury yields are taken from Lehman Brothers' database of Treasury yields for the US, Germany and the UK.

These are constructed by fitting a continuous and smooth yield curve that matches closely the prices of Treasury bonds which are not special in the repo market. Since the fitted yields are computed excluding on-the-run bonds and since they are available for all maturities, our measure of swap spreads is free from the two biases previously mentioned. However, remember that fitted yields are abstractions and may not be yields on any traded security.

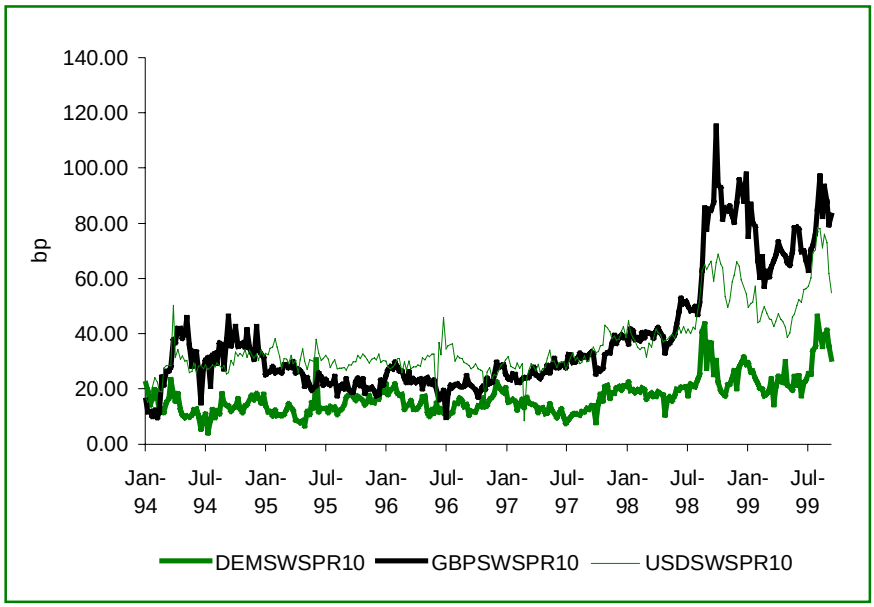
Our data consists of weekly observations of swap spreads over the period January 1994 to September 1999. The swap yields we use are the mid-quotes, as reported in Bloomberg. Treasury yields are taken from Lehman Brothers' databases.

Behaviour of swap spreads from 1994 onwards

We now provide key features of the time-series behaviour of swap spreads in the three countries we consider. Figure 1 shows 10-year swap spreads in Germany, the UK and the US over the period January 1994-September 1999.

[4] A bond trades special on repo when effectively the owner of this bond can borrow at below-market interest rates using the bond as a collateral. A bond that is not trading special can be used as a "general collateral". The interest rate available for borrowing against general collateral is the gc repo rate.

Figure 1 10-year swap spreads in Germany, the UK and the US



The mean swap spread over the entire sample ranges between 15bp to 40bp for the three countries. However, after the financial market turmoil of autumn 1998, spreads widened in the three countries, with the most pronounced effects in the UK and the US. The mean spread computed from July 1998 onwards in the US and the UK is about 55-75bp. Figure 1 also shows that the spread in Germany has tended to be smaller than those in the US and the UK. In the post July 1998 period, for example, the 10-year swap spread in Germany averaged around 26bp while this average was 75bp in the UK and 55bp in the US.[5] (To provide a brief preview of the analysis of the following section, Box 1 discusses why German swap spreads are so much lower than their US counterparts.)

Table 1 provides key statistics describing the behaviour of swap spreads over our sample period. Inter-country differences in levels already mentioned are apparent in Table 1 for the three maturities we consider. A significant volatility in spread movements is also shown. The annualised basis point volatility of spread changes has been around 20-30bp in Germany and in the US and as large as 30-50bp in the UK

[5] Remember we measure swap spreads relative to fitted par yields. The 10-year US swap spread, computed with respect to benchmark yields, averaged around 80bp over July 1998-September 1999.

Box 1: Why are euro swap spreads lower than US dollar swap spreads?

A number of factors explain why there is a persistent difference between the US dollar and the euro swap spreads:

- The difference between Libor and the riskless rate (say the gc repo rate) is much lower in Europe than in the US. At the end of August 1999, this spread was about 10bp in euros and about 30bp in US dollars. In section II we show that swap spreads are weighted averages of forward Libor-gc spreads. Therefore, a lower Libor-gc spread will translate into smaller swap spreads. The reason for a lower Libor-gc spread in Europe might be the higher perceived credit quality of European banks. Another possible reason for lower Libor-gc spreads in Europe could be the fact that there are numerous alternatives available to investors in the US for short-term money market investments (T-bills, commercial papers, bankers' acceptances and bank deposits). Such a variety of instruments is not available in Europe. For example, T-bills have been only recently issued in Germany —and only in relatively small quantities. If unsecured bank deposits were the dominant avenue for short-term investments, then a consequence would be the lowering of the Libor-gc spread.
- Supply of credit products is lower in Europe for a variety of institutional reasons. These reasons include the fact that capital market financing dominates bank financing in the US, unlike Europe. Moreover, the number of large corporate issuers suitable for public markets which are also agreeable to obtaining a debt rating has been smaller in Europe. Finally, the European market for collateralised debt securities is not yet mature. These factors tend to lower credit spreads in Europe. As we explain later, there is an important credit premium component in swap spreads. Thus, a lower credit premium tends to result in tighter swap spreads.
- In Germany landesbanken, which are active players in capital markets in general and swap markets in particular, have their indebtedness effectively guaranteed by each federal state, with support ultimately extended by the federal government. As a result their credit ratings are in the high AA and AAA categories. These banks are typically receivers in the swap market and may contribute to a receiver bias there. Also, large German commercial banks have tended to be of higher credit quality than their US counterparts.
- A factor that has been in play recently — and will probably become more important in the future — has been the persistent specialness of certain Treasury issues (which in itself could be a reflection of the lessening supply for US Treasuries as the US budget surplus grows). The result has been extra wide swap spreads when computed with respect to benchmark bonds.
- The (government) yield curve is much steeper in the euro area than in the US. As we explain in section IV, this tends to tighten swap spreads.
- Lastly, it could be argued the euro-area government debt itself contains a credit risk premium because national governments have ceded the control of their monetary policy to the European Central Bank under EMU.

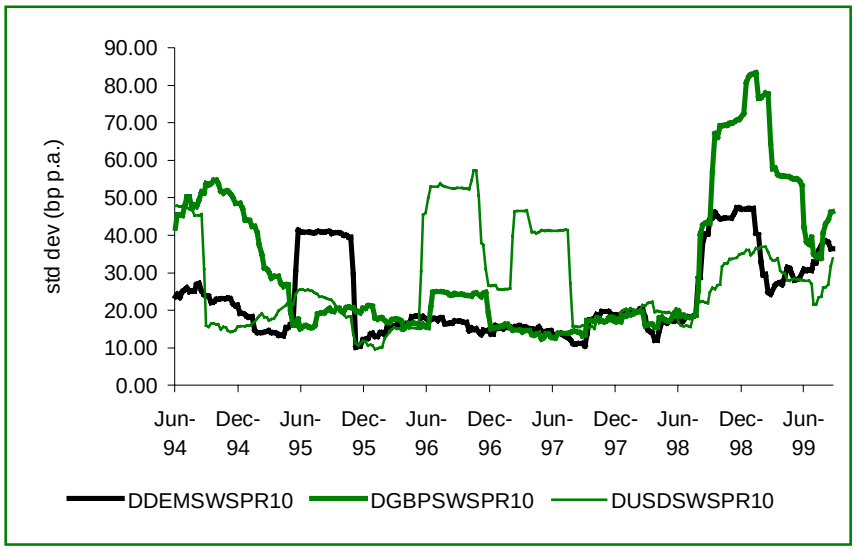
Table 1 Summary statistics for swap spreads, January 1994-September 1999

	Mean of levels (bp)	Half-life of spread levels (weeks)	Volability of spread changes (annual bp)	Skewness of spread changes	Excess kurtosis of spread changes
Germany					
2-year	10.75	6.22	21.42	0.25	4.25
5-year	15.77	2.24	28.93	-0.58	6.04
10-year	17.08	5.02	25.61	-0.20	6.59
UK					
2-year	29.56	19.98	33.65	0.53	2.50
5-year	34.47	18.57	53.38	0.09	10.26
10-year	38.14	31.21	36.58	0.25	6.01
US					
2-year	27.80	13.89	28.78	-0.49	5.11
5-year	34.07	20.04	25.64	-0.49	5.92
10-year	36.13	10.67	31.00	0.08	8.45

Note: Swap spreads computed with respect to fitted par yields.

These levels translate into a weekly basis point volatility of 2.5-4bp in Germany and the US and 4-7bp in the UK. Furthermore, there is evidence of significant time variation in volatility (Figure 2). The distribution of spread changes appears to shift between regimes of different levels of volatility. Thus, volatility tends to be clustered, just as in many other financial time series.

Figure 2 Volatility of changes in 10-year swap spreads in Germany, the UK and the US



The estimates of skewness indicate that the distribution of spread changes tends to be symmetric. More importantly the distribution has significantly fatter tails than the Normal distribution. This indicates a significant probability of extreme values. Table 1 shows the evidence for fat tails is present in all the markets considered.

Additionally, there is evidence of mean reversion in swap spreads. This is seen in the estimated half-life of swap spread levels (Table 1). The half-life is an estimate of the time it takes for a spread level to converge half-ways to its long-term mean. A lower value of estimated half-life implies stronger mean-reversion or less persistent spread levels. Table 1 reports half-lives in the region of 5-39 weeks[6]. The mean-reversion tends to be high in Germany and the US, while UK spreads are relatively more persistent. The UK market is smaller in size than the other two and probably has fewer relative-value players seeking to profit from the deviation of spreads from their long-run equilibrium values. The resulting illiquidity contributes to a high persistence of UK spreads. Moreover, the lack of liquidity also contributes to the volatility of spreads, which in turn keeps market participants away.

On average the term structure of swap spreads tends to be upward sloping[7]. However, there are significant time variations in the shape of this term structure.

Effect of using fitted par yields instead of benchmark yields

Our study measures swap spreads relative to fitted par yields. Table 2 documents the effect of using benchmark yields in place of fitted par yields and contains all the statistical measures reported in Table 1, except that here swap spreads are measured relative to benchmark yields as reported on Bloomberg.

The benchmark effect can also be seen in Figure 3. The mean levels of spreads are higher when measured with respect to the benchmark than when measured with respect to fitted yields. The difference between the two measures of the swap spread reflects the benchmark premium. This averages around 12bp in Germany and the US and 6bp in the UK in the 10-year sector. The premium tends to be lower for smaller maturities.

The volatility of spread changes is in general slightly bigger for spreads relative to benchmark yields than for spreads relative to fitted yields but the difference is small and sometimes negative as in the case of the 5-year in the UK.

[6] It is instructive to test the hypothesis if the persistence of swap spreads is high enough to suggest that they follow a random walk. Random walks have the property that they drift off into infinity over a long time period. A process without a random walk component is stationary and remains well behaved at arbitrarily long horizons. Statistical tests for a random walk component are known as unit root tests. The results of unit root tests on German swap spreads tend to reject the hypothesis of a random walk, while US and UK swap spreads tend to show up as having a random walk component. This is not surprising, given the estimates of half-lives (Table 1). The results of unit root tests need to be interpreted with caution, however. These tests tend not to reject the random walk hypothesis and cannot distinguish between a process that has a random walk component and one that is close to a random walk but stationary. Also a time-series whose parameters have shifted during the sample may look like one having a random walk component.

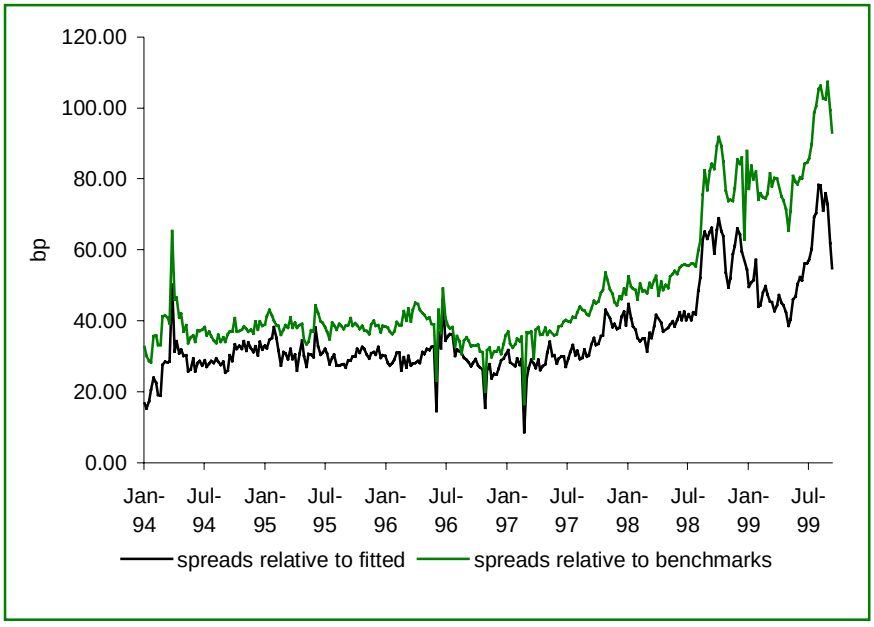
[7] One exception is the 10-30 year portion of the euro swap spread curve (not reported).

Table 2 Summary statistics for swap spreads, January 1994-September 1999

	Mean of levels (bp)	Half-life of spread levels (weeks)	Volability of spread changes (annual bp)	Skewness of spread changes	Excess kurtosis of spread changes
Germany					
2-year	15.17	4.80	31.23	-0.73	3.87
5-year	32.53	10.72	31.50	-1.19	5.82
10-year	31.05	8.47	26.80	0.14	2.62
UK					
2-year	32.52	16.83	43.44	-0.32	14.96
5-year	41.77	26.10	40.01	0.87	6.71
10-year	44.73	38.78	36.80	0.57	6.17
US					
2-year	30.38	11.86	34.83	-0.11	8.67
5-year	38.95	25.85	31.11	-0.64	11.44
10-year	48.33	28.82	34.03	0.65	10.49

Note: Swap spreads computed with respect to benchmark yields.

Figure 3 US 10-year swap spreads (with respect to benchmark and fitted yields)



In fact the benchmark premium is roughly as volatile as spreads relative to par. However, the added volatility coming from the volatility of the benchmark premium can be more than offset by the negative correlation between changes in the swap spreads relative to the benchmark and changes in the benchmark premium. The spreads tend to be more persistent, especially for longer maturity. This reflects the persistence of the benchmark premium.

Financial crisis of autumn 1998: a regime shift in swap spread dynamics

Panel A of Table 3 shows the statistics of spread changes that occurred over July 1998-September 1999. These can be compared to the values in Panel B, where the statistics for the January 1994-June 1998 are shown. The effect of the large spread widening seen at the time of the financial crisis of autumn 1998 is evident. Average spread levels doubled in the US and the UK over the last year. Likewise, volatilities are much larger across the board. Note also that the mean reversion of swap spreads computed in the two sub-periods tend to be higher than those computed using the full sample. This supports the idea that the financial crisis of autumn 1998 triggered a regime shift in the distribution of spreads.

Over the last year, there has been a significant reduction in the risk capital employed by relative-value hedge funds which were typical receivers on swaps. This risk aversion has contributed to the spread widening. Simultaneously, the resulting reduction in liquidity has been a factor in the increase in the volatility of spreads. Lately, these tendencies have been reinforced by Y2K-related liquidity concerns, risk aversion among dealers and nervousness about the performance of US equity markets. If the reduction in the leverage employed by relative-value hedge funds is permanent, and there is finally a cyclical slowdown in the US economy (possibly either led or followed by an equity market decline), then the new regime of higher spreads and higher spread volatility is unlikely to be short-lived, at least in the US.

The fact the mean reversion of swap spreads is estimated to be low (especially in the US and the UK) when we use the full sample could also be explained by a regime shift in the distribution of spreads. This is because a process that switches among a few regimes but is highly mean reverting within a regime could wrongly be interpreted as a process with low mean-reversion, if structural breaks are not accounted for. There is also evidence of an increase in the strength of mean-reversion in the July 1998-September 1999 period in the US and the UK, although a relatively smaller number of observations in this period make the estimates of mean-reversion imprecise.

Later we show the financial crisis of last year also changed swap spread dynamics in other respects. First, the correlation of swap spreads with spreads on credit products became much larger. This has brought new players into the swap markets. Second, international correlations in swap spread movements increased during the crisis period, confirming the hypothesis that in times of global crisis, financial markets move in sync, reducing the benefits from international diversification. The high international correlations have persisted through 1999. Finally, over the last year, the US market has witnessed a dramatic increase in the benchmark premia. This has contributed to the widening of swap spreads relative to benchmark bonds (Box 2).

Table 3 Summary statistics for swap spreads

Panel A: July 1998-September 1999

	Mean of levels (bp)	Half-life of spread levels (weeks)	Volatility of spread changes (annual bp)	Skewness of spread changes	Excess kurtosis of spread changes
Germany					
2-year	15.36	3.07	25.22	-0.46	0.63
5-year	17.49	1.54	33.44	-0.13	0.08
10-year	26.01	2.62	38.03	-0.15	1.44
UK					
2-year	52.89	4.59	45.92	0.58	0.36
5-year	78.64	3.80	68.70	0.66	1.94
10-year	75.04	3.73	60.67	0.16	2.07
US					
2-year	43.65	3.82	38.37	-0.63	3.00
5-year	55.77	3.50	43.25	-0.70	1.79
10-year	54.92	6.53	33.32	-0.43	0.73

Panel B: January 1994-June 1998

	Mean of levels (bp)	Half-life of spread levels (weeks)	Volatility of spread changes (annual bp)	Skewness of spread changes	Excess kurtosis of spread changes
Germany					
2-year	9.49	6.28	20.32	0.62	6.20
5-year	15.30	2.42	27.64	-0.78	9.19
10-year	14.63	2.28	21.06	-0.31	11.59
UK					
2-year	23.15	14.11	29.52	0.45	3.75
5-year	22.33	5.40	48.51	-0.33	16.81
10-year	28.00	7.12	26.57	0.09	2.49
US					
2-year	23.44	8.60	25.61	-0.38	5.85
5-year	28.11	6.80	18.18	0.55	2.79
10-year	30.97	2.19	30.40	0.25	11.48

Note: Swap spreads computed with respect to fitted par yields.

International co-movements in swap spreads

Table 5 shows that swap spreads across countries tend to move together. In Panel A we report estimates of correlations of changes in swap spreads of various maturities for the three countries over the entire sample period. Panels B and C contain the correlations computed from data observed before and after July 1998. These panels reflect the increased correlation (especially at longer maturities) in spreads during times of financial crisis. The high correlations seen during the crisis of autumn 1998 did not disappear in 1999. The correlations computed for the first half of 1999 tend to be even larger than those computed for the last half of 1998. For comparison, Table 5 also provides an international correlation of changes in par yields.

Box 2: Increasing benchmark premium in US Treasuries

The benchmark premium is stable in Germany and the UK, while it increased on average by 9bp in the US during the last 12-15 months. The increases in US benchmark premia is clear from Table 4, where average differences between benchmark and fitted par yields are reported. Since last July benchmark US Treasury issues are commanding benchmark premia which are almost twice their long-run average. These premia have also become much more volatile. This is true for all maturities, but especially pronounced at longer maturities. Two reasons could explain this structural shift. First, it is a reflection of the severity of the flight-to-quality moves of autumn 1998. Second, growing US budget surpluses are gradually reducing the supply of US Treasury paper. Since the declining supply of US Treasuries is likely to be a permanent feature of the financial landscape for the years to come, the increase in benchmark premia is also likely to be long-lived. US swap spreads computed relative to benchmark yields, therefore, would be increasingly affected by this premium.

Table 4 Benchmark premium in US Treasuries

Panel A: Full sample (January 1994-September 1999)			
Maturity	2-year	5-year	10-year
Mean	2.58	4.88	12.20
Standard Deviation of changes (bp, pa)	25.78	23.10	22.69
Panel B: July 1998-September 1999			
Maturity	2-year	5-year	10-year
Mean	6.55	13.34	25.30
Standard Deviation of changes (bp, pa)	41.26	39.57	39.28

IV Economic Determinants of Swap Spreads

We now discuss the economic determinants of swap spreads. Chief among these determinants are: the spread between interest rates for collateralised and non-collateralised borrowing; credit spreads, the level of yields, the slope of the yield curve and the level of volatility in interest rates and spread sectors and perceptions of overall risk in the financial markets. Risk aversion among market participants and imbalances in the demand and supply of swaps also influence the movement of swap spreads. We now examine each of these determinants.

Libor gc spread

In section II we showed that swap spreads are weighted averages of the forward spreads between Libor and the short term riskfree rate. Therefore, movement in the spread between Libor and the general collateral repo rates should generally be associated with movements in swap spreads in the same direction.

Table 5 Cross-country correlations between swap spread changes and between fitted par yield changes (spreads computed with respect to fitted par yields)

Panel A: Full sample (January 1994-September 1999)

	Changes in swap spreads			Changes in fitted par yields		
	2 year	5 year	10 year	2 year	5 year	10 year
Germany-UK	-0.044	0.161	0.248	0.487	0.642	0.744
Germany-US	0.128	0.203	0.197	0.510	0.546	0.597
US-UK	0.144	0.189	0.201	0.492	0.560	0.596

Panel B: January 1994-June 1998

	Changes in swap spreads			Changes in fitted par yields		
	2 year	5 year	10 year	2 year	5 year	10 year
Germany-UK	-0.017	0.066	0.139	0.461	0.601	0.717
Germany-US	0.179	0.209	0.073	0.399	0.515	0.565
US-UK	0.056	-0.005	0.095	0.459	0.508	0.545

Panel C: July 1998-September 1999

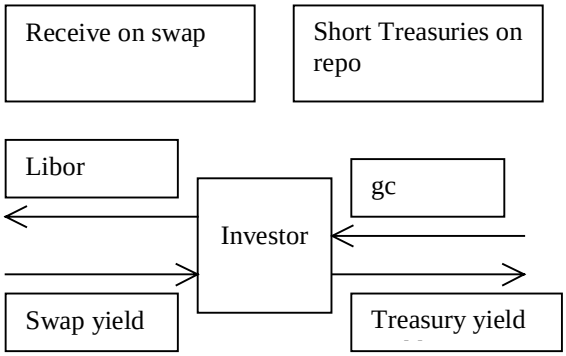
	Changes in swap spreads			Changes in fitted par yields		
	2 year	5 year	10 year	2 year	5 year	10 year
Germany-UK	-0.098	0.365	0.349	0.607	0.774	0.831
Germany-US	0.029	0.223	0.445	0.534	0.639	0.685
US-UK	0.284	0.415	0.388	0.630	0.734	0.760

The relation between Libor-gc spread and swap spread can be understood using a trading strategy that is commonly executed in fixed income markets when swap spreads are perceived to be too wide. This strategy is to receive fixed on swaps and short Treasuries (using the repo market). Typical users of such strategies have been leveraged investors, such as hedge funds, attempting to monetise the swap spreads — or to express a view about spread tightening — in exchange for assuming the risk of spread changes. The strategy — being leveraged in the repo market — requires a small up front investment (or a "haircut"). The following stylised example describes the risk and returns on this strategy.

Example 3

An investor receives USD fixed and pays six-month LIBOR on a 10-year swap contract, sells a 10-year US par Treasury bond short and receives a 6-month repo rate. All cash flows occurs semi-annually. The fixed swap rate is 6.80% and the Treasury rate is 6%. The initial Libor and repo rates are 5.5% and 5.3%. All rates follow the semi-annual bond convention in this example. The investor receives on the first payment date [(6.8%-6%)-(5.5%-5.3%)]/2= 0.3% of the notional. This amounts to the difference between the swap spread and the Libor-repo rate spread. The modified duration of both the bond and of the swap six months forward is 7.5 years and the trade horizon is six months. The mark-to-market value (in per cent of notional) of the trade in six months is the negative of the change in swap spread (%) x 7.5. Therefore, the carry element (30 cents of notional) will protect the trade to the extent the swap spread does not increase by more than 4bp.

The cash flows of this strategy are represented in this diagram:

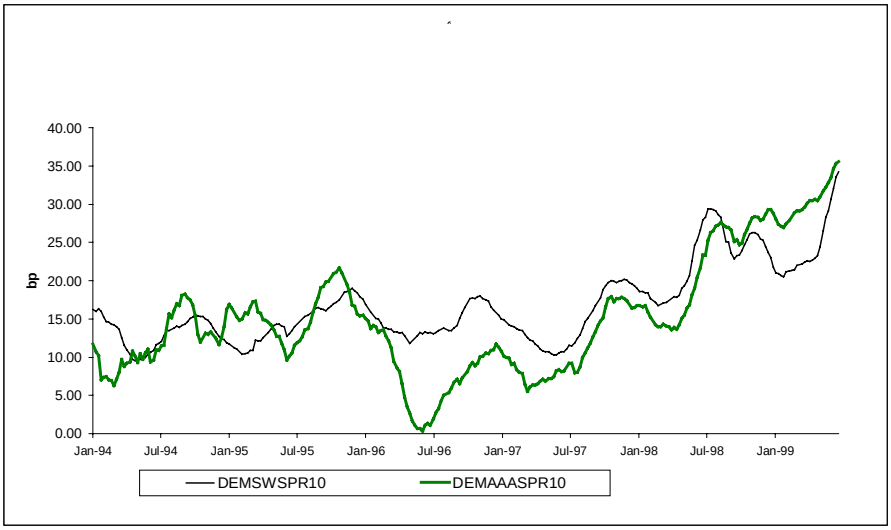


For a given swap spread volatility, the lower the Libor-gc spread relative to swap spreads, the more attractive the strategy. A large-scale application of such strategies would help eliminate any significant risk-adjusted carry advantages.

Credit spreads

Swap spreads are also intimately linked to credit spreads. Many market participants view swap spreads as drivers of credit spreads. However, as shown by the market interrelationships we discuss in this paper, it is difficult to disentangle the direction of causality in the movements of credit and swap spreads. The co-movement in credit spreads and swap spreads is evident in Figure 4 where we plot a rolling moving average of 10-year swap spreads and AAA-spreads in Germany for 1994-99.

Figure 4 10-year swap and (AAA) credit spreads in Germany (12 week moving average)



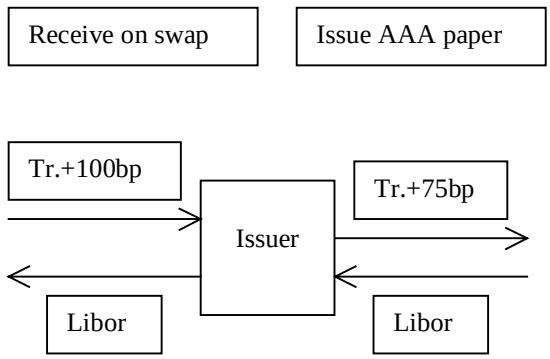
The spread between Libor and gc repo rate we discussed above is also a credit spread as it impounds a risk premium for the creditworthiness of the banking system as a whole. An important driver of the Libor-gc spread, and consequently of swap spreads, is the credit risk premium for the banking system.

Even though Libor-gc and credit spreads contain similar information, it is useful to think of them as two separate drivers of swap spreads. The reasons for this are threefold. First, note that swap cash flows are indexed to Libor and, therefore, a variable directly linked to the level of Libor would be essential in explaining the behaviour of swap spreads. Second, while Libor-gc spread measures the credit risk premium at short maturities, credit spreads measure this premium for longer maturities. As a result they are informative about investors' long-term expectations of the credit premium in the future. Finally — and crucially — credit spreads capture potential shifts in supply and demand of bonds. These shifts in turn will affect the supply and demand of swaps and the swap spread. Later we discuss supply and demand imbalances.

Excessive divergence between credit spreads and swap spreads is limited by issuer arbitrage. Corporate, sovereign and supranational issuers of debt securities have incentives to time their debt issues when the difference between credit spreads and swap spreads becomes wide. This is illustrated in the following example.

Example 4

The 10-year swap spread is at 100bp in US. The credit spread on a AAA-rated bonds of supranational issuers stands at about 75bp. Thus, if a supranational institution were to issue new paper at these levels and swap the issue into floating, it would have raised financing at Libor less 25bp. The following diagram clarifies the cash flows for the issuer:



If the above issuer could turn around and invest the proceeds into short-term USD bank deposits, it would pocket a positive carry of 25bp a year with little risk.[8] This sort of activity is standard practice for many highly rated issuers. Issuer arbitrage, such as the one just described, would tend to limit large differences in credit and swap spreads. A similar arbitrage by issuers also keeps international differences in swap spreads and credit spreads roughly in

[8] In example 4, the spread of 25bp compensates the issuer for investing the issue proceeds in an asset class of inferior credit than its own.

line with each other. However, there are limits to the issuer arbitrage described here When spread volatility is high, investor demand for credit products may decrease. This would reduce the scale at which new issues from supranational borrowers can be brought to the market.

As already discussed in Box 1, the differences in credit spreads across countries may partly explain large international differences in swap spreads currently observed. It is also worth noting that while movements in swap spreads and credit spreads should be positively correlated, the moves in swap spreads may be more muted than those in credit spreads. This may be because the corporate bond market is much less liquid than the swap market. Another possible reason is a "survivorship bias" in the construction of the Libor index. This is explained in Box 3.

The financial crisis of 1998 also heightened the recognition that swaps are an effective hedge for credit products in general. Traditionally, the dealer community hedged credit products using Treasuries. However, during the 1998 crisis, the relationship between Treasuries and credit products was broken, as attested by the large negative correlation between Treasury yields and swap spreads (discussed later).

Box 3: Survivorship bias in the Libor indices

Libor is the average borrowing rate available to prime banks in a panel selected by the British Bankers Association (BBA) in London. The process goes as follows: for each currency Libor, there is a sample of 16 banks. Every day the BBA surveys the rates and eliminates the top and bottom four quotes, then averages the remaining eight. This average is the Libor fixing for the day. If a bank is deemed of poor credit standing, it drops out of the Libor panel. There is a survivor bias in the Libor panel in that only banks of good credit standing will comprise it. Unlike the coupon on a corporate bond that could go to zero in case of bankruptcy, an investor receives the Libor coupon in a swap which is an average applying to survivors. This should, therefore, be less volatile. We illustrate the effect of survivorship bias through three stylised facts:

- When two Japanese banks placed out of the JPY Libor panel early in 1999, the JPY swap spread decreased by 7bp, reflecting the lower than expected Libor coupons in a swap.
- The volatility of the credit spread of an average bank bond or of a cohort of banks is typically higher than that of the swap spread. Even more we find the volatility of credit spreads to be higher than that of swap spreads.
- A typical bank may borrow at a spread over Libor on its floating rate debt because a single bond, unlike Libor, does not benefit from a survivor bias.

It could, however, be argued that a survivor bias has been of greater importance in the Japanese market where credit events have in fact led to banks placing out of the Libor panel. In other currencies the changes in the Libor panels have occurred because banks reduced their business activity in particular money markets.

Table 6 Correlation between US agency spread changes and swap spread changes

	2 year	5 year	10 year
Jan96-Sep99	0.026	0.379	0.344
Jan96-Jun98	-0.113	0.047	0.092
Jul98-Dec98	0.239	0.807	0.640
Jan99-Sep99	0.141	0.706	0.853

Note: All spreads are computed with respect to fitted par yields.

The increase in the benchmark premium made the experience especially painful for corporate bond dealers who hedged their positions with on-the-run government bonds. This led many dealers to increase the use of swaps as a hedging tool. As a result the spread products, notably US agency securities, became highly correlated with swap spreads precisely because both incorporated a risk premium (Table 6).

In the post-crisis financial world, the correlation between swaps and credit bonds is inducing a stronger demand from dealers of corporate and agency paper for swaps to hedge their inventories.

Level of Treasury yields

The level of bond yields is another important factor that impacts on the movement of swap spreads. Nowhere is this more obvious than in a comparison of the volatilities of changes in swap yield and of Treasury yield changes. Consider, for example, the realised volatility of changes in swap and Treasury yields (of similar maturities). Table 7 provides these volatilities for our sample period and those observed more recently.

Table 7 shows that Treasury volatilities tend to be of similar magnitude as swap volatilities. This implies that, on average, the changes in swap spreads are negatively correlated with changes in Treasury yields. Table 7 also shows that this is indeed the case. Furthermore, the values reported in Panel B for the second half of 1998 show that swap and Treasury yields are likely to diverge much more — especially when "flight-to-quality" moves take place as Treasuries outperform all other sectors and spreads widen. Panels B, C and D considered together reveal that the correlations were mild in over January 1994-June 1998, then strongly negative during the financial crisis. This has persisted in the US (January-September 1999). This negative correlation was one reason behind the poor hedging performance of long positions in credit bonds using Treasury securities during the 1998 financial crisis.

Even during a normal period, a negative correlation between Treasury yields and swap spreads could be due to the fact that the flow of funds into Treasuries, consequent to portfolio reallocations by fund managers, typically takes place at the expense of an outflow from spread products. This would simultaneously reduce Treasury yields and increase spread sector yields (or increase spreads). A flight-to-quality move of the kind seen in autumn 1998 is an extreme example of such flows.

Another reason — possibly operating over a longer horizon — could be that a prolonged period of low interest rates may be associated with large increases in private borrowing, leading ultimately to a higher credit risk premium.

Slope of the Treasury curve

In a steep yield curve environment, borrowers who typically issue fixed-rate debt have greater incentives to reduce the debt servicing cost by swapping into floating. This would lead to a receiver bias in the swap market, which ought to reduce swap spreads. Conversely in a flat curve environment, the incentives to receive fixed are less pronounced. Also the balance sheets and profitability of banks tends to be stronger in steep curve environment.

In addition, over business cycle frequencies, the slope of the yield curve is a good predictor of future economic growth and corporate profits. Inverted yield curves typically signal the onset of recessions[9]. This implies that a steep yield curve environment is associated with high expected growth (holding other variables fixed) and, therefore, superior creditworthiness of the economic sys tem.

This should be associated with lower swap spreads. Similarly, wider spreads should be expected in a flat (or inverted) yield curve setting. Table 8 illustrates this feature.

Indeed, the correlation between changes in swap spreads and changes in the slope of the Treasury curve is generally negative and around -0.2. Furthermore, Panels B, C and D show the dynamics of these correlations: they increased during the July-December 1998 period, and remained high in the January-September 1999 period. Finally, comparing countries, correlations tend to be weaker in Germany than in the UK and US.

Table 7 Negative correlation of fitted par yield changes and swap spread changes

Panel A: Full sample (January 1994-September 1999)

	Volatility of fitted par yield changes (annual, bp)	Volatility of swap yield changes (annual, bp)	Correlation of yield and spread changes
Germany			
2-year	74.05	73.12	-0.188
5-year	81.51	82.94	-0.128
10-year	76.82	77.52	-0.139
UK			
2-year	103.76	100.48	-0.258
5-year	109.63	107.62	-0.281
10-year	102.91	102.83	-0.180
US			
2-year	98.22	104.84	0.091
5-year	106.59	105.53	-0.161
10-year	99.36	102.01	-0.069

[9] See Harvey (1993) ("Term Structure Forecasts Economic Growth", *Financial Analysts Journal*, May-June 1993) for evidence on the US. Evidence on Germany is in Harvey (1991) ("Interest Rate Forecasts of German Economic Growth", *Weltwirtschaftliches Archiv*, 127). The recent experience in the UK is possibly an exception, as curve inversion in the UK seems to be driven largely by the excess demand of long-dated gilts from insurance companies and pension funds.

Panel B: July 1998-December 1998

	Volatility of fitted par yield changes (annual, bp)	Volatility of swap yield changes (annual, bp)	Correlation of yield and spread changes
Germany			
2-year	60.57	55.533	-0.399
5-year	91.92	67.607	-0.763
10-year	95.02	77.104	-0.596
UK			
2-year	101.19	78.048	-0.651
5-year	115.24	78.311	-0.734
10-year	122.79	81.761	-0.777
US			
2-year	113.46	108.915	-0.280
5-year	142.24	115.381	-0.765
10-year	126.99	125.639	-0.174

Panel C: January 1999-September 1999

	Volatility of fitted par yield changes (annual, bp)	Volatility of swap yield changes (annual, bp)	Correlation of yield and spread changes
Germany			
2-year	68.50	66.194	-0.278
5-year	84.77	94.187	0.145
10-year	76.59	84.088	0.028
UK			
2-year	87.34	100.309	0.092
5-year	100.10	117.611	0.046
10-year	88.74	94.262	-0.205
US			
2-year	67.75	75.340	-0.131
5-year	86.89	87.176	-0.260
10-year	91.96	91.987	-0.179

Panel D: January 1994-June 1998

	Volatility of fitted par yield changes (annual, bp)	Volatility of swap yield changes (annual, bp)	Correlation of yield and spread changes
Germany			
2-year	76.02	75.56	-0.156
5-year	79.17	81.98	-0.071
10-year	74.05	76.00	-0.049
UK			
2-year	104.69	100.53	-0.279
5-year	109.04	107.82	-0.247
10-year	101.95	105.82	0.018
US			
2-year	100.27	108.24	0.196
5-year	104.63	106.98	0.044
10-year	96.77	100.52	-0.031

Note: Swap spreads computed with respect to fitted par yields.

Table 8 Negative correlation of changes in the slope of the yield curve (10y - 2y) and swap spread changes

	Full sample	July-December 1998	January - September 1999	January 1994 - June 1998
Germany				
2-year	0.028	0.123	-0.266	0.059
5-year	-0.132	-0.281	-0.245	-0.085
10-year	-0.206	-0.330	-0.176	-0.182
UK				
2-year	0.161	0.290	-0.172	0.207
5-year	-0.330	-0.174	-0.381	-0.369
10-year	-0.259	-0.247	-0.402	-0.264
US				
2-year	-0.069	0.158	-0.067	-0.126
5-year	-0.135	-0.116	-0.241	-0.122
10-year	0.076	0.094	-0.367	-0.021

Note: Swap spreads computed with respect to fitted par yields.

Market volatility, financial crises and risk aversion

Times of high volatility in financial markets are associated with investors demanding an increased premium for holding risky assets. As a result one expects a direct relation between perceptions of risk and swap spreads. For similar reasons increases in investor risk aversion will tend widen swap spreads. Increases in the volatility of interest rates, credit spreads and returns on other aggregate assets such as equity markets are all likely to lead to increases in swap spreads. Example 3 (Libor-gc spreads) also clarifies this, showing that the risk of a strategy of receiving on swaps and shorting bonds is related to the volatility of changes in swap spreads. When this volatility is high, there should be less interest from risk-averse investors attempting to earn a positive carry by receiving on swaps against bonds. This should tend to move swap spreads higher. Also, a decrease in risk capital devoted to such strategies because of risk aversion will also have the same effect.

Large declines in asset markets are typically associated with an increase in perceptions of risk and risk-aversion among investors. To capture this and to introduce an explanatory variable not related directly to fixed-income markets, our econometric analysis uses returns on broad-based equity indices as proxy for asset market volatility and risk aversion. One would expect that returns on equity indices would be strongly negatively correlated with swap spread changes[10] .

Demand-supply imbalance

Finally, institutional constraints and the idiosyncrasies of individual market structures can lead to a payer or receiver bias in particular areas of the swap curve. These factors — and variation over time in their relative strengths — can be powerful drivers of swap spreads both in the short and the medium term. A good example of when demand and supply factors may have been important is the swap spread widening in July-August (1999), especially in the US. Some have argued, for example, that after the debacle of relative value hedge funds in autumn 1998, there is little risk capital available for trades where investors receive on swaps and short Treasury paper, trying to profit from their views about

[10] We have also experimented with implied volatility of equity index options as a proxy for risk and risk aversion. This yields similar results.

spreads and positive carry in return for assuming the risk of widening swap spreads[11]. As a result there is a shortage of natural receivers on swaps.

At the same time heavy corporate issuance has prompted dealers to hedge their inventories by paying on swaps, as we said earlier. Also as we noted, this is a relatively recent phenomenon. These factors contributed to the dramatic widening of US swap spreads in August 1999 to levels seen at the time of the financial crisis of 1998[12]. Other examples where demand-supply imbalances may be relevant are found in the UK market (Box 4).

Box 4: Why are UK swap spreads persistently high?

UK swap spreads have been consistently higher than their German counterparts over the last five years, sometimes by as much as 100bp in some maturity buckets. There are several reasons:

- First and foremost the UK government bond market is relatively expensive owing to declining fiscal deficits and hence declining supply of bonds.
- Concurrently, government regulations require UK pension funds to maintain their holdings of British government paper above a minimum level. This puts additional downward pressure on yields.
- Swap spreads are particularly wide on certain parts of the curve. On the 5-year portion, building societies pay fixed on swaps to hedge their fixed rate mortgage assets. In the 30-year sector, pension funds buy long bonds (but cannot use swaps for regulatory reasons) to match their high-duration annuity liabilities. Both these factors contribute toward wide swap spreads.

So, the UK Treasury could arbitrage the swap market in the following way: buy German government bonds, swap the proceeds into GBP and issue UK government bonds. The resulting gain is approximately the difference between the UK swap spread and the German swap spread. For example in September 1999, the differential in 30-year swap spreads was about 55bp. With a modified duration of 14 years, the UK government can generate arbitrage gains in the order of 7-8% of the notional swapped amount.

This completes our list of economic determinants of swap spreads. In assessing the effect of a given factor on swap spreads, our implicit assumption so far was that all other variables are held fixed. In reality, of course, all variables change simultaneously. Therefore, to study the effect of the above variables in a more realistic setting, we now undertake a multi-variate econometric analysis. The methodology and results of our econometric analysis are presented in section V.

[11] See Sparks (1999) in Lehman Brothers *Global Relative Value*, various issues.
[12] Other factors that could be cited include Y2K-related liquidity concerns, increased risk in the Treasuries market (stemming from future Fed moves) and the vulnerability of equity markets.

V An Econometric Model of Swap Spreads

Our econometric analysis consists of estimating a multi-variate model of changes in swap spreads. In our model, spread changes are explained in terms of coincidental values of changes of explanatory variables discussed in the previous section and a lagged value of the level of the spread. Using symbols the model we estimate is:

$$\begin{aligned}\Delta SwSpr(M)_t = \alpha + \beta(1)SwSpr(M)_{t-1} \\ + \beta(2)\Delta Slope_t + \beta(3)\Delta Level_t + \beta(4)\Delta(Libor - gc)_t \\ + \beta(5)\Delta CredSpr(M)_t + \beta(6)StockReturn_t + \varepsilon_t\end{aligned}$$

In this equation the lagged value is included to account for the mean-reversion present in swap spreads. The beta coefficients measure the sensitivity of changes in swap spreads to the level of swap spread in the previous period and changes in the other explanatory variables. The random shock ε_t accounts for omitted factors. We allow this shock to be correlated over time and estimate the parameters of the above model by the method of maximum likelihood.

The explanatory variables in the above model are constructed as follows:

- The slope of the term structure is the difference between the 10-year par rate and the 2-year par rate. The level is the 10-year par rate.
- The Libor-gc spread is the difference between the 3-month Libor and the 3-month general collateral rate in the US. In the case of Germany, where we do not have data on repo rates, the Libor-gc spread is the difference between the 1-month Libor and the official 14-day repo rate. For the UK this spread is the difference between the 3-month Libor and the 3-month Treasury bill yield.[13]
- The credit spread is the difference between rates on Euro currency A-rated bonds and the corresponding par rate for the US and the UK. For Germany we use AAA corporate spreads.
- Finally, equity market returns are measured by the returns on the S&P500 for the US, by returns on the FTSE 100 for the UK and by the DAX for Germany.

All series (except the par rates) are obtained weekly from Bloomberg, over the period 7 January 1994-17 September 1999. The par constant maturity rates are obtained from the Lehman Brothers government bond model.

The results are reported in Table 9 and summarised in the following table where expected (in theory) and realised (empirically) sign of regression coefficients are reported. The effects of various factors are generally in line with those suggested by our previous discussion.

Explanatory variable	SwSpr(M)	ΔSlope	ΔLevel	Δ(Libor-gc)	ΔCredSpr(M)	Stock return
Expected sign	–	–	–	+	+	-
Realised sign	Significantly negative	Mainly negative	Mainly negative	+/–	Significantly positive	Significantly negative

[13] It should be noted that the Libor-T-bill spread is not the same as the Libor-gc spread as typically T-bills will trade at a premium to gc. However, the lack of data prevents us from using the gc repo rate in the UK and Germany.

Table 9 also shows the estimates of the coefficients for the sample before and after July 1998.

The lagged swap spread always has a negative and significant coefficient. These coefficients capture the mean reversion in swap spreads that we documented in the section IV. Moreover, as discussed in section III, the mean-reversion tends to be lower before July 1998.

There is clear evidence that credit spreads are an economically significant driver of swap spreads and that their role has increased markedly since the financial crisis of 1998. The negative relation of swap spreads and equity returns is also shown in our estimates, although the high volatility of equity returns relative to the spread volatility makes the estimates of this relation imprecise.

The slope of the yield curve and the level of yields both have a negative effect, as expected. These effects are pronounced for longer maturities. The effect of the Libor-gc spread is positive and significant for the shortest maturity. This is consistent with the idea that the swap spread carry trade — described in the section IV — is less risky for shorter maturities. One reason why this spread does not show up with more significance may be the error in their measurements for the UK and Germany where we do not have clean gc repo rate data.

Since the lagged swap spreads, changes in credit spreads and equity market returns are the variables that are most significant in the above regression, we provide in the appendix — the parameter estimates for a reduced model which only has these variables as explanatory variables.

Overall we conclude that the variables we use explain a large portion of the variance of swap spreads (R^2 in the range of 20 to 40%), and, broadly speaking, have regression coefficients of the expected sign. The F-test of joint significance always rejects the null hypothesis of no explanatory power.[14]

[14] The auto-correlation co-efficient of the errors is estimated to be negative. This indicates that the deviations of swap spreads from their theoretical values tend to correct themselves gradually over time.

Table 9 Full model regressions

Germany

Change in 2-year swap spreads

	Constant	SwSpr2(t-1)	ΔSlope(t)	ΔLevel(t)	ΔLibor-GC(t)	ΔCredSpr2(t)	StockRet(t)	Estimated rho	R^2
Full sample	**0.839**	**-0.071**	0.002	*-0.032*	-0.001	**0.052**	3.555	**-0.316**	0.191
Jan94-Jun98	**0.760**	**-0.070**	-0.003	-0.022	-0.019	*0.042*	-0.318	**-0.345**	0.203
Jul98-Sep99	**2.632**	**-0.170**	0.028	-0.063	*0.126*	**0.532**	4.259	-0.001	0.371

Change in 5-year swap spreads

	Constant	SwSpr5(t-1)	ΔSlope(t)	ΔLevel(t)	ΔLibor-GC(t)	ΔCredSpr5(t)	StockRet(t)	Estimated rho	R^2
Full sample	**2.793**	**-0.172**	**-0.071**	0.026	-0.023	**0.138**	-10.698	**-0.309**	0.278
Jan94-Jun98	**2.722**	**-0.168**	**-0.073**	**0.050**	-0.035	**0.118**	*-19.210*	**-0.284**	0.285
Jul98-Sep99	**4.456**	**-0.253**	-0.042	-0.044	0.025	**0.563**	-1.019	**-0.323**	0.469

Change in 10-year swap spreads

	Constant	SwSpr10(t-1)	ΔSlope(t)	ΔLevel(t)	ΔLibor-GC(t)	ΔCredSpr10(t)	StockRet(t)	Estimated rho	R^2
Full sample	**1.228**	**-0.067**	**-0.064**	-0.018	0.004	**0.079**	*-11.199*	**-0.303**	0.186
Jan94-Jun98	**2.421**	**-0.164**	-0.043	-0.002	0.003	0.040	-4.449	**-0.298**	0.226
Jul98-Sep99	**3.938**	**-0.147**	-0.095	-0.055	0.004	**0.523**	-8.739	**-0.379**	0.385

United Kingdom

Change in 2-year swap spreads

	Constant	SwSpr2(t-1)	ΔSlope(t)	ΔLevel(t)	ΔLibor-GC(t)	ΔCredSpr2(t)	StockRet(t)	Estimated rho	R^2
Full sample	**0.879**	**-0.023**	*0.050*	**-0.053**	0.038	**0.154**	*-21.260*	**-0.252**	0.217
Jan94-Jun98	**1.996**	*-1.688*	1.299	-1.228	*1.962*	**4.992**	0.420	**-0.313**	0.261
Jul98-Sep99	4.879	*-0.094*	0.039	-0.085	-0.013	**0.431**	-41.582	-0.137	0.303

Change in 5-year swap spreads

	Constant	SwSpr5(t-1)	ΔSlope(t)	ΔLevel(t)	ΔLibor-GC(t)	DCredSpr5(t)	StockRet(t)	Estimated rho	R^2
Full sample	**0.733**	-0.014	**-0.098**	0.007	0.015	**0.297**	**-57.103**	**-0.335**	0.377
Jan94-Jun98	**1.260**	**-0.054**	**-0.150**	**0.107**	0.007	**0.266**	14.184	**-0.276**	0.424
Jul98-Sep99	5.395	-0.069	-0.074	*-0.142*	0.168	**0.643**	*-60.617*	**-0.349**	0.560

Change in 10-year swap spreads

	Constant	SwSpr10(t-1)	ΔSlope(t)	ΔLevel(t)	ΔLibor-GC(t)	ΔCredSpr10(t)	StockRet(t)	Estimated rho	R^2
Full sample	0.527	-0.006	**-0.073**	*-0.037*	-0.020	**0.088**	**-65.631**	**-0.367**	0.236
Jan94-Jun98	**1.764**	**-0.061**	**-0.104**	**0.046**	-0.003	**0.047**	-2.355	**-0.298**	0.195
Jul98-Sep99	3.393	-0.042	-0.072	**-0.123**	0.000	**0.569**	-38.388	**-0.473**	0.598

United States

Change in 2-year swap spreads

	Constant	SwSpr10(t-1)	ΔSlope(t)	ΔLevel(t)	ΔLibor-GC(t)	ΔCredSpr10(t)	StockRet(t)	Estimated rho	R^2
Full sample	**1.240**	**-0.037**	*-0.069*	0.019	0.024	**0.084**	**-36.149**	**-0.195**	0.107
Jan94-Jun98	**1.240**	**-0.049**	**-0.126**	**0.038**	**0.055**	**0.126**	*-23.991*	**-0.397**	0.295
Jul98-Sep99	**16.469**	**-0.376**	0.138	*-0.087*	0.014	0.036	*-3.021*	0.434	0.192

Change in 5-year swap spreads

	Constant	SwSpr10(t-1)	ΔSlope(t)	ΔLevel(t)	ΔLibor-GC(t)	ΔCredSpr10(t)	StockRet(t)	Estimated rho	R^2
Full sample	**0.987**	*-0.022*	-0.048	**-0.048**	-0.008	**0.080**	**-33.749**	**-0.189**	0.119
Jan94-Jun98	**1.852**	**-0.061**	**-0.073**	-0.012	0.000	*0.046*	**-30.383**	**-0.373**	0.234
Jul98-Sep99	**12.036**	**-0.213**	0.126	**-0.199**	0.002	*0.141*	-4.521	0.204	0.376

Change in 10-year swap spreads

	Constant	SwSpr10(t-1)	ΔSlope(t)	ΔLevel(t)	ΔLibor-GC(t)	ΔCredSpr10(t)	StockRet(t)	Estimated rho	R^2
Full sample	**1.578**	**-0.036**	-0.013	**-0.042**	-0.023	**0.096**	**-43.772**	**-0.345**	0.184
Jan94-Jun98	**5.104**	**-0.158**	-0.023	*-0.032*	-0.032	0.051	**-34.927**	**-0.441**	0.311
Jul98-Sep99	**6.993**	**-0.123**	0.021	*-0.075*	-0.009	**0.206**	*-34.316*	0.049	0.245

Note: Bold means significant at 5% level; italics means significant at 10% level. Rho denotes the auto-correlation coefficient of the errors.

V Conclusions

We have documented the dynamics of swap spreads across three countries, Germany, the UK and the US. We have also provided an analysis of the economic drivers of swap spreads. We have shown that the main economic drivers of swap spread can be classified into:

- credit risk premium related variables (Libor-gc spreads and credit spreads)
- yield curve related variables (the level of yields and the slope of the government curve)
- variables measuring the level of risk in financial markets.

In addition we have documented a number of institutional factors in the markets we examined that give rise to demand-supply imbalances impinging on the dynamics of swap spreads. It has been shown that since the financial crisis of autumn 1998 there may have been a regime shift in the behaviour of these spreads. Swap spread levels and volatilities have increased significantly, as have their correlations across countries and their correlation with credit spreads. An increase in investor and dealer risk aversion, the reduction in leverage of risk capital employed by relative-value hedge funds (which were typical receivers on swaps), a perception of increased risk in asset markets and increases in spread volatility induced by lower liquidity could all be cited as factors that have contributed to the recent spread widening.

Euro-area swap spreads continue to remain at half the levels of their UK and US counterparts. Lower credit spreads in Europe and lower Libor-gc spreads — which in turn could be the result of bank deposits being the dominant avenue for short-term investing in Europe, the somewhat higher credit quality of European banks and a dearth of European credit bonds — may partly explain this feature. The issuance of credit bonds in Europe, the risk appetite of dealers and hedge funds, the shrinking supply of Treasury securities in the US, the performance of global (especially US) equity markets and cyclical movements in the US economy relative to the European economy are all likely to be the key drivers of swap spreads in the near to intermediate term.

The importance of swaps is now recognised widely as hedging instruments, as instruments for implementing yield curve, credit spread and relative value views and as instruments linking treasury, credit and money markets globally. Given this the findings documented here on their empirical behaviour are expected to be useful to investors participating broadly in swap and fixed income markets.

Appendix

This appendix reports the parameter estimates of the following reduced-form version of our full regression model (section V):

$$\Delta SwSpr(M)_t = \alpha + \beta(1)SwSpr(M)_{t-1} + \beta(2)\Delta CredSpr(M)_t + \beta(3)StockReturn_t + \varepsilon_t$$

Results are given in Table 10. These are consistent with those given in Table 9. Additionally, parameters are estimated with greater precision.

Table 10 Reduced model regressions

Germany

Change in 2-year swap spreads

	Constant	SwSpr2(t-1)	ΔCredSpr2(t)	StockRet(t)	Estimated rho	R^2
Full Sample	**0.757**	**-0.063**	**0.065**	5.859	**-0.328**	0.180
Jan94-Jun98	**0.694**	**-0.064**	**0.053**	3.141	**-0.358**	0.195
Jul98-Sep99	*1.770*	*-0.116*	**0.628**	5.950	-0.190	0.325

Change in 5-year swap spreads

	Constant	SwSpr5(t-1)	ΔCredSpr5(t)	StockRet(t)	Estimated rho	R^2
Full Sample	**2.812**	**-0.175**	**0.124**	-9.282	**-0.322**	0.262
Jan94-Jun98	**2.630**	**-0.163**	**0.092**	**-20.177**	**-0.312**	0.261
Jul98-Sep99	**3.925**	**-0.227**	**0.642**	-0.014	**-0.356**	0.444

Change in 10-year swap spreads

	Constant	SwSpr10(t-1)	ΔCredSpr10(t)	StockRet(t)	Estimated rho	R^2
Full Sample	**1.366**	**-0.077**	**0.099**	-7.160	**-0.297**	0.160
Jan94-Jun98	**2.560**	**-0.175**	*0.045*	-0.821	**-0.300**	0.213
Jul98-Sep99	**4.198**	**-0.163**	**0.550**	-6.971	**-0.334**	0.331

United Kingdom

Change in 2-year swap spreads

	Constant	SwSpr2(t-1)	ΔCredSpr2(t)	StockRet(t)	Estimated rho	R^2
Full Sample	**0.772**	*-0.020*	**0.179**	-12.833	**-0.245**	0.194
Jan94-Jun98	*0.729*	*-0.025*	**0.148**	10.846	**-0.310**	0.242
Jul98-Sep99	*5.211*	*-0.099*	**0.444**	*-45.934*	-0.132	0.273

Change in 5-year swap spreads

	Constant	SwSpr5(t-1)	ΔCredSpr5(t)	StockRet(t)	Estimated rho	R^2
Full Sample	**0.832**	*-0.016*	**0.324**	**-53.819**	**-0.357**	0.359
Jan94-Jun98	**1.302**	**-0.047**	**0.277**	-18.211	**-0.344**	0.367
Jul98-Sep99	5.060	-0.066	**0.699**	-58.625	**-0.344**	0.480

Change in 10-year swap spreads

	Constant	SwSpr10(t-1)	ΔCredSpr10(t)	StockRet(t)	Estimated rho	R^2
Full Sample	*0.640*	-0.008	**0.130**	**-52.202**	**-0.380**	0.195
Jan94-Jun98	**1.595**	**-0.050**	**0.058**	-14.406	**-0.291**	0.120
Jul98-Sep99	3.559	-0.046	**0.681**	-30.553	**-0.464**	0.531

United States

Change in 2-year swap spreads

	Constant	SwSpr2(t-1)	ΔCredSpr2(t)	StockRet(t)	Estimated rho	R^2
Full Sample	**1.269**	**-0.036**	*0.069*	**-38.196**	**-0.203**	0.093
Jan94-Jun98	**1.214**	**-0.042**	**0.091**	**-38.847**	**-0.380**	0.219
Jul98-Sep99	**14.219**	**-0.323**	0.045	0.417	0.146	0.328

Change in 5-year swap spreads

	Constant	SwSpr5(t-1)	ΔCredSpr5(t)	StockRet(t)	Estimated rho	R^2
Full Sample	**1.093**	**-0.026**	**0.089**	**-21.958**	**-0.195**	0.076
Jan94-Jun98	**1.749**	**-0.056**	*0.048*	**-25.893**	**-0.352**	0.197
Jul98-Sep99	**12.473**	**-0.222**	**0.204**	6.617	0.055	0.194

Change in 10-year swap spreads

	Constant	SwSpr10(t-1)	ΔCredSpr10(t)	StockRet(t)	Estimated rho	R^2
Full Sample	**1.573**	**-0.037**	**0.104**	**-34.002**	**-0.327**	0.164
Jan94-Jun98	**4.861**	**-0.151**	0.057	-21.975	**-0.430**	0.296
Jul98-Sep99	**7.376**	**-0.132**	**0.192**	-24.232	0.138	0.198

Note: Bold means significant at 5% level; italics means significant at 10% level. Rho denotes the auto-correlation coefficient of the errors.