Links among Interest Rate Swap Markets: U.S., U.K., and Japan

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The internationalization of trade and finance, financial deregulation, and advances in information technology have all strengthened the connections among national financial markets. In the presence of strong international links, it is likely that developments in one national market will rapidly affect other markets, a development that concerns regulatory authorities, who observe they have lost autonomy and find it increasingly difficult to formulate independent monetary policies, especially when markets are very volatile. Concern is also felt by international investors, whose hedging and diversification strategies depend on the nature and strength of the relationships between or among different financial markets.

The near collapse of Long-Term Capital Management is a highly public example of the potential significance of relationships across markets in general and between swap spreads in particular (Lowenstein [2001, ch. 8]).

It is therefore important to determine how much interest rates in different countries are correlated. If regulatory authorities and international investors know more about the strength and the direction of influences between countries, they will be better able to formulate and implement appropriate economic policies and investment strategies.

Correlation between markets may arise through a number of channels. If investors' portfolios are diversified internationally, price changes in one country will cause portfolio adjustments in other countries, and security prices may be affected as a result. If financial markets are sufficiently integrated that there is a single worldwide price of risk, there will be very strong links between national markets; that is, in pricing terms, there is but one financial market in the world, rather than a collection of national markets. In principle, these observations apply to many markets, including the market for interest rate swaps.

Although we have many studies of international transmission between financial markets, most of them focus on links between equity returns in various national markets. And while there is also a substantial literature on interest rate links between countries, most of this work has focused on the behavior of real interest rates, using monthly or quarterly data.

A major theme of this research is whether real interest rates are equal between countries and their causal relationships. Examples include Modjtahedi [1988], Dutton [1993], Goodwin and Grennes [1994], Throop [1994], Chinn and Frankel [1995], Fujihara and Mougoue [1996], and Monadjemi [1997].

Because these studies require the measurement of price movements, they are inevitably restricted to the investigation of long-run phenomena. Excluding the rare occurrence of hyperinflation, daily fluctuations in the expected or realized inflation rate are not measurable over short periods such as a single day. If interest rate markets are competitive, however, and if information flows freely among countries, interest rate shocks in one country should lead to almost immediate adjustments in other countries. In this environment, international links between nominal interest rates should be examined over short periods such as a single day.

Lekkos and Milas [2001] and Eom, Subrahmanyam, and Uno [2002] represent two of the very few studies that investigate short-run international links between nominal interest rates. Lekkos and Milas [2001] investigate the linkage between the U.S. and U.K. swap markets using weekly data. They find that in both currencies most of the change in the swap spread is due to its own variance, followed by the slope of the domestic risk-free term structure. The adjustment process is remarkably long-lived, with considerable variations in proportions continuing to occur even after 12–18 months. In some cases, it is not clear whether the proportions have settled at a stable level even after two years.

Lekkos and Milas also find that the influences operate in both directions. Depending on swap maturity, U.S. variables contribute in total between 22% and 42% of U.K. swap spread variance, while U.K. variables contribute between 12% and 26% of U.S. swap spread variance. These estimates refer to variance proportions for 52 weeks ahead.

Using weekly data, Eom, Subrahmanyam, and Uno [2002] examine the relationship between Japanese yen and U.S. dollar interest rate swap spreads. They use swap spreads as proxies for credit risk, and draw three main conclusions. First, Japanese yen and U.S. dollar swap spreads have a low correlation, suggesting that credit risk is country-specific, rather than global. Second, changes in U.S. dollar interest rate swaps Granger-cause the changes in yen swap spreads, and the causality is unidirectional. Third, yen swap spreads are highly correlated with interest rate differentials between the two markets.[1]

There are two potential weaknesses of the work in both Lekkos and Milas [2001] and Eom, Subrahmanyam, and Uno [2002]. First, both studies use weekly data. The ease of information flow between modern financial markets suggests that if changes in one market are relevant to another market, the major impact should be observable almost immediately. If this conjecture is correct, then it is desirable to use higher-frequency data. In addition, use of higher-frequency data increases sample size for any given sample period. We use daily data in our study.

Second, both studies consider links between only two markets, and we would expect all markets to be linked. While it is impractical to analyze all markets simultaneously, it is possible to extend the analysis to three markets. We analyze the linkages among the U.S., U.K., and Japanese swaps markets.

Variance decomposition analysis (VDA) and impulse response analysis (IRA) are used to reexamine the determinants of interest rate swap spreads in the U.S., the U.K., and Japan, and to investigate the links among these three major markets. Our research makes three main contributions. First, we provide evidence that should be of value to policymakers and international investors. Second, the use of daily data allows more reliable measurement of the international links among swap markets. Third, these three swaps markets are located in different time zones, which allows an examination of their efficiency and the structural form of information flows among them.

We reach five major conclusions. First, the slope of the risk-free term structure is the most significant determinant of swap spreads across the three currencies, and the strength of its influence increases with the term of the swap.

Second, the significance of other potential determinants of swap spreads varies across currencies. The level of interest rates is important in the U.S. market, but not in the U.K. or Japan, while default spreads have a significant influence on the U.K. market but not on the U.S. or Japanese markets. The influence of interest rate volatility and the liquidity premium is negligible in all three currencies.

Third, there is a significant bidirectional influence (particularly through the term structure slope) between the U.S. and U.K. markets. Fourth, U.S. swap spreads have some influence on U.K. swap spreads, and this influence is asymmetric.

Finally, the U.S. and U.K. markets have no impact on the Japanese market and vice versa. That is, the Japanese swaps market is influenced only by country-specific factors, and not global factors.

I. DETERMINANTS OF SWAP SPREADS: THEORY AND EVIDENCE

The main pricing variable in an interest rate swap is the swap spread, which is defined as the difference between the swap rate and the Treasury bond yield for the same maturity. Early studies on the dynamic behavior of swap spreads focus mainly on counterparty default risk. Examples include Cooper and Mello [1991], Sundaresan [1991], Sun, Sundaresan, and Wang [1993], Sorensen and Bollier [1994], and Longstaff and Schwartz [1995].

Cooper and Mello [1991] characterize swaps as equivalent to an exchange of default-risky floating-rate bonds for default-risky fixed-rate bonds, and develop a swaps valuation model that relates the swap rate to the credit spreads on bonds. They show that counterparty default risk is a major contributor to the swap spreads.

To examine the significance of default risk on swap spreads, Sun, Sundaresan, and Wang [1993] study quoted bids and offers from two swaps dealers with different credit ratings. They find that the higher-rated dealer quotes a higher bid-ask spread than the lower-rated dealer, which suggests that the default risk is priced in the bid-ask spread.

Sorensen and Bollier [1994] argue that swap default risk can be explained using an option pricing model. The option value embedded in the replacement cost of a swap depends on the current shape and the estimated volatility of the yield curve. For example, if the yield curve is upward-sloping, future rates are expected to rise, but if there is default these higher floating-rate cash flows will not be paid. Thus, the floating-rate receiver (i.e., the fixed-rate payer) bears more default risk, and to reflect this risk, a lower fixed rate is set, causing the swap spread to decline.

Longstaff and Schwartz [1995] show that the correlation between default risk and interest rate has a significant impact on swap spreads, and that the shape of the term structure of swap spreads depends on the sign of the correlation.

In more recent theoretical and empirical studies by Duffie and Huang [1996], Duffie and Singleton [1997], Minton [1997], Grinblatt [1999], and Lekkos and Milas [2001], it is shown that counterparty default risk is only one of the factors that explain the magnitude and behavior of swap spreads.

Minton [1997] finds that swap rates reflect a credit risk factor, but also suggests that other factors such as the regulatory, institutional, and microstructural features of the market may also be important. Duffie and Singleton [1997] show that liquidity affects the behavior of swap spreads in the short term, while credit risk affects them in the longer term. Grinblatt [1999] argues that the liquidity premium between government securities and short-term eurodollar borrowings is a more plausible explanation for the behavior of swap spreads. He finds that the liquidity premium can explain about 35% to 40% of the variation in swap spreads for various maturities.

Lekkos and Milas [2001] find that the slope and the level of the term structure of risk-free interest rates have significant impacts on the swap spreads. They also find that the liquidity premium has an impact on short-term swap spreads, while the default risk premium is more significant for longer-term swap spreads.

II. DATA AND METHODOLOGY

We use daily closing midrate data on swap maturities of three, five, and ten years, for the U.S., the U.K., and Japan in the period January 8, 1996, through June 29, 2001, giving a sample size of 1,366 observations for each swap maturity. The swap spread is calculated by subtracting the Treasury bond rate from the swap rate for the same maturity. Data for all three currencies are collected from Datastream.

The level of the risk-free term structure is proxied by the 90-day Treasury bill rate, and its slope is proxied by the difference between the 10-year Treasury bond rate and the 90-day Treasury bill rate. Interest rate volatility is proxied by the squared change in the 90-day Treasury bill rate (see Lekkos and Milas [2001]). Following Grinblatt [1999], the spread between 3-month LIBOR and the 90-day Treasury bill rate is used as a proxy for liquidity, and the spread between the yield on a portfolio of medium-maturity AAA-rated corporate bonds and the yield on comparable BAA-rated corporate bonds is used as a proxy for the default premium (see Duffie and Singleton [1997], Minton [1997], and Brown, Harlow, and Smith [1994]).

Descriptive statistics for U.S., U.K., and Japanese swap rates and swap spreads for three different maturities are reported in Exhibit 1. On average, the yield curves for swaps and swap spreads are upward-sloping in the three currencies during the sample period. The standard deviation ranges from 0.480 to 0.899 for swap rates and from 0.101 to 0.330 for swap spreads.

We use two methods for the test of unit roots: augmented Dickey-Fuller (ADF), and Park-Choi (PC). The RATS statistical package is used to carry out these tests for each of the 14 series in each currency (three maturities for each of the Treasury bond rate, the swap rate, and the swap spread; plus the proxy variables for the level and the slope of the term structure of interest rates, the volatility of interest rates, liquidity, and default).[2]

We hypothesize that five factors may affect the stochastic nature of swap spreads: 1) the level of the risk-free term structure; 2) the slope of the risk-free term structure; 3) the volatility of the spot rate; 4) the liquidity premium; and 5) the default premium.

A vector autoregression (VAR) methodology is used to assess the relative impact of these factors on swap spreads and to analyze the dynamic links among the term structure variables. An advantage of the VAR methodology is that it can capture not only the direct impact (i.e., instan-

Exhibit 1
Descriptive Statistics

Panel A. U.S.

Rates	*Mean*	*Standard Deviation*	*Maximum*	*Minimum*
Swap Rates				
3-year	6.169	0.662	7.755	4.625
5-year	6.333	0.626	7.835	4.865
10-year	6.573	0.587	7.925	5.105
Treasury Rates				
3-year	5.675	0.653	6.913	3.992
5-year	5.743	0.664	6.848	3.941
10-year	5.868	0.619	7.048	4.152
Swap Spreads				
3-year	0.493	0.209	0.954	0.033
5-year	0.590	0.265	1.125	0.169
10-year	0.705	0.301	1.399	0.258
Proxy Variables				
Level	4.986	0.550	6.240	3.370
Slope	0.883	0.614	1.974	-0.769
Volatility	0.002	0.012	0.240	0.000
Liquidity	0.588	0.218	1.426	-0.075
Default	0.899	0.376	1.850	0.180
Panel B. U.K.				
Swap Rates				
3-year	6.632	0.657	7.520	5.060
5-year	6.666	0.714	7.905	5.020
10-year	6.659	0.899	8.505	5.010
Treasury Rates				
3-year	6.178	0.768	7.345	4.472
5-year	6.106	0.871	7.564	4.255
10-year	6.010	1.146	8.240	4.140
Swap Spreads				
3-year	0.454	0.205	1.101	0.006
5-year	0.560	0.241	1.250	0.150
10-year	0.649	0.330	1.411	0.161
Proxy Variables				
Level	6.058	0.754	7.531	4.813
Slope	-0.048	1.269	2.555	-2.714
Volatility	0.002	0.015	0.265	0.000
Liquidity	0.208	0.169	0.938	-0.515
Default	0.817	0.353	1.596	-0.103
Panel C. Japan				
Swap Rates				
3-year	0.996	0.480	2.320	0.195
5-year	1.498	0.588	3.010	0.395
10-year	2.295	0.610	3.660	1.095
Treasury Rates				
3-year	0.812	0.380	1.901	0.115
5-year	1.311	0.536	2.725	0.356
10-year	2.028	0.643	3.462	0.761
Swap Spreads				
3-year	0.184	0.143	0.516	-0.229
5-year	0.187	0.101	0.550	-0.216
10-year	0.267	0.106	0.616	-0.093
Proxy Variables				
Level	0.370	0.210	1.250	0.047
Slope	1.658	0.588	2.905	0.002
Volatility	0.014	0.059	0.610	0.000
Liquidity	0.180	0.138	0.994	-0.228
Default	0.821	0.570	2.670	-0.528

taneous) of each of the proxies on the spread, but also the indirect effect (i.e., lagged) of each variable on the spread through its interaction with the remaining variables in the system (Lekkos and Milas [2001]).

The VAR analysis in this study reports the variance decomposition of the three-year, five-year, and ten-year swap spreads for a vector of six endogenous variables (level, slope, volatility, liquidity, default, swap spread).[3] It is useful to partition the variance of the forecast error into proportions attributable to innovations of each variable in the system. The sources of variability of each variable in the system are traced and attributed to other variables in the system. In this sense, we can detect and measure feedback effects between or among the variables.

Impulse response analysis (IRA) is also used to support the variance decomposition analysis for the short-run dynamic relationships among the variables. IRA is a shock evaluation procedure used to assess the dynamic characteristics of a system. With 1,000 replications, the impulse response functions are portrayed via Monte Carlo simulation, computing a two-standard deviation confidence interval. This analysis reveals the effect on a system of an exogenous shock to one of the variables in the system.

Like variance decomposition analysis, IRA is a moving-average representation of a system whose coefficients provide impulse response functions that map out the responses of all the variables in a model to a one-standard deviation increase in one of the variables. Hence, the effects of a shock to the system are traced through the deviations of the shocked time paths from the expected time paths as given by the model. For example, IRA could be used to predict what happens to the Japanese swap spread change if there is an unexpected shock in the U.S. interest rate level. This technique is quite useful in analyzing the dynamic interrelationships among variables in a VAR system.[4]

III. EMPIRICAL RESULTS

The variance decomposition analysis (VDA) results help to assess the relative importance of the factors that contribute to changes in the swap spread in the three major swap markets. More specifically, it allows a quantification of the contribution of each determinant of swap spread variation.

Exhibit 2 shows that swap spread own-variation explains the highest proportion of the variance in each currency, ranging from 70% for U.S. ten-year swaps to more than 97% for Japanese three- and five-year swaps. In all

EXHIBIT 2
Variance Decomposition

	Days	Level	Slope	Volatility	Liquidity	Default	Swap Spread
Panel A. Variance Decomposition of U.S. Swap Spreads							
3-Year	1	2.254	16.452	0.008	0.230	0.035	81.021
	2	2.517	20.145	0.041	0.189	0.135	76.972
	3	2.925	20.540	0.059	0.225	0.177	76.074
	5	3.006	20.948	0.060	0.261	0.179	75.546
	10	3.007	20.952	0.060	0.265	0.180	75.536
5-Year	1	1.744	18.890	0.005	0.181	0.014	79.166
	2	1.890	22.807	0.120	0.142	0.072	74.970
	3	2.219	22.938	0.121	0.282	0.127	74.312
	5	2.262	23.204	0.121	0.354	0.136	73.923
	10	2.262	23.204	0.121	0.360	0.137	73.916
10-Year	1	1.720	20.812	0.030	0.178	0.065	77.194
	2	1.956	26.427	0.091	0.155	0.147	71.224
	3	2.521	26.457	0.100	0.370	0.146	70.406
	5	2.584	26.677	0.099	0.471	0.146	70.022
	10	2.585	26.678	0.099	0.478	0.146	70.014
Panel B. Variance Decomposition of U.K. Swap Spreads							
3-Year	1	0.012	6.150	0.174	0.024	1.667	91.973
	2	0.069	6.262	0.171	0.068	1.645	91.787
	3	0.074	6.289	0.170	0.101	1.663	91.704
	5	0.075	6.285	0.170	0.121	1.674	91.676
	10	0.075	6.285	0.170	0.121	1.674	91.675
5-Year	1	0.006	4.995	0.097	0.087	1.960	92.855
	2	0.006	5.149	0.097	0.104	1.908	92.737
	3	0.095	5.372	0.102	0.104	1.941	92.387
	5	0.098	5.374	0.102	0.105	1.942	92.379
	10	0.098	5.374	0.102	0.105	1.942	92.378
10-Year	1	0.064	8.933	0.032	0.231	0.755	89.984
	2	0.063	9.277	0.032	0.248	0.749	89.631
	3	0.169	9.465	0.051	0.292	0.797	89.226
	5	0.172	9.469	0.051	0.303	0.802	89.203
	10	0.172	9.469	0.051	0.304	0.802	89.202
Panel C. Variance Decomposition of Japanese Swap Spreads							
3-Year	1	0.030	1.845	0.010	0.260	0.135	97.721
	2	0.047	2.241	0.045	0.283	0.131	97.252
	3	0.074	2.222	0.045	0.294	0.141	97.224
	5	0.076	2.221	0.045	0.297	0.151	97.210
	10	0.077	2.221	0.045	0.297	0.152	97.208
5-Year	1	0.034	2.035	0.038	0.008	0.116	97.769
	2	0.033	2.166	0.056	0.010	0.106	97.629
	3	0.047	2.624	0.060	0.010	0.110	97.149
	5	0.052	2.727	0.061	0.018	0.110	97.032
	10	0.052	2.730	0.061	0.018	0.110	97.029
10-Year	1	0.113	17.398	0.258	0.028	0.762	81.442
	2	0.110	14.727	0.507	0.036	0.675	83.945
	3	0.115	14.831	0.582	0.104	0.670	83.698
	5	0.126	14.802	0.586	0.104	0.668	83.714
	10	0.131	14.801	0.586	0.104	0.668	83.709

Each row reports the proportion of variance of forecast error of swap spreads one to ten days ahead that can be attributed to own shocks versus shocks to the remaining variables in the VARs.

three currencies, the influence of own-variation declines as swap term lengthens. Further, in all three currencies, the second-highest contributing factor is the slope of that currency's term structure.[5]

One explanation for the importance of the slope of the term structure is its association with an economy's growth rate and business conditions, which in turn affect credit quality and thus the swap spread. This result is consistent with those reported by Duffie and Singleton [1997] and Lekkos and Milas [2001]. In the U.S. and Japanese swap markets, the impact of changes in the slope of the term structure on the swap spread has a positive relationship with swap maturity, but in the U.K. swap market, as swap maturity lengthens, the impact lessens slightly and then increases.

The percentage impact of the slope variable is: 21.0% (U.S.), 6.3% (U.K.), and 2.2% (Japan) for three-year swaps; 23.2% (U.S.), 5.4% (U.K.), and 2.7% (Japan) for five-year swaps; and 26.7% (U.S.), 9.5% (U.K.), and 14.8% (Japan) for ten-year swaps.[6] In general, as the maturity of the swap lengthens, the greater the contribution of the slope of the risk-free term structure.

In U.S. swaps, the next-most important contributing factor is the general level of interest rates, which has an impact of about 2% to 3%, depending on the swap maturity. In U.K. and Japanese swaps, the level of interest rates has a negligible impact on the swap spread. The default premium has a slight effect in the U.K. of up to 2% but has almost no impact in the U.S. or Japan. The liquidity premium in all three currencies has minimal impact; the maximum is less than 0.5%. Finally, interest rate volatility also has virtually no impact; all contributions are less than 1%. This finding is consistent with the results of Sundaresan [1991] and Lekkos and Milas [2001].

While many of these results are broadly comparable with those of Lekkos and Milas [2001], there is an important difference between the two sets of results. Lekkos and Milas find that the proportions in the U.S. and U.K. swap markets seem to reach a stable level between the 26th week and the 52nd week, and in some cases significant changes continue into the second year. Moreover, in many cases, it is not clear that the percentage contributions have converged to a stable value even after 104 weeks. For example, their slope variable for three-year U.S. swaps contributes 2.8% after 26 weeks, rising to 5.3% after 52 weeks and 12.3% after 104 weeks.

The evidence in Exhibit 2 suggests a much faster adjustment. In all three currencies, the percentage contributions reach a stable level within three to five days, and convergence is not in doubt.

Following Lekkos and Milas [2001], we undertake a VAR analysis that includes both domestic and international variables to investigate the links among the three swaps markets. To keep the dimensions of the VAR analysis to a manageable level, for each currency we look at the three main domestic swap market variables (the swap spread itself, the general level of domestic interest rates, and the slope of the domestic term structure), and also the counterpart variables from the other two currencies. We can therefore derive a measure of the cross-market links of the main swap determinants (as measured by the level and slope of the term structure) and the direct effect of the swap spread in one currency on the swap spread in the others.

Exhibit 3 reports the results of this analysis for forecast errors of up to ten days ahead for the U.S. swap spread (Panel A), the U.K. swap spread (Panel B), and the Japanese swap spread (Panel C).

The results in Panel A show that the main factors driving U.S. swap spreads are domestic U.S. factors, particularly the slope of the term structure of U.S. risk-free interest rates and the swap spread itself. All three Japanese variables (level, slope, and spread) and two of the U.K. variables (level and spread) have virtually no influence on U.S. swap spreads. The U.K. slope variable does have a significant effect on the U.S. swap spread, ranging from 5.4% (three-year swaps) to 8.3% (ten-year swaps).

In Panel B, the slope of the domestic term structure is the most significant factor influencing U.K. swap spreads across all maturities, next to the own-swap spreads. The influence of the U.S. market on the U.K. market is notable; both the U.S. slope and the U.S. spread variables are significant. The U.S. swap spread contributes 2.0% to three-year swaps, 3.4% to five-year swaps, and 3.8% to ten-year swaps.

A reasonable explanation for the stronger integration of the swap spreads at longer maturities is related to the greater liquidity of ten-year swaps and their increased significance as hedging instruments due to a lack of alternative instruments, such as interest rate futures, that could perform a similar role (Lekkos and Milas [2001]). The influence of the Japanese variables (level, slope, and spread) on the U.K. swap spread is almost negligible in all maturities.

The results in Panel C show clearly that the U.S. market exerts only a very weak influence on the Japanese market. The U.S. swap spread has a small impact on the three- and five-year Japanese swaps market, with a high

EXHIBIT 3

Variance Decomposition of U.S., U.K., and Japanese Swap Spreads in an International Framework

Panel A. U.S.

	Days	U.S. Level	U.K. Level	Japan Level	U.S. Slope	U.K. Slope	Japan Slope	U.S. Spread	U.K. Spread	Japan Spread
3-Year	1	2.357	0.007	0.296	16.465	5.133	0.004	75.738	0.000	0.000
	2	2.609	0.006	0.528	19.989	5.486	0.005	71.166	0.158	0.053
	3	2.999	0.128	0.669	20.331	5.403	0.011	70.013	0.195	0.251
	5	3.065	0.156	0.669	20.746	5.409	0.027	69.245	0.288	0.396
	10	3.067	0.156	0.674	20.749	5.408	0.027	69.220	0.291	0.408
5-Year	1	1.857	0.025	0.261	18.949	6.357	0.054	72.497	0.000	0.000
	2	1.953	0.020	0.385	22.851	6.736	0.043	67.869	0.081	0.062
	3	2.297	0.059	0.519	22.957	6.661	0.049	67.202	0.162	0.094
	5	2.371	0.064	0.526	23.300	6.676	0.066	66.631	0.271	0.097
	10	2.374	0.064	0.534	23.300	6.676	0.066	66.614	0.275	0.097
10-Year	1	1.861	0.002	0.180	20.983	7.842	0.001	69.131	0.000	0.000
	2	2.075	0.010	0.212	26.434	8.323	0.004	62.861	0.002	0.079
	3	2.627	0.190	0.354	26.444	8.214	0.005	62.059	0.014	0.094
	5	2.713	0.229	0.371	26.687	8.255	0.005	61.590	0.024	0.126
	10	2.719	0.231	0.373	26.687	8.255	0.005	61.578	0.024	0.128

Panel B. U.K.

	Days	U.S. Level	U.K. Level	Japan Level	U.S. Slope	U.K. Slope	Japan Slope	U.S. Spread	U.K. Spread	Japan Spread
3-Year	1	0.001	0.016	0.052	0.690	4.960	0.031	2.043	92.208	0.000
	2	0.048	0.076	0.052	0.886	5.532	0.087	1.991	91.162	0.166
	3	0.100	0.083	0.205	0.881	5.531	0.087	2.010	90.754	0.350
	5	0.109	0.083	0.282	0.918	5.545	0.090	2.042	90.523	0.408
	10	0.111	0.083	0.291	0.924	5.544	0.090	2.048	90.496	0.414
5-Year	1	0.017	0.027	0.003	0.387	3.864	0.000	3.009	92.693	0.000
	2	0.262	0.026	0.077	1.892	3.663	0.180	3.348	90.322	0.230
	3	0.366	0.136	0.446	1.924	3.782	0.178	3.340	89.525	0.303
	5	0.385	0.138	0.527	1.992	3.794	0.190	3.369	89.263	0.341
	10	0.388	0.138	0.543	1.996	3.794	0.190	3.371	89.238	0.343
10-Year	1	0.088	0.097	0.094	0.311	8.939	0.005	3.629	86.837	0.000
	2	0.101	0.093	0.261	1.933	8.625	0.148	3.796	84.998	0.046
	3	0.237	0.208	0.419	1.925	8.809	0.150	3.775	84.361	0.116
	5	0.240	0.209	0.434	1.937	8.823	0.150	3.777	84.309	0.121
	10	0.241	0.209	0.439	1.937	8.823	0.150	3.777	84.304	0.121

Panel C. Japan

	Days	U.S. Level	U.K. Level	Japan Level	U.S. Slope	U.K. Slope	Japan Slope	U.S. Spread	U.K. Spread	Japan Spread
3-Year	1	0.137	0.084	0.013	0.059	0.048	2.291	0.299	0.120	96.950
	2	0.316	0.141	0.027	0.055	0.045	2.602	0.729	0.127	95.958
	3	0.317	0.223	0.046	0.095	0.223	2.558	1.234	0.140	95.163
	5	0.345	0.260	0.047	0.102	0.231	2.552	1.300	0.142	95.020
	10	0.345	0.261	0.047	0.108	0.232	2.551	1.305	0.143	95.008
5-Year	1	0.732	0.012	0.015	0.556	0.435	2.460	0.716	0.205	94.870
	2	0.680	0.017	0.015	0.511	0.459	2.475	0.879	0.221	94.742
	3	0.690	0.155	0.026	0.746	0.721	2.865	1.059	0.306	93.433
	5	0.694	0.174	0.032	0.753	0.771	2.933	1.066	0.311	93.265
	10	0.696	0.176	0.032	0.754	0.774	2.935	1.067	0.311	93.255
10-Year	1	0.390	0.012	0.082	0.537	0.658	18.669	0.147	0.001	79.505
	2	0.351	0.010	0.081	0.609	0.706	15.826	0.182	0.004	82.231
	3	0.410	0.031	0.091	0.685	0.733	15.872	0.221	0.078	81.878
	5	0.439	0.043	0.096	0.687	0.772	15.819	0.227	0.112	81.804
	10	0.441	0.043	0.098	0.688	0.773	15.818	0.228	0.112	81.799

Each row reports the proportion of variance of forecast error of swap spreads one to ten days ahead that can be attributed to its own shocks versus shocks to the remaining variables in the VARs.

Exhibit 4

Impulse Responses for Five-Year U.S. Swap Spread

of only 1.3%. The U.K. influence on Japan is negligible.

Finally, it is useful to compare these results with those of Lekkos and Milas [2001]. We have noted the Lekkos and Milas finding that, in total, U.S. variables contribute between 22% and 42% of U.K. swap spread variation, while U.K. variables contribute between 12% and 26% of U.S. swap spread variation. That is, there are significant influences in both directions. These contributions are as of a forecast date 52 weeks ahead.

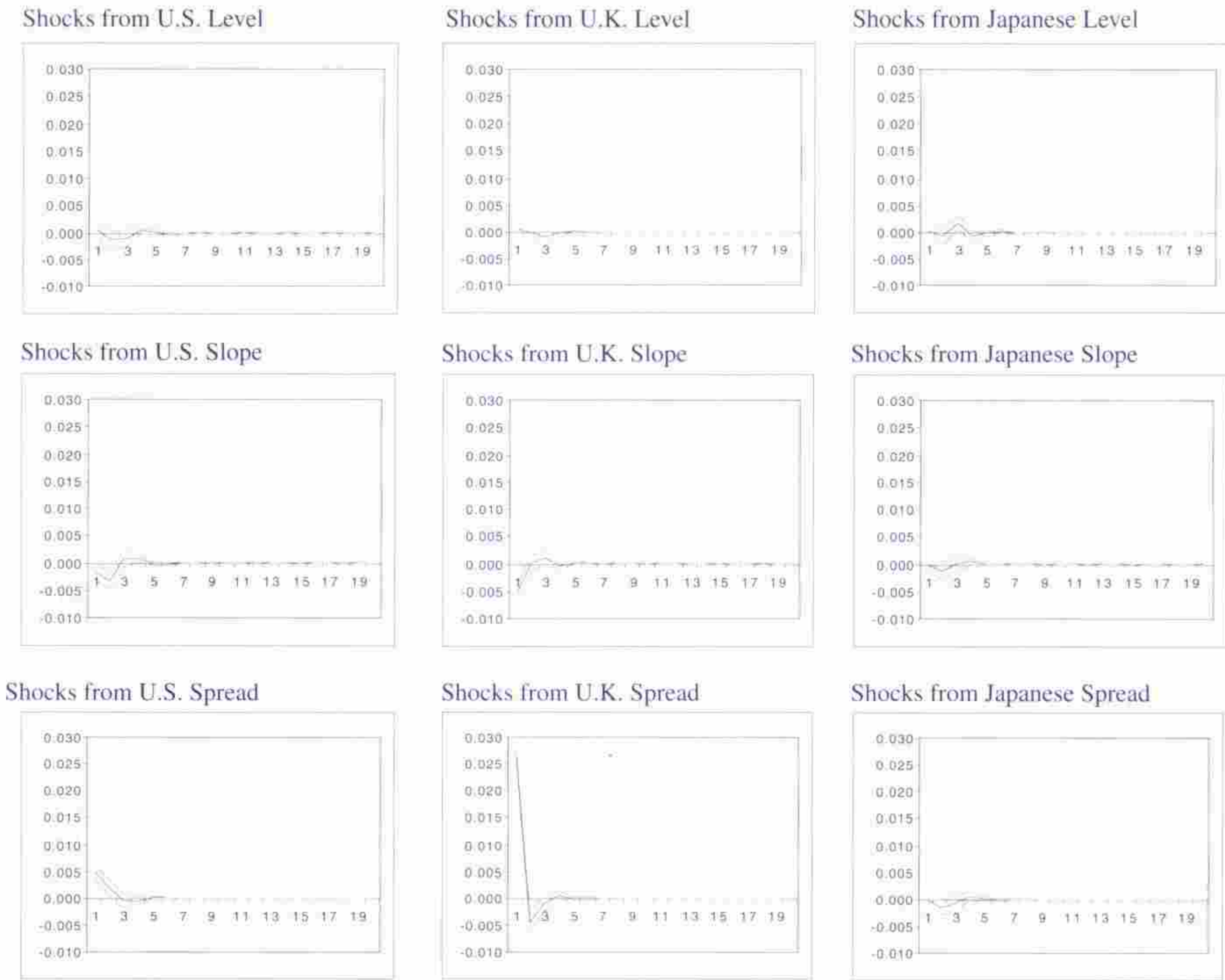
Our results show a weaker but much faster connection. The total of the U.S. variables (level *plus* slope *plus* swap spread) contributes between 3.0% and 5.9% of U.K. spread variation, while U.K. variables contribute between 5.9% and 8.5% of U.S. variation. The influence of both the U.S. and the U.K. on the Japanese swap market, and vice versa, is minuscule. The influences flowing between the U.S. and the U.K. seem almost immediate, and convergence to stable levels is rapid.

To get more insight into how the U.S., U.K., and Japanese term structure factors influence swap spreads, an impulse response analysis is undertaken for all three swap maturities in all three currencies. The results for the U.S., U.K., and Japanese five-year swap spread are shown in Exhibits 4, 5, and 6.[8]

The most significant feature in Exhibit 4 is that the U.S. swap spread is affected most by its own shock, followed by the U.S. slope, and then the U.S. level. In each case, the impact vanishes after five days, indicating that the

EXHIBIT 5

Impulse Responses for Five-Year U.K. Swap Spread



market quickly reaches a new equilibrium.

Consistent with Exhibit 3, the IRA results in Exhibit 5 show that the U.S. variables (slope and especially spread) have a significant effect on the U.K. swap spread, even though the greatest impact on the U.K. swap spread is its own shock. The U.K. term structure slope also has a significant effect in the short run on the U.K. swap spread. In Exhibit 6 for Japanese swap spreads, the shocks from the U.S. and U.K. variables (level, slope, and spread) have a negligible impact in the short run. The great proportion of the Japanese swap spread is explained by its own shock.

A shock from the U.S. slope variable significantly affects U.K. swap spreads, and vice versa. In both cases, the typical pattern after the shock is initially a large fall, then a rise, then a slower fall toward the long-run equilibrium level. The process is completed after about five days.

The evidence from the impulse response analysis is thus highly consistent with that of the variance decomposition analysis.

IV. CONCLUDING REMARKS

Our main objectives are, first, to identify and compare the determinants of changes in interest rate swaps spreads in three major swaps markets—the U.S., the U.K., and Japan—and, second, to investigate the strength and influence of the links among the U.S., the U.K., and the Japanese swaps markets. Analysis using variance

EXHIBIT 6
Impulse Responses for Five-Year Japanese Swap Spread

decomposition and impulse response analysis supports five conclusions.

First, in all three currencies, the higher the slope of the domestic term structure of interest rates and the longer the maturity of the swap, the greater its contribution. Second, the general level of interest rates is of some importance in the U.S. but not in the U.K. or Japan. Third, the default spread is of some importance in the U.K. but not in the U.S. or Japan. Fourth, in all three currencies, interest rate volatility and the liquidity premium have very little impact.

Finally, there is a significant bidirectional influence (particularly through the term structure slope) between the U.S. and U.K. swap markets, but neither of these markets has a major impact on the Japanese swap market. Similarly, the Japanese market has a negligible influence on the U.S. and U.K. markets.

ENDNOTES

[1]Two other studies of nominal interest rate transmission are Chinn and Frankel [1994], who use monthly observations, and Edwards [1998], who uses both weekly and monthly observations. Chinn and Frankel focus on long-term trends rather than short-term influences, while Edwards focuses on an especially volatile period for three developing countries (Argentina, Chile, and Mexico). Hodgson, Kremmer, and Lee [1998] use intraday data, but their study relates only to the U.S. and Australia and uses interest rate futures data.

[2]Both tests support the unit root hypothesis at the 5% significance level for all data series. Hence the vector autoregression (VAR) tests were conducted using first differences. Complete results of the unit root tests are available from the authors on request.

[3]This type of orthogonalization permits most exogenous factors to come first in ordering so as to allow the greatest opportunity for the factors to have an impact on the daily movements in the swap spreads. For example, the three-month Treasury bill rate is the first variable in the VARs, in the sense that shocks to the three-month rate may have a contemporaneous effect on all remaining variables, while shocks to all other variables may have only lagged effects on the short rate (Lekkos and Milas [2001]).

[4]As noted by Lekkos and Milas [2001], one disadvantage of variance decomposition analysis is the contemporaneous correlation of forecast errors; to account for the possibility of correlation of the errors across different equations, the equation errors of each VAR are orthogonalized by Choleski decomposition so that the covariance matrix of the resulting errors is diagonal (see, e.g., Lütkepohl [1993]).

[5]Note that Exhibits 2 and 3 report the decomposition of variance of the forecast errors of U.S., U.K., and Japanese swap spreads for one to ten days ahead. Results for periods longer than ten days ahead are not provided because they are identical to those for a ten-day period. Indeed, both exhibits show that in most cases there is very little change after just three days.

[6]The term *impact* is used to mean the percentage contribution of the variable after it has reached a stable level. In the case of Exhibit 2, the period is ten days.

[7]When we change the ordering of the six variables and reestimate the VARs, overall the results are consistent with those in Exhibit 3. For example, the variance decomposition of Japanese ten-year swap spreads with the ordering of U.S. level, U.S. slope, U.S. spread; U.K. level, U.K. slope, and U.K. spread; Japan level, Japan slope, and Japan spread in the VAR produces 0.44%, 0.68%, 0.46%, 0.04%, 0.54%, 0.11%, 0.09%, 15.82%, and 81.79%, respectively. The decision that the U.S. variables precede the U.K. and Japanese counterparts is justified on the basis of the relative size and liquidity of the markets (Lekkos and Milas [2001]).

[8]To conserve space, we do not present exhibits for the three- and ten-year swaps. For each currency, the results are very similar to those for the five-year maturity, and are available on request.

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